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Author
Voigt, Matthew K

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Queer-Spectrum Student Experiences and Resources in Undergraduate Mathematics

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Mathematics and Science Education

by

Matthew Voigt

Committee in charge:

University of California San Diego

Professor David Quarfoot
Professor Gabriele Wienhausen
Professor Luis A. Leyva

San Diego State University

Professor Chris Rasmussen, Chair
Professor William Zahner
Professor Marissa Vasquez

2020

The Dissertation of Matthew Voigt is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California San Diego

San Diego State University

2020

DEDICATION

For my family – whose love has shaped me into the person I am today.

For Arthur – whose dedication and love supported me throughout this journey.

For all Queer youth who need to hear this - You are loved, and you are strong.

EPIGRAPH

There will always be more questions. Every answer leads to more questions.

The only way to survive is to let some of them go.

-David Levithan

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LIST OF ABBREVIATIONS

P2C2	Precalculus to Calculus 2; refers to the introductory mathematics courses required of most STEM majors
STEM	Science, Technology, Engineering, and Mathematics
oSTEM	Out in STEM; refers to student organization designed to support LGBT STEM students
LGBTQIA	Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual
PtC	Progress through Calculus
SEMINAL	Student Engagement in Mathematics through an Institutional Network for Active Learning

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ACKNOWLEDGEMENTS

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VITA

2008	Bachelor of Arts, Saint John’s University (Collegeville, MN)
2015	Master of Science, University of Minnesota – Twin Cities
2020	Doctor of Philosophy, University of California San Diego, San Diego State University

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ABSTRACT OF THE DISSERTATION

Queer-Spectrum Student Experiences and Resources in Undergraduate Mathematics

by

Matthew Voigt

Doctor of Philosophy in Mathematics and Science Education

University of California San Diego, 2020
San Diego State University, 2020

Professor Chris Rasmussen, Chair

Supporting student success in introductory mathematics courses is a growing national imperative in order to both diversify and increase the number of well-prepared Science, Technology, Engineering, and Mathematics (STEM) graduates. Efforts to diversify STEM fields have focused on broadening participation, addressing equitable outcomes, and promoting inclusive learning environments for an array of student identities. At the same time, educational research, institutional programs, and policies to support Queer-spectrum students remain largely underdeveloped and undertheorized. By Queer-spectrum, I mean students who identify as Lesbian, Gay, Bisexual, Transgender, Two-spirit, Intersex, Pansexual, Asexual, or in other ways Queer because of their queer sexual identity or non-cisgender identity (Kumashiro, 2001). Broadly speaking, this dissertation study seeks to explore the lived experience of Queer-

spectrum undergraduate STEM students through a transformative mixed methods design (Mayoh & Onwuegbuzie, 2015), which is structured in three phases.

Drawing on large scale quantitative survey data (n=25,785) for the first phase, I examine how Queer-spectrum students describe mathematical learning opportunities in introductory mathematics courses and how these reported descriptions differ within Queer-spectrum students and between Queer-spectrum and Straight students. In the second phase of this study, I use a phenomenological approach and grounded theory techniques to identify mathematical discourses (e.g., beliefs, norms) related to Queer identity based on individual interviews with 17 Queer-spectrum students. Based on this analysis, I define the exclusion-irrelevancy space to network together mathematical discourses that positions queer identity as excluded and irrelevant to the pursuit of STEM. In the third phase of this study, I draw on thematic analysis and Nasir's (2011) identity resource constructs to document the resources that support Queer-spectrum students in STEM using focus groups with Queer-spectrum students at four universities.

Taken together, these three phases seek to transform and advocate for inclusive STEM environments for Queer-spectrum students. The aim of this study is to provide both a broad understanding of Queer-spectrum student experiences in mathematics while providing illustrative accounts to capture the nuance of the lived experiences for Queer-spectrum students. I conclude this dissertation study by looking across the three phases and, most importantly, provide implications for practice and policy in STEM education to promote more inclusive STEM environments.

Chapter 1: Introduction

There has been a growing effort within Science, Technology, Engineering, and Mathematics (STEM) education to broaden participation, address equitable outcomes, and promote inclusive learning environments along an array of various student identities. At the same time, educational research, institutional programs, and policies to support students with a minoritized sexual identity in undergraduate mathematics environments remain largely underdeveloped and undertheorized. By minoritized sexual identity, which I henceforth refer to as Queer-spectrum, I mean students who identify as Lesbian, Gay, Bisexual, Transgender, Two-spirit, Intersex, Pansexual, Asexual, or in other ways Queer because of their sexual identity or non-cisgender identity (Kumashiro, 2001). This study seeks to address this gap in the literature by documenting the experiences of Queer-spectrum students in introductory mathematics courses and identifying the resources that can lead to equitable and inclusive experiences for Queer-spectrum STEM-intending students. To accomplish this goal, I take a mixed methods approach in order to broadly understand how Queer-spectrum students report their experiences in introductory mathematics courses using quantitative survey data while leveraging illustrative accounts to understand casual factors related to student success and belonging in mathematics. I take a transformative approach in this research drawing on sociopolitical theories to advocate and elevate the voices of Queer-spectrum STEM students.

Motivation

There is national imperative in the United States for increasing both the number and diversity of graduates with STEM degrees in order to promote scientific discoveries and technological innovations (PCAST, 2012). One of the reasons for the stagnation in the number of STEM graduates is due, in part, to the low retention rates for those intending to major in a STEM field (Bressoud, 2015). This is often attributed to the documented weaknesses in undergraduate STEM teaching, learning opportunities, and student supports (Bressoud et al., 2015; National Academies of Sciences Engineering and Medicine, 2017). This has led to mounting pressure on educators and policy makers to create learning opportunities that are engaging and inclusive for all students.

The pressure to improve undergraduate STEM education is particularly salient in the field of mathematics, which often serves as a gateway to other STEM disciplines. Students are often required to take several undergraduate mathematics courses as a requirement for other STEM majors. As a result, mathematics has historically acted as a gatekeeper, preventing students who intend to major in a STEM field from advancing in their educational trajectory (Bryk & Treisman, 2010). This bottleneck in mathematics is due, in part, to introductory mathematics courses that are often uninspiring, unwelcoming or lacking structural supports for students (PCAST, 2012; Seymour, 2006).

Given the need for increasing the number of STEM graduates, recent research has focused on the underrepresentation of certain student identities in STEM (e.g., women, students of color, and students with a disability). Students with these identities are often disproportionately impacted by systemic barriers from obtaining successful educational outcomes (Bryk & Treisman, 2010; Martin, 2009; PCAST, 2012), contributing to higher rates of switching out of STEM majors (Ellis et al., 2016), or leaving college altogether. Efforts to increase equitable outcomes for underrepresented groups has resulted in a myriad of research that address structural inequalities (e.g., access to content), psychological factors (e.g., stereotype threat, bias), teaching practices (e.g., research opportunities, active learning), and positive identity formation and belonging within mathematics.

Mathematical and Social Identities

Identity formation is particularly relevant to this study as it is important to understand how students, especially students from communities underrepresented in STEM, develop a sense of membership in the practice of mathematics and the extent to which they identify as "learners" and "doers" of mathematics (Martin, 2000; Nasir & de Royston, 2013). Mathematical identity, as defined by Martin (2006), encompasses the "dispositions and deeply held beliefs that individuals develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics to change the conditions of their lives" (p. 206). Positive mathematical identity formation is critical in addressing persistence as it has been shown to increase retention for marginalized students throughout K-16 settings (McGee, 2014; Nasir & Saxe, 2003) and has dramatic effects on the learning and well-being of students overall (Nasir & de Royston, 2013).

In recognizing the importance of supporting students with marginalized identities, position statements on issues of equity and diversity have been issued by several of the professional organizations in mathematics (American Mathematical Association of Two-Year Colleges, 2005; Association of Mathematics Teacher Educators, 2015; National Council of Supervisors of Mathematics (NCSM) and TODOS: Mathematics for ALL, 2016; National Council of Teachers of Mathematics, 2014). Each of these positions statements calls on educators to be responsive to the backgrounds and experiences of students with a goal to end systemic forms of inequality. These position statements refer to students' racial, ethnic, linguistic, gender, age, dis/ability, religious, and socioeconomic backgrounds. In only one of these position statements is sexual identity specifically mentioned as a social identity (Association of Mathematics Teacher Educators, 2015). While the list of social identities in these position statements cannot possibly be exhaustive, the absence of sexual identity is nevertheless troubling. The absence of sexual identity can convey implicit messaging that sexual identity is considered an inappropriate topic in mathematical environments, that sexual identity is not perceived as impacting equitable outcomes, or that issues of sexual identity are so understudied they fail to gain public recognition.

It may be the case that mathematical policy statements are not reflective of the field at large, since they are often designed to be politically prudent, and thus avoid potential conflicts, such as including sexual identity. However, examination of the field of mathematics education research, reveals a dearth of literature related to sexual identity. For example, a search of peer reviewed articles using Academic Search Premier, revealed 70 peer-reviewed articles with the keyword "mathematics and Queer" or "mathematics and LGBT". In contrast there exists extensive research examining issues with the keywords "mathematics" and "gender" with 7,222 articles (e.g., Esmonde & Langer-Osuna, 2013) or "mathematics and "race" with 2,458 articles (e.g., Martin, 2009; McGee, 2014). There is also more research highlighting the different experiences of "first-generation college students" with 335 articles (Darling & Smith, 2007; Hicks & Wood, 2016; Wilson & Kittleson, 2013) and "English-language learners" with 277 articles (Bresser et al., 2012; Mosqueda & Maldonado, 2013; Zahner, 2015). Although this cursory search only represents articles containing these keywords, it helps to provide a sense of the magnitude at which these issues have been noted in the literature. Despite this attention paid to student identities, when it comes to the topic of sexual identity, the research literature remains largely in the closet.

There are, however, emerging efforts in STEM broadly to address the inclusion of Queer-spectrum scientists. For example, some professional societies are forming committees to support Queer-spectrum people in STEM fields such as the American Astronomical Society Working Group on LGBTIQ Equity, American Society for Engineering Education's LGBTQ+ Advocacy in STEM Virtual Community of Practice, and the American Chemical Society Division of Professional Relations Gay & Transgender Chemists & Allies Subdivision. Additionally, there have been calls to include sexual identity questions on National Science Foundation surveys in order to account for Queer-spectrum people in the analysis of academic and STEM outcomes (Freeman et al., 2018; Langin, 2018). Collecting such data can help promote visibility and further support research on Queer-spectrum student experiences.

Next, I provide two illustrative vignettes highlighting why Queer-spectrum identity is a relevant social identity in the context of mathematics. The first vignette illustrates the social and psychological impact that may be experienced by those with a Queer-spectrum identity within STEM environments. The second vignette illustrates the heteronormative assumptions that can permeate mathematical problems and curriculum, providing hidden messages conveyed about who are the primary "learners" and "doers" of mathematics.

Illustrative Vignette: The Social and Psychological Impact

The following excerpt comes from a research article entitled, “Queering science for all: Probing Queer theory in science education” written by Kristin Gunckel (2009). Gunckel, who identifies as a Lesbian and is a graduate student, describes their[1] experience during a STEM project meeting with other graduate students, post-docs, and the principal investigators. The following scenario occurred during a project meeting centered around discussion on how science curriculum can address issues of equity:

> My pulse begins to race to about 110 beats per minute. I feel the sweat begin to bead on my forehead, and I feel short of breath. I don’t hear what anyone else is saying right now; I am only trying to figure out how I am going to say it. I want everyone to realize that there are other people who get left out of science education, who are invisible in the discourse, and who are marginalized in schools. Can anyone tell how anxious I am? I silently curse that it always works this way, that whenever I want to bring up this topic, it always feels like I am coming out again (and again) for the first time, even though most of the people in this room and on the TV know I am a Lesbian (I think they do, anyway). But every time it feels this same way. The anxiety is there about how the topic will be received and whether or not people will see it as relevant. I am going to take the risk, once again, because it is relevant, it is important, and it has bearing on all students’ learning and all teachers’ teaching. […] Suddenly, a voice in the corner of the room, my voice, I think, says, “Well, I think we need to think about sexual orientation and about how school science helps or hinders Gay, Lesbian, Bisexual, and Transgender students learning science and teachers teaching science.” There, I said it! Now, what will they say? How will they react? I look around the room and at the TV, anticipating someone will say something, anything. I wait. Silence. (Gunckel, 2009, pp. 62–63)

Notice in this excerpt the psychological impact experienced by Gunckel as they raise issues of sexual identity: increased heartbeat, anxiety, and hesitancy to address the topic. In addition, the lack of response from others is deafening and reinforces the notion that issues of sexual identity are inappropriate or uncomfortable for others in the sexual majority in this context. Even though Gunckel is a graduate student, who has

[1] [1] They/Them/Theirs pronouns are used to describe individuals whose pronouns are unknown.

already persisted in the field and demonstrated understanding of the content knowledge, they still experience hesitancy in discussing the topic in this space. One can only imagine how that experience may be heightened for undergraduate students still forming their sense of STEM identity and belonging. Additionally, the context of the meeting is to specifically address issues of equity in science and yet the response of others seems to indicate sexual identity is not pertinent to that discussion. Reflecting on this example, how might undergraduate students experience similar or different feelings as they navigate disclosing their sexual identity in mathematical environments? Might their emerging mathematical proficiency or the relative neutrality of the mathematics classroom, inhibit their ability to freely communicate with their peers and instructor?

Illustrative Vignette: The Curricular Impact

Many people believe that mathematics is an objective field or inherently unbiased, since it is often portrayed as the universal language. Yet, as the following example illustrates, even a problem drawn from a precalculus textbook related to similar triangles (Young, 2012) can have imbedded messages about the types of individuals that perform and interact with mathematics.

EXAMPLE 3 Calculating the Height of a Tree

Billy wants to rent a lift to trim his tall trees. However, he must decide which lift he needs: one that will lift him 25 feet or a more expensive lift that will lift him 50 feet. His wife Jeanine hammered a stake into the ground and by measuring found its shadow to be 1.75 feet long and the tree's shadow to be 19 feet. (Assume both the stake and tree are perpendicular to the ground.) If the stake was standing 3 feet above the ground, how tall is the tree? Which lift should Billy rent?

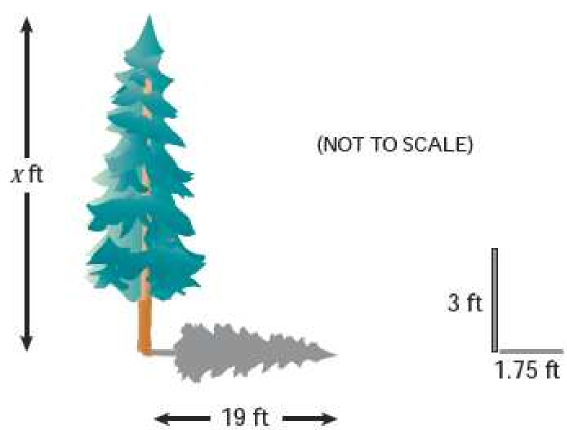


Figure 1.1. Calculating the height of a tree problem from Young (2012).

Notice in this example, the author uses both possessive and gendered language ("his wife") in describing the heterosexual relationship between the individuals in the mathematics problem. The presence of gender, marital status, and implied sexual identity illicit certain connotation that may impede a student to engage with the problem and its solution. This may psychologically position a student into accepting a heteronormative and doing the mathematics (Rubel, 2016). In fact, this is not an isolated example, since there are countless examples that are embedded with gendered and heteronormative contexts in mathematics and science problems (Esmonde, 2011; Rubel, 2016; Snyder & Broadway, 2004). Mendick (2006a) has even suggested that the nature of mathematics has been cast into binaries, that often correlate traits of masculinity with success in mathematics.

Sociopolitical Analysis

As the two previous vignettes illustrate, there often are social and cognitive hurdles that Queer-spectrum undergraduates face in mathematics. In this dissertation study, I aim to illuminate the experiences of Queer-spectrum students in undergraduate mathematics contexts by employing a sociopolitical analysis (Gutiérrez, 2013). Sociopolitical theory extends sociocultural theories of learning, which focus on the ways that activity in learning environments are socially and culturally organized, by foregrounding issues of power and marginalization. Using a sociopolitical stance, means understanding, “knowledge, power, and identity as interwoven and arising from (and constituted within) social discourses” (Gutiérrez, 2013, p. 4). The meaning of discourses in this context comes from post-structural theory (Foucault, 1977), and encompasses more than just spoken and written words. Discourses include “institutions, actions, words, and taken-for-granted ways of interacting and operating” (Gutiérrez, 2013, p. 7). Specifically, I draw on post-structural feminist theory (Mendick, 2006a), critical race theory (Ladson-Billings, 1998), and Queer theory (Kumashiro, 2001; McWilliams & Penuel, 2017) to interrogate issues of identity, power and knowledge that arise for Queer-spectrum students in mathematical environments. For example, in the previous vignette, Gunckel transgresses the shared understanding of allowable discourses by discussing sexual identity in that shared space and is thus met with silence.

Queer Theory and Terminology

Queer theory seeks to account for how normative assumptions regarding sex, sexuality, gender, and gender identity have been shaped by institutional structures. Queer theory is often used to deconstruct dominant theories of identity, and positions identity as culturally and historically situated, and often fluid throughout a person's lifetime (Creswell, 2013). Queer theory explores the phenomenon of otherness through interrogating anything that comes between normative and deviant activities (Jagose, 1996). In this study, I use the term "Queer-spectrum" to broadly refer to students with a minoritized sexual identity. The choice of the term Queer is purposeful, as it represents a political statement in terms of reclaiming the transgressive nature of the word Queer, a term which has historically been used to denigrate individuals in society (Brontsema, 2004; Rocheleau, 2019). Additionally, the term Queer-spectrum serves as a mechanism to coalesce among the many different Queer identities (e.g., Bisexual, Lesbian, pansexual) to understand their shared experiences in mathematics, while also recognizing that there are differences and fluidity among these identities. For this reason, I avoid, when possible, using acronyms (LGBTQIA[2]) to discuss issues for sexual minoritized students as these can imply rigid boundaries between the identities while also suggesting that they represent the totality of sexual identities. I also do not claim that all Queer-spectrum individuals relate to the same experiences in the same way, as this would be both disingenuous and unrealistic. Yet, I argue that, there is commonality and community among Queer-spectrum individuals who experience "otherness" within society.

[2] Common acronym for Queer-spectrum identities indicating Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual.

Research Questions

As noted previously, I take a sequential transformative mixed methods approach (Creswell et al., 2007; Mayoh & Onwuegbuzie, 2015), drawing on sociopolitical frameworks, to understand the experiences of Queer-spectrum undergraduate students in mathematical learning opportunities and how these experiences relate to the development of mathematical identity (Leyva, 2016a; Martin, 2006). The following italicized *research goals,* each with specific research questions guide this dissertation:

1. *Unpacking Queer-spectrum students' mathematical learning opportunities:* How do Queer-spectrum students describe their experiences with various mathematical learning opportunities (e.g., classroom instruction, peer groups, tutoring, assessment) while taking precalculus and calculus courses? In relation to these identified learning opportunities, what differences (if any) exist between the experiences of Queer-spectrum and Straight students?
2. *Characterizing and navigating mathematical discourses in relation to Queer identity*: What discourses about mathematics do Queer-spectrum students describe in relation to their Queer identity? And how do Queer-spectrum students respond to and navigate these discourses about mathematics?
3. *Resources that impact Queer-spectrum students:* In what ways do curricular, interpersonal, and institutional factors impact Queer-spectrum students' participation, perceived capability or success, and sense of belonging in mathematics?

Roadmap of the Manuscript

Chapter 2:Literature Review and Theoretical Perspective, situates this study within the guiding theoretical frameworks and relevant literature. This begins with an overarching description of a sociopolitical theory of learning, followed by more detailed accounts for how post-structuralism, critical race theory, and Queer theory inform the design of this study. I then provide an overview for how mathematical identity has been discussed in the literature, and I put forth a definition of a Queer mathematical identity that allows Queer-spectrum students to fully participate and perform effectively in mathematical contexts as Queer individuals. The chapter concludes with a review of the literature related to Queer-spectrum identities in education broadly, higher education, and what is known about queerness in STEM.

Chapter 3: Methods, begins with an overview of the design of this study. This study consists of a pilot study and three distinct phases. The first phase, which corresponds to research question one, draws on a quantitative analysis of student survey data to examine the mathematical learning opportunities described by Queer-spectrum students. I outline the specifics of the survey, data collection procedures, and data analysis techniques used to answer research question one. The second phase, which corresponds to research question two, uses a phenological approach and grounded theory techniques to identify the mathematical discourses related to Queer identity and the navigational strategies that arise within those discourse. I outline the participants, the data collection processes, coding techniques, and an operational definition of the codes that emerged from the data. The third phase, which corresponds to research question three, draws on thematic analysis and Nasir's (2011) identity resource constructs to document the resources that support Queer-spectrum students in STEM. I outline the details of the data collection and analysis techniques used to answer research question three.

Chapter 4: Queer-Spectrum Students' Mathematical Learning Opportunities, begins with an account for how Queer-spectrum identity was determined from the student survey. I then provide descriptive statistics follows to situate the data and context of the respondents. This is followed by an analysis of several composite variables describing mathematical learning opportunities, first by comparing differences within Queer-spectrum identities, followed by comparison between Queer-spectrum and Straight students. The impact of Queer identities on these outcomes variables is then contrasted with the impact of other demographic information using linear regression. The chapter concludes with key findings from the analysis.

Chapter 5: Mathematical Discourses for Queer-Spectrum Students in STEM, begins with a description of the seven identified mathematical discourses. Next, each discourse and the evidence used to identify the discourse are described along with an illustrative account of the navigational strategies utilized by students within each particular discourse. The chapter concludes with key findings from the analysis that serves to network together the mathematical discourses through the identification of an exclusion-irrelevancy space.

Chapter 6: Resources to Support Queer-Spectrum STEM Students, begins with a review of Nasir's (2011) three identity resources: material, relational, and ideational. Based on the thematic analysis of the focus groups, specific resources were classified among the three types of identity resources and further categorized as to whether they occurred in classroom-related environments or external educational environments. The chapter discusses each identified resource and situates it within broader literate when appropriate. I first present material resources, followed by relational resources, and ending with ideational resources. The chapter concludes with key findings looking across all of the identity resources.

Chapter 7: Conclusion and Implications, begins with a summary of the findings looking across the three research questions and the three associated phases of this study. Limitations of the study are discussed, followed by implications for practice and policy in STEM education. The chapter concludes with areas of future research and a final reflection on this study.

Chapter 2: Literature Review and Theoretical Perspective

The purpose of this study is to understand the experiences of Queer-spectrum undergraduate students in mathematical learning environments and how these experiences relate to the development of mathematical identity. This entails understanding how students describe their experiences while taking introductory precalculus and calculus courses, how those experiences may be affirming or challenging to their Queer identity, and how the experiences relate to the development of their mathematical identity. The amount of literature on this topic is rather limited, and thus, this research is supported by a grounding in various theoretical frameworks related to identity and the emerging literature related to the experience of Queer-spectrum individuals in STEM and in education more broadly. In this chapter, I begin with a discussion of a sociopolitical view of learning, and its enactment in research to investigate identity through post-structuralism, critical race theory and Queer theory. I then outline a definition of mathematical identity that draws on both a participative and discursive orientation towards identity. Finally, I present an overview of emerging literature related to the experiences of Queer-spectrum individuals in STEM and education.

Theoretical Frameworks

In this section, I begin with a discussion of a sociopolitical view of knowledge that views learning as tied to power and identity. I then present examples of how some sociopolitical frameworks (e.g., post-structuralism, critical race theory) have been used to explore the connected nature of gender and racial identity with power and mathematical learning. I then discuss how Queer theory will be leveraged to understand how sexual identity is connected to power and mathematical learning within this research. I leverage these three theories (post-structuralism, critical race, and Queer theory) to account for the ways in which queerness is related to the interplay between sexual, gender, and racial identities. In the last section, I develop a definition of mathematical identity that can account for the ways that Queer-spectrum students participate and are positioned as learners of mathematics.

Sociopolitical Theory of Learning

The common view of mathematics, held both by mathematicians and in popular culture, is that mathematics is culture-free, neutral, timeless, and objective (Battey & Leyva, 2016; Martin et al., 2010; Nasir et al., 2008). However, numerous scholars have problematized this view, by elucidating the close link between mathematics and culture (Gutiérrez, 2009; Nasir et al., 2008) and the evolution of mathematics over history (P. Ernest, 1992). From this perspective, mathematics is a human creation that cannot be removed from its social and historical context. According to sociopolitical theories of learning, learning is a cultural process involving social beings and interactions, while at the same time choosing to foreground the political nature of those interactions as influenced by power and identity. Taking such a view, allows one to interrogate and disrupt normative rules and practices that have historically privileged some individuals and marginalized others. Sociopolitical theories allow researchers to capitalize on activist notions that move beyond simply understanding mathematics education but seek to transform mathematics education as a tool for social justice.

Gutiérrez (2013) differentiates how notions of identity and power are conceptualized from a sociopolitical standpoint that is often separate from mainstream notions of these terms in mathematics education. Identity represents acts of a performative nature (J. Butler, 2011) and not a fixed social category to which one belongs (e.g., white, mathematician). Identity is transformed into something one does through the repetition of acting, moving, talking, telling stories, joining groups, and positioning oneself and others to social discourses (Darragh, 2016). In this way, identity is mutually constructed with others; it is dynamic, multiple, reinforcing, and even contradictory. *Power* is viewed as a relational capacity of actors to position themselves in different situations and is not viewed as a monolithic force acting in one direction (e.g., learning mathematics or being successful in mathematics gives students power in society). Power is not something that can be acquired, but is exercised through innumerable interplays of social relationships, acting in both negative and positive ways, and manifests itself in both oppressive and productive ways. Power relations are constructed and circulated in our everyday lives, and thus, individuals can both reproduce and subvert ongoing acts of cultural production of power (Gutiérrez, 2013).

A sociopolitical theory of learning aligns with the goals of this research which seeks to capture how Queer-spectrum students may characterize mathematical learning as illuminating their Queer identity (or not) as they navigate various discourses. For example, in answering research question 2, how might acting or performing Queer (e.g., dress, mannerisms, statements) while working in mathematical environments position a student as less mathematically knowledgeable? Additionally, how might mathematical discourses which privilege precision and definitions manifest in oppressive ways for gender non-binary or Queer-spectrum students? Understanding the relation between a Queer-spectrum student’s identity and how structures of power influence their experiences will inform the ways in which they are able to develop mathematical identities.

A variety of sociopolitical theories have been used recently in mathematics education to explore issues of identity and power. Two of the most prevalent sociopolitical theories include post-structuralism and critical race theory. Next, I will highlight how post-structuralism and critical race theory have been used to interrogate structures around gender and race (respectively) and power in mathematics. Finally, I will explore how Queer theory can be used to interrogate structures around sexual identity and power.

Post-structuralism and Gender Identity

Post-structuralism is a philosophical theory which seeks to critique modern notions of identity as a coherent self-authored object, but instead seeks to position identity as arising through systems of knowledge and discourses (Foucault, 1977). Discourses in this sense are more than just words and speech but instead represent, "institutions, actions, words, and taken-for-granted ways of interacting and operating" (Gutiérrez, 2013, p. 40). Discourses are paradigms of language and practice that bring things into being, or "systematically form the objects of which they speak" (Foucault, 1977, p. 49). Discourses represent a powerful tool in that they describe regimes of truth, not because they describe reality but because they act to produce reality. Discourses also change with time and setting, meaning all knowledge is considered subjective and historically situated (Walshaw, 2004).

Because post-structuralism considers all knowledge to be subjective, constructs such as "woman" or "Queer" are also socially constructed (Walshaw, 2004, 2013). This is counter to essentialist tendencies which maintain that, for instance, there is a common central experience that makes one a woman. Drawing on post-structuralism, this study also resists such notions that Queer-spectrum individuals have a central experience that makes one Queer. Instead, Post-structuralism often uses tools such as discourse analysis to examine the ways that hegemonic power structures are produced and reproduced. For example, some of the discourses within mathematics frame it as a universal subject, consisting of rational processes for discovering a body of pre-existing truths (Mendick, 2006a). Such a discourse is enacted through the use of language (e.g., “prove that,” “find x”) which often positions the doer of mathematics as someone who is discovering a given truth that is objective and universal. Additionally, the convergence of western mathematics on a set of rules and syntactical operators popularizes the notion that mathematics is a universal language. The discourse of universality is reproduced through assessment and computer-aided tutors that enforce the correctness of syntactical precision. Discourses thus shape our thinking, our viewpoints, our practices, and our ways of being in the world (Walshaw, 2013).

Mendick (2006a), in a highly influential piece, draws on post-structuralism to interrogate the ways in which mathematical discourses have been cast in terms of dichotomies, that position femininity and masculinity in opposition to one another, with mathematics firmly fixed on the masculine side. Mendick (2006a) interviewed 42 adolescents (age 16-19) in A-level mathematics in England and asked them to describe typical mathematics lessons, learning styles, their reason for choosing mathematics, and their feelings on gender. Using thematic analysis and case study stories, Mendick (2006a) identified patterns whereby girls were more likely to choose mathematics because of a specific career goal or to prove something to themselves, while boys wanted to prove something to others and had the strongest identification as mathematicians.

Mendick (2006a) further analyzed why choices of doing mathematics were gendered for these students, by highlighting how through doing mathematics, people are performing masculinity, and that this introduces more tensions for girls and women than for boys and men. Students often made sense of mathematics and their relationship to it through a series of binary oppositions, presented in Table 2.1. Within this binary system, the discourses of mathematics are aligned with those associated with stereotypical masculinity (e.g., fast, dynamic, objective, reasonable). The masculinity of mathematics is maintained "through powerful fictions about rationality and genius" (Mendick, 2006a, p. 68). Access to these positions are often highly dependent on a person's assigned gender and thus perpetuate gender disparities in mathematics.

Table 2.1. Binary oppositions in mathematics identified by Mendick (2006a).

Binary Opposition categories
• Masculine/Feminine • Math people/Non-math people • Math and Sciences/Languages and arts • Ordered and rule based/Creative and emotions • Numbers/Words • Thinking/Writing • Fast/Slow • Competitive/Collaborative • Independent/Dependent • Active/Passive • Dynamic/Static • Naturally-abled/Hard-working • Real understanding/Rote learning • Reason/Calculating • Really good at math/good at math • Objective/Subjective • Hard/Soft • Mind/Body • Separation/Connection • Theory/Experience • Reading books/living life

Taking a post-structural viewpoint, as informed by Mendick, in this research study affords the ability to question the ways that mathematics is positioned in dichotomies that align with Straight performativity. Often Straightness is given privilege and power in society, in the same way that masculinity affords certain privileges and power. This research seeks to account for the ways that Queer-spectrum students experience and navigate mathematical learning environments and whether those experiences support notions of Queerness.

Critical Race Theory and Racialized Identity

Critical race theory (CRT) is a sociopolitical perspective that foregrounds attention on systemic issues of power, race, and racism. The core principles of CRT include (1) an assertion that racism is normalized and perpetuated in American society (2) a centering of experiential knowledge through storytelling (3) a critique of liberalism; and (4) a recognition that white individuals have been the primary beneficiaries of civil rights legislation (Crenshaw et al., 1995; Delgado & Stefancic, 2017; Ladson-Billings, 1998). Researchers have built upon CRT, such as Latinx critical race theory (LatCrit), to expand the notions of white-black binary to include Latinx populations. Specifically, LatCrit has expanded CRT to include issues such as language, immigration, borders, ethnicity, culture, work-status and identity (Solorzano & Bernal, 2001).

Educators who have utilized CRT and LatCrit, highlight various forms of institutional racism in education that often devalue and decenter Black and Latinx identities (Langer-Osuna, 2015; Leyva, 2016a; Martin, 2013; McGee, 2014, 2016; McGee & Martin, 2011). Scholars of race in mathematics education have drawn attention to the ways that mathematics education has been used as a tool of racist oppression (Martin, 2019; M. L. Miles et al., 2019). For instance, racist narratives around mathematics ability position some racial groups as more mathematically competent than others (Joseph et al., 2017; Larnell et al., 2014; Shah, 2017). The framing of student success often centers around discussions of high stakes testing and the resulting achievement gap between that of students of color and white students (Gutiérrez, 2008). These discussions reinforce orientations of deficit thinking and negative narratives related to students of color that position the students, and not societal structures, as the underlying factors contributing to the gap (Gutiérrez, 2008). For instance, students of color have to navigate both master narratives about race and education (e.g., academic failure for African-American youth) as well as encountering racial micro-aggressions, which are defined as ‘‘subtle, stunning, often automatic, and nonverbal exchanges which are ‘put downs’ of blacks by offenders’’ (Solorzano et al., 2000, p. 145).

McGee and Martin (2011) use CRT to put forth the notion of stereotype management, which “encompasses the strategies high-achieving students develop and utilize to cope with the strain of being racially stereotyped while maintaining traditionally high standards of academic success” (p. 1363). Researchers who draw on CRT and LatCrit resist deficit framing of students and, through counter-narratives, focus on the array of cultural knowledge, skills, and abilities possessed by marginalized groups. CRT and LatCrit help guide this study by (1) providing a framing for understanding and accounting for the ways in which Queer experiences are also racialized and linked to intersectional identities, (2) understanding how Queer experiences may be internalized and managed by the student, and (3) using story-telling of Queer-spectrum students’ experiences to resist deficit orientations and to capture the multitude of resources Queer-spectrum students leverage to understand their experiences in mathematical settings. The use of storytelling is described further in the methods with the development of narrative accounts and member-checking documents that were informed by CRT.

Queer Theory and Sexualized Identity

Queer theory seeks to account for how normative assumptions regarding sex, sexuality, gender, and gender identity have been shaped by institutional structures. Queer theory is often used to deconstruct dominant theories of identity and to position identity as culturally and historically situated (J. Butler, 2011; Creswell, 2013). Furthermore, Queer theory views identity as dynamic, which is often fluid throughout a person's lifetime. As such, one of the principal aims of Queer theory is to challenge what is considered normal and to offer alternative ways of thinking and performing in the world (McWilliams & Penuel, 2017). Butler (2011) contends that through social institutions, we become naturalized to normative assumptions prescribed by the *heterosexual matrix* (see Table 2.2) which positions gender (man and woman) and sexual identity (Straight, Gay, Bisexual) as a set of finite, discrete categories.

Table 2.2. Representation of the heterosexual matrix reproduced from McWilliams and Penuel (2017).

	Straight	**Gay**	**Bisexual**
Man	Straight man	Gay man	Bisexual man
Woman	Straight woman	Gay woman	Bisexual woman

McWilliams and Penuel (2017) contend that all human activity is mediated through the heterosexual matrix, making it either difficult to see things that fall outside one of the six entries in the matrix, or making such things deviant and a target for obliteration. For example, individuals who identify as cisgender men may transgress normative assumptions of gender by performing in drag and wearing make-up and dresses in certain contexts. These individuals may fall outside one of the six cells, and thus, are either not acknowledged as being fully cisgender men or may even be targeted as the victims of violence for transgressing against the heterosexual matrix. Queer theory attempts to expose the tensions that reside within the heterosexual matrix by decentering identity as a fixed category, and instead, draws on post-structural theories that view identity as performative.

Researchers in the field of symbolic interactionism (Hutson, 2010; Stone & Farberman, 1982) have studied how appearance and performance are related to social identity and social positioning. Appearance serves as a prediscursive form of interaction that allows individuals to ascertain the identities of participants, the social values attached to those identities, and inform a possible course of action (Stone & Farberman, 1982). Appearance is a growing area of interest in Queer identity research, with some suggesting that appearance and dress are one of the primary mechanisms for ascertaining and displaying such identities. Research in this area has primarily focused on the archetypes of Gay men with muscular body image and fashionable dress, and Lesbian women displaying as butch or androgynous (Clarke & Smith, 2015; Clarke & Turner, 2007). The use of dress or appearance for Gay and Lesbian individuals can serve to create a sense of group belonging in Queer communities, resist normative gender expectations, express authentic self-identity, and signal their identity to other people “in the know” (Hutson, 2010; Rothblum, 2014). Furthermore, appearance by Queer individuals is a process of negotiation that is impacted by the environment and the current socio-political context. For example indicators of Queer identity status have shifted over time from more coded indicators in the “era of the closet” (S. Seidman, 2004) using colored handkerchiefs (Reilly & Saethre, 2013), fashion brand logos (Clarke & Turner, 2007), to more explicit indicators and gender-Queer fashion (Barry & Martin, 2016) in the post-closet era.

As a post-structural theory, Queer theory is concerned with the power of discourse and resisting dominant notions of identity. Queer theory is even more anti-essentialist than post-structural feminism; where a post-structural feminist might be able to define what “woman” means in one particular time and place, a Queer theorist tends to resist labels and static identities. As such, in this study I avoided placing rigid boundaries around categories like STEM, Queer-spectrum, and instead opted to let participants decide whether those words or others applied to them or not. Viewing identity as performative and resisting binary categorization, allows for Queer theorists to account for the ways that identity may be fluid and changing, both situationally and temporally, throughout the lifespan of an individual (Creswell, 2007; Mendick, 2014).

Abes and Kasch (2007) use Queer theory to document how KT, a Lesbian college student, resisted heteronormative assumptions through constant forming and reforming of their multiple identities through negotiation of their sexuality, religion, gender, and social class. KT originally believed that that being a Lesbian precluded them from being religious, and KT did not disclose their religion to friends nor believe they was accepted in religious contexts. Through the development of close interpersonal relationships during the duration of the study, KT, aligned their multiple identities and found that their Lesbian and religious identities were complementary. In the context of this dissertation study, how might Queer performative acts and their acceptance or rejection as deviant differ in various mathematical contexts (e.g., classrooms, study groups, learning centers)? How might these differ temporally for a student as they transition or come out to others within this space?

One of the major critiques of Queer theory, is that by casting identity as performative and thus exploring the tensions of things that come between normal and deviant, Queer theory becomes too broad and abstract to speak of the experiences of Queer-spectrum individuals. Additionally, some Queer theorists have argued that even Straight individuals can be Queer, which some believe discounts the experiences of Queer-spectrum individuals who face marginalization in society. In this study, I conceptualize Queer-spectrum as individuals who identify as Lesbian, Gay, Bisexual, Transgender, Two-spirit, Intersex, Pansexual, Asexual, or in other ways Queer because of their sexual identity or non-cisgender identity (Kumashiro, 2001). The choice of this terminology reflects a decision based in a particular time and setting, and will likely become outdated, but is meant to convey an inclusive approach that resists essentialization. This definition also allows for the various intersections that impact the ways in which Queerness is enacted and experienced by individuals. For instance, many Queer people of color experience a paradox of identities; whereby, the Queer community often centers and normalizes white Gay experiences and communities of color often position Queer experiences into the margins of the margin (Kumashiro, 2001). Even within Queer-spectrum individuals, the experiences of Transgender individuals are often different from those within the sexual minority. Yet, there is commonality and community among Queer-spectrum individuals who experience the phenomenon of otherness within society.

Queer theory helps guide this study by (1) coalescing Queer-spectrum participants in this study to include Lesbian, Gay, Bisexual, Transgender, Two-spirit, Intersex, Pansexual, Asexual, and individuals who are “Queer” because of their exclusion from being normative; (2) accounting for the ways that Queer identity is performed and can vary across different situations; (3) acknowledging that Queer performance is viewed through a heteronormative society as deviant and thus may be regulated by students and others while learning mathematics; and (4) resists essentializing the experience of all Queer-spectrum students as similar by attending to the varied and intersectional nature of the self.

Mathematical Identity

The previous section showcased the ways in which sociopolitical theories have been used to understand different social identities such as gender, race, and sexuality. In this next section, I develop a definition of mathematical identity. Mathematical identity is leveraged as a 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 & Esmonde, 2017). Based on a review of mathematics education identity literature, Darragh (2016) highlights that most theoretical definitions of identity can be broadly defined as either participative, performative, discursive, narrative, or psychoanalytic. I draw largely from participative and discursive notions of identity as they help capture the ways in which Queer identity relates to power and the discourses available to the individual. Furthermore, participative and discursive notions of identity, highlight how the individual is positioned to be a learner and doer of mathematics both locally and more broadly in society.

Participative identities (or positional identities) examine the ways in which identity is constructed through participation and engagement in a social group. Researchers who use participative identity draw heavily from “communities of practice” (Lave & Wenger, 1991; Wenger, 1998) or from figured worlds (Holland et al., 1998). Communities of practice in this setting refer to a group of individuals participating in a shared domain of human endeavor and, through participating, create a shared identity (Lave & Wenger, 1991). Participating means taking part in activities, interacting, negotiating, agreeing, disagreeing, formulating, and sense-making. For the individual participant, Lave and Wenger (1991) argue that identity is formalized as a result of belonging to a community of participants, centering into their activities, imagining a personal trajectory towards becoming old-timers within that community, and aligning with the communities’ norms and expectations. Similarly, Holland and colleagues (1998) draw upon the situatedness of identity in culturally formed activities, referred to as *figured worlds*, that trace the participation and agency of the individual. Figured worlds are socially and culturally constructed. Within a figure world, certain actors are recognized, significance is assigned to certain acts, and particular outcomes are valued. Figured worlds are, “formed and re-formed in relation to the everyday activities and events that ordain happenings within it” (Holland et al., 1998, p. 53). Participative identities foreground the individual agency of the individual while also focusing on the local construction of identity rather than “broad societal discourses and the circulation of power and control” (Langer-Osuna & Esmonde, 2017, p. 640). For example, Boaler and colleagues’ work (Jo Boaler, 1998; Jo Boaler & Greeno, 2000; Jo Boaler & Staples, 2008) draw on participative identities linking communities of practice and figured worlds to understand how the learning environment impacts the types of mathematical identities available to students.

Building on participative identities, Nasir (2011) defines identity as a sense of self that is constructed by available social categories and ascribed by social groups and settings. In particular, Nasir (2011) documents how particular learning environments provide access to *identity resources*, making some identities readily available to students and constraining others. There are 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. 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.

Nasir and Cooks (2009) use these constructs to show how various learning environments resources can support practice-linked identities. The context of their study examined resources within an African-American high school track and field team. For example, one of the material resources that supported a practice-linked identity as a track athlete was the “starting block.” This resource promoted a practice identity since those who knew how to use the material resources were positioned as experts;

however, access to these material resources were not equally available to all athletes since the coaches would restrict them. If the coaches felt an athlete was promising, they would attribute them with positive ideational resources such as saying they were going to be a “hurdler” thus making this identity available to the student. Even the structure of the learning environment such as having daylong track meets, helped provide relational resources allowing athletes to socialize and form connections. In a similar fashion, this dissertation study draws on the identity resources made available to Queer-spectrum students to understand how they can develop practice-linked identities in STEM.

In contrast, discursive identities are seen to arise, and be subjugated from, discourses or meta-narratives that constitute the person. The term discourse conveys various meanings depending on the context. Gee (2015, p. 2) distinguishes between “Big ‘D’ Discourses,” which are meant to capture the ways in which people enact or recognize socially and historically significant identities and “little ‘d’ discourse” as any segment of language or speech. According to Gee (2015), being recognized as a certain “kind of person” happens through “well-integrated combinations of language, actions, interactions, objects, tools, technologies, beliefs, and values” (p. 1). Similarly, post-structural theories (Foucault, 1977; Mendick, 2006a) frame discourses as the broader societal context or meta-narratives that exist in society. For example, Leyva (2016b, 2016a) identified dominant discourses in mathematics based on undergraduate women of color’s counter-stories that included the ideas that mathematical ability is innate, men are better than women in mathematics, African-Americans and Latinxs students are not good at mathematics, and Latinx women are expected to become young mothers and wives. Shah (2019b) documented societal narratives that position

Asians as good at mathematics and Black and Brown students as less mathematically inclined. These discourses then impact the way students encounter institutional structures and develop interpersonal relationships with others.

Combining both a participative and discursive orientation towards identity, seeks to account for the ways that broader societal discourses and their enactment impact a student's ability to be recognized as a participant (learner and doer) of mathematics. Martin (2000) provides one such example which combines both participative identities and discursive identities to understand the learning experiences for African-American students. According to Martin, "Mathematics identity encompasses 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 and to use mathematics to change the conditions of their lives" (2006, p. 206) Usually this presents a choice between being a competent performer or incompetent performer of mathematics, but often flowing back and forth between the two states. A mathematical identity is, therefore, a negotiation between our own assertions and external ascriptions of others that occur during the mathematical socialization processes (Martin, 2006). Mathematical identities are always under construction and the development of particular kinds of mathematical identities reflect how mathematical socialization experiences, "are interpreted and internalized to shape people's beliefs about themselves as doers of mathematics" (Martin, 2006, p. 207). Martin argues that, as African Americans negotiate their mathematical identity within larger contexts of African-American, political, socioeconomic, and education struggle, mathematical learning and participation becomes a racialized form of experience. Leyva (2016a) extends Martin's definition using a intersectional post-structural lens to understand that mathematical identities "are social constructions constantly negotiated across different contexts in response to discourses shaped by intersecting systems of oppression such as racism, sexism, classism, and heteronormativity" (2016a, p. 89). As such, there are often multiple and contradictory discourses that individuals negotiate that are upheld by institutions, other individuals, and society.

Synthesizing elements of both participative and discursive identities, I 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. Mathematical identity is constantly negotiated through social discourses that are shaped by institutions, individuals, society, and intersecting systems of oppression.

Mathematical identity, as defined previously, promotes the goals of this study that seek to account for the factors and strategies that promote Queer-spectrum undergraduate students to develop mathematical identities. 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).

Queer Mathematical Identity in a STEM Environment

Extending this conceptualization of Mathematical identity, I seek to define a Queer Mathematical or Queer STEM identity that promotes the development of both a mathematical identity and Queer identity. Mattheis, Arellano, and Yoder (2019) developed a Queer STEM identity framework which was initially developed to understand how individuals working in STEM fields navigate personal and professional identities. It was developed through a synthesis of literature on Queer identity development and STEM professional identity development. The Queer identity literature draws attention to a number of important and unique experiences of Queer individuals, including: the significance of “coming out” as an event (D’Augelli, 1994; Eliason, 1996), the potential fluidity of gender and sexual identities (Katz-Wise, 2015; S. T. Russell et al., 2009), the importance of intersectionality with other identities (Brockenbrough, 2015), and the potential issues with conflating gender identity and sexual orientation in a single umbrella category (Galupo et al., 2014). These experiences draw attention to the unique identity development issues for Queer-spectrum students in STEM that are not necessarily experienced by other minoritized groups. These concepts were then combined with STEM professional identity development, to analyze a large corpus of online surveys, open-questionnaire emails, and qualitative interviews with Queer individuals in STEM. The analysis resulted in a model for a Queer STEM identity framework with three key processes: defining, navigating, and forming.

Defining explains how individuals come to understand and name themselves as Queer in terms of their gender and/or sexuality. Defining is a complex process especially because most social settings are heteronormative and can be hostile towards Queer individuals. Despite these pressures, many individuals come to define themselves as Queer at an early age, contributing to a more well-developed identity as they mature (Mattheis et al., 2019). Many individuals come to understand their Queer identity by “coming out” or revealing their Queer identity to others. Coming out is not a singular event that simply happens once, but instead is a process that individuals continually negotiate and re-negotiate in different settings. How this process is negotiated depends on the individual and their own sense of their Queer identity. Some individuals may choose to express their identity publicly, while others may not, and this, at least in part, relates to how the individual defines their own identity. Defining one’s Queer identity is also impacted by and interwoven with familial history, other salient identities (e.g., Queer Latina), and the sociopolitical context.

Forming refers to how individuals construct their own specific STEM identities. Forming a STEM identity includes how one develops a personal interest in their subject matter. An internal interest in STEM typically develops through socialization, in early life, schooling, and university settings. The process of forming captures how an individual comes to know what it means to be a member of a particular discipline (e.g., a mathematician) through training and experiences. In addition to creating a view of a mathematician, individuals must form their own identity as someone who belongs to that group.

Navigating describes how the interplay of professional (or academic) and personal influences impacts expression of identity in places of work and study. For instance, in a mathematics classroom, a Queer student needs to navigate whether and how to express their Queer identity to peers, and how much detail of their personal life to share or not. This is a negotiation process that Straight, cis-gender students typically do not encounter in the same way. Here the focus is on how the STEM environment impacts the expression of their identity as opposed to the defining processes where coming out is viewed as one process for understanding their own identity.

In developing this model for Queer STEM identity, one key finding was that "heteronormative assumptions frequently silence conversations about gender and sexuality in STEM" which result "in complicated negotiations of self for Queer professionals" (Mattheis et al., 2019, p. 22). When Queer-spectrum individuals are not able to share their identities due to such an environment, it often creates pressure to conceal one's identity, which causes additional stress for Queer-spectrum individuals. Thus, a Queer mathematical identity is one that allows Queer-spectrum students to fully participate and perform effectively in mathematical contexts as a Queer individual.

Queer-spectrum Individuals in STEM and Education

In the following section, I highlight existing research that has explored the experiences of Queer-spectrum individuals in education and specifically in STEM related contexts. First, I present a broad picture of the educational experiences of Queer-spectrum students in K-12 educational environments, Queer-inclusive curriculum, followed by a discussion of undergraduate climate and experiences of Queer-spectrum students. Next, I draw on research related to Queer-spectrum STEM professionals. Finally, I detail the few studies that have explored the experiences of Queer-spectrum undergraduate students in STEM and a dissertation that focused specifically on Queer-spectrum undergraduate mathematics students.

Queer-spectrum Students and Coming Out

As Queerness has become more broadly mainstreamed in American culture and society, there are a growing number of students who are coming out during middle and high school grades (Denizet-Lewis, 2009). Coming out is an important identity development process where an individual comes to understand and name themselves as Queer-spectrum. One might reveal their Queer identity to others, which can promote a sense of self-integration and personal empowerment (Baiocco et al., 2016; Corrigan & Matthews, 2003); however, the ability and decision to reveal one's Queer identity is often multifaceted and situational. For instance, Toynton (2016) put forth the notion of Queer identity in STEM as the "invisible other," such that being Queer-spectrum is an experience of being the "other" and yet invisible if wished. The invisible nature of Queer identity provides agency to reveal one's identity, while at the same time requiring ongoing decision-making to determine whether and how to disclose this identity. Given that coming out is an ongoing process of negotiation, this can create a cognitive burden for Queer-spectrum students in mathematics environments. For example, research indicates that having to navigate coming out in educational spaces creates more emotional and psychological work for Queer-spectrum students than that of Straight students, and often results in daily decisions about revealing their sexuality in the classroom (Eliason, 1996; Lopez & Chims, 1993; Savage & Harley, 2009; Toynton, 2016).

The issue of coming out is further complexified for students who may be minoritized in other ways in mathematics classrooms, due to the existence of multiple problematic discourses (Leyva, 2016b). For example, some Lesbian women in STEM report facing a form of "double jeopardy" by having both visible and invisible identities that are marginalized by normative mathematical practices (Trauth & Booth, 2013). Nonetheless, the salience of any particular identities is situational. For example, a study of Queer-spectrum students of color found that gender and sexual identity were reported as more salient for the students than racial identity, when considering the erasure of Queer diversity in STEM (Ware, 2018). Given these complexities, Queer-spectrum students of color often make their own efforts to “create space” for themselves in white, heteronormative institutional spaces. For instance, Venzant, Chambers, and McCready (2011) documented the ways in which Kevin, a Gay black high school student, was able to “make space” through artistic and performative acts that rejected dominant notions of masculinity. Kevin challenged dominant notions of masculinity by transgressing against the masculine dress code by wearing “yarn wigs” and performing what he called his “Gay boy illusion.” In doing so, Kevin made his Queer identity more visible, thus freeing himself from the emotional work of coming out. However, by making this identity visible it was met with taunts from male peers, acts which served to marginalize and challenge the presence of Queer identity in the educational environment. Yet his female friend group was quick to defend his performative identity, which mitigated against the marginalizing pressures, by giving him the support of a peer group. Kevin’s experience highlights the navigational strategies of coming out and the power structures that seek to oppress Queer identities.

Queer-spectrum students are especially vulnerable during the identity development period as they are often susceptible to stress derived from cultural and social prejudices towards non-heterosexual individuals (Meyer, 1995). These forms of stress have been shown to result in higher rates of depression, substance abuse, social isolation, and suicide (Herek et al., 2009). Queer identity can also be marginalized and oppressed within education even without students disclosing their Queer identities. These marginalizing forces occur through the presence of microaggressions (e.g., derogatory statements, invalidations, insults) that creates barriers for students in coming out (Vaccaro, 2012; Vaccaro & Koob, 2018). For instance, 99% of Queer-spectrum youth report hearing the derogatory use of phrases such as “that’s so Gay” or “you’re so Gay” in school (Kibirige & Tryl, 2013). These forms of oppression help align education with heteronormative experiences.

Queer-Spectrum Course-Taking Patterns

The relatively few quantitative studies of LGBT students have mostly examined outcomes for non-heterosexual high school students by using the National Longitudinal Study of Adolescent Health data, often resulting in mixed findings. Gottfried, Estrada and Sublett (2015) claimed that status as a sexual minority does not contribute any additional explanatory power in predicting advanced course-taking patterns in mathematics and science above and beyond factors that included GPA, number of previous courses, and interest in college (Gottfried et al., 2015). However, the lower-order models they developed, which controlled for personal demographic information, did indicate that a student’s Queer status was a statistically significant predictor of their mathematics and science course-taking patterns. One reason to explain the discrepancy in their models, is that the advanced models they developed failed to account for the interaction effect between sexual minority status and general academic achievement (e.g., number of previous courses, GPA), suggesting that Queer-spectrum students may not have the same levels of academic achievement as their Straight counterparts.

Russell, Seif, and Truong's (2001) analysis of the same data support the notion that same-sex attracted youth do have lower academic outcomes and that relationships with teachers may play a leading role in explaining this difference. In a separate analysis using the same data set, Pearson, Muller and Wilkinson (2007) showed that same-sex attracted youth do worse on measures of academic achievement, higher on measures of emotional distress and substance abuse, are less socially integrated to their schools and teachers, and have lower expectations for attending college. Pearson and colleagues (2007) showed using logistic regression that, even when controlling for feelings of attachment and engagement in school, same-sex attracted boys are approximately 47 percent less likely to complete algebra II and 41 percent less likely to complete chemistry compared to their opposite-sex attracted peers. Interestingly, this same trend was not present in course taking patterns for foreign language, suggesting that something is "unique about mathematics and science that makes them more intimidating than other subjects" (Pearson et al., 2007, p. 113). Given the data suggesting that Queer-spectrum students may not take the same advanced mathematics courses, students in this study, who will be enrolled in precalculus and calculus courses, will represent those students who persisted, which will help contribute to the literature by documenting the strategies they employed to be successful in mathematics.

Queer-Inclusive Mathematics Curriculum

Queer-spectrum students in K-12 face higher rates of bullying, abuse, homelessness, absenteeism, and they report an overwhelmingly hostile school climate (GLSEN, 2013; Kosciw et al., 2018). These negative effects for Queer-spectrum students have been mitigated by some high schools through the development of inclusive curricular resources. In fact, high schools that have implemented inclusive curriculum report increased rates of acceptance for Queer-spectrum students, indicating that academic disciplines can have an impact on the overall campus climate (GLSEN, 2013). Unfortunately, K-12 mathematics classes have the lowest percentage of students (4.8%) across all disciplines reporting positive portrayals of Queer people in their classroom (Kosciw et al., 2018). In comparison, positive portrayals of Queer topics occurred in 58.5% of social sciences or history classes (Kosciw et al., 2018). This is especially problematic if one hopes to encourage Queer-spectrum students to take an interest in mathematics during the formative period of their lives.

Moving beyond general inclusive curricular revisions, there is a need to revise the mathematics curriculum specifically to combat heteronormative ideologies. For example, consider the well-known “stable marriage problem” in mathematics that reinforces normative assumption of gender and heterosexuality, “There are *n* men and *n* women. Each person ranks those of the opposite gender for marriage. The goal is to find a way to create a set of stable pairings” (D. Gale & L. S. Shapley, 2013). Rubel (2016) problematizes the stable marriage problem as heteronormative and highlights that even the original framing of the problem has been that of men selecting wives. The stable marriage problem not only assumes heteronormative relationships, but also puts forth a notion of binary gender constructs.

In addition to revising and problematizing heteronormative curriculum, there is also a need to create Queer-inclusive curriculum. Although there are difficulties and concerns with including Queer themes within mathematics problems, there are emerging examples that demonstrate that such curriculum is possible. Dubbs (2016) highlights two approaches for having Queer-inclusive mathematics curriculum. The first approach incorporates Queer context to the names or mathematical settings, referred to as the “add Queers and stir” model. One such example was developed by Kellermeier (1995, 2002) and used Lesbian, Gay and Bisexual word problems to contextualize statistics problems. A second approach to Queer-inclusive curriculum, incorporates Queer notions to reconceptualize the nature of mathematics referred to as “mathematical inqueery.” As an example of Queering the notion of mathematics, Rands (2013) draws on data related to Queer discrimination and factors impacting intervening to help students understand and unpack issues of proportional reasoning and statistics. This model is more aligned with mathematical inqueery since it problematizes open-ended exploration of Queer topics. Another example of this approach presented by Rands (2009) describes a mathematics problem under the scenario of a curriculum night at school where families are invited to attend. A description of several families is given (e.g., one kid lives with two moms sometimes and a mom and a dad other times, eight kids live with a dad and a mom, two kids live with a grandma), and students are asked a series of questions about the amount of materials needed, as well as what kinds of families are represented and what kinds of families are possible. These few examples demonstrate that Queer-inclusive curriculum in mathematics is possible and different avenues for approaching such topics deserve further investigation.

Queer-spectrum Undergraduates and Campus Climate

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).

Lopez and Chims (1993) interviewed undergraduate Gay and Lesbian students related to their identities, classroom experiences, relationships with instructors, and general learning issues. They documented how the coming out processes had a clear impact on the academic performance of students and required a psychological balance with daily decisions about revealing their sexuality in the classroom. Coming out in the classroom was related to the receptiveness of the instructor. 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, even 27 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.

Queer-spectrum students, like other minority groups, demonstrate courage, resilience, and other strengths-based qualities in the face of adversity (Morrow & Messinger, 2006). Studies at the college level have demonstrated that “Lesbian and Gay students were the most likely to report increased growth in critical thinking and analysis abilities and growth in their liberal learning” (Longerbeam et al., 2007, p. 219). Lesbian and Gay students reported more discussion with peers about sociocultural issues such as human rights, and Gay men were more likely to discuss academic or career issues with their peers. Additionally, Gay men also had the highest mean scores for an array of intellectual outcomes, including applying acquired knowledge to different contexts, growth in cognitive complexity, and development of a personal philosophy. These results suggest that Gay and Lesbian students might thrive academically in mathematical and science settings that require cognitive complexity and interpersonal discussions.

Queer STEM professionals

There is evidence suggesting that marginalization due to sexuality might be felt more acutely within STEM-related disciplines. In a qualitative study of departmental climate Queer-spectrum faculty in science and engineering described an, “overt hostility, a sense of invisibility, interpersonal discomfort, and pressure to ‘cover’ one’s sexuality” (Bilimoria & Stewart, 2009, p. 85). In a comparison between STEM and non-

STEM departments, results suggested that STEM faculty who are out, are less comfortable in their department and more likely to report wanting to leave their institution (Patridge et al., 2014). Autum Kent, who identifies as a trans mathematician spoke of the overt transphobia, homophobia and racism from academics and mathematicians, especially in social media (Lamb, 2017). As a Transgender mathematician in academia, Kent points to issues related to health care, changing articles published under their "dead name"[3] and transitioning in front of students, which all contribute to carrying around dread and psychological anguish in everyday tasks. Given the reports of exclusion and psychological anguish that some Queer-spectrum faculty report, how can we expect them to take on the ownership of serving as role models for Queer-spectrum students in these courses? Would Queer-spectrum faculty be comfortable being out to students and how might this limit the development of interpersonal relationships with Queer-spectrum students?

Yoder and Mattheis (2016), using a quantitative sample of 1,427 Queer-spectrum individuals in STEM workplaces, including individuals from academia, found that a majority (92%) of individuals described their workplace as safe for Queer-spectrum people, yet only a minority (43%) of respondents were out to half their colleagues. Further results suggest that STEM fields with better representation of women reported higher degrees of openness. Individuals from the fields of earth science, engineering, mathematics, and psychology reported the least amount of being out to their colleagues. While the previous studies looked exclusively at Queer-spectrum

[3] "dead name" is largely used by Transgender communities to refer to an individual's legal or birth name prior to transitioning.

professionals, Cech and Pham (2017) compared the experiences of Queer-spectrum and Straight employees in STEM-related federal agencies. Results from their study indicated that inequalities appear to be widespread for Queer-spectrum employees ranging from a “lower likelihood of reporting that their success is fostered and that they have adequate resources, to their perception of a lack of support for diversity, to lower job satisfaction” (Cech & Pham, 2017, p. 15). Cech (2015) also provided one of the few data points to suggest that Queer-spectrum individuals may be underrepresented in STEM fields, by comparing the percent of Queer-spectrum respondents in STEM-related federal agencies (2.7%) to other non-STEM federal agencies (3.1%).

These studies point to the current systemic inequalities that exist within STEM for Queer-spectrum professionals. In part, these inequalities are fueled by the cultural norms within STEM fields that constrain diverse forms of expression or attitudes (Grunert & Bodner, 2011). For example, competition and dominance have been associated with successful advancement in mathematics and science courses (Fisher & Waldrip, 1999). These traditionally masculine and heteronormative values experienced by faculty and within the field may make STEM environments unwelcoming for Queer-spectrum professionals and students (Antecol et al., 2008; Toynton, 2007).

Queer Undergraduate STEM Students

Due to the fact that sexual identity is often not included on national surveys (e.g., U.S. National Science Foundation Survey of Earned Doctorates, U.S. National Survey of College Graduates), there is limited data to determine if Queer undergraduate students are under-represented in STEM fields in the same way as women, students of color, or persons with a disability (Freeman et al., 2018). Hughes (2018) conducted one of the first longitudinal studies of Queer-spectrum students retention in STEM fields. Drawing on multilevel regression with student survey data, Hughes (2018) documented that Queer-spectrum students were 7% more likely to switch from a STEM major to a non-STEM major compared to their Straight peers. Switching rates increased to a 10 percentage-point difference when controlling for retention factors such as undergraduate research and STEM identity (Hughes, 2018). Research on factors related to STEM switching are often related to power structures that impact a student's perceptions of feeling "fit and community" within the environment (Stout & Wright, 2016) or is negatively correlated with reported experiences of discrimination (Schneider & Dimito, 2010).

Toynton (2007), who examined the de-representation of Queer science students in higher education, showed that students expressed feelings of otherness, isolation, and vulnerability and reported monitoring their thoughts and actions. These students recognized a personal struggle, rather than a group struggle, and did not feel represented by the Queer movement as a STEM student. In fact, the study of science and the perception of being perceived as a "nerd" or "geek" appeared to be at odds with popular Gay portrayals of the metropolitan socialite (Toynton, 2007). This tension between science and sexual identity was manifested and described as, "students do not choose to discuss issues of sexuality or gender within the educational environment is partly due to the perceived irrelevancy of this to their chosen studies, but also the perceived irrelevancy of their subject, and themselves, to the Queer discourse" (Toynton, 2007, p. 597). There is a need to integrate the sciences within popular culture if Queer-spectrum students are to be engaged with the STEM discourses and Queer discourses are able to embrace the STEM perspectives.

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. Students navigated these situations by having an awareness of the types of people they prefer not to collaborate with (e.g., jocks, people from a sorority) and, when assigned new groups, required them to test the level of acceptance of their peers. 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. Although Cooper and Brownell's study was in the context of undergraduate biology, the same themes would likely appear to hold and be relevant in mathematics classrooms, especially as there is a shift towards more cooperative group work. Thus, the interactional nature of the classroom environment makes the relational power structures and potential oppression of Queer identities more readily apparent (J. B. Ernest et al., 2019).

In their dissertation study, Smith (2014) focused on the experiences of five Gay male undergraduate students in STEM fields. By focusing entirely on Gay men, the research spotlights the ways in which Gay identity is mediated by the heteronormative masculinity of STEM fields. Smith identified three themes emerging from the studied population: Gay students in STEM attempt to use their academic environment as an escape from their identities, feel uncomfortable disclosing their identities in the academic environment, and experience extensive challenges because of their identities. Gay men in the study identified STEM as an escape from their identity since "STEM creates objective viewpoints where orientation is not considered…[and] gender and sexuality are not important to the efficiency of work" (Smith, 2014, p. 60). This viewpoint combined with data suggesting higher drop-out rates for Queer-spectrum students overall suggests needing to unpack experiences within Queer identifies.

In Smith's (2014) dissertation study, Gay men reported feeling uncomfortable revealing their sexual orientation in STEM spaces because of their desire to not make others uncomfortable, and since coming out created a sense of constant vulnerability that meant staying closeted was safer and easier in these spaces. Gay men also experienced extensive challenges in STEM because of their sexual identity, including switching majors because of perceived hostility and, hearing homophobic remarks; however, they were also supported through small gestures from faculty perceived to be allies (Smith, 2014). Smith (2014) suggests that, "being Gay in the heterosexist society is never easy, but being Gay in a heterosexist environment and in an academic program that devalues your sexual orientation and encourages you to hide your identity for the sake of efficiency can have very negative consequences" (p. 85).

Smith's (2014) study helps shed light on the possible emerging themes in the current dissertation study; however, Smith focused solely on Gay men and not on Queer-spectrum students generally. Additionally, Smith recruited students using contacts from LGBT student organizations, which may impact how these students feel supported and view the relevancy of their Gay identity. By recruiting through an LGBT student organization, the non-random sampling impacts which students were recruited for the study, as such, these students might place greater emphasis in their Queer identity and see value in having their Queer identity supported.

Fischer (2013) explored in their dissertation study 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 (2013) draws on the idea that a leading identity, such as Queer identity, can support other subordinate identities, such as mathematical identity. Fostering a "strong Queer identity creates a personal environment that is conducive to understanding and absorbing other information and knowledge" (Fischer, 2013, p. 113). 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. One of the limitations of Fischer’s study is that all of the students interviewed, as a result of the recruitment processes through the LGBT center, had a strong sense of their Queer identity. These students utilized the resources at the LGBT student center and thus Fischer’s findings may only be applicable to students who place important and saliency to their queer identity. This dissertation study seeks to address this challenge by recruiting students from mathematics classrooms who may or may not have a strong leading Queer identity. Additionally, I take up the suggestion by Fisher to explore the ways in which Queering the mathematical curriculum (Pennell, 2016; Rands, 2009) might impact students’ mathematical identity by using mathematical problems that present Queer and non-Queer contexts as a starting point.

Chapter 3: Methods

Introduction and Study Design

There is a dearth of research that investigates and illustrates the experiences of Queer-spectrum students in undergraduate mathematics, and thus this study seeks to be among the first to communicate the voices of these students. Given the lack of existing literature, I utilize a sequential transformative mixed methods approach (Creswell et al., 2007; Mayoh & Onwuegbuzie, 2015) to explore the phenomenon of Queer-spectrum students' experiences in mathematics. As described by Creswell and colleagues (2007), mixed methods designs draw on both quantitative and qualitative data within the same study, but the structure of the data collection and analysis can vary. Sequential transformative mixed methods design consists of both distinct data collection phases with one following the other (sequential) and makes explicit a theoretical lens that guides the study during an integrated interpretation phase of the data (transformative).

The purpose of the sequential transformative mixed methods design is to employ the methods that will best serve the theoretical perspective of the researcher. In this study, the theoretical perspective being employed is that of a sociopolitical framework (post-structuralism, Critical Race theory, and Queer theory) that describes identity, knowledge, and power as interrelated. The benefits of employing this type of design are to "give voice to diverse perspectives, to better advocate for participants, or to better understand a phenomenon or process that is changing as a result of being studied" (Creswell et al., 2007, p. 183). The goal at the conclusion of a sequential transformative study is for advocacy to improve society and/or the lives of the individuals studied.

The following section provides an overview of the design aspects of this study, including the structure for data collection and methodology for analysis. This study consisted of a pilot study and three phases of data collection and analysis. An overview of each of the phases, timing of the data collection and analysis is outlined in Table 3.1.

Table 3.1. Overview of data collection and analysis timeline.

#	Phase	Data Collection	Primary Data Analysis	Collection Timeline	Research Question	Analysis Timeline
0	Pilot study	Individual interviews (n=4)	Grounded Theory/	Spring 2017	NA	Spring 2017-Fall 2017
		Student surveys (n=2,976)	Comparison of means (t-test)	Fall 2016 – Spring 2017		Spring 2017-Fall 2017
1	Mathematical learning opportunities	Student surveys (n=24,327)	Descriptive, comparative measures	Fall 2017 – Spring 2019	1	Summer 2019
2	Mathematical discourses	Individual interviews (n=17)	Phenomenological analysis, Grounded theory	Spring 2018	2	Spring 2018 – Fall 2019
3	Mathematical identity resources	Focus group interviews (n=4 groups)	Thematic analysis, Identity resource coding	Fall 2018	3	Fall 2019-Spring 2020

A pilot study was conducted drawing on both qualitative and quantitative data exploration related to Queer-spectrum student experiences in undergraduate mathematics. The qualitative component of the pilot study included interviews with four Queer-spectrum undergraduate students involved in the LGBT STEM organization Out in STEM (oSTEM). Emerging themes were identified based on open coding (Corbin & Strauss, 1990; Strauss & Corbin, 1994) that informed the development of interview protocols in the subsequent phases. The quantitative component consisted of an exploratory investigation of quantitative survey data was used to determine reported differences in students' descriptions of their mathematical learning opportunities (e.g., peer interactions, going to tutoring sessions). The pilot study also informed revisions to the survey instrument. After the pilot study, the primary dissertation study was carried out in three phases.

The first phase of the dissertation study was a quantitative analysis of large-scale student survey data of mathematical learning opportunities administered at 20 universities. Quantitative analysis was used to examine reported learning opportunities and differences within Queer-spectrum identities and between Queer-spectrum students and Straight students. This phase was also used to identify and invite participants in the subsequent two phases. The second phase of the dissertation study consisted of individual interviews with 17 Queer-spectrum students at four different universities, who completed the student survey administered in their mathematics course. I used a phenomenological open coding approach to identify mathematical discourses described in relation to their Queer identity and how students navigated those discourses in STEM environments. In the third phase of the dissertation study, I utilized focus group interviews at each of the four universities with three to five Queer-spectrum students. Drawing on identity resource constructs and thematic analysis, I identified resources to support Queer-spectrum students in mathematics. A visual depiction of the relationship between the pilot and the three phases of the primary dissertation study is shown in Figure 3.1.

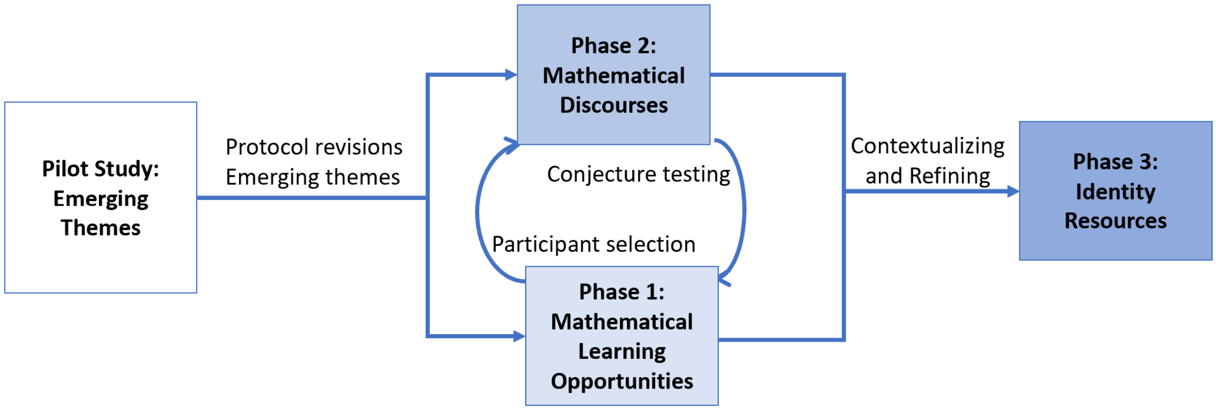


Figure 3.1. Visual relationship between the pilot study and three phases of the primary dissertation study.

Researcher Positionality

I identify as a Gay white cisgender man with a disciplinary background in mathematics, psychology, and mathematics education. I grew up in the state of Minnesota in a rural low-income farming community. As a first-generation college student, I viewed education as an economic tool to escape a heteronormative environment that I experienced as hostile and exclusionary. Mathematics for me was a “safe” environment because it was neutral, removed and I could excel academically in the subject. My initial view of mathematics aligns with popular discourses that have positioned mathematics as neutral and culture-free; however, as I progressed in mathematics from my undergraduate to my masters, I began to see the ways in which mathematics was exclusionary and weaponized against non-normative identities. This viewpoint was furthered during my studies in mathematics education and shaped my desire to conduct this dissertation study.

In this study, I was able to build positive rapport with the students through a mutual identification as Queer-spectrum. This aided in the interviews to allow for more authentic conversation since I was able to relate to the feelings Queer-spectrum students shared as they were pursuing a STEM degree. I also acknowledge the gender and racial privilege that I have experienced in mathematics as a white cisgender man that was not relatable to all the students in this study. Understanding my own positionality guided the data analysis and interpretations, as I drew on my own rich lived experiences as a gay man, as well as my personal knowledge of the four universities to approach the data. At the same time, I used methodologies to support the trustworthiness of the analysis. This included using member-checking document to confirm the narrative and interpretations that were shared during the interviews. I also had a second Queer-spectrum researcher interview me as the participant using the same interview protocols before the start of my dissertation study. In doing this, my own experience and bias were made transparent and allowed me to understand those in relation to what was shared by students in the study.

Phase Zero: Pilot Study

Through analysis of pilot study data, I gained insight into the protocol questions and identified emergent themes, which informed the sequential transformative mixed methods design of this study. In the following section, I highlight the context of the pilot interviews and emergent themes, followed by the context of the pilot survey and emerging themes.

Participants and Context of Interviews

Students from two universities that have active oSTEM student organizations were recruited for the pilot study. Four students, Amber, Charles, Jenny, and Juan agreed to participate in the study (see Table 3.2). A semi-structured interview protocol (Ginsburg, 1997) was used to target information about: their personal history, experiences as a Queer-spectrum student in STEM, how they perceive the nature of

STEM, their favorite courses and instructors, description of the “coming out” processes, advice for other students, and the completion of two mathematical tasks. The focus of these interviews was more broadly targeting STEM and not specifically mathematics in order to understand a broader perspective to inform the subsequent phases of the study. The interviews lasted roughly one hour and were audio and video recorded. Each interview was transcribed using the transcription software InqScribe (Inquirium, 2018). I utilized grounded theory to identify emergent themes (Corbin & Strauss, 1990; Strauss & Corbin, 1994).

Table 3.2. Summary of pilot participant identities, pronouns, and STEM major.

Pseudonym	Affiliated Identities and Communities	Pronouns	Major
Amber	Gay, Gender fluid, African-American, Youtuber	They/Them/Their* or He/Him/His	Former Applied Math Current Interdisciplinary Studies
Charles	Straight, Trans, Canadian Citizen, German Proficient	He/Him/His*	Mechanical Engineering
Jenny	Bisexual, Gender fluid, Fem Identity, Musician (Violinist)	She/Her/Hers* or They/Them/Theirs	Physics
Juan	Gay, Male, Mexican-American	He/Him/His*	Premed (Biochemistry and Cellular Biology)

* Indicates the pronoun used in the dissertation to refer to the participant

Emergent Interview Themes for Future Phases

There were two major themes that emerged from the pilot data that informed the subsequent phases of the dissertation study: students had a paradoxical view of STEM as objective that positioned their Queer identity at odds with the nature of STEM, and students managed the disclosure of their Queer identity while interacting with peers in STEM environments. In the subsequent paragraphs, I briefly expand on each of these themes, followed by a reflection on lessons learned from the interview process.

Students felt that the nature of STEM is removed from their personal identities and described the classroom as a vacuum operating without consideration to the external world. As an example, Jenny characterized her Bisexual identity in STEM as "silent," and felt that her mathematics professor did not create space for processing traumatic events (e.g., impact of presidential election). Jenny's description informed the design of a vignette (narrative scenario) for phase two to target how Queer topics emerge within the mathematics classroom (see Appendix C and Appendix D). Additionally, this guided the use of Queer-themed mathematical problems in order to capture the ways in which Queer identity is positioned towards the goals of mathematics classrooms.

Students described "coming out" in STEM spaces as either a form of information control or as a psychological distractor. Students reported a desire to not disclose their Queer identity to others, feeling tokenized, deciding how personal information is regulated and disclosed to others. For instance, Charles used a form of "vetting" if he deemed a person "safe enough," he would slowly engage the person in conversation to determine whether he would "come out" to the person. Charles's description of the vetting procedure informed the design of a vignette (narrative scenario) targeting the psychological implications and social dynamics of coming out in the classroom used in the interview protocols for phase two (see Appendix C and Appendix D).

In addition to the targeting of emerging themes, there were also several structural lessons learned that informed revisions to the interview protocol in the subsequent phases. One of the primary considerations is that the use of pseudonyms can be an emotionally charged issue for those who identity as Transgender and have undergone a process of using a different name. As such, in the dissertation study, I allowed students to self-select a pseudonym (could be their chosen name), or have a researcher assigned pseudonym. This decision also gives voice and agency to the students whose narratives will be portrayed in phase two and phase three.

Recruitment from oSTEM resulted in students who were reflective and attuned to their Queer and STEM identities, which is possibly not descriptive of students in introductory mathematics courses who may have emerging relationships with their Queer and mathematical identities. Prior studies examining Queer-spectrum students in STEM have used similar recruiting approaches, supporting the notion that having a strong Queer identity can impact having a strong mathematical identity (Fischer, 2013; Smith, 2014). As such, students in this dissertation study were primarily recruited based on their completion of a survey administered as part of their mathematics course, and not on their participation in oSTEM or similar Queer organizations.

Instrument and Context of Survey

For the pilot study, an exploratory quantitative analysis was used to identify emerging themes drawing on data from the Student Post-Secondary Instructional Practices Survey in Mathematics (SPIPS-M). The survey instrument is discussed in greater detail in phase one of the methods section. The SPIPS-M survey pilot data was administered online via the survey platform Qualtrics (Qualtrics, 2019) during the Spring of 2017 at eight post-secondary institutions across the United States. These institutions were selected based on their participation in two NSF-funded grants examining introductory mathematics courses. There were 175 Queer-spectrum students, and 2,801 Straight students who completed the survey. Analysis from the pilot version of the survey was used to inform the sequential transformative mixed methods approach to design the interview protocols used in this study. I analyzed survey data using IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA). I used a two-sided independent samples t-test to compare the means of Queer-spectrum students and Straight students for frequency of classroom experiences, perception of inclusion, and affective gains. A p-value threshold of $\alpha = .01$ was used to identity results of interest. Although this creates a higher risk of identifying a false-positive, since the intent of this analysis is to identity *possible* emerging themes to target in phase two, I accepted this risk and viewed the results through this lens. A summary of these results is included in Appendix A.

Emerging Survey Themes for Future Phases

All the survey items with statistically significant differences between Queer-spectrum and Straight students were analyzed and grouped into associated themes. This resulted in four emerging topic areas that informed the design of the phase 2 interview protocols. These topic areas included: peer-to-peer interactions, instructor interactions, assessment, and student attitudes towards mathematics. Each of these themes is described below as well as a description for how it informed the subsequent phases.

Peer-to-peer interactions are less frequent and less helpful.

Queer-spectrum students reported that they less often presented their ideas (or their groups ideas) during whole-class discussions, and when these did occur, they rated them overall less helpful to their learning. Additionally, Queer-spectrum students were less likely to talk about course concepts with others during class, and less likely to work with peers on mathematics problems outside of class. Most of the reported differences occurred during recitation sections, which are typically smaller course meetings with instruction from a graduate teaching assistant. The largest effect size difference (Cohen’s d= -.31) was Queer-spectrum students being less likely to report a sense of community among students in their recitation section. Interview questions were added to target why Queer-spectrum students are less likely to present ideas during whole class or work with peers on mathematical problems. One hypothesis is that Queer-spectrum students may sense an unwelcoming climate and thus reserve their cognitive resources for individual learning opportunities. Alternatively, Queer-spectrum students may have a strong proficiency in the content and thus do not view peer-interactions as assisting in their learning of the material.

Instructor relationships are heightened.

Queer-spectrum students described more lecture-based activities and view this as less helpful overall to their learning. Additionally, Queer-spectrum students are more likely to report that their instructor knows their name. During recitation, Queer-spectrum students describe less listening and taking notes (e.g., lecture), and less equitable teaching practices (e.g., call on a wide range of students, adjust teaching, explain concepts in variety of ways, allows time to reflect). Interview questions as well as one of the illustrative vignettes were designed to target why Queer-spectrum students are more likely to report that the instructor knows their name. One hypothesis is that Queer-spectrum students have more interactions with their instructor and thus develop a closer relationship. Alternatively, Queer-spectrum students may have a heightened awareness of their presence in the classroom and thus believe the instructor knows their name.

Assessment occurs less frequently and is less helpful.

Queer-spectrum students report they are less likely to receive formative assessment (e.g., immediate feedback) in both lecture and recitation. Additionally, Queer-spectrum students report summative assessments (e.g., exams) as overall less helpful for their learning. In the dissertation study, I examined the types of feedback that Queer-spectrum students report as helpful as well as well as underlying factors that may contribute to students viewing formative assessment as less helpful to their learning. One hypothesis is that perhaps Queer-spectrum students have a strong knowledge of the material, and thus exams don't provide opportunities for learning. Alternatively, exams may trigger a form of minority stress based on evaluation and thus are deemed as less helpful.

Decrease in attitudes related to mathematics.

Queer-spectrum students report a greater decrease in their interest, enjoyment, confidence, ability, and maintaining a growth mindset related to mathematics. Interview questions were added to capture features of persistence and attitudes towards mathematics. I investigated the underlying factors that contribute to Queer-spectrum students reports of decreases in attitudes towards mathematics in the dissertation study. One hypothesis is that Queer-spectrum students, who report less a sense of community, become disengaged with the learning opportunities, and thus are reflected in their attitudes toward the subject of mathematics. Alternatively, Queer-spectrum students may be processing other psychologically demanding events (e.g., coming out, transitioning) that preclude them from engaging in the learning opportunities as part of the mathematics course.

Phase One: Mathematical Learning Opportunities

In phase one of the dissertation study, I drew on quantitative analysis of student survey results to describe how Queer-spectrum students report experiencing various mathematical learning opportunities and to identify differences between Queer-spectrum students and Straight students.

SPIPS-M Survey Instrument

I used the survey instrument Student Post-Secondary Instructional Practices Survey for Mathematics (SPIPS-M). This survey instrument was developed by a team (including myself) as part of the NSF-funded project Progress through Calculus (PtC) in collaboration with the NSF-funded project Student Engagement in Mathematics through an Institutional Network for Active Learning (SEMINAL). A complete description of the instrument and history of the development is available online through the Mathematical Association of America (Apkarian et al., 2019). The SPIPS-M was adapted from existing instruments assessing teacher reports of instructional practices (Walter et al., 2016), classroom equity scales (Dorman, 2003), along with internally developed items based on observable equitable practices (Equity Initiatives Unit, 2010; Tanner, 2013).

The SPIPS-M survey was designed to capture a broad description of the instructional practices and learning opportunities that students report in their mathematics classroom. It was not specifically tailored to this dissertation study with the exception of including a question about sexual identity. Minor revisions were made to the survey between the pilot and the final version, notably the inclusion of items to assess the perception of classroom climate, and an item asking about any impact of experiences based on a student’s identity. Additionally, the demographic item related to sexual identity was changed from gradient response options (completely Gay or Lesbian) to broader identity categories (Gay, Lesbian, Queer, etc.). This change was supported by pilot work that resulted in a number of open-ended responses. Additionally, this change was informed by Queer theory and literature that makes broader categories more aligned with sexual identity rather than sexual behavior or sexual attraction (Cimpian, 2017). An overview of the survey items is included in Table 3.3, and a copy of the survey is included in Appendix B.

Table 3.3. Overview of the SPIPS-M survey items.

Category of questions	Data source
Helpfulness of mathematical learning opportunities and resources	Open-ended
Description of class time *(lecture, group work, individual work, and whole class)*	Percent of time
Attendance	Interval (1=almost never, 4=missed more than half)
Frequency and helpfulness of classroom experiences (27 items) *(student–student interaction, content delivery, formative assessment, student-content engagement, summative assessment, equity-oriented practices)*	Interval (5= very descriptive, 1= does not occur) Interval (3=very helpful and 1=not helpful)
Help seeking (3 items) *(tutors, instructor, and peers)*	Interval (5= very descriptive, 1= does not occur)
Perception of Inclusion (6 items) *(answer questions, attention, help, encouragement, contribute to discussion, praise)*	Interval (1=A lot less than other students, 5=A lot more than other students)
Perception of climate (3 items) *(rigor, intellectual engagement, and friendliness)*	(Interval 1, 5)
Growth mindset	Interval (1 Strongly agree, 5 strongly disagree)
Affective (4 items) *(interest, enjoyment, confidence, and ability)*	Interval (1=strongly agree, 6=strongly disagree)
Identity has impacted experience	Open-ended
General description of experience	Open-ended
Agree to future contact	Yes / No

Data Collection

The SPIPS-M was administered at 20 universities in conjunction with the previously mentioned PtC and SEMINAL projects. The survey was sent to students roughly three-quarters of the way through the semester with a direct link provided via the online platform Qualtrics (Qualtrics, 2019). At the discretion of the course instructor, incentives to complete the survey included nominal homework credit and voluntary participation. As such, this is a non-random sample and inferences only extend to these types of students. Data for this study was collected starting Fall 2017 to Spring 2019, consisting of two full academic years. The data was merged using R software (R Core Team, 2013) resulting in a total of 25,785 student responses. Data cleaning was conducted based on recommendations from Cimpian (2017) in order to avoid classification errors and bias when researching sexualized identities. Mischievous responses were identified through screening techniques which examined responses to all demographic questions. Data was removed from the analysis if mischievous responses were detected. This included checking all items to a demographic question or providing a response in the write-in options that were deemed frivolous or flippant (e.g., listing “apache helicopter” for gender). A total of 197 responses were removed from analysis due to mischievous responses.

Data Analysis

The analysis of the SPIPS-M data draws on both descriptive statistics and tests for comparison of means between various groups of respondents. I used R software version 1.1.456 (R Core Team, 2013) for all of the quantitative data analysis. The code is included in Appendix H. Given the exploratory nature of this study, descriptive statistics were used to summarize responses from Queer-spectrum students in order to understand how they describe their mathematical learning opportunities from the various items on the SPIPS-M. This included reports of frequencies, percentages, mean responses, and measures of variation in the sample for Queer-spectrum students. These descriptive statistics are presented in Chapter 4.

I then examined the entire SPIPS-M survey to determine and create relevant outcome measures based on the survey items to address the research goals. The survey was designed in sections each addressing various topics related to the mathematical learning experiences in the classroom, as detailed in Table 3.3. The largest section on the survey contained 22 items which described the relative frequency for which instructional practices occurred in the classroom. I conducted an exploratory factor analysis to identify constructs that underlie the data. The factor analysis used maximum-likelihood extraction and promax rotations, as this allowed for some of the factors to be oblique (correlated). The scree plot and factor loadings suggested there were four factors underlying the data. Using the factor loading weights and correlation between items, the following scales were developed: instructor interactions, peer interactions, community and participation, and responsive instruction. The detail of each of these items is discussed in Chapter 4 when they are used to understand the experience of Queer-spectrum students.

Apart from the instructional practice section, there were two sections that had a small number of survey items and were operationally well-defined. The first is the perceived equitable instructor interaction scale which included six items related to whether students reported equitable interactions with their instructor. The second were four items related to positive mathematical affect (e.g., interest, confidence, enjoyment).

Using R software (R Core Team, 2013) and the psych package (Revelle, 2019), I calculated the inter-rater reliability of each of these sets of items to determine if they could be treated as a single scale. The Cronbach alpha (which measures the level of agreement between the items) and the Cohen’s Kappa (which accounts for random agreement) were calculated. The inter-rater reliability scores meet the moderate acceptability threshold (Cronbach Alpha >.70, and Cohen's Kappa >.41) to treat these items as a scale (Taber, 2018).

Table 3.4. Composite survey measures and interrater reliability scores.

Measure Name	Items	Cronbach Alpha	Cohen's Kappa
Instructor interactions	4	.73	.36
Perceived equitable instructor interactions	6	.88	.55
Peer interactions	4	.82	.53
Sense of community and participation	4	.85	.58
Responsive instructional environment	6	.84	.46
Positive mathematical affect	4	.89	.62
Expected grade	1	-	

After I constructed the outcome measures, I identified the statistical tests best suited to the data that would answer the research question. A one-way ANOVA was selected to test for difference within Queer-spectrum respondents (e.g., Gay, Lesbian). The choice to use a one-way ANOVA limited to only to Queer-Spectrum identities was a purposeful design decision to limit the amount of gap-gazing between Queer-spectrum and Straight identities and to unpack differences within Queer-spectrum identities. Each of the outcome scales was assessed for normality and homogeneity of the variance to verify the assumptions of the one-way ANOVA test. On each outcome measure, a two-sample t-test was used to compare the difference between Queer-spectrum students and Straight students, and an effect size, Cohen's d, was calculated. Lastly, I used linear regression models using predictors of sexualized minority status, gender, racialized identity, and first-generation college student status to determine the impacts of identity markers on outcome variables. This helps situate the impact of Queer identity within other known and researched identities in mathematics. These results are presented in Chapter 4.

Phase Two: Mathematical Discourses Related to Queer Identity

In phase two of this dissertation study, I used semi-structured interviews with 17 Queer-spectrum students at four universities. A phenomenological analysis using grounded theory techniques was used to identify mathematical discourses students described in relation to their Queer identity and how students navigated those discourses in STEM environments. The following sections describe the institutional context, participants, data collection, and data analysis.

Institutional Context

I identified four universities from among the 20 universities to recruit students for individual interviews and subsequent focus groups. The selection of the universities was a purposeful sampling to allow for comparison of similarities, but also institutional differences in learning opportunities and resources, resulting in high contrast cases. Black University and Gold University were selected since they are both large public universities that reside within the same urban center, have local chapters of oSTEM, but provide contrast between the community-serving mission of the university and the typical format of introductory mathematics courses (e.g., coordinated active labs versus various problem solving recitation approaches). Cardinal University and Blue University were selected as they are both small to medium-sized private universities with small class sizes, but provide contrast in the selectivity of enrollment, presence of LGBT STEM organizations, and structure of mathematics courses (active and theoretically driven labs versus problem solving recitation). Details for each of the universities is provided along with a summary in Table 3.5.

Table 3.5. Institutional overview of university context.

Code Name	Institution Description	Typical Introductory Math Classroom	oSTEM Organization
Black University	Large public Hispanic serving institution	Large lectures with active learning lab sections	Yes
Gold University	Large public research institution	Large lectures with problem solving recitation sections	Yes
Cardinal University	Medium private religiously affiliated institution located in major urban center	Small lecture with problem solving recitation sections	No
Blue University	Small private highly selective institution	Small lecture with active learning lab sections	No (Graduate chapter exists)

Black University.

Black University is a large public research university with an engineering program ranked in the top 10% in the United States. It has a special designation as a Hispanic-serving institution (HSI), with the makeup of the student's body in 2019 consisting of 31% Hispanic, 34% White, 14% Asian and 4% African-American students. The university is socioeconomically diverse with 38% of students identifying as low-income. Black University is consistently ranked in the top 25 LGBT friendly colleges and universities, with a campus pride index of 5 out of 5. The campus has an LGBT student resource center, LGBT studies program, Queer student union, LGBT Greek communities, and an undergraduate student chapter of oSTEM. The precalculus and calculus courses feature a large lecture three times a week (2 days a week for 50 minutes in Precalculus), with two 50-minute recitation sections, one of which is a dedicated active learning lab activity.

Gold University.

Gold University is a large public research-intensive institution located in the same urban setting as Black University. Gold University, as of 2019, has a substantial international student population (19%), with a student demographic make-up of 48% Asian, 24% White, 20% Hispanic, 5% American-Indian, and 2.9% African-American. Gold University is an LGBT-friendly university with a 4.5 out of 5 on the campus pride index. The campus has an LGBT student resource center, Queer student union, and an undergraduate student chapter of oSTEM. Mathematics classes at Gold University are taught three times a week for 50 minutes in large lectures and meet for an additional 50-minute recitation section with problem solving help taught by a graduate student or undergraduate recitation leader.

Cardinal University.

Cardinal University is a medium-size, private religiously-affiliated institution in an urban setting. It is a predominantly white institution (PWI) with a student composition in 2019 of 56% white, 18% Hispanic, 9% Asian, 8% African-American. Cardinal University actively recruits students from the local urban setting and has a 33% first-generation college student population. Cardinal University is not ranked on the Pride Index, but does have an LGBT student resource center, LGBT student organization, and an LGBT studies program. Mathematics classes at Cardinal university are taught in small sections led by an instructor primarily meeting twice a week for 90 minutes, and calculus courses meet for an additional 1-hour recitation section with problem solving taught by a graduate student.

Blue University.

Blue University is a small-size, private highly-selective university. It is a PWI with a demographic composition as of 2019 consisting of 52% White, 24% Asian, 11% African-American, and 8% Hispanic. Blue University is an LGBT-friendly campus with a 4 out of 5 on the Pride Index. The campus has an LGBT student resource center, LGBT studies program, Queer student organizations, and a graduate student chapter of oSTEM. Mathematics classes at Blue university are taught in small sections three times a week for 50 minutes and have an additional 1 hour and 45-minute lab section that focus on laboratory projects, group work, and written reports.

Participants

Queer-spectrum students were recruited based on their completion of the SPIPS-M survey that was administered at the four universities during the academic year 2017-2018. There were 82 students who indicated a Queer-spectrum identity and were either pursuing a STEM degree or undecided at the time of the survey, and who agreed to further follow-up be providing their email address. An email was sent to all 82 students inviting them to participate in a research project that would explore the experiences of Lesbian, Gay, Bisexual, Transgender, Queer, Intersex and Asexual (LGBTQIA) students who have taken an undergraduate mathematics course. 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. A nominal financial incentive in the amount of a $25 gift card was given to students willing to participate in the study. Follow-up emails were sent with the goal of having four students per university participating in the study.

Seventeen students agreed to participate in the study. Four of the students identified as Bisexual, seven students identified as Gay, four students identified as pansexual, and two students identified as Queer. Seven identified as men, six identified as women, and four identified as gender fluid or non-binary. Regarding race, nine were students of color, and eight of the students were White. Students of color included students who identified as Black or African-American, Latinx, and Asian. All students chose to either have a researcher assigned pseudonym or identified their own pseudonym. The ability to select a pseudonym as previously discussed was especially important in this study both to provide agency to the students and due to issues around Transgender chosen names and assigned dead names. Aidan, Azra, Martha, and Ninah were enrolled at Cardinal University. Adam, Erin, Jesse, and Ronald were enrolled at Blue University. Corine, Gavin, Leigh, Robert, and Wren were enrolled at Black University. Fran, Fredo, Magda, and Swappi were enrolled at Gold University. A list of each of the students and accompanying demographic information is presented in Table 3.6.

3.6. Queer-spectrum student phase two participants and demographic information.

Pseudonym	Pronouns	Sexual Identity	Gender	Race/Ethnicity	Major
Adam	He, Him, His	Gay	Man	White	Economics
Aidan	She, Her, Hers	Bisexual	Woman	White	Mathematics and Psychology
Azra	They, Them Theirs	Queer/ Asexual	Non-Binary/ Fluid	South Asian	Biological Sciences
Corine	She, Her, Hers They, Them, Theirs	Pansexual	Non-Binary/ Fluid	Black or African American	Math (Single Subject)
Erin	She, Her, Hers	Bisexual	Non-Binary/ Fluid	White	Environmental Sciences
Fran	She, Her, Hers They, Them Theirs	Pansexual	Non-Binary/ Fluid	Southeast Asian	Global Health
Fredo	He, Him, His	Gay	Man	Hispanic or Latinx	Nanoengineering
Gavin	He, Him, His	Gay	Man	White	Civil Engineering
Jesse	He, Him, His	Gay	Man	White	Physics
Leigh	She, Her, Hers	Pansexual/ Queer	Woman	White	Mechanical Engineering
Magda	She, Her, Hers	Pansexual	Woman	Hispanic or Latinx, White	Computer Engineering
Martha	She, Her, Hers	Bisexual	Woman	Black or African American, Middle Eastern	Psychology
Ninah	She, Her, Hers	Queer	Woman	Black or African American, Middle Eastern	Chemistry
Robert	He, Him, His	Gay	Man	White	Economics
Ronald	He, Him, His	Gay	Man	Southeast Asian	Biomedical Engineering
Swappi	He, Him, His	Gay	Man	South Asian	Molecular Biology
Wren	She, Her, Hers	Bisexual/ Queer	Woman	White	Applied Mathematics

The following section presents a highlight of how each student described themselves, how they identified as Queer-spectrum, and other salient identities that shaped their experiences. Each of these descriptions was shared with the participants for member-checking, which is discussed in the analysis section. The tone of each of the descriptions (which differs from the rest of this manuscript) was written in a third person point of view to factually convey the information shared by the participants during the interview and is meant to honor the spirit of the participants.

Adam.

Adam describes himself as a mature, responsible, outdoorsy type of person. Adam said that he considers himself Gay, meaning he has a physical, emotional, and sexual attraction to guys and does not feel anything for girls. According to Adam he doesn't fit the stereotype of being Gay very well, which he described as being more effeminate, high-pitched voice, girly, ditzy, and into art or fashion. Adam said that being Gay doesn't really have an "impact on my social life," because he doesn't value or emphasize that part of his identity and instead puts more emphasis on beliefs and values as opposed to social identities. Adam stated that, "I'm not very outgoing when it comes to being Gay. I'm perfectly happy to talk about it with anyone and everyone but it's not really like a very large aspect of my life." Adam is pursuing a degree in Economics.

Aidan.

Aidan describes herself as fun, understanding and intelligent. She identifies as Bisexual, which to her means that she is "attracted to everyone" and dates both genders. She said that in practice this means she "swipes" for both men and women on dating applications. One of the biggest impacts she expressed with being Bisexual is that she is attracted to a bigger pool of individuals to pick from when considering dating. She expressed that this can impact her while in class because she can find more people attractive and has even tried to give her number to another student in her math class. Aidan identifies as someone who is newly Catholic. Aidan is pursuing a degree in both Mathematics and Psychology.

Azra.

Azra identifies strongly as a Queer, brown, South-Asian international student from Pakistan. In terms of being Queer, Azra is still "figuring out the particulars," but is questioning their gender identity and identifies as Queer and might even consider their self to be on the Asexual spectrum. Azra specifically identifies as South-Asian, because to them Asian doesn't mean anything, and often people associate Asian with people from East Asia. Azra is pursuing a degree in Biological Sciences.

Corine.

Corine describes themselves as someone who is passionate, hardworking, and insecure. They identify as pansexual and gender fluid. Being pansexual means for them that who they love is not based on gender. Being gender fluid means they don't have to identify with one gender and can go between different presentations. For example, Corine said some days they will wake up more on the "masculine side" of things in terms of dressing, pinning up their hair, and giving a manly persona, and then other days will be the complete opposite where they are feminine all day. Corine also identifies as African-American and that being a black pansexual gender fluid individual contributes to her diversity and intersectionality, which gives her "a bit more drive and a bit more purpose to do something that could change the people around me." Corine is pursuing a degree in Mathematics with the aim of being a teacher.

Erin.

Erin describes herself as someone who “appreciates life in its entirety.” Erin identifies as a polyamorous Bisexual, which for her means that she is attracted to someone regardless of gender. Erin expressed that although she is attracted to people regardless of gender, which some may refer to as pansexual, she doesn’t use that label since not everyone in familiar with “Queer theory and gender binary” and thus it makes it harder to explain to others. She said that she doesn’t really act on her polyamorous behaviors since she doesn’t have the time to “dedicate myself to multiple partners in a healthy way.” Erin is part of the Reserve Officer Training Corps (ROTC), a decision she made based on financial reasons, but she has found a community among her class of cadets and has enjoyed the structure and career pathway it is providing her. Erin also strongly identifies as an environmentalist and is part of several student clubs that promote conservation and environmental related issues. Erin is pursuing a degree in Environmental Science.

Fran.

Fran describes herself as open, flexible, and physically short. Fran identifies as gender-Queer pansexual, which to her means being fluid, open-minded and challenging labels (even though she recognizes that gender-Queer pansexual are labels themselves). Being gender-Queer pansexual impacts Fran in that she does not assume other people’s gender or sexuality and has shifted to seeing the gray area in things that have often been portrayed as black and white. For example, she will ask for people’s pronouns. Fran doesn’t distinguish between gender-Queer and pansexual, she recognizes that gender is fluid, and that there are things between male and female. She considers herself more female, but there are days in which she feels less feminine and so identifies as gender-Queer. Being pansexual for her means she loves people and tries to find the good in somebody to admire. Fran also identifies as Asian-American from a Filipino community and a first-generation college student. Fran is pursuing a degree in Global Health.

Fredo.

Fredo describes himself as curious, ambitious, and sometimes lazy. Fredo identifies as Gay, which to him means he cannot be attracted to women and instead is just attracted to guys. One of the ways in which this impacts Fredo's experience is that he said his "friend group is composed mainly of girls rather than other guys" and that this is really one of the only things different from other people. He said he wasn't sure the reason he is friends with more women but that he feels more at home and comfortable around females, even though he has plenty of male friends. In addition to identifying as Gay, Fredo mentioned two other important aspects of his identity that have impacted his experience, the first being that Fredo is a first-generation college student and the second that his parents currently live in Mexico. Fredo is pursuing a degree in Nanoengineering.

Gavin.

Gavin describes himself as happy, emotional, and adaptable. Gavin identifies as Gay, which to him means being attracted to only males. Being Gay for Gavin means that his life is, "slightly more complicated and that sometimes I need to watch what I do or say around other people that I wouldn't otherwise have to worry about." Additionally, Gavin identifies as a white male, which he said makes it harder sometimes to find a community to fall into as compared to other marginalized groups. Another impactful identity or experience for Gavin was growing up in Missouri, which he said gave him less exposure to diversity and has made him more sensitive to issues of race and sexuality. Gavin is pursuing a degree in Civil Engineering.

Jesse.

Jesse describes himself as passionate, determined, and joyful. Jesse identifies as a cisgender Gay man, which is an identity he views as being central and important to his lived experience. For Jesse, identifying as Gay impacts both the communities he associates with and his views of traditional masculine identities and roles. In terms of community, Jesse spends a lot of his free time in the LGBTQIA+ center and will be working at the center for his on-campus employment next year. Jesse said that he has a more “nuanced take” on masculinity and doesn’t feel “bound to traditional gender roles.” Jesse also identifies strongly with his upbringing in rural North Carolina in a middle to low income family. Jesse is pursuing a degree in Physics.

Leigh.

Leigh describes herself as a strong, questioning, and an honest person. Leigh identifies as pansexual and/or Queer, with each of these terms carrying different implications and significance. The term pansexual conveys the idea that gender is not important to her, but that an emotional connection to a person is paramount. For instance, Leigh shared that when she met her current boyfriend, she was not attracted to him, until getting to form a personal connection and then found him attractive. Leigh rejects the term Bisexual because of its implied importance and adherence to two genders. Yet identifying as pansexual, has presented difficulties since it “may be undermined by the idea you’re dating a guy” with others assuming you are Straight or not Queer-spectrum. As such the term Queer was preferable since it doesn't have to be explained, "I am just Queer." Additionally, another strong personal identity for Leigh was being a woman with short hair. Leigh is pursuing a degree in Mechanical Engineering.

Magda.

Magda describes herself as simply curious, which is driven by an interest in logic and understanding how things work. Magda identifies as pansexual, which for her means to be attracted to all genders. Magda explained that being pansexual is more related to sexual preferences and she is attracted to guys, girls, non-binary people, and people across the gender spectrum. It's because of non-binary people and those across the spectrum why she identifies with the term pansexual. Being pansexual impacts who she dates, but also is a mechanism used by her mostly Straight friends to joke around and talk with her. In addition to being pansexual Magda identifies as polyamorous, meaning she will meet up with anyone, and questions the normative assumptions about relationships. Magda is from Brazil and identifies as Latina and White. Magda is also a vegan and identifies as an atheist. She is pursuing a degree in Computer Engineering.

Martha.

Martha describes herself as a social, funny, and calm person. She identifies as Bisexual, which for her means that she likes guys and girls. She expressed that she doesn't think about being Bisexual all that often since, "I still live my life as if I were Straight, as if I were Gay…I feel like it doesn't affect my day-to-day life." Martha however acknowledged that it mattered that she was Bisexual since, "it's part of who I am," but that it didn't matter to the friendships and relationships she has with others. Additionally, Martha identifies as a female and has strong connections to her African heritage, especially since her dad is an African immigrant. Martha said that all of her identities feel of equal importance, “in my mind I don't feel like I'm more of a black girl than other identities I have,” but that since people see her as a woman and person of color that those identities are more apparent or “outwardly present.” Martha is pursuing a degree in Psychology.

Ninah.

Ninah describes herself as a pessimist, antisocial-extrovert, and a logical person. She identifies with the broad label Queer but has some reservations about using that terminology since it has been used as an insult against LGBTQIA+ individuals. She typically uses the label Queer within a safe space where it will be understood by others Queer-spectrum people. For her, being Queer means having a sexual attraction to all people, and she doesn’t see herself as “picking a partner or staying with someone based off of their gender or sex.” She described her sexuality as very fluid which some may refer to as pansexual, but she chooses not to use that label. Her identification as Queer has evolved over time, originally coming out in high school as Bisexual, saying she was 80% Gay and 20% Straight, but now can no longer quantify her sexuality and so uses the label Queer. Additionally, Ninah identifies as a woman of color, being half Arab and half Black. Ninah is pursuing a degree in Chemistry.

Robert.

Robert describes himself as someone who is ambitious, responsible, and introspective. He identifies as a Gay man and said he has been out for nearly 10 years with that identity; however, for Robert being Gay is not a highly salient identity. Robert said that in relation to being Gay he doesn’t “really carry that identity with me, it’s been kind of very passive." He said that being Gay has carried differing levels of significance, but over time it has become much smaller. Robert said that his experience as a Gay man has been "colored by my grandfather who is also Gay." Robert mentioned that his existence is due in part to his grandfather who married and hid his sexual orientation while conceiving children. A highly relevant interest or identity for Robert is his pursuit and interest in Economics.

Ronald.

Ronald describes himself as someone who is perseverant, logical, and empathetic. He considers himself Gay, which to him means it is part of his sexuality and that he is "attracted to guys." Ronald also grew up in Thailand and considers himself as an Asian student. He actively explores the intersectionality of his LGBT identity and being Asian through participation in an Asian and Pacific-Islander Queer (APIQ) discussion forum. Ronald said that "technically" he hasn't really come out, and only a few of his closest friends are aware he is Gay. He said he doesn't really broadcast that information, partly due to the fact that people don't need to know that information, but also because it might create a "target on his back." Ronald is pursuing a degree in Biomedical Engineering.

Swappi.

Swappi describes himself as confident, hardworking and one who makes mistakes. Swappi identifies as Gay, which for him relates to his sexual orientation but "also defines a lot of how I interact with people…So it's a part of who I am." Swappi said that it's important for others to know who he is so that they can understand the context of what he is saying and how it influences his thinking. For Swappi being Gay is an “important factor in what I do or how I behave” because it “influences most of my decisions.” Additionally, Swappi considers himself an Indian person, having grown up in India and coming to the United States for college. He identifies heavily with academics, research, mathematics, and sciences. He also belongs to a group of people “who are really interested in fashion on campus.” Swappi said that all of these identities are important, because he puts efforts into them all, and they give him confidence in who he is, and will eventually pay off. Swappi is pursuing a degree in Molecular Biology.

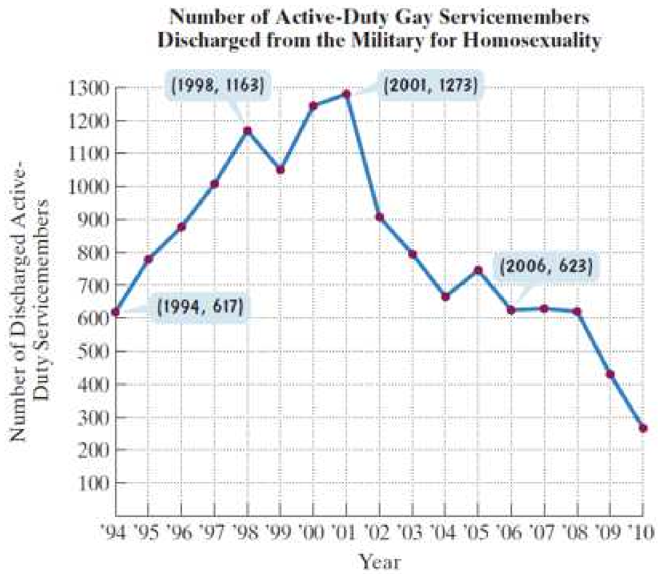
Wren.

Wren describes herself as someone who is a nerdy, a rational thinker who can be an impartial mediator, and ambiverted (meaning being both extroverted and introverted). Wren identifies as Bisexual, which for her means being interested in both girls and boys. Although not a big part of her identity, Wren also experiments with make-up and her physical presentation in non-conforming ways that lie in the middle of butch and fem presentations. One of the ways in which this plays out for her is that she will jokingly call herself a “butch Lesbian” depending on how she presents on a certain day even though she isn’t “fully Lesbian.” In high school she experimented with the gender-Queer label and pushed herself and overcompensated to look more boyish. Currently, she has short hair which see described as making it easier to reside in the middle of gender presentation. Wren said, “as Gay as I look, my only experience was dating a girl for two weeks, so I don't feel like it's a big part of my past. I don't feel like it's a huge part of my identity, it's just something that's there, and I also happen to look the part.” Wren is pursuing a degree in Applied Mathematics.

Data Collection

Each student took part in two semi-structured interviews occurring in either the Fall 2017 or Spring 2018. The interviews were scheduled one to three days apart. The interviews were based on the three-interview format described by Seidman (2006). In this manner, a participant's behavior becomes meaningful and understood in the context of their lives, history, and community. The first interview focused on the life history and background of the participant, to understand the context of being Queer in mathematics. It included questions about how they personally identify, their history with mathematics, coming out, motivation to pursue college, intended major, along with the presentation of Queer-themed mathematics problems. The inclusion of the Queer-themed mathematics problems was informed by the pilot study to help illustrate the taken-for-granted ways of operating in mathematical classrooms. For instance, having students reflect on Queer-themed mathematics problems can illicit whether they have seen such examples in their mathematics courses, whether they would be resistant to such problems, or whether they appear similar to other mathematics problems. A sample problem is shown in Figure 3.2. Students were not asked to solve the problem but reflect on how they would react if they were given such a problem in a mathematics class. A total of five problems were used each originating from existing mathematics textbooks. Two of the problems featured fictional scenarios with either a Queer-spectrum couple or a Straight couple. The remaining three problems used data about Queer issues or heterosexual issues to contextualize mathematical calculations. The entirety of the first interview protocol is included in Appendix C.

The stated intent of the 1994 "don't ask, don't tell" policy was to reduce the number of discharges of gay men and lesbians from the military. Nearly 14,000 active-duty gay servicemembers were dismissed under the policy, which officially ended in 2011, after 18 years. The line graph shows the number of discharges under "don't ask, don't tell" from 1994 through 2010. Use the data displayed by the graph to solve Exercises 29–30.



Source: General Accountability Office

29. Find the average rate of change, rounded to the nearest whole number, from 1994 through 1998. Describe what this means.

30. Find the average rate of change, rounded to the nearest whole number, from 2001 through 2006. Describe what this means.

Figure 3.2. Queer-themed mathematics problem example.

The second interview targeted the lived experience of the participants in mathematical environments. It used vignettes or narrative accounts (Leyva 2016a; Stinson, 2008) which described mathematical scenarios to assist students in engaging in critical conversations and making sense of their navigational strategies in relation to their Queer identity. There were three vignettes developed based on examples from literature and informed by the emergent themes in the pilot study. The first vignette focused on "coming out" while working in groups in a math classroom. The second vignette contained a discriminatory statement from another student while working on group project outside of class. The third vignette featured a supportive relationship with a mathematics instructor. Students were first given the vignette describing the scenario and then asked how they would respond in the situation. After students described their imagined response, a potential response was given, and students were then asked to reflect on how that resonated with their own experience. The potential response was based on the emerging themes identified in the pilot study and provided the participants an opportunity to confirm or reject how it resonated with their own experience. Participants were first asked how they would respond before seeing the potential response in order to mitigate against it from influencing their opinion. The entire second interview protocol is included in Appendix D. The first sample vignette and hypothetical response which describes a groupwork scenario where Queer affiliation is elicited is presented below.

First sample vignette.

You are working in small groups during your recitation section on problem computing the $\lim_{x\to\infty}\left(\frac{1}{2}\right)^x$. One of your group members says that it must go to infinity since ½ raised to a number returns another number and as x goes to infinity the result will also go to infinity. You explain that since ½ <1 this is a decreasing function and thus as x gets bigger, the results will tend towards zero as you are multiplying smaller numbers together. Your group accepts your answer and finishes the worksheet.

As you are waiting for the class to end, your group members talk about what they did over the weekend. One of them asks you what you did over the weekend, you don’t feel comfortable sharing with them since over the weekend you hung out with some of your Queer friends at an LGBT movie night. Usually you try and slowly determine how accepting your group mates are by finding out certain information about them. Are they religious? Part of a fraternity? But this is a new group and you don’t know how they will react.

How would you react in this situation?

Response to first sample vignette.

> You deflect the answer, and say, “oh nothing exciting,” and disengage from the group conversation. It reminds you how much you dislike working in groups and wish the instructors would just lecture.
>
> Towards the end of the class, the instructor asks each group to select one person to present their explanation to the problem. Your group mates nominate you, since you came up with the solution. You would rather not talk in front of the entire class, as it makes you nervous. You suggest one of your other group members and they accept. You are relieved you won’t have to present in front of the class, and spend the remainder of the session taking notes.

Each interview lasted between 45-90 minutes and was audio recorded. After each interview I completed a contact summary form (see Appendix E) that acted as both a practical first-run of data condensation (M. Miles et al., 2014) and was used for reference during the second follow-up interview with the student. Following the guidelines provided by Miles, Huberman and Saldaña (2014), the contact summary form consisted of a single sheet of paper, capturing the main concepts, themes, issues and questions during contact with the participant. All of the interviews were then transcribed using the transcription software InqScribe (Inquirium, 2018) and ©TEMI (Temi, 2017). The transcripts were then loaded into the qualitative coding software MAXQDA (VERBI Software, 2019).

Data Analysis

Analysis of this phase drew on the structures of a Phenomenology as outlined by Moustakas (1994, 2011). Phenomenological studies describe the meaning for several individuals of their lived experiences of a concept or a phenomenon. In this case, the phenomenon being studied is that of Queer-spectrum students’ experiences within mathematical learning environments and discourses towards their Queer identity. Phenomenology is an appropriate methodology for this study given the focus of the research questions on the lived experience of Queer-spectrum students in mathematics. The goal of the analysis is to produce a description of the essence of the student's experience which includes both the "what" they experienced and "how" they experienced it (Creswell, 2007; Moustakas, 2011). Based on the suggested analysis by Moustakas (1994, 2011), analysis of the transcripts was first reduced to all relevant non-repetitive statements and quotes, known as invariant meanings. Each of the invariant meanings was paraphrased for interpretability and was directly linked to the transcript text.

For each student, I then developed a textural description of the experience of the person (what the participant experienced), a structural description of the experience (how they experienced it in terms of the conditions, situations, or context), and finally I developed a combination of the textural and structural descriptions to convey the overall essence of the experience in a single document. In an effort to promote validity, these documents were sent to the participants for member checking. Participants were asked if the overall description of their experience was accurately captured and aligned with their experience as a Queer-spectrum student. Feedback from participants in this way helps inform a researcher's judgment but cannot substitute for it, therefore feedback from participants was used to help inform the trustworthiness and credibility of the analysis document (I. Seidman, 2006). Additionally, the use of member checking in this manner aligned with the transformative nature of the research design, which seeks to change the conditions for Queer-spectrum students in STEM. By sharing insights gained with Queer-spectrum student participants, it helped to convey a sense that their lived experiences are valued, important, and not isolated. The member checking documents were first reviewed by my committee chair and then sent to students as a Google cloud-based document. Students were invited to directly make edits or comments on the member checking document. Sending them as Google documents allowed for monitoring any changes and edits to the documents. Eleven of the students responded to the member checking document by making edits or providing email confirmation affirming the accuracy of the document. A sample member checking document with track change edits enabled is included in Appendix F.

After the completion of the member checking documents, which provided illustrative accounts of the phenomenon of being Queer-spectrum in mathematics, I re-examined the interview transcripts in order to identify and operationalize the mathematical discourses and navigational strategies discussed by Queer-spectrum students. Informed by grounded theory (Corbin & Strauss, 1990; Strauss & Corbin, 1994), I employed coding techniques using MAXQDA (VERBI Software, 2019) to develop a conceptual account for the mathematical discourses and navigational strategies. Grounded theory describes a methodology rooted in pragmatism and symbolic interactionism (Kanter & Blumer, 1971) implying that phenomena are considered to be continually changing and whose meaning resides in the actions and consequences of the students in the study. Grounded theory uses the coding techniques of open coding, axial coding, and selective coding to generate substantive theories. In the broadest sense, open coding is the first round of coding related to the data, axial coding is the coding between categories, and selective coding is used to define and elaborate each category. In summary, grounded theory should result in the development of a theoretical account which emerges from the data and gives explanatory power to the concept being explored. Strauss and Corbin (1994) suggest the “theory” part of grounded theory refers to, “plausible relationships proposed among concepts and sets of concepts” (p. 278). The theories being developed are intended to be conceptually dense and grounded to the specific population and phenomenon being studied and thus are not generalizable to universal principles.

Open coding was first used on the transcript data utilizing a constant comparative method of observed concepts to formulate categories and subcategories with characteristics and dimensions. In line with the grounded theory approach, no a priori coding scheme was used to analyze the data, and, when possible, “in vivo” codes of specific student statements were used as codes to limit inferential conclusions of the researcher. Next, axial coding was utilized to develop relationships between the categories and subcategories to further refine their characteristics and dimensions. This resulted in a codebook describing the mathematical discourses and five categories of navigational strategies (see Appendix H).

This codebook along with eight interviews from four students were shared with two external coders who had a background in educational research methods but limited familiarity with the topic being studied. Each of the external coders independently coded the transcripts and we met twice to discuss the codes until 100% agreement was reached. This resulted in refinements to the codebook to further operationalize the construct and increase the interpretability of the codes. Selective coding then took place whereby all the codes were unified by underlying constructs categories to create two frameworks related to mathematical discourses and navigational strategies. In the following section I present a description of the codes for the mathematical discourses and the navigational strategies.

Mathematical Discourses

In this section I highlight the mathematical discourses that were identified in the data. A more illustrative description of these discourses is presented in Chapter 5 as they represent the results of research goal 2 characterizing the mathematical discourses. Seven prominent discourses emerged relating to how Queer identity arise within social discourses in STEM environments.

The *marginalized discourse* conveys a belief that Queer-spectrum identity is discriminated against or marginalized in mathematics. There exists hostility or pressures to disregard Queerness in mathematics. This discourse occurred frequently throughout the interviews and was referenced by fifteen of the students in a total of 27% of the coded discourse statements (117 times).

The *erasure discourse* conveys a belief that Queer-spectrum identity is not discussed when in mathematical environments. There is overt or intentional pressure to erase Queerness from mathematics. The erasure discourse was the most commonly referenced discourse both in the 28% of coded discourses (127 times) and occurring across all 17 students.

The *heteronormative discourse* conveys a belief that Queer-spectrum identity does not exist in mathematical environments. Queerness is described as a less visible identity thus mathematical environments are perceived as Straight. This was a common discourse occurring across all 17 students with a total of 18% of the coded discourse statements (80 times).

The *ambiguous discourse* conveys a belief that Queer-spectrum identity acceptance is unknown. It's uncertain how people in mathematics will react to Queer issues. This discourse was discussed by 16 of the students representing 12% of the coded discourse statements (53 times).

The *normalized discourse* conveys a belief that Queer-spectrum identities are treated the same or regarded equally with Straight identities. In effect this normalizes Queer identity in mathematics. The normalized discourse was less frequently discussed, referenced by 10 students and 6% of the coded discourses (28 times).

The *accepted discourse* conveys a belief that Queer-spectrum identity is accepted in mathematics. There are overt or implicit messages that Queer-spectrum identity is accepted in mathematics. This discourse was referenced by 10 of the students in 5% of the coded discourse statements (22 times).

The *valued discourse* conveys a belief that Queer-spectrum identity is valued and seen as relevant to the pursuit of mathematics. This discourse was infrequently referenced by four students representing 2% of the coded discourses (7 times).

Navigational Strategies

Drawing on the student interviews, I coded a series of strategies and ways of interacting that Queer-spectrum students utilized when navigating mathematical discourse. There were five axial codes that represent categories of navigational strategies, each of which are discussed in detail in the subsequent section. Three of the strategies relate to how Queer-spectrum students navigate their Queer identity in relation to STEM. This included how they *position* their identity, whether or not they *disclose* their identity, and how they *connect* their Queer identity and STEM identity.

These codes represent navigational strategies about one's identity and are more internalized. In addition to the ways in which students navigate their own Queer identity in relation to STEM, another navigational strategy is how students respond to Queer topics and issues in STEM. The final navigational strategy is how students develop interpersonal relationship in STEM environments.

Positioning Queer identity in STEM.

The first navigational strategy considers how students' position their Queer identity in STEM. Responses within this strategy included *positioning it as a strength*, *viewing it as intersectional* with other identities, and *downplaying the importance* of Queer identity. Positioning Queer identity as a strength meant that students viewed having a Queer identity as an asset when pursuing STEM since it made one "more open" to topics, helped develop "instant connection to other people", and their prior experience with struggle and resilience gave them the grit needed to succeed in STEM. Viewing Queer identity through an intersectional lens was often employed to contextualize the environment (e.g., STEM has been oppressive to Women) or to highlight how Queer identity was different than their experiences with race and gender. This response strategy aligns with the notions from critical race theory that social discourses are shaped by intersecting systems of oppression (Martin, 2013). Downplaying the importance of Queer identity was discussed in how having such an identity was not important to the pursuit of STEM, had minimal impact on their experiences, or was not considered an important aspect of their own identity (e.g., "it's not really like a very large aspect of my life"). Each of these navigational strategies of positioning Queer-identity was coded in the interviews with similar frequency (*position* *as strength* occurring 41 times, *view intersectional occurring* 68 times, and *downplaying significance* occurring 52 times).

Disclosing (or not) Queer identity in STEM.

Another navigational strategy is related to disclosing (or not) one's Queer identity in STEM. One response was to disclose one's Queer identity or to come out in STEM environments. This response occurred both in terms of coming out to others or describing an environment that does not limit this capacity. Coming out was not always verbal, there were many visual indicators discussed that students used to come out in STEM. Such examples included women with short hair, Queer jewelry or clothing, and other visual indicators of dress. Alternatively, Queer-spectrum students can choose not to disclose their Queer identity or to be "closeted" in STEM. This included a desire or hesitancy to not disclose or come out in STEM (e.g., reservation to come out), filtering what is shared so as to not "come out," and gauging the acceptance of others before coming out. This strategy also included constraining one's physical attire or monitoring one's gender performance to match normative expectations. There were 92 instances of *not disclosing* Queer identity and fewer instances, 77, of *disclosing* Queer identity.

Connecting Queer Identity and STEM Identity.

The third navigational strategy related to how students connect their Queer identity and STEM identity. This included the strategies of *integrating* the two identities or *separating* the two identities. Integrating their identities included pursuing STEM research that focused on Queer topics. For example, doing research on the economic mobility of Queer people and working with a professor to explore the AIDS crisis. Evidence of integrating also included participating in social clubs that promoted Queer

STEM students (e.g., oSTEM) and describing combined social groups of STEM and Queer peers (e.g., “I am part of oSTEM to be able to connect my interest in STEM with my Queer interests”). Separating the two identities included explicit messages about not wanting to connect the two identities, experiencing a tension between the two identifies, and experiencing fractured or separated STEM and Queer peer groups. This also included an expression of not feeling “Queer enough” because you are in STEM, or not feeling “STEM enough” because you are Queer. The *separating* response strategy (54 times) was equally referenced as the *integrating* response strategy (54 times).

Reacting to Queer topics in STEM.

In addition to the ways in which students navigate their own Queer identity in relation to STEM, another navigational strategy is how students respond to Queer topics and issues in STEM. This is a different strategy as it externalizes the action from the self to the STEM environment. Responses within this strategy include *engaging and advocating for Queer topics in STEM*, *redirecting to the mathematical content*, or *disengaging with Queer topics in STEM*. The engage response included “taking up space,” such as asserting yourself and your opinions in relation to these topics. Students expressed wanting to see more representation of Queer issues in STEM and advocating for more representation of Queer role models. A different navigational response is to disengage or view the presence of Queer issues in STEM as a distraction. This included students personally acknowledging a disagreement with a certain practice or interaction in STEM, but not having the agency to alter this practice. For example, a few students discussed how some people may assume one’s pronouns and while they disagree with that approach, they did not have the agency in the classroom to take any action. This code also included a desire to pursue studies or interests outside of STEM. In contrast to engaging or disengaging, another response was to redirect the focus to the mathematical task. Students put a primary focus on the mathematical objective and solving the tasks, often shifting away from possible discussion of Queerness. The most common response was to *engage or advocate* (138 times), followed by *disengage* (91 times) and lastly to *redirect the focus to the mathematics* (45 times).

Developing relationships.

The final navigational strategy was how students developed interpersonal relationship in STEM. This includes responses of *building and forming relationships with Queer individuals*, *building, and forming relationships with STEM individuals*, and *avoiding STEM individuals*. Although students can also avoid Queer individuals as a response, this was not discussed in the interviews. Connections with STEM individuals were manifested in a view that people are bonded together in experiencing mathematics as a difficult discipline. Another response is to form community with other Queer people. This includes forming connections through oSTEM, LGBT student resource centers, and connecting with other known Queer people in STEM. A final response is to avoid developing connections with STEM people. This includes the empowerment or agency of not interacting with someone, which was often the case when discussing bias or discrimination experiences. The *build and form connections with STEM people* was the most prevalent response strategy (140 times), followed by the *build and form connections with Queer people* (84 times). Finally, there were 60 instances of the *avoiding STEM people*.

Navigational Strategies and Queer STEM identity

After identifying the navigation strategies each was assessed for whether it helped promote or hinder one to develop a Queer STEM identity. It is important to note that none of these strategies is more beneficial than any other, but instead, reflect an appropriate response within a time, situation, and context. However, certain responses afford students power and agency to be able to foster a Queer STEM identity of their choosing, and hence I identified strategies that promote or hinder the development of a Queer STEM identity. Developing such an identity meant the navigational strategy allowed for Queer-spectrum students to fully participate and perform effectively in mathematical contexts as a Queer individual. This meant that regardless of the importance or relevance that students placed on their queer identity, there were not pressures to disregard or inhibit that identity from being present. This allows for students to be wholly present in mathematical environments. For instance, downplaying the importance of Queer identity, while valid to the lived experience of the student, doesn't provide the agency to fully participate as a Queer-spectrum student in mathematics and serves to minimize its presence in STEM.

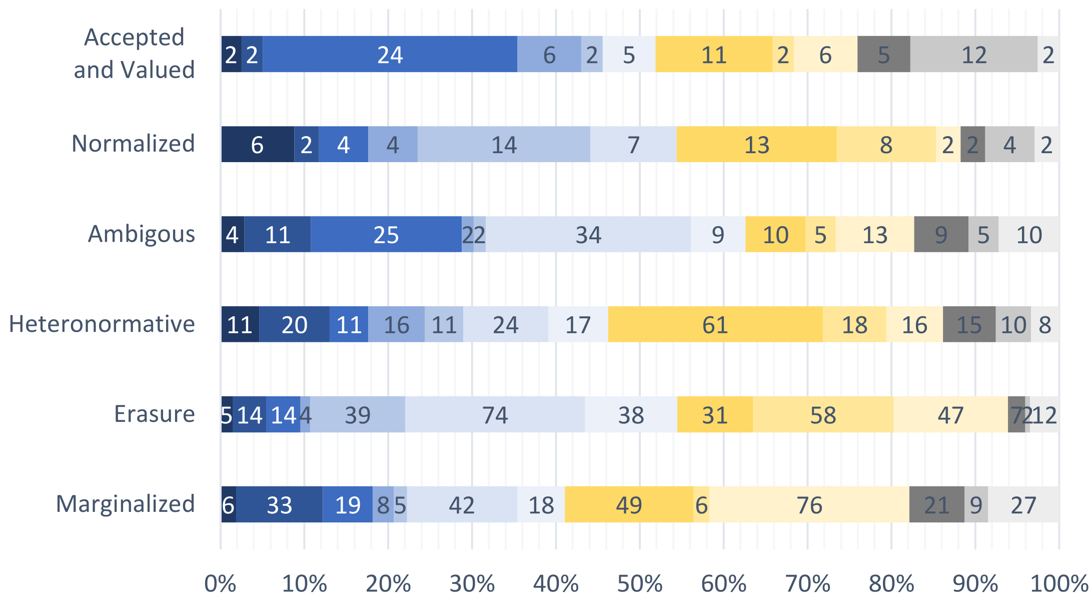
The navigational strategies that promoted a Queer STEM identity included positioning as a strength, disclosing (coming out), integrating or connecting, engaging or advocating, interacting with STEM individuals and interacting with Queer individuals. Response options which hindered a Queer STEM identity included downplaying the importance, not disclosing (remaining closeted), separating or dividing, disengaging or distracting, and avoiding STEM individuals. Two of the navigational strategies neither promoted nor hindered the development of a Queer STEM identity which were redirecting the focus to the mathematics and to view intersectional. A summary of these navigational strategy codes and their impact on a Queer STEM identity are included in Table 3.7.

Table 3.7. Overview of navigational strategy and impact on Queer STEM identity along with frequency counts.

Navigational Strategy	Response options	Queer STEM Identity impact	Frequency of occurrences
Positioning Queer Identity in STEM	Position as strength	Promotes	41
	View intersectional	Neutral	68
	Downplay importance	Hinders	52
Disclosing (or not) Queer identity in STEM	Disclose (come out)	Promotes	77
	Don’t disclose (closeted)	Hinders	92
Connecting Queer identity and STEM	Integrate or connect	Promotes	54
	Separate or divide	Hinders	54
Reacting to Queer topics in STEM	Engage or advocate	Promotes	138
	Redirect to mathematics	Neutral	45
	Disengage or distract	Hinders	91
Developing relationships	Interact with STEM individuals	Promotes	140
	Interact with Queer Individuals	Promotes	84
	Avoid STEM individuals	Hinders	60

Building Narrative Accounts

After contextualizing each of the navigational strategies for their impact on Queer Identity, I then examined the relationship between how the navigational strategies arose from the mathematical discourses. The first step in this process was to examine the co-occurrence of the mathematical discourse with the navigational strategies in the transcripts to determine which mathematical discourses elicited particular strategies. This relationship is presented in Figure 3.3. For each discourse, the coded segments within a navigational strategy were reviewed and compared to further the development of a theoretical account of the constructs in line with grounded theory.



	Marginalized	Erasure	Heteronormative	Ambigous	Normalized	Accepted and Valued
Position as strength	6	5	11	4	6	2
View intersectional	33	14	20	11	2	2
Disclose (Come Out)	19	14	11	25	4	24
Integrate or connect	8	4	16	2	4	6
Downplay importance	5	39	11	2	14	2
Don't disclose (Closeted)	42	74	24	34	7	
Separate or divide	18	38	17	9		5
Engage or advocate	49	31	61	10	13	11
Redirect to STEM	6	58	18	5	8	2
Disengage or distract	76	47	16	13	2	6
Form with Queer Individuals	21	7	15	9	2	5
Form with STEM individuals	9	2	10	5	4	12
Avoid STEM Individuals	27	12	8	10	2	2

Figure 3.3. Co-occurrence of mathematical discourses and navigational response strategies.

After the developments of the theoretical accounts for how the navigational strategies arose from particular mathematical discourse, I identified which dominant discourse students were drawing from in their interviews. This was based on the frequency at which they discussed discourses and is presented in Table 3.8. Instances in which the leading discourse frequencies were similar for a student the interviews were reviewed for the most salient topics in light of the discourses. Gavin, Azra, Corrine, and Erin held a dominant marginalized discourse. Wren, Fran, Swappi, Ninah, Robert, Adam, and Jesse held a dominant erasure discourse. Magda, Leigh, Ronald, and Martha held a dominant heteronormative discourse. Fredo held a dominant normalized discourse, and Aidan held a dominant accepted and valued discourse. I then examined each student's conveyed lived experience through an examination of their entire interview transcript and member checking document. This helped inform the narrative account building of the mathematical discourses and navigational strategies presented in Chapter 5.

Table 3.8. Leading or dominant mathematical discourse counts for Queer-spectrum phase two participants.

Leading or dominant discourse	Student	Marginalized	Erasure	Hetero-normative	Ambiguous	Normalized	Accepted and Valued
Marginalized	Gavin	**21**	4	5	3	1	1
	Azra	**18**	8	5	3		
	Corine	**14**	3	5	10		1
	Erin	**7**	4	1	4		2
Erasure	Wren	6	**15**	4	1	1	2
	Fran	4	**14**	3	3	2	4
	Swappi	2	**13**	3	5		2
	Ninah	2	**12**	4	3	3	2
	Robert		**11**	4	2		
	Adam	4	**10**	1	5	3	
	Jesse	6	**8**	5	2	3	2
Hetero-normative	Magda	8	4	**10**		2	1
	Leigh	10	2	**9**	5		1
	Ronald	8	5	**8**	1	2	
	Martha	3	6	**7**	1		
Normalized	Fredo	4	5	1	2	**9**	6
Accepted and Valued	Aidan		3	5	3	2	**5**

Phase Three: Queer-Spectrum Mathematical Identity Resources

Phase three of this study used student 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, 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

I initially recruited Queer-spectrum students based on their completion of the SPIPS-M survey and, additionally, I invited all the students that participated in the individual interviews from phase two. An email was sent to the students inviting them to participate in a research project focus group that would explore the experiences of Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual (LGBTQIA) students who have taken an undergraduate mathematics course. 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. Students were asked to complete a scheduling form to determine the date and time of the focus group. This initial recruitment effort did not result in a high response from contacted students. As a result, I broadened my recruitment efforts by posting flyers around campus, asking instructors to distribute the information to their current students and recruited through LGBT student resource centers, oSTEM, and various STEM student organizations. Eventually this resulted in three to five students at each university agreeing to participate during a common time. Students were provided with food and beverages, but no financial incentive was provided for participating.

The focus groups represented a range of Queer-spectrum identities. Three of the students (Isabella, Luciana, and Flora) identified as Asexual, five (James, Time, Swappi, JP, and Jonathan) identified as Gay or as “men attracted to men”, two (Cat and Aidan) identified as Bisexual, two (Erin and Chelsea) identified as Lesbian, two (Meh and Fran) identified as Pansexual, one (Alexis) identified as Demisexual, and two (Naseem and Katherine) did not disclose their Queer identity during the focus group. The same processes for pseudonyms was used in the focus groups that was used in the individual interviews. Fran, Swappi, Jesse, and Aidan participated in the individual interviews and their pseudonyms are kept the same. A summary of the students, pronouns, sexual identity, major, and university is presented in Table 3.9.

Table 3.9. Queer-spectrum student focus group phase three participants and demographic information.

Pseudonym	Pronouns	Sexual Identity	Major	University
Naseem	She, Her, Hers		Multimedia Business with Computer Science minor	Black
Flora	She, Her, Hers	Asexual Aromantic	Health Communications	Black
Meh	She, Her, Hers	Pansexual	Marine Biology	Black
Erin	She, Her, Hers	Lesbian	Mechanical Engineering	Black
Katherine	She, Her, Hers		Statistics with Computer Science Minor	Black
Isabella	She, Her, Hers	Asexual	Global Health	Gold
Fran*	She, Her, Hers, They, Them, Theirs	Pansexual	Global Health	Gold
James	He, Him, His	Attracted to men	Mathematics and Chemistry	Gold
Tim	He, Him, His	Gay	Computer science	Gold
Swappi*	He, Him, His	Gay	Molecular biology	Gold
Alexis	She, Her, Hers	Demisexual Panromantic	Biology	Blue
Chelsea	She, Her, Hers	Lesbian	Biology and Anthropology	Blue
Cat	She, Her, Hers	Bisexual	Computer Science	Blue
Jesse*	He, Him, His	Gay	Mathematic and Earth and Ocean Science	Blue
Aidan*	She, Her, Hers	Bisexual	Psychology	Cardinal
Luciana	She, Her, Hers	Asexual	Computer Science	Cardinal
Jonathan	He, Him, His	Gay	Mathematics	Cardinal

*Indicates students who also participated in the individual interviews

Data Collection

Focus groups were scheduled for 90 minutes and took place in the mathematics building at each of the universities. Focus groups were purposefully selected in order to share back findings from the previous study with a larger number of participants and because focus groups are well suited to help illuminate the environmental factors in which students are currently residing. Since attitudes and opinions are socially formed, focus groups help provide deeper understanding of a phenomenon as it is enacted in the day to day experiences of the students. Additionally, focus groups complement the use of statistical information to probe for explanatory factors. The structure of the focus group was informed by the best practices outlined by Breen (2006). As such, focus group size aimed to consist of four to six Queer-spectrum students, which was achieved at all but Cardinal University. The general agenda for the focus group was shared with the participants and included a welcome, overview of the topic, statement of the ground rules for communication, three discussion sections, and summarizing main points and getting agreement that these were summarized adequately. As the facilitator my goal was to “spend a large portion of the discussion time probing participants’ experiences, asking them to share and compare experiences, and discussing the extent to which they agree or disagree with each other” (Breen, 2006, p. 468). The focus group was structured into three distinct parts. The first part was an exploration of emergent themes from phase two with the individual interviews. The second part was an identity resources matching activity with resources identified from phase one and phase two. The third part was an exploration of a preliminary data analysis from phase one of the quantitative survey. Next, I will detail each part of the focus group. The entire focus group protocol is included Appendix G.

Focus group part one: Emerging qualitative themes.

In the first part of the focus group students were given a handout that presented four emerging themes related to Queer-spectrum students experiences in STEM that were identified from the phase two individual interviews. Students were given time to read over the themes independently. I then facilitated a discussion asking students to respond to which themes resonated with their own experiences, and what was similar or dissimilar to their experience in STEM. The themes as they were presented to students are as follows:

- 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.

- 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.

- 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.

- 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: Identity resource matching activity.

The second part of the focus group had students do a matching activity with identity resources and 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 phase two and consisted of the following:

- Ability to ask questions or seek advice from faculty
- Availability of gender neutral bathrooms on campus
- Availability of lab or breakout sections with TAs

- Availability of LGBT clubs or resources
- Availability of safe-spaces on campus to study and hang-out
- Availability of STEM clubs or resources
- Class size and format of Math course
- Hearing slurs or disparaging remarks (e.g., that's so gay) on campus
- Location of university in [City, State]
- Opportunities for undergraduate research
- Opportunities to learn about LGBTQIA issues and terminology
- Presence of other LGBTQIA students
- Representation of LGBTQIA faculty in STEM
- Use of pronouns in classes
- Usefulness of Math learning center

Students were also given blank cards and encouraged to generate their own resources that impacted their STEM experiences. Students had color-coded sheets in front of them and were asked to sort the identity resources accordingly (see Figure 3.4). After all the students had sorted the identity resources, I facilitated a conversation starting with resources that were positive or benefited, followed by negative or hindered, and finally neutral. The goal of the activity was not focus on where students placed a particular resource but to elicit the underlying rationale and explanation for each resource.

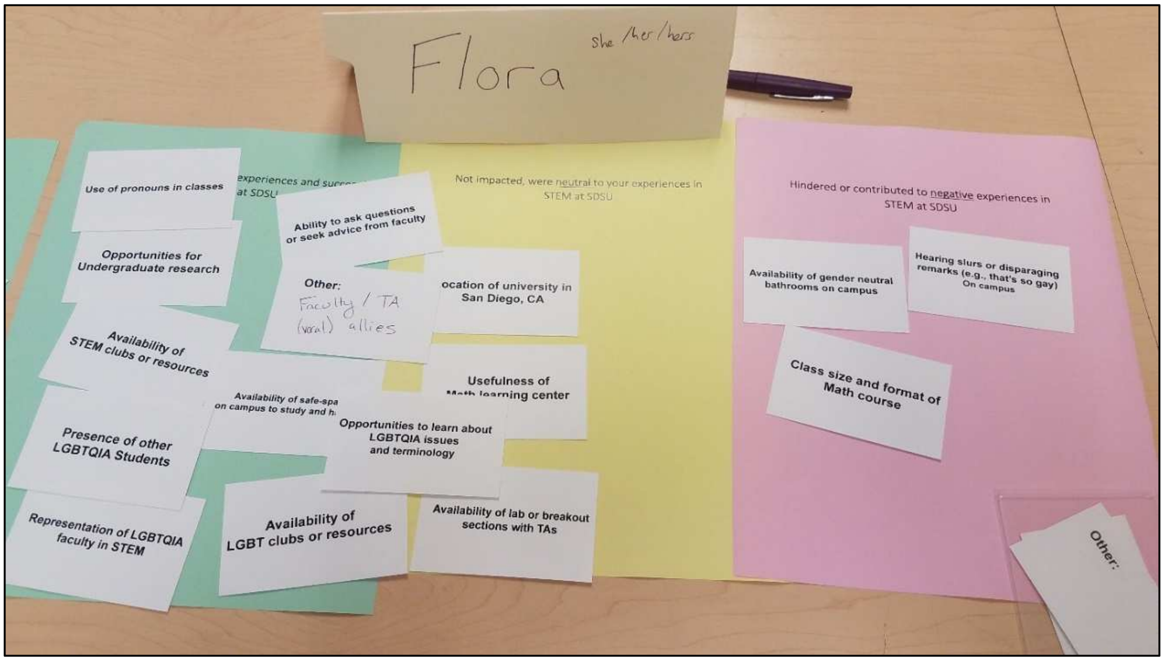


Figure 3.4. Identity resource matching activity example for Flora.

An account for how each of the students sorted their identity resources is provided in Table 3.10. The table is sorted based on the identity resources that received the most beneficial indicators from the student participants. Some students placed the identity resources between the different groups. I did not force students to conform to the categories since the aim was to understand their rationale and explanation which was elicited during the conversation. Ten of the students generated their own written identity resources that they added to the activity, which are displayed in Table 3.11.

Table 3.10. Focus group student responses to identity resource matching activity.

	Cardinal			Blue				Black				Gold				
	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

Table 3.11. Focus group student generated responses to the identity resource matching activity.

Student	Identity Resource Write In 1	Identity Resource Write In 2	Identity Resource Write In 3
Luciana	Benefit: Diverse teachers	Hinder: Not knowing who my peers are	Hinder: The Math CS Department themselves
Aidan	Hinder: Having the feeling that I don’t fit the math mold	Benefit: Connecting with faculty personally	
Meh	Hinder: Ethnic Diversity of my major - Imposter syndrome -	Hinder: The "so when are you graduating" question	
James	Hinder: Being in [specific] college my 1st year	Hinder: Staff who are not prepared to serve historically underrepresented students	
Johnathan	Benefit: On campus employment		
Alex	Hinder: Mentorship recourses / opportunities		
Kat	Hinder: Intimidated by peers		
JP	Hinder: Intimidated by peers		
Naseem	Hinder: The computer science TA's		
Flora	Benefit: Faculty / TA (Vocal) allies		

Focus group part three: Examining data

In the third part of the focus group, I gave students a handout with emerging findings from the quantitative data that had been collected during academic year 2017-2018. This was roughly about half of the overall quantitative data that was collected and analyzed in this study. Given the timeline of data collection, and the opportunity to conduct these focus groups in conjunction with the larger NSF-funded projects, this necessitated identifying emerging findings from the partial dataset. The partial data dataset consisted of 13,796 student responses with 1,352 Queer-spectrum and 12,444 Straight student responses. Exploratory factor analysis was not performed at this stage, but descriptive statistics and comparison of means were performed on individual items to identity themes. The original intent was to share this data with the students in the focus group but given the limited time available the underlying data outcomes were not shared, and instead the findings from this exploration were presented descriptively to students in a handout. Students were asked probing questions for their conjecture of explanatory reasons underlying the differences in the data analysis. The presented themes were grouped into three categories, engagement with peers, the classroom environment, and impact of taking mathematics courses. The emerging themes and question prompts are included in Table 3.12.

Table 3.12. Focus group emerging quantitative themes as presented to students.

Category	**Emerging Theme and Question Prompt**
Engagement with peers	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?
Engagement with peers	Similarly, why do you think LGBTQA students feel more comfortable in offering constructive criticism of mathematical ideas?
Classroom Environment	LGBTQA student describe their math classes as being more hostile and exclusionary compared to straight peers, what do you think contributes to that?
Classroom Environment	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	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?
Impact of taking math courses	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?

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 Software, 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. These constructs have been extended to STEM identities and further operationalized within STEM environments (Hyater-Adams et al., 2018; Reinholz et al., 2019). There are 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. 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.

I initially drew on the operational detentions outlined by Hyater-Adams, Fracchiolla, Finkelstein, and Hinko (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. This further operational refinement did not provide greater explanatory power of the data. Instead, there seemed to be emerging explanatory power in understanding in which environment the identity resources were residing. This resulted in extending the identity resource constructs to identity if they occurred as a part of classroom-related resource or as an external resource that occurred within the broader educational settings. For example, oSTEM interactions was a relational resource that occurred external to the classroom environment, while teaching assistants were a relational resource occurring within the classroom environment.

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). When extracting themes it was especially important “to attend to the extensiveness, intensity, and specificity of comments made, and more weight should be assigned to such quotes” (Breen, 2006, p. 472). Themes emerged that named and identified particular identity resources that impacted Queer-Spectrum students. In this way, the analysis drew on the principles of thematic analysis which is “a method for identifying, analyzing, and reporting patterns (themes) within data” (Braun & Clarke, 2006, p. 6). Thematic analysis is not theoretically bounded, and thus drawing on the identity resource constructs aligns with the methods outlined by Braun and Clark (2006). Braun and Clarke outline six phases of thematic analysis which were used for this analysis. The first phase is familiarizing yourself with the data which was done both in terms of conducting the interviews, transcribing the data, and reviewing the transcripts. The second phase is generating initial codes which was “theory-driven” by the identity resource constructs using MAXQDA (VERBI Software, 2019). The third phase is searching for themes which was done through examining the coded segments and creating table summaries for each focus group. The fourth phase is reviewing the themes, which occurred by condensing and removing codes from the analysis. The fifth phase is naming the themes and the sixth stage is producing the report, which occurred in the write-up and analysis of the results.

Summary

The aim of this sequential transformative mixed methods study is to provide a broad window into the understudied nature of Queer identity in mathematics. As such, the research questions were designed to capture both the individual agency of the Queer student as well as the impact of broader societal power structures that impact the experiences of Queer-spectrum students. A summary design matrix that links each of the research questions to the data and analysis is provided in Table 3.13. Phase one of the study aims to capture a large-scale picture of how Queer-spectrum students describe mathematical learning opportunities at various universities across the United States. Phase two seeks to narrow the unit of analysis to illustrate the lived experience and belief systems that guide Queer-spectrum students in mathematics. Phase three adjusts the unit of analysis on environmental structures in order to understand the identity resources that can support Queer-spectrum students in mathematics.

Table 3.13. Design matrix for this dissertation study.

#	Research Questions	Sampling decisions	Data analysis
1	*Unpacking Queer-spectrum students' mathematical learning opportunities*: How do Queer-spectrum students describe their experiences with various mathematical learning opportunities (e.g., classroom instruction, peer groups, tutoring, assessment) while taking precalculus and calculus courses? In relation to these identified learning opportunities, what differences (if any) exist between the experiences of Queer-spectrum and Straight students?	Student survey	Quantitative Comparison of means
2	*Characterizing and navigating mathematical discourses in relation to Queer identity:* What discourses about mathematics do Queer-spectrum students describe in relation to their Queer identity? And how do Queer-spectrum students respond and navigate to these discourses about mathematics?	Individual Interviews	Phenomenological analysis with grounded theory methods Contact summary forms Member checking documents
3	*Resources that impact Queer-spectrum students:* In what ways do curricular, interpersonal, and institutional factors impact Queer-spectrum students' participation, perceived capability or success, and sense of belonging in mathematics.	Focus Groups	Thematic analysis Identity resource coding

Chapter 4: Queer-Spectrum Students' Mathematical Learning Opportunities

This chapter addresses my first research goal, *Unpacking Queer-Spectrum students' mathematical learning opportunities,* which includes the following research questions:

- How do Queer-spectrum students describe their experiences with various mathematical learning opportunities (e.g., classroom instruction, peer groups, tutoring, assessment) while taking precalculus and calculus courses?
- In relation to these identified learning opportunities, what differences (if any) exist between the experiences of Queer-spectrum and Straight students?

As noted in chapter 2, there is relatively little research examining reports from Queer-spectrum students on classroom experiences in STEM generally and in mathematics in particular. In order to address the dearth of research on this topic, this chapter takes a broad approach in reporting findings from Queer-spectrum students based on their responses to the SPIPS-M. This chapter begins with a description of how Queer identity was determined based on the survey responses and reports the prevalence of these identities in the survey sample. This is followed by a section with descriptive statistics related to how Queer-spectrum students describe their mathematical learning opportunities on the survey as a window into the classroom environment. In the third section, I explore differences within Queer identity and between Queer-spectrum and Straight students. In doing so, I leverage composite variables, which provide descriptions of the instructional environment and students' relation to mathematics. The final section summarizes key findings, looking across all outcomes from the survey analysis.

Accounting for Queer Identity

One of the first challenges in addressing this research goal is determining how to account for Queer identity using quantitative methods. Because Queer theory seeks to deconstruct dominant theories of identity and resist normative categorization, there is inherent tension in using quantitative methods to analyze sexual identity because it often results in a reductionist view of Queerness (Browne & Nash, 2016). However, there are a growing number of researchers arguing for the use of quantitative methods that more closely align with Queer theory.

In an interview with Juana Rodríguez, who is a Queer feminist scholar, they discuss how certain quantitative methods can decenter dominant Queer perspectives (Srinivasan, 2015). Such dominant queer perspectives often focus on the experiences of Gay men and Lesbian women. Using normative sexual identities categories beyond Gay and Lesbian (e.g., Bisexual, Asexual), researchers can help center Queer theory on the experiences of Bisexual and Asexual individuals who represent a large portion of Queer-spectrum individuals in society. Furthermore, centering the experience of Bisexual individuals resists normative assumptions of sexuality since, “Bisexuality unsettles attempts to make Queerness respectable within the binary logics of hetero- or homo-normativity” (Srinivasan, 2015). In the subsequent analysis, I attend to the vast arrays of sexual identities within Queer-spectrum so as not to center the experiences on Gay and Lesbian students.

Another way in which scholars have sought to align quantitative methods with Queer theory is through survey design and the creation of indicators that deconstruct normative categorization impulses (Browne, 2008; Browne & Nash, 2016). For example, Browne (2008) used grouping techniques with large enough samples to create new Queer identity categories based on how individuals responded to questions about sexual identity, sexual attraction, and relationship status. Using similar grouping techniques, which are described below, I sought to resist normative categorization by allowing survey respondents to select multiple options and included write-in choices. The format of the sexual identity question prompt and response options are presented in Table 4.1.

Table 4.1. Question prompt and response options for sexual identity survey item.

Prompt	Response options
(Select all that apply) Do you consider yourself to be:	Asexual Bisexual Gay Straight (heterosexual) Lesbian Queer Not listed (please specify) ________________________ Prefer not to disclose

A total of 24,327 students responded to the sexual identity question on the survey. There were 107 open-ended responses which I analyzed and then categorized. The most common write-in responses included pansexual (*n* = 56), questioning (*n* = 11) demisexual (*n*=8), or the responses provided were categorized as existing options (*n* = 29). Since multiple options could be selected when responding to the sexual identity question, I created a categorical variable to indicate the students' desired responses. For instance, if a student selected both Straight and Bisexual a categorical variable called Straight-Bisexual was assigned to this student. In the first round of classification to determine the sexual identity categories, I considered all categorical variables and counted each possible response. I then conducted an iterative binning process informed by theory and response counts, to combine categories when appropriate (Browne &

Nash, 2016; McWilliams & Penuel, 2017). The first round of binning resulted in 13 different categories which included Straight, Straight-Asexual, Straight-Bisexual, Straight-Multiple (e.g. they selected Straight and more than one other Queer-spectrum response), Asexual, Bisexual, Gay, Lesbian, Pansexual or Demisexual, Queer, Questioning, Multi-Queer (e.g., those selecting more than one Queer-spectrum response) and Not disclose. The response counts for each of these categories are presented in Table 4.2.

Table 4.2. First iteration of sexual identity categories with response counts and percentages.

Category	Sexual identity	Count	Percentage
Queer-spectrum	Asexual	633	2.6%
	Bisexual	932	3.8%
	Gay	303	1.2%
	Lesbian	146	0.6%
	Pansexual or Demisexual	64	0.3%
	Queer	94	0.4%
	Questioning	11	0.0%
	Multi-Queer	119	0.5%
	Straight-Asexual	77	0.3%
	Straight-Bisexual	53	0.2%
	Straight-Multiple	22	0.1%
Straight	Straight	20855	85.7%
NA	Not Disclose	1018	4.2%

I then conducted a second iteration of binning to combine categories with smaller response counts in order to have categories that are communicative and interpretable for the reader and large enough to allow for statistical inference. A new category of Queer+ (read Queer plus) was used to indicate students who indicated Pansexual or Demisexual, Queer, or Multi-Queer. A new category of Straight+ (read Straight plus) was used to combine students indicating Straight-Asexual, Straight-Bisexual, Straight-Multiple and Questioning. Considering these students to be Queer-spectrum is informed by my theoretical perspective of Queer theory which interrogates categorical essentialization and is consistent with research suggesting that some adults while uncomfortable indicating Bisexual still report same-sex attractions (Copen et al., 2016). A summary of the categories along with response counts and percentages is presented in Table 4.3.

Table 4.3. Final sexual identity categories with response counts and percentages.

Category	Sexual identity	Count	Percentage
Queer-spectrum	Asexual	633	2.6%
	Bisexual	932	3.8%
	Gay	303	1.2%
	Lesbian	146	0.6%
	Queer+	277	1.1%
	Straight+	163	0.7%
Straight	Straight	20855	85.7%
Not disclose	Not disclose	1018	4.2%

There were 2,454 Queer-spectrum student responses across 898 classrooms. Queer-spectrum students account for 10.0% (*n* = 2,454) of the total student responses to the sexual identity questions (*n* = 24,327), while Straight students (*n* = 20,855) account for 85.7% of the response and the remaining 4.2% were from students who did not disclose (*n* = 1,018). To provide further context of the students surveyed in this study, I provide descriptive statistics for various demographics in Table 4.4. A notable highlight from Table 4.4 is that of the 2,454 Queer-spectrum students, 52% identify as women, which is larger than the 43% of Straight students that identity as women. Additionally, 2% of Queer-spectrum responses to the gender identity question indicated Transgender man or Transgender woman and 2% wrote in an option indicating non-binary or gender fluid identity. It should also be noted that Transgender identity was not included in the Queer-spectrum category for analysis since Transgender identity more closely aligns with gender identity than sexual identity and was asked in a different survey question. This approach aligns with past quantitative research examining Queer-spectrum and trans-spectrum identities independently (Greathouse et al., 2018). Racial identity is similar between Queer-spectrum and Straight students with the majority of Queer-spectrum students identifying as white (58%), Hispanic or Latinx (21%) and Black or African American (10%). Queer-spectrum students in the survey were more likely to identify as a first-generation college student (31% vs. 29%), an international student (10% vs 7%), a student with a disability (6% vs 3%), and as Pell Eligible (34% vs 32%), which is an indicator for low socio-economic status. Most of the Queer-spectrum students taking the survey report intending to major in a STEM discipline (71%), which is not surprising given that the survey was administered in precalculus and calculus courses. This percentage, however, is slightly less than that of Straight students who intend to major in a STEM discipline (73%).

Table 4.4. Demographic counts and percentages for Queer-spectrum and Straight Students.

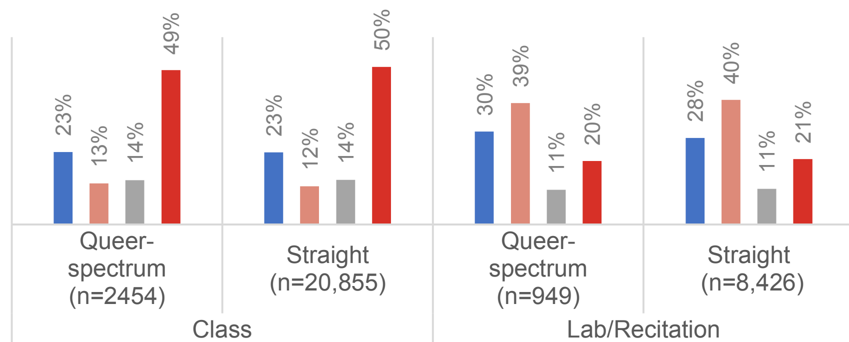
Demographic Categories	Response Items	Queer-spectrum Count	%	Straight Count	%
Gender	Man*	1035	42%	11865	57%
	Non-Binary*	40	2%	6	0%
	Transgender, Trans Man, Trans Woman*	53	2%	21	0%
	Woman*	1287	52%	8922	43%
Ethno-Racial	Alaskan Native or Native American	53	2%	279	1%
	Black or African American	236	10%	2192	11%
	Central Asian	33	1%	190	1%
	East Asian	157	6%	1042	5%
	Hispanic or Latinx	526	21%	4452	21%
	Middle Eastern or North African	121	5%	829	4%
	Native Hawaiian or Pacific Islander	39	2%	240	1%
	Southeast Asian	124	5%	821	4%
	South Asian	52	2%	525	3%
	White	1416	58%	12269	59%
Special Population	International student*	250	10%	1534	7%
	First-generation college student*	768	31%	6047	29%
	Commuter student	493	20%	4332	21%
	Transfer student	267	11%	2071	10%
	Student with a disability*	151	6%	538	3%
	Student athlete	107	4%	1104	5%
	Current or former English language learner	152	6%	1300	6%
	Parent or guardian	17	1%	155	1%
SES Indicator	Pell Eligible Yes (Low SES)*	832	34%	6643	32%
	Pell Eligible No	651	27%	5474	26%
	Pell Eligible Unsure	246	10%	2327	11%
Class Rank	First-Year*	1317	54%	11769	56%
	Sophomore	674	27%	5469	26%
	Junior*	309	13%	2327	11%
	Senior	95	4%	815	4%
	Other	44	2%	312	1%
STEM Major	STEM Major*	1733	71%	15176	73%
	Non-STEM Major	471	19%	3659	18%
	Undeclared	212	9%	1653	8%

Differences between Queer-spectrum and Straight students greater than 1 percentage points are noted in the table with an asterisk (*).

Unpacking Mathematical Learning Opportunities

In this section, I present descriptive statistics to illustrate the context of the mathematical classrooms surveyed as well as how Queer-spectrum students described their mathematical learning opportunities as a result of the course. When relevant, comparisons between Queer-spectrum and Straight students are highlighted. However, to resist constant comparisons to the dominant group, I also present the experiences of Queer-spectrum students independently.

To account for the types of instructional formats used in the classroom, students were asked what percent of regular class time, over the whole term, they spent on the following tasks: working on problems individually, working on problems in small groups, participating in whole-class discussion, and listening to the instructor lecture or solve problems. The total percentage of class time was forced to sum to 100%, and if students had a recitation or breakout section the question was repeated with the same options. The breakdown of instructional activities (see Figure 4.1) included mostly listening to the instructor lecture or solve problems (49%), working on problems individually (23%), and to a lesser extent participating in whole class discussion (13%) or working on problems in small groups (14%). For students who had a recitation or lab breakout, the class time was mostly spent working on problems in small groups (39%) and working on problems individually (30%). Even though most of the time was spent on lecture activities, the results suggest there was still considerable interactions occurring in the classrooms. The presence of interaction is important in this study, since I am guided by a sociopolitical perspective, thereby viewing identity, knowledge and power arising through social discourses and performative acts. The reported percentage of instructional activities was similar between Queer-spectrum students and Straight students. However, as later analysis will reveal, the descriptions of these instructional practices differed both within Queer identity and between Queer-spectrum and Straight students.



	Class: Queer-spectrum (n=2454)	Class: Straight (n=20,855)	Lab/Recitation: Queer-spectrum (n=949)	Lab/Recitation: Straight (n=8,426)
Working on problems individually	23%	23%	30%	28%
Working on problems in small groups	13%	12%	39%	40%
Participating in whole-class discussions	14%	14%	11%	11%
Listening to the instructor lecture or solve problems	49%	50%	20%	21%

Figure 4.1. Average instructional activities as a percent of time in regular class and lab/recitation.

In addition to describing the broad instructional formats within the classroom, students were asked to rate the level of descriptiveness for activities that occurred inside and outside the classroom environment. Response options ranged from very descriptive to does not occur. A summary of all of the activities is provided in Figure 4.2. A few items to highlight are: (1) nearly 90% of Queer-spectrum students use technology or online resources in relation to the course, (2) 90% of students believe the test questions focus on important facts and definitions from the course, and (3) only 35% of students see their instructor outside of class. The summed percentages for Queer-spectrum students describing an item as somewhat, mostly, or very descriptive (indicating presence of such action) were within 1% of those reported for Straight students with two notable exceptions. Only 54% of Queer-spectrum students work with peers outside of class on mathematics problems, while 58% of Straight students work with peers outside of class, which is statistically significantly based on a two-sample test for equality of proportions, $\chi^2(1,\ 23{,}258) = 7.82, p = .003$. The second difference that occurs, is that while 43% of Queer-spectrum students attend tutoring sessions outside of class, only 41% of Straight students attend tutoring sessions, which is statistically significant, $\chi^2(1,\ 23{,}260) = 4.28, p = .02$. Such a finding suggests that there may be less academic and social integration occurring for Queer-spectrum students in mathematics with peers, but that formalized tutoring sessions offer institutional safety for mathematical learning opportunities.

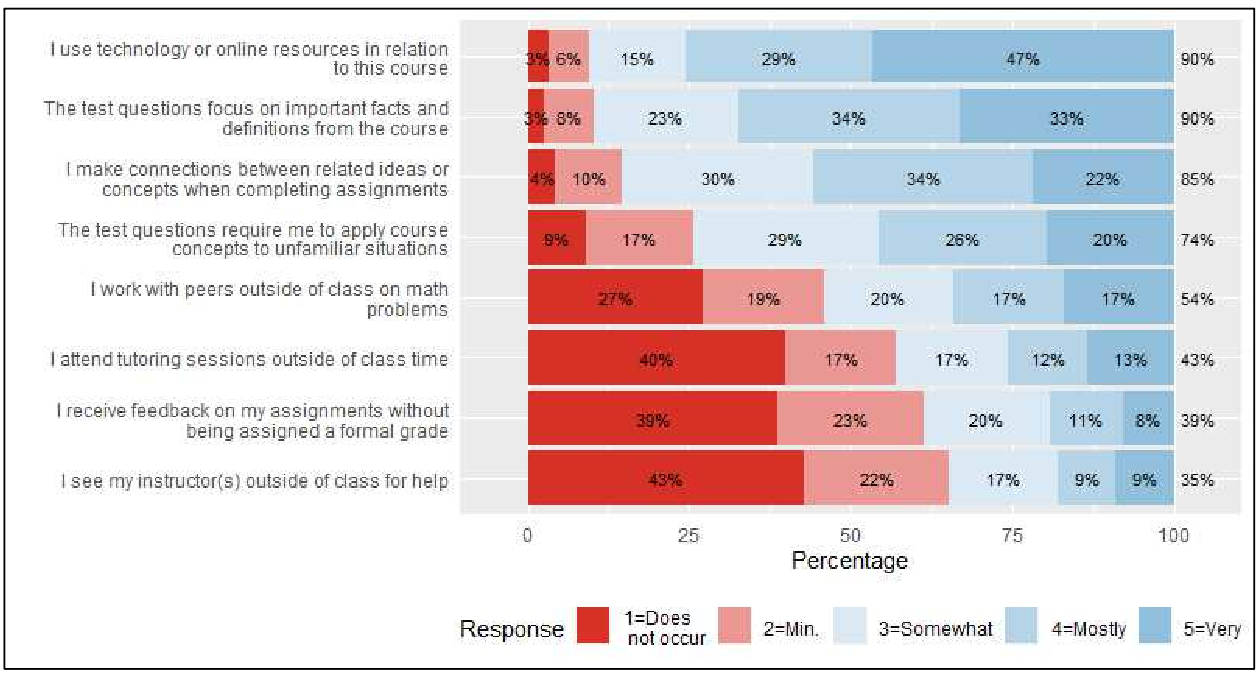
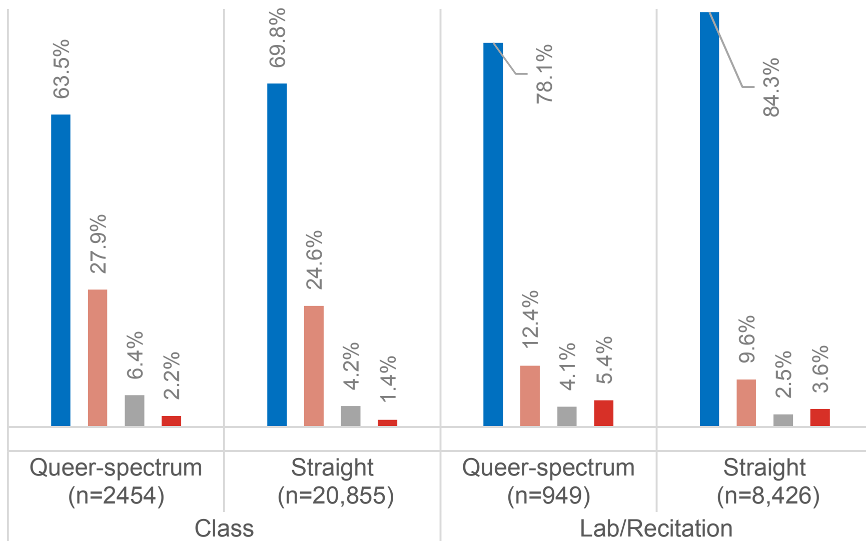


Figure 4.2. Queer-spectrum student reports of course experiences and external classroom activities.

The final measures to contextualize students' mathematical learning opportunities are their sense of preparation and classroom attendance. When asked about mathematical preparation, 80.3% of Queer-spectrum students indicated that they felt their previous mathematics courses adequately prepared them for their current course, with 19.7% of students feeling that their previous mathematics courses did not adequately prepare them. Students were also asked how often they missed their regular class meeting, with options of almost never, occasionally, frequently, and more than half. The same question was also asked about recitation or lab sections. Results show that 63% of Queer-spectrum students almost never miss class and 27% only occasionally miss class. These values, however, are lower than Straight students, with 69.2% almost never missing class and 24.4% occasionally missing class. A two-sample test for equality of proportions was conducted showing that the proportion of Queer-spectrum students who report almost never missing class was statistically significant compared to the proportion of Straight students missing class, $\chi^2(1, 23{,}115) = 39.78, p < .001$. This data suggest that Queer-spectrum students are 6% more likely to miss regular class session than their Straight counterparts. A similar trend exists for lab or recitation where the majority of Queer-spectrum students almost never miss lab or recitation (78.1%) but this is statistically significant compared to Straight students (84.3%), $\chi^2(1, 9{,}065) = 22.77, p < .001$.



	Class		Lab/Recitation	
	Queer-spectrum (n=2454)	Straight (n=20,855)	Queer-spectrum (n=949)	Straight (n=8,426)
(Almost) Never	63.5%	69.8%	78.1%	84.3%
Occastionaly	27.9%	24.6%	12.4%	9.6%
Frequently	6.4%	4.2%	4.1%	2.5%
More than Half	2.2%	1.4%	5.4%	3.6%

Figure 4.3. Percent of missing regular class or lab/recitation for Queer-spectrum and Straight students.

In summary, although Queer-spectrum students feel similarly prepared for their course, and describe the same percentages of instructional activities, Queer-spectrum students are more likely to miss class and not work with peers outside of class. What factors are adding to the barrier of classroom attendance for Queer-spectrum students? Perhaps there are external factors such as job demands, interpersonal, and familial relationships that make it more difficult for Queer-spectrum students to attend classes. Alternatively, perhaps students are less willing to attend mathematics classroom due to the climate and interactions occurring within those spaces. I explore the second hypothesis in the following section by unpacking how Queer-spectrum students describe their interactions, instructional environment, sense of mathematical self, and how these contribute to student success. A third hypothesis for the observed difference that is beyond the scope of this dissertation, is that Queer-spectrum students may interpret and have different meanings for the response options such as “almost never” and “occasionally” when compared to Straight students.

Comparing and Investigating Mathematical Learning Opportunities

In this section, I provide an analysis of composite survey measures that address how Queer-spectrum students responded to these measures, differences among Queer-spectrum students, and comparisons between Queer-spectrum students and Straight students. The composite measures are presented in Table 4.5. The survey measures for each student were calculated using an average score based on responses to each of the included items in the measure. I analyze the composite survey measures in detail in the following sections: Student reports of instructor interactions, Perceived equitable instructor interactions, Peer interactions, Sense of community and classroom participation, Responsive instructional environment, and Positive mathematical affect (e.g., confidence, enjoyment). Additionally, a single item was used to examine student academic success based on anticipated course grade.

Table 4.5. Description of composite survey outcome measures.

Measure Name	Items	Description
Instructor interactions	4	Degree to which a student interacts with their instructor in the classroom
Perceived equitable instructor interactions	6	Perceived sense that a student receives the same treatment and interactions with their instructor as compared to other students
Peer interactions	4	Degree to which a student interacts with other students in the classroom
Sense of community and participation	4	Perceived sense of community in the classroom and participation from a wide array of students
Responsive instructional environment	6	Instructional environment that is responsive to the needs of students

Positive mathematical affect	4	Measure of affect towards mathematics which includes confidence, interest, enjoyment, and sense of ability to do mathematics
Expected grade	1	Expected course grade

Instructor Interactions

Instructor interactions is a measure of how students describe receiving feedback from their primary instructor and the extent to which they contribute to whole-class discussion. The instructor interactions measure included two items related to receiving feedback from the instructor, and two items related to sharing ideas during class, as shown in Table 4.6.

Table 4.6. Instructor interactions composite measure.

Prompt	Indicate the degree to which the following statements describe your experience in regular course meetings of [course] with [primary instructor].
Items	1. I receive feedback from my instructor on homework, exams, quizzes, etc. 2. I receive immediate feedback on my work during class (e.g., student response systems such as clickers or voting systems; short quizzes) 3. I share my ideas (or my group's ideas) during whole class discussions 4. I am asked to respond to questions during class time
Response options	(1) Does not occur; (2) Minimally descriptive; (3) Somewhat descriptive; (4) Mostly descriptive; (5) Very descriptive;

Queer-spectrum student responses

Queer-spectrum students reported an average score of 2.87 (e.g., somewhat descriptive) that they had robust instructor interactions, which included receiving feedback and contributing to classroom discussions. By robust, I mean both in terms of the frequency and range with which these practices occurred and that these outcomes are deemed to be beneficial instructional practices. As seen in

Table 4.7, 12.6% of Queer-spectrum students indicated very descriptive instructor interactions, while 19.7% of Queer-spectrum students said they did not have any instructor interactions.

Table 4.7. Instructor interactions descriptive statistics table by sexual identity.

Sexual Identity	Count	Mean	SD	[1,1.8]	(1.8,2.6]	(2.6,3.4]	(3.4,4.2]	(4.2,5]
Asexual	631	3.05	1.05	15.5%	20.3%	27.3%	20.3%	16.6%
Lesbian	146	2.91	1.04	19.9%	19.9%	26.0%	19.9%	14.4%
Straight+	163	2.89	0.94	15.3%	26.4%	27.0%	21.5%	9.8%
Gay	303	2.84	1.06	20.8%	23.4%	23.1%	18.2%	14.5%
Bisexual	931	2.77	1.04	23.3%	24.2%	23.4%	18.3%	10.8%
Queer+	276	2.77	0.95	18.1%	27.9%	25.0%	21.4%	7.6%
Queer-spectrum	2450	2.87	1.03	19.7%	23.4%	24.9%	19.4%	12.6%
Straight	20830	2.89	1.00	17.2%	24.0%	26.7%	19.8%	12.3%

*Cell shading was done with the darkest color used for values greater than the 86th percentile, white used for values lower than the 14th percentile and gradient shading for values in between. The Queer-spectrum identities are sorted from highest to lowest mean values.

A one-way ANOVA was conducted to test for differences within Queer-spectrum students on the reported levels of instructor interactions. There was a statistically significant effect of Queer identity on instructor interactions, $F(5, 2444) = 6.19$, $p = .0001$. A post-hoc pairwise t-test using Bonferroni correction indicated statistically significantly difference between the mean score for Asexual students ($M = 3.05$, $SD = 1.05$) and Bisexual students ($M = 2.77$, $SD = 1.04$) and between Asexual students and Queer+ students ($M = 2.77$, $SD = 0.95$). Asexual students reported the highest level of robust instructor interactions, while Queer+ and Bisexual students indicated the lowest levels of robust instructor interactions, as shown in Figure 4.4.

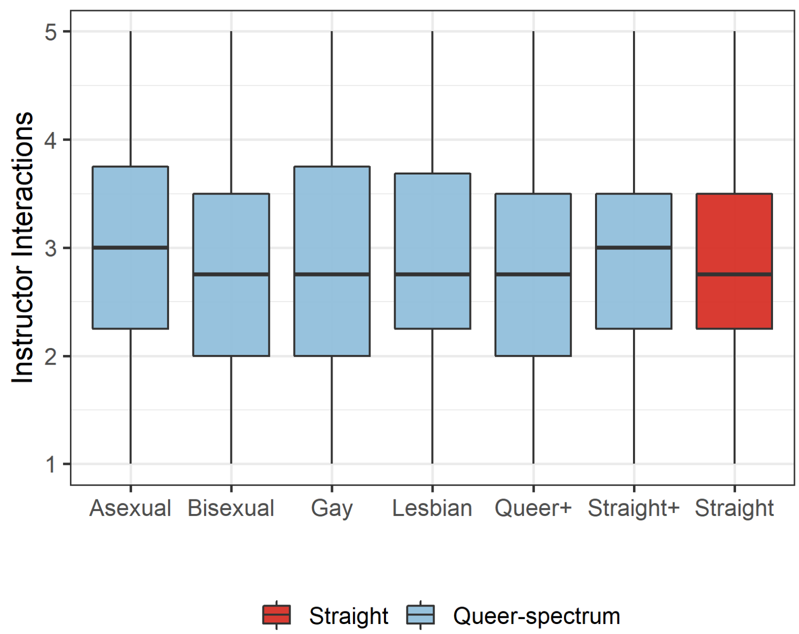


Figure 4.4. Instructor interactions boxplots for Queer-spectrum and Straight students.

Queer-spectrum and Straight student responses

A Welch's two sample t-test was conducted to compare instructor interactions for Queer-spectrum and Straight students. There was not a statistically significant difference in instructor interactions for Queer-spectrum students (*M* = 2.87, *SD* = 1.03) and Straight students (*M* = 2.89, *SD* = 1.0); *t*(3021.2) = 1.928, *p* =.275, 95% *CI* [-0.019, 0.067].

Perceived Equitable Instructor Interactions

The equitable instructor interactions measure describes the perceived equitable interactions that students have with their primary instructor. Students were asked to consider, in comparison to other students in the class, how much interaction occurred with their primary instructor in the course. The equitable instructor interaction measure consists of six items that include: encouragement, praise, attention, help, and contributions to questions or to class discussion (see Table 4.8).

Table 4.8. Perceived equitable instructor interaction measure.

Prompt	Consider your regular course meetings [*course time*] and primary instructor [*instructor name*] of [*course name*]. As compared to other students in class…
Items	1. How much encouragement do you receive from the instructor? 2. How much praise does your work receive? 3. How much opportunity do you get to contribute to class discussions? 4. How much attention does the instructor give to your questions? 5. How much help do you get from the instructor? 6. How much opportunity do you get to answer questions in class?
Response options	(1) A lot less than other students; (2) Somewhat less than other students; (3) The same as other students; (4) Somewhat more than other students; (5) A lot more than other students

Queer-spectrum student responses

Queer-spectrum students reported an average *of* 2.90 on the equitable instructor interactions measure, indicating they receive close to the same interactions with their instructors as compared to other students. A majority of Queer-spectrum students, 77.8%, reported receiving equitable experience as measured by having an average score between 2.6 and 3.4 on the equitable instructor interactions measure (see Table 4.9). A one-way ANOVA was conducted to test for differences within Queer-spectrum on the reported levels of equitable instructor interactions. There was not a statistically significant effect within Queer-spectrum on equitable instructor interactions, $F(5, 2431) = 0.084$, $p = 0.995$.

Table 4.9. Perceived equitable instructor interactions descriptive statistics table by sexual identity.

Sexual Identity	Count	Mean	SD	[1,1.8]	(1.8,2.6]	(2.6,3.4]	(3.4,4.2]	(4.2,5]
Asexual	627	2.90	0.63	5.7%	12.8%	71.8%	6.9%	2.9%
Straight+	162	2.90	0.62	4.9%	8.6%	79.0%	4.3%	3.1%
Lesbian	146	2.92	0.52	4.1%	7.5%	82.2%	4.8%	1.4%
Queer+	273	2.91	0.50	5.1%	8.8%	80.6%	4.4%	1.1%
Bisexual	929	2.89	0.50	4.5%	9.4%	80.6%	4.7%	0.8%
Gay	300	2.89	0.62	8.0%	6.3%	76.3%	8.7%	0.7%
Queer-spectrum	2437	2.90	0.56	5.3%	9.6%	77.8%	5.7%	1.5%
Straight	20743	2.92	0.50	4.5%	7.6%	82.0%	4.6%	1.3%

*Cell shading was done with the darkest color used for values greater than the 86th percentile, white used for values lower than the 14th percentile and gradient shading for values in between. The Queer-spectrum identities are sorted from highest to lowest mean values.

Queer-spectrum and Straight student responses

A Welch's two sample t-test was conducted to compare equitable interactions for Queer-spectrum and Straight students. There was not a statistically significant difference between Queer-spectrum students (*M* = 2.90, *SD* = 0.56) and Straight students (*M* = 2.92, *SD* = 0.5); *t*(2922.5) = 1.77, *p* = 0.077, 95% *CI* [-0.002, 0.044]. Further examination suggests Asexual and Gay students have greater spread in their responses, resulting in a greater number of students reporting both more equitable and less equitable experiences with their instructor. A one-way test of equal proportions for Asexual equitable experiences compared to Straight equitable experiences reveals statistically significant difference in percentages, $\chi^2(1, 21370) = 41.9, p < .001$. A one-way test of equal proportions of equitable experiences for Gay students compared to Straight equitable experiences reveals statistically significant differences in percentages, $\chi^2\ (1, 21{,}043) = 6.03, p = .007$. There were not statistically significant differences for any of the other Queer-spectrum identities. This suggests that within the sample, Asexual and Gay students had more polarizing experiences of both inequitable and more equitable treatment from their instructor.

Peer Interactions

The peer interactions measure captures the amount of peer-to-peer interactions occurring in students' primary course setting. Students were asked if they work with other students in small groups, talk with other students about course topics, discuss their difficulties with other students, and whether class was structured to encourage peer-to-peer interactions, as shown in Table 4.10.

Table 4.10. Peer interactions measure.

Prompt	Indicate the degree to which the following statements describe your experience in [*course name*].
Items	1. I talk with other students about course topics during class 2. Class is structured to encourage peer-to-peer support among students (e.g., ask peer before you ask instructor, having group roles, developing a group solution to share) 3. I work with other students in small groups during class 4. I discuss the difficulties I have with math with other students during class
Response options	(1) Does not occur; (2) Minimally descriptive; (3) Somewhat descriptive; (4) Mostly descriptive; (5) Very descriptive;

Queer-spectrum student responses

Queer-spectrum students reported an average score of 2.97 (e.g., somewhat descriptive) that they had robust peer interactions. There was a considerable spread of responses to this question, with standard deviation of 1.16 for Queer-spectrum students. As seen in Table 4.11, 19.2% of Queer-spectrum students indicated having peer interactions as very descriptive while 20.6% of Queer-spectrum students said they did not have robust peer interactions.

Table 4.11. Peer interactions descriptive statistics table by sexual identity.

Sexual Identity	Count	Mean	SD	[1,1.8]	(1.8,2.6]	(2.6,3.4]	(3.4,4.2]	(4.2,5]
Asexual	631	3.14	1.10	15.5%	15.2%	27.1%	22.8%	19.3%
Lesbian	146	3.02	1.18	19.9%	20.5%	17.8%	20.5%	21.2%
Straight+	163	2.98	1.07	17.8%	22.1%	22.1%	23.3%	14.7%
Gay	303	2.95	1.23	25.1%	17.5%	19.1%	15.5%	22.8%
Bisexual	931	2.92	1.17	21.8%	21.3%	21.1%	16.8%	19.1%
Queer+	276	2.80	1.15	25.0%	23.9%	19.6%	14.5%	17.0%
Queer-spectrum	2450	2.97	1.16	20.6%	19.6%	22.1%	18.6%	19.2%
Straight	20829	2.99	1.13	19.4%	19.1%	22.9%	20.1%	18.4%

*Cell shading was done with the darkest color used for values greater than the 86th percentile, white used for values lower than the 14th percentile and gradient shading for values in between. The Queer-spectrum identities are sorted from highest to lowest mean values.

A one-way ANOVA was conducted to test for differences within Queer-spectrum students on the reported levels of peer interactions. There was a statistically significant effect within Queer-spectrum on peer interactions, $F(5, 2444) = 5.67$, $p = .0007$. A post-hoc pairwise t-test using Bonferroni correction indicated that the difference in mean score for Asexual students ($M = 3.14$, $SD = 1.10$) was statistically significantly compared to Bisexual students ($M = 2.92$, $SD = 1.17$) and compared to Queer+ students ($M = 2.80$, $SD = 1.07$). A similar pattern emerges to that of instructor interactions, such that in our sample population, Asexual students report the highest levels of peer interactions with Queer+ and Bisexual students indicated the lowest levels of peer interactions as seen in Figure 4.5.

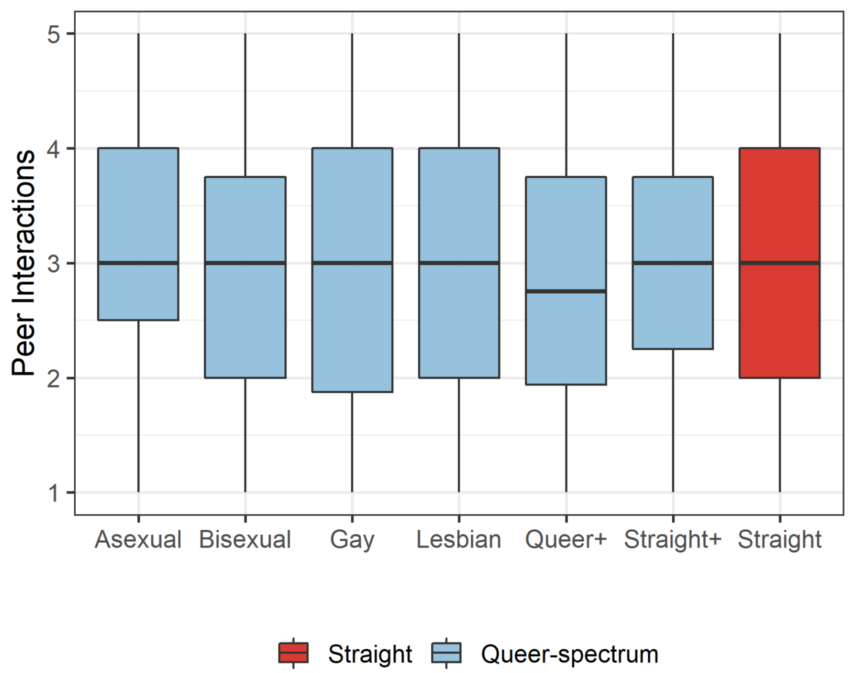


Figure 4.5. Peer Interactions boxplot for Queer-spectrum and Straight students.

Asexual student reports of greater peer interactions could be attributed to their comfort in initiating or interacting with peers during class as their identity is less visibly salient in the classroom. The lower reports of student interactions by Queer+ students, who might have a more visible and fluid identity, might lead them to monitor their thoughts and actions, and thus disengage from the mathematical learning environment with peers.

Queers spectrum and Straight student responses

An independent Welch's two sample t-test was conducted to compare peer interactions for Queer-spectrum and Straight students. There was not a statistically significant difference for Queer-spectrum students ($M=2.97$, $SD=1.16$) and Straight students ($M=2.99$, $SD=1.13$); $t(3022.6) =0.77$, $p =.44$, 95% CI [-0.029, 0.067].

Sense of Community and Classroom Participation

The sense of community and classroom participation measure describes both if students perceive a sense of community in the classroom and if there is participation arising from a wide range of students. A set of four questions was used to determine this measure, including three that determine if a wide range of students participate and a single item determining if there is a sense of community among the students (see Table 4.12).

Table 4.12. Sense of community and classroom participation measure.

Prompt	Indicate the degree to which the following statements describe your experience in [*course name*].
Items	1. A wide range of students participate in class 2. A wide range of students respond to the instructor's questions in class 3. There is a sense of community among the students in my class 4. My instructor uses strategies to encourage participation from a wide range of students
Response options	(1) Does not occur; (2) Minimally descriptive; (3) Somewhat descriptive; (4) Mostly descriptive; (5) Very descriptive;

Queer-spectrum student responses

Queer-spectrum students reported an average score of 3.04 (e.g., somewhat descriptive) that there was robust community and participation. There was a considerable spread of responses to this question, with standard deviation of 1.04 for Queer-spectrum students. As seen in Table 4.13, 16.3% of Queer-spectrum students indicated as very descriptive of having robust sense of community and classroom participation while 14.1% of Queer-spectrum students said they did not have a robust sense of community and classroom participation in their course.

Table 4.13. Sense of community and classroom participation descriptive statistics table by sexual identity.

Sexual Identity	Count	Mean	SD	[1,1.8]	(1.8,2.6]	(2.6,3.4]	(3.4,4.2]	(4.2,5]
Asexual	631	3.22	1.02	9.2%	20.8%	25.7%	25.0%	19.3%
Lesbian	146	3.13	1.13	14.4%	20.5%	25.3%	15.8%	24.0%
Straight+	163	3.02	0.98	11.0%	25.8%	26.4%	22.7%	14.1%
Bisexual	931	2.98	1.06	17.6%	20.4%	25.6%	20.5%	15.9%
Gay	303	2.96	1.07	16.5%	22.8%	26.4%	19.1%	15.2%
Queer+	276	2.91	0.93	12.7%	26.4%	33.0%	18.5%	9.4%
Queer-spectrum	2450	3.04	1.04	14.1%	21.8%	26.6%	21.1%	16.3%
Straight	20828	3.12	1.03	12.4%	20.7%	26.4%	22.3%	18.1%

*Cell shading was done with the darkest color used for values greater than the 86th percentile, white used for values lower than the 14th percentile and gradient shading for values in between. The Queer-spectrum identities are sorted from highest to lowest mean values.

A one-way ANOVA was conducted to test for differences within Queer-spectrum students on the reported levels of community and classroom participation. There was a statistically significant effect within Queer-spectrum on community and classroom participation, $F(5, 2444) = 6.40$, $p < .0001$. A post-hoc pairwise t-test using Bonferroni correction indicated that the difference in mean score for Asexual students ($M = 3.22$ $SD = 1.02$) was statistically significantly compared to Bisexual students ($M = 2.98$, $SD = 1.06$), Queer+ students ($M = 2.91$, $SD = .93$) and Gay students ($M = 2.96$, $SD = 1.07$). Taken together a similar pattern emerges from the sample, such that Asexual students report the highest levels of community and classroom participation, while Queer+, Bisexual, and Gay students indicate the lowest levels of community and classroom participation as seen in Figure 4.6.

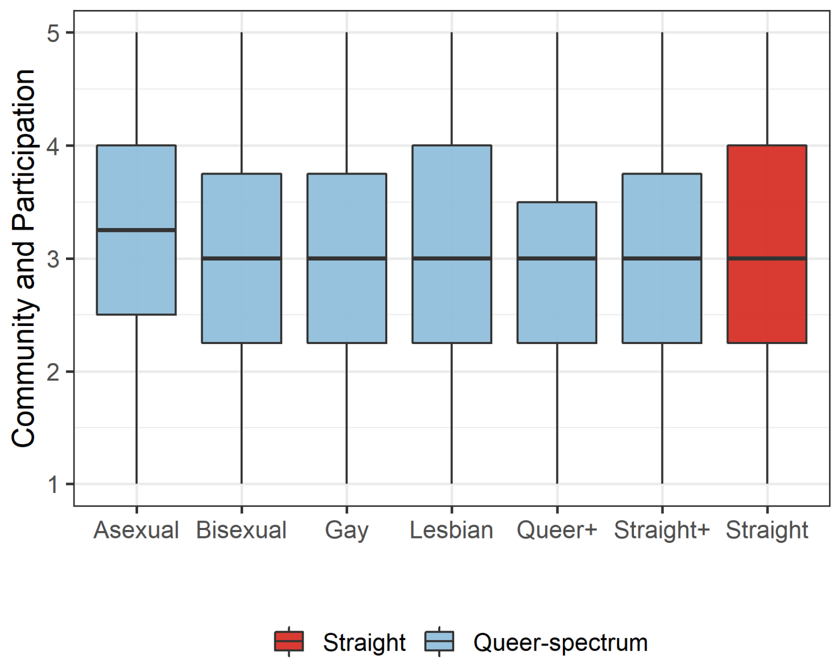


Figure 4.6. Sense of community and classroom participation boxplot for Queer-spectrum and Straight students.

Queer-spectrum and Straight student responses

A Welch's two sample t-test was conducted to compare community and classroom participation for Queer-spectrum and Straight students. There was a statistically significant difference for Queer-spectrum students (*M* = 3.04, *SD* = 1.04) and Straight students (*M* = 3.12, *SD* = 1.03); *t*(3038.2) = 3.34, *p* <.001, 95% *CI* [0.03, 0.112], *d*=.07. A histogram is presented in Figure 4.7 showing the distribution of scores for Queer-spectrum students, Straight students, and an overlay of the two distributions for comparative purposes. The effect size of this difference is small (d=.07), yet statistically significant. Results from the sample indicate Queer-spectrum students report lower levels of community and classroom participation occurring in their courses. The community and classroom participation measure is an important indicator as it suggests a sense of whether students feel engaged and part of the mathematical community in the classroom. The differences here suggest that there are subtle indicators that exclude Queer-spectrum students from the community, especially for Queer+ students.

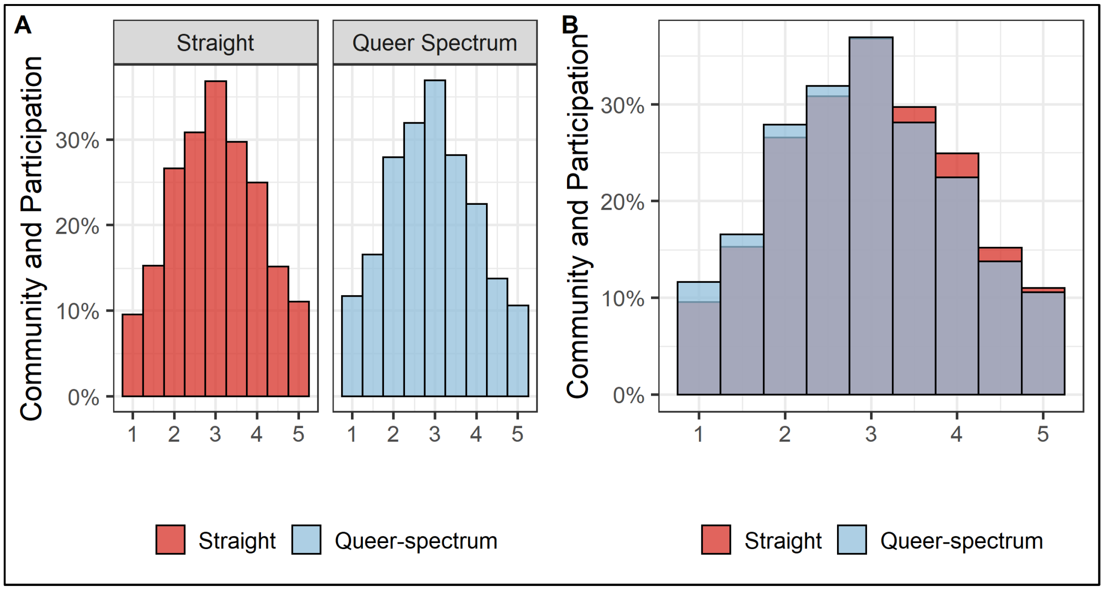


Figure 4.7. Sense of community and classroom participation histograms for Queer-spectrum and Straight students.

Responsive instructional environment

The responsive instructional environment measure accounts for student's description of the how responsive and flexible the classroom environment is to the needs of the students. It includes items about instructors using a variety of mathematical representations, using multiple problem-solving approaches, and time to reflect about the learning processes. The responsive instructional environment measure is composed of an average of 6 items, which are presented in Table 4.14.

Table 4.14. Responsive instructional environment measure.

Prompt	Indicate the degree to which the following statements describe your experience in [*course name*].
Items	1. In my class a variety of means are used to represent course topics and/or solve problems 2. Multiple approaches to solving a problem are discussed in class 3. I have enough time during class to reflect about the processes I use to solve problems 4. The instructor explains concepts in this class in a variety of ways 5. The instructor adjusts teaching based upon what the class understands and does not understand 6. The instructor knows my name
Response options	(1) Does not occur; (2) Minimally descriptive; (3) Somewhat descriptive; (4) Mostly descriptive; (5) Very descriptive;

Queer-spectrum student responses

Queer-spectrum students reported on average 3.49 (mostly descriptive) that their instructional environments were responsive. The distribution of responses for Queer -spectrum students on this item skew left, with a majority of students indicating robust responsive instructional environments. For example, 56% of Queer-spectrum students indicate a score greater than 3.4 to describe their responsive instructional environment (see Table 4.15). A one-way ANOVA was conducted to test for differences within Queer-spectrum on the reported levels of responsive instructional environment. There was not a statistically significant difference within Queer-spectrum students on measures of responsive instructional environment, $F(5, 2448) = 0.711$, $p = .427$.

Table 4.15. Responsive instructional environment descriptive statistics table by sexual identity.

Sexual Identity	Count	Mean	SD	[1,1.8]	(1.8,2.6]	(2.6,3.4]	(3.4,4.2]	(4.2,5]
Queer+	276	3.54	0.86	2.9%	12.7%	25.4%	35.1%	23.9%
Asexual	631	3.53	0.91	3.3%	11.7%	30.6%	29.6%	24.7%
Gay	303	3.53	0.98	5.9%	10.6%	25.1%	32.0%	26.4%
Lesbian	146	3.51	1.03	8.2%	10.3%	18.5%	35.6%	27.4%
Straight+	163	3.48	0.90	1.8%	18.4%	23.3%	33.7%	22.7%
Bisexual	931	3.42	0.99	7.0%	15.3%	23.4%	32.7%	21.7%
Queer-spectrum	2450	3.49	0.95	5.2%	13.4%	25.4%	32.3%	23.7%
Straight	20827	3.54	0.93	4.2%	12.7%	25.0%	32.4%	25.8%

*Cell shading was done with the darkest color used for values greater than the 86th percentile, white used for values lower than the 14th percentile and gradient shading for values in between. The Queer-spectrum identities are sorted from highest to lowest mean values.

Queer-spectrum and Straight student responses

A Welch's two sample t-test was conducted to compare the responsive instructional environment for Queer-spectrum and Straight students. There was a statistically significant difference for Queer-spectrum students (M = 3.71, SD = 0.85) and Straight students (M = 3.78, SD = 0.83); $t(3034.2) = 3.58$, p <.001, 95% CI [0.03, 0.10], d=0.08. A histogram overlay is presented in Figure 4.8, showing the distribution of scores for Queer-spectrum students, Straight students, and an overlay of the two distributions for comparative purposes. The effect size of this difference is small (d=.08), yet statistically significant. Results from the sample indicate that Queer-spectrum students on average report lower levels of having a responsive instructional environment than Straight students. This suggest that overall Queer-spectrum students perceive their mathematics classrooms as less responsive and flexible than their Straight peers.

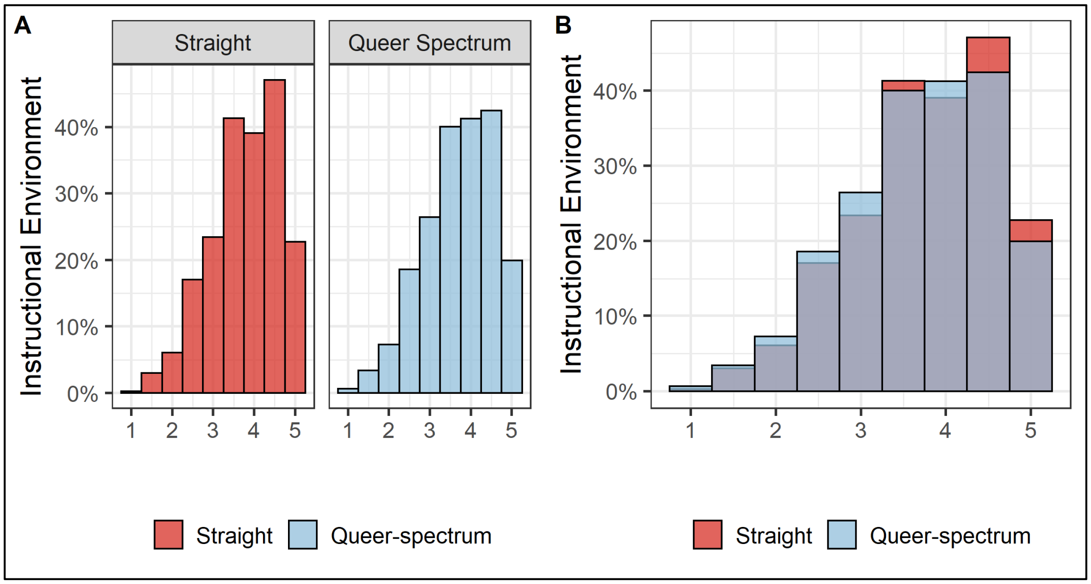


Figure 4.8. Responsive instructional environment histogram for Queer-spectrum and Straight students.

Positive Mathematical Affect

The positive mathematical affect measure captures student responses to how, roughly three-quarters of the way through the term, they feel about confidence, ability, interest, and enjoyment of mathematics. The positive mathematical affect measure is an average of 4 items, now on a 6-point Likert scale with no neutral option (See Table 4.16).

Table 4.16. Positive mathematical affect measure.

Prompt	Please indicate your level of agreement for the following statements from the beginning of the course and now.
Items	1. I am confident in my mathematical abilities 2. I am able to learn mathematics 3. I am interested in mathematics 4. I enjoy doing mathematics
Response options	(1) Strongly disagree; (2) Disagree; (3) Slightly disagree; (4) Slightly agree; (5) Agree; (6) Strongly agree;

Queer-spectrum student responses

Queer-spectrum students reported an average of 4.38 (e.g., Slightly agree) to having positive mathematical affect in the course, with the distribution skewed to the left. Over 64% of Queer-spectrum students agree with having positive mathematical affect in their course (See Table 4.17).

Table 4.17. Positive mathematical affect descriptive statistics table by sexual identity.

Sexual Identity	Count	Mean	SD	[1,2]	(2,3]	(3,4]	(4,5]	(5.6]
Asexual	609	4.30	1.30	8.5%	10.8%	18.7%	33.7%	28.2%
Queer+	267	4.19	1.31	10.5%	10.5%	23.6%	28.5%	27.0%
Straight+	158	4.17	1.30	10.8%	8.2%	24.7%	32.3%	24.1%
Gay	294	4.16	1.33	8.8%	13.3%	21.8%	28.9%	27.2%
Lesbian	136	4.12	1.30	8.1%	14.0%	23.5%	30.9%	23.5%
Bisexual	915	4.03	1.33	11.3%	12.7%	23.3%	30.7%	22.1%
Queer-Spectrum	2379	4.15	1.32	10.0%	11.8%	22.1%	31.1%	25.1%
Straight	20328	4.32	1.24	7.2%	10.6%	19.2%	35.3%	27.6%

*Cell shading was done with the darkest color used for values greater than the 86th percentile, white used for values lower than the 14th percentile and gradient shading for values in between. The Queer-spectrum identities are sorted from highest to lowest mean values.

A one-way ANOVA was conducted to test for differences within Queer-spectrum students on the reported levels of positive mathematical affect. There was a statistically significant effect within Queer-spectrum students on positive mathematical affect, $F(5, 2436) = 4.29$, $p = .0068$. A post-hoc pairwise t-test using Bonferroni correction indicated that the mean score for Asexual students ($M = 4.5$ $SD = 1.13$) was statistically significantly compared to Bisexual students ($M = 4.27$, $SD = 1.17$). A similar pattern emerges from the sample dataset, such that Asexual students report the highest levels of positive mathematical affect while Bisexual students report the lowest levels of positive mathematical affect as seen in Figure 4.9.

Figure 4.9. Positive mathematical affect boxplot for Queer-spectrum and Straight students.

Queer-spectrum and Straight student responses

A Welch's two sample t-test was conducted to compare mathematical affect for Queer-spectrum and Straight students. There was a statistically significant difference for Queer-spectrum students (M=4.38, SD=1.16) and Straight students (M=4.53 SD=1.08); t(2966.1) =6.31, p <.001, 95% CI [0.11, 0.20], d=0.14. A histogram overlay is presented in Figure 4.10, showing the distribution of scores for Queer-spectrum students and Straight students. The effect size of this difference is small (d=.14), yet statistically significant. Examining the sample, indicates that Queer-spectrum students on average report lower levels of positive mathematical affect when compared to Straight students. This measure had the largest effect size out of any of the statistically significant differences. Given that this measure is an internalized sense of students' relationship with mathematics (e.g., one's mathematical identity), differences on this measure are important to understand in order to support Queer-spectrum students mathematical identity development. Examining each of the items that contribute to this scale, the largest differences in means between Queer-spectrum and Straight students is for confidence (-.24), followed by ability (-.16), interest (-.16), and then enjoyment (-.10). A subset of the student surveys (n=3,941) administered at institutions using active learning strategies included an item with the same scale asking, "I feel anxious when working with others on mathematics during class." A Welch's two sample t-test shows statistically significant differences on mathematical anxiety between Queer-spectrum (M=3.49) and Straight student (M=3.2), t(529) =-2.97, p =.003, 95% CI [-0.41, -0.08], d=0.15. The largest effects occurring for confidence and anxiety highlight how power structures within mathematics classrooms position Queer-spectrum students to question their mathematical abilities when interacting with others, and how peer interactions may produce more anxiety for Queer-spectrum students.

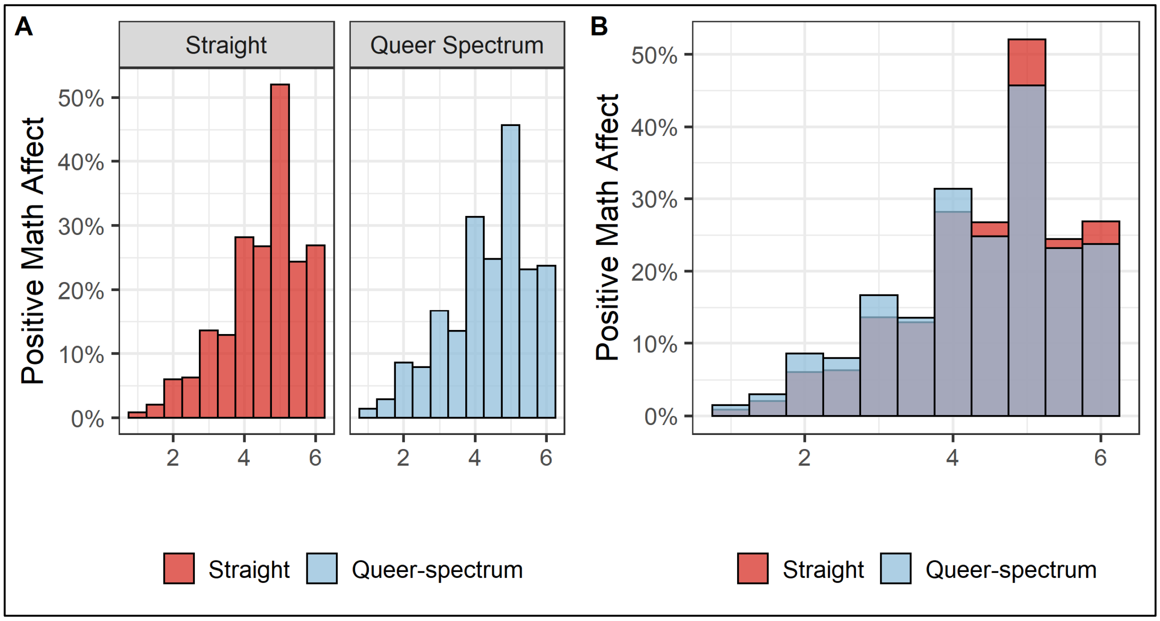


Figure 4.10. Positive mathematical affect histogram Queer-Spectrum and Straight students.

Expected Grade

The expected grade item is a measure of what grade students expect to get in the course and is measured roughly three-quarters of the way through the term. Although this is not the final course grade, it serves as a proxy for their course performance. Prior research indicates that generally students in science courses are able to predict their course performance 73% of the time (Falchikov & Boud, 1989). The question prompt and response options are presented in Table 4.18.

Table 4.18. Expected grade item.

Question	Response Options
What grade do you expect to get in [course name]	(1) F; (2) D; (3) C, C+ or C-; (4) B, B+ or B-; (5) A, A+, or A-;

Queer-spectrum student responses

Queer-spectrum students on average report an expected grade of 3.90 (e.g., B+/-). Roughly 94% of Queer-spectrum students expect to receive a C- or higher, with

6% of students anticipating receiving a D or F grade in the course. A one-way ANOVA was conducted to test for differences within Queer-spectrum students on expected course grades. There was not a statistically significant effect within Queer-spectrum students on expected grade, $F(5, 2403) = 1.66$, $p = 0.141$.

Table 4.19. Expected grade descriptive statistics table by sexual identity.

Sexual Identity	Count	Mean	SD	F	D	C+/-	B+/-	A+/-
Gay	299	3.99	0.93	1.0%	4.3%	25.1%	34.1%	35.5%
Queer+	268	3.96	0.92	1.1%	3.0%	29.1%	32.8%	34.0%
Bisexual	916	3.92	0.92	1.2%	3.6%	27.9%	36.1%	31.1%
Straight+	160	3.87	0.98	1.2%	6.9%	26.9%	33.8%	31.2%
Asexual	623	3.83	0.98	2.1%	5.6%	27.9%	35.5%	28.9%
Lesbian	143	3.82	0.93	2.1%	4.9%	26.6%	42.0%	24.5%
Queer-Spectrum	2409	3.90	0.94	1.5%	4.4%	27.6%	35.5%	31.0%
Straight	20538	3.98	0.89	1.0%	3.1%	25.4%	38.1%	32.4%

*Cell shading was done with the darkest color used for values greater than the 86th percentile, white used for values lower than the 14th percentile and gradient shading for values in between. The Queer-spectrum identities are sorted from highest to lowest mean values.

Queer-spectrum and Straight student responses

A Welch's two sample t-test was conducted to compare expected grade for Queer-spectrum and Straight students. There was a statistically significant difference for Queer-spectrum students (M = 3.90, SD = .94) and Straight students (M = 3.98, SD = .89); t (2933.2) = 3.94, p <.001, 95% CI [0.03, 0.12], d=0.09. A histogram is presented in Figure 4.11, showing the distribution of scores for Queer-spectrum students, Straight students, and an overlay for comparison. Queer-spectrum students in the dataset report expecting a lower course grades compared to Straight students.

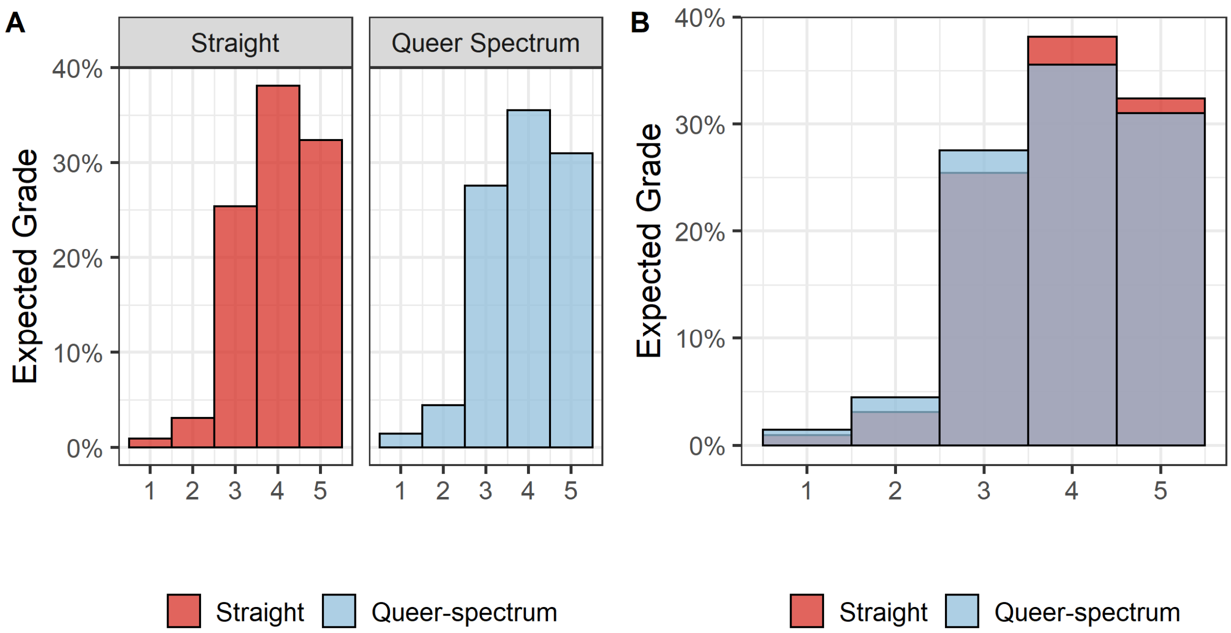
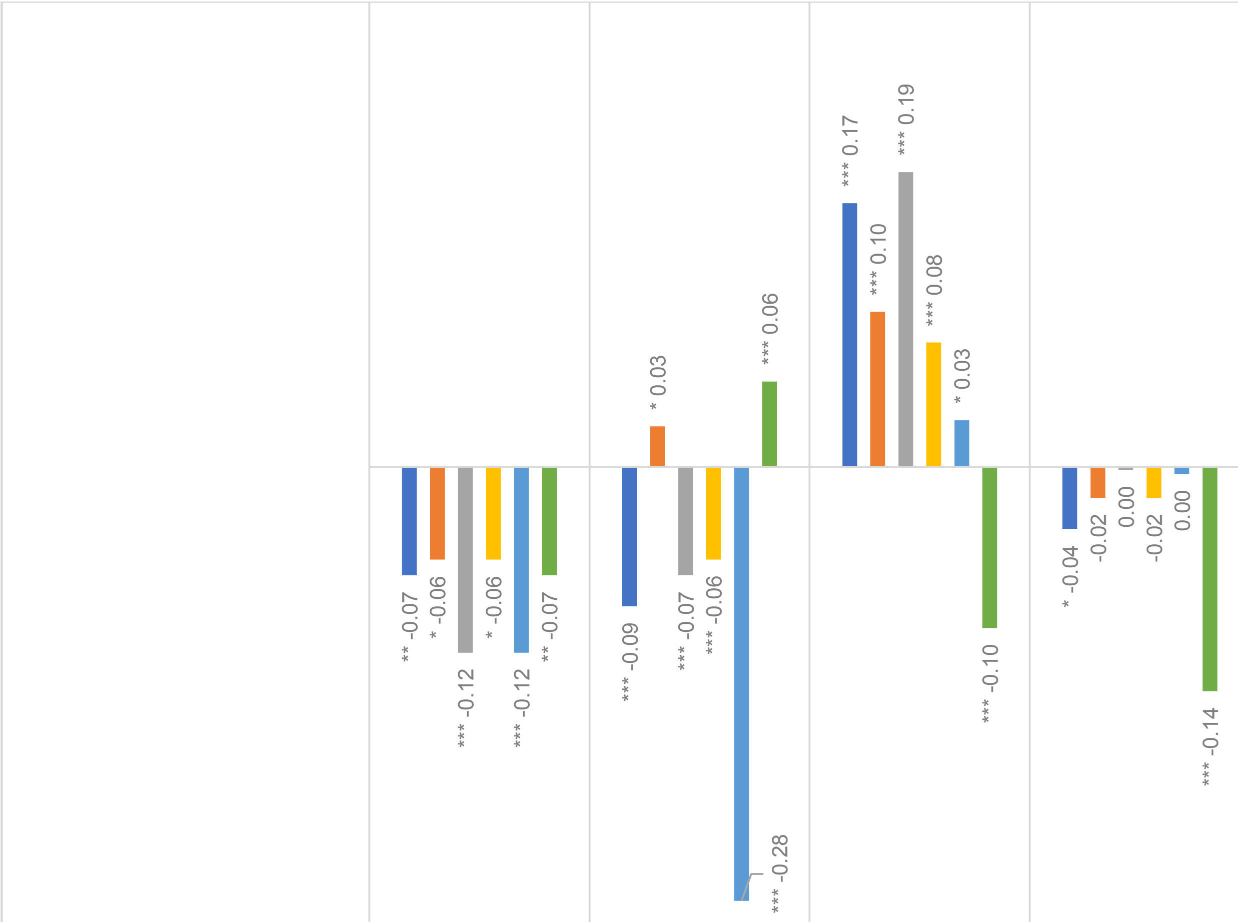


Figure 4.11. Expected grade histogram of Queer-spectrum and Straight students.

Situating the Impact of Effects with Other Student Identities

As I have detailed in the previous section, there were several statistically significant differences both within Queer identity and statistically significant differences between Queer-spectrum and Straight students. Given that all differences resulted in small effect sizes, a discerning reader might want to understand the relative differences on student experiences. As such, I contextualize the impact of Queers-spectrum identity on student experiences by examining the effect of other well-studied student demographic groups within the data. Specifically, a linear regression model was fitted to each of the scaled outcome variables (mean = 0, standard deviation = 1) with predictor variables including sexual identity, gender, race, and first-generation status. The sexual identity category is a dummy variable, referred to as sexualized minority, which compares the effect of being Bisexual, Gay, Lesbian, Queer+, Straight+ to the control group of Straight and Asexual students. This grouping choice was selected given the differences in Asexual reports on the outcome variables, which are more closely aligned with Straight students. The underrepresented gender category is a dummy variable that includes cisgender women and Transgender individuals compared to the control of cisgender men. The underrepresented racial minority is a dummy variable that includes Black or African American, Hispanic or Latinx, Middle Eastern or North African, Alaskan Native or Native American, and Native Hawaiian or Pacific Islander compared to the reference group of White, Central Asian, East Asian, Southeast Asian, and South Asian. The variable for first-generation college student represents a dummy variable indicating first-generation college student compared to the reference group of non-first-generation college student. Gender and race were selected since these are well-researched student identities and are often a more visible identity. First-generation status was selected since it represents both a researched and supported identity, and because similar to Queer identity it is often less visibly apparent.

The coefficients and significance indicators of the linear regression models are presented in Figure 4.12. Each coefficient is the amount (measured in standard deviations) that the average of that group’s identity differs from the reference group when controlling for all other student identity measures. For example, the difference in means for instructor interactions as a result of being *Queer-spectrum* man white non-first-generation is -.07 compared to being *Straight* man white non-first-generation.



	Sexualized minority	Woman and Transgender	Under-representred racial minority	First-generation college
Instructor Interactions	-0.07	-0.09	0.17	-0.04
Peer Interactions	-0.06	0.03	0.10	-0.02
Community	-0.12	-0.07	0.19	0.00
Instructional Environment	-0.06	-0.06	0.08	-0.02
Math Affect	-0.12	-0.28	0.03	0.00
Expected Grade	-0.07	0.06	-0.10	-0.14

Figure 4.12. Regression coefficients on outcome measures for sexualized minorities, women and transgender, under-represented racialized minorities, and first-generation college students

Looking across these identities one can see that the overall impact of being Queer-spectrum is a negative predictor on all outcome measures, based on all statistically significant negative coefficients in the regression model. The largest of these impacts is on community and classroom participation and positive mathematical affect, both suggesting that Queer-spectrum students might not hold a strong mathematical identity or sense of belonging in mathematical spaces.

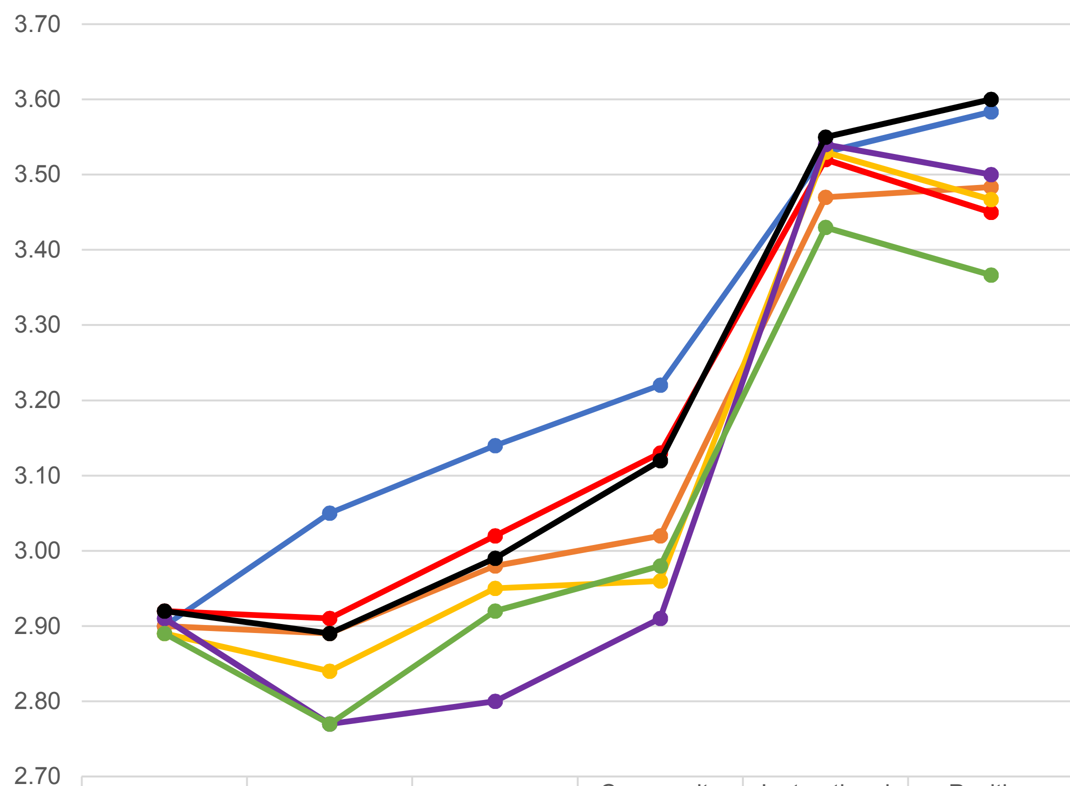
The magnitude of Queer-spectrum coefficients is larger than almost all the first-generation predictors, many of which are not statistically significant. Given that first-generation status is also less visible, it is noteworthy that first-generation status is not a predictor of peer interactions, sense of community, and mathematical affect in the same way that Queer-spectrum status has across these measures. The only statistically significant predictor for first-generation students is on expected grade, with first-generation students expecting a lower course grade. The difference in expected grade is not surprising given the literature, which indicates that first-generation students are more likely to have lower first-semester and first-year GPAs (Lombardi et al., 2012), and more likely to drop out or leave without a degree (Darling & Smith, 2007).

The largest impact overall is that of positive mathematical affect for women (-0.28), which is a well-documented issue in relation to productive disposition and STEM success (Bishop, 2012; Madison, 1995). This finding supports the notion by Mendick (2006a) that there are discourses in mathematics that privilege traits of masculinity, such as being fast, able, and confident. The presence of this finding further suggests the need for targeting supports for women and Transgender individuals in mathematics. Sexualized minority identity on mathematical affect was the next largest of the identities (-.12), suggesting the need to understand and target supports for Queer-spectrum students in STEM.

One of the more surprising and hopeful findings in the data is that under-represented racial minority students report greater amounts of instructor interactions, peer interactions, sense of community and participation, and a responsive instructional environment. This suggests that the day-to-day interactions within the classroom for the students in this population are interactive and engaging. This may be due in part to the selection of the universities that included Hispanic Serving Institutions, Historically Black Colleges and Universities, and many that are trying to infuse active learning into their courses. What is troubling in the reports on under-represented racial minorities is that given the positive environments they are experiencing, they still anticipate receiving a lower grade in the course, which may be a perpetuation of mathematical discourses that Black and Brown students are poor-performers in mathematics, while Asian and White students are high achievers in mathematics (Shah, 2019b; Trytten et al., 2012).

Summary and Conclusions

In this section I summarize cross-cutting themes, discuss potential explanatory hypothesis, and suggest future analysis. A visual representation of the mean values for the outcome variables based on sexual identity is presented in Figure 4.13. The emergence of four key findings arose from the data and will be discussed in detail. The first is the difference in reports for Asexual students compared to other sexual identities. The second finding is the fewer reports of interactions for Bisexual and Queer+ individuals. The third finding arose from the absence of differences present for Gay students, and especially Lesbian students. The fourth finding is the overall impact of Queer identity on diminished sense belonging and engagement in mathematics.



	Equitable Interactions	Instructor Interactions	Peer Interacitons	Community and Paricipation	Instructional Environemn t	Positive Math Affect (Scaled)
Asexual	2.90	3.05	3.14	3.22	3.53	3.58
Straight+	2.90	2.89	2.98	3.02	3.47	3.48
Lesbian	2.92	2.91	3.02	3.13	3.52	3.45
Gay	2.89	2.84	2.95	2.96	3.53	3.47
Queer+	2.91	2.77	2.80	2.91	3.54	3.50
Bisexual	2.89	2.77	2.92	2.98	3.43	3.37
Straight	2.92	2.89	2.99	3.12	3.55	3.60

Asexual Straight+ Lesbian Gay Queer+ Bisexual Straight

Figure 4.13. Mean values for outcome variables for Queer-spectrum and Straight students.

Key Finding 1: Markedly Different Experiences of Asexual Students

Looking across all the outcome variables, the variation within Queer-spectrum students was largely attributed to Asexual students, who had different reports compared to other Queer-spectrum identities. In fact, the only differences that were statistically significant in all of the pairwise comparisons were between Asexual identity and another Queer identity. Asexual students reported the greatest amount of instructor interactions, peer interactions, community and classroom participation, and positive mathematical affect (see Figure 4.13). This was a surprising finding, given that past research suggests Asexual students report lower levels of school belonging (Kosciw et al., 2018), and experience a denial of epistemic agency from others (e.g., denying the existence of Asexuality) (Mollet & Lackman, 2019). Asexual students, who are characterized by a lack of sexual attraction toward any gender, may have an identity that aligns with the normative discourses in mathematics that are identity neutral and assumed heteronormative, meaning that issues of identity are not relevant to the pursuit of mathematics. Such a finding would be consistent with data that suggests Asexual students report less victimization due in part to the assumed visibility of Asexual identity (Kosciw et al., 2018). This hypothesis is explored in results Chapter 5, which examines the discourses in STEM related to Queer identity.

Some previous studies on Queer identity have removed Asexual individuals (Greathouse et al., 2018) due to methodological concerns that the question was misinterpreted as not sexually active, resulting in an over-representation of Asexual individuals in the survey (Hinderliter, 2009). Surveys with over-representation such as the ACHA National College Health Assessment have Asexual response rates close to 6.5% of the population surveyed, whereas the general population estimates are closer to 1% (Bogaert, 2004). An assessment of campus climate at UC Berkeley suggested the collegiate representation of Asexual individuals was 3.1%, which aligns with the greater percentages of Queer-spectrum reporting individuals in college settings compared to the general population (Rankin & Associates Consulting, 2014). Given the 2.6% representation in this sample of college-aged individuals and the methodological choice of multiple selection, I can reasonably assume that this question was interpreted correctly by respondents. However, further analysis is warranted to determine the interpretability of this question on the survey by students.

Given the marked differences for Asexual individuals, there is a need for future research on Queer-spectrum identities to differentiate between sexualized underrepresented minorities (Bisexual, Gay, Lesbian, Queer) and Asexualized underrepresented minority students (Asexual). Combing all Queer-spectrum students under one category can mitigate differences and result in the appearance of null findings when examining the experiences of Queer-spectrum students in STEM. Taking such an approach to differentiate between sexualized minorities and Asexualized minorities also prevents researchers from disregarding Asexual identity from data analysis, and thus erasing the experiences of Asexual students. For instance, although my analysis revealed greater reports of interactions and sense of community for Asexual students, they also had more polarizing reports of equitable treatment from instructors and their positive experiences in classroom interactions did not contribute to their academic success in the course, which warrants further investigation.

Key Finding 2: Fewer Interactions for Bisexual and Queer+ Students

Bisexual and Queer+ students reported the least amount of interactions, with a marked difference for Queer+ students in peer interactions. Additionally, Queer+ and Bisexual students reported less sense of community and classroom participation in their mathematics courses. These findings suggest that there is something occurring within the interactional patterns of mathematics classroom that disengages or positions Bisexual and Queer+ students outside the community. Bisexual and Queer+ identity generally resist binary logics that promote hetero- or homo-normativity. Bisexual identity is often made invisible both within Gay/Lesbian and Straight social circles (Srinivasan, 2015). The pressures of invisibility and alienation within both social circles may contribute to Bisexual and Queer+ students sense of not belonging in mathematics classrooms. This effect may be heightened in mathematics classrooms that promote binary oppositions, as was discussed in Chapter 2 (Mendick, 2006a).

Key Finding 3: The absence of Differences for Lesbian and Gay Students

At the onset of this research, I anticipated Gay and Lesbian students reporting less interactions, diminished sense of community, and less positive mathematical affect. The existing literature suggests that Gay men often hear homophobic remarks, don’t feel comfortable revealing their STEM identities, and experience challenges in STEM environment (Smith, 2014). Lesbian students, who have multiple marginalized identities, may experience microaggressions towards gender and sexuality (Vaccaro & Koob, 2018). Yet the results from this study suggest that the only statistically significant difference occurred between Gay and Asexual students on community and classroom participation. Lesbian and Gay students reported similar levels of participation compared to their Straight peers. One possible reason that there are not as many differences for Gay and Lesbian students is the response counts for these groups are less than other identities, producing small differences but not resulting in statistically significant findings. Additionally, past research looking at the experiences of Gay and Lesbian students have often recruited students through LGBT student resource centers or targeted list-servs, likely resulting in a sampling of students whose identity has been salient and impactful. For example, in the above analysis the reports of equitable instructor interactions resulted in greater spread of data for Gay students, and the tails of this distribution are likely those individuals whose Queer identity has been impactful. Another reason differences may not be occurring is that the survey is not capturing the ways in which Gay and Lesbian identity is impacting students' experiences in mathematics classrooms. They may be able to orient themselves to engage in interactions, and feel that they belong in mathematics, but accomplish this by downplaying their Gay and Lesbian identity. The hypothesis to account for the lack of differences and the experiences of Gay and Lesbian students are examined further in Chapter 5.

Key finding 4: Diminished Belonging and Engagement for Queer-spectrum Students

At the onset of this chapter, I noted that Queer-spectrum students by and large report the same percentage of instructional activities occurring in the classroom as their Straight peers but are more likely to miss classes and less likely to work with peers outside of the classroom. Further investigation shows that, overall, Queer-spectrum students report lower amounts of community and classroom participation, less responsive instructional environment, lower mathematical affect (especially less confidence and increased anxiety), and anticipate getting a lower course grade. There were not significant differences in how students described interacting with instructors, peers, and a perception of equitable interactions. This suggest that Queer-spectrum students experience mathematical learning opportunities in a qualitatively different manner than their Straight peers. Queer-spectrum students perceive on a larger scale that mathematics classes are not normative places to be a part of the community, resulting in negative dispositions (mathematical affect) and lower academic success. The impact of Queer identity on mathematical learning opportunities, although small, is on par with the impact of race, gender, and first-generation student status, and contributes across the board to negative indicators of robust mathematical learning opportunities. This finding highlights the need to provide supports for Queer-spectrum students in STEM, which is addressed in Chapter 6. While the differences between Queer-spectrum and Straight students are highlighted along with the marginalizing impacts, it should also be noted the success that Queer-spectrum reported in the survey. Nearly 63% of Queer-spectrum students never miss class, 31% anticipate getting an A in the course, 78% agree with having positive mathematical affect, and 71% intend to major in a STEM discipline.

Chapter 5: Mathematical Discourses for Queer-Spectrum Students in STEM

This chapter focuses on addressing research goal 2, *Characterizing and navigating mathematical discourses in relation to Queer identity*, which poses the following two research questions:

- What discourses about mathematics do Queer-spectrum students describe in relation to their Queer identity?
- And how do Queer-spectrum students respond and navigate to these discourses about mathematics?

This the aim of this chapter is to interpret and illustrate the lived experiences of Queer-spectrum students as they describe and navigate mathematical discourses in relation towards their Queer identity in STEM environments. The aim is to foreground how these discourses relate to mathematics and Queer identity, yet these are inherently situated within STEM environments and with students who have STEM interests more broadly than mathematics. The analysis from this chapter draws on the data from individual interviews with 17 Queer-spectrum students at four universities across the United States. As described in Chapter 3, all students were recruited based on surveys they completed in introductory mathematics courses where they self-identified as Queer-spectrum and indicated an interest in a STEM major. Aidan, Erin, Martha, and Wren identified as Bisexual. Adam, Fredo, Gavin, Jesse, Robert, Ronald and Swappi identified as Gay. Corine, Fran, Leigh, and Magda identified as Pansexual. Azra and Ninah identified as Queer. Students were interviewed twice about their experiences in mathematics courses and their Queer identity. As discussed in Chapter 3, the results from this chapter draw on phenomenological analysis in order to illustrative the lived experiences of Queer-spectrum students as they characterize and navigate mathematical discourses in STEM environments. Navigational strategies were first identified and coded to understand how these strategies arise within particular mathematical discourses. Then emergent themes were developed between the ways in which navigational strategies were used within a particular discourse. This chapter starts by providing an overview of seven identified mathematical discourses. Next, each discourse and the evidence used to identify the discourse are described along with an illustrative account of the navigational strategies utilized by students within each particular discourse. Finally, all of the discourses and navigational strategies are discussed in the summary and conclusion section towards the development of a Queer-spectrum mathematical discourse framework.

Mathematical Discourses for Queer-Spectrum Students in STEM

Seven prominent discourses emerged relating to how Queer identity arise within social discourses in STEM environments. The seven discourses are not necessarily disjoint, since social discourses are context specific and constantly shaped by institutions, individuals, and society (Foucault, 1977; Gutiérrez, 2013). Yet examining the features of these social discourses, reveals the taken-for-granted assumptions about Queer identity in mathematics and how that contributes to power and positioning of Queer-spectrum students as mathematical learners. Three of the discourses, which were the most prevalent, limit the capacity of students to position themselves as Queer-spectrum mathematical learners, manifesting in oppressive and exclusionary power relations. These discourses are referred to as *Marginalized, Erasure, and Heteronormative.* One of the discourses, referred to as the *Ambiguous* discourse, conveys neither exclusionary nor inclusionary beliefs about Queer identity in mathematics. Three of the discourses promote the capacity of students to position themselves as Queer-spectrum mathematical learners, manifesting in more productive and inclusionary power relations. These discourses are referred to as *Normalized, Accepted*, and *Valued*. The seven discourses represent belief systems that range from the most exclusionary to students' Queer identity (Marginalized) to the most inclusionary (Valued) which is depicted in Figure 5.1.

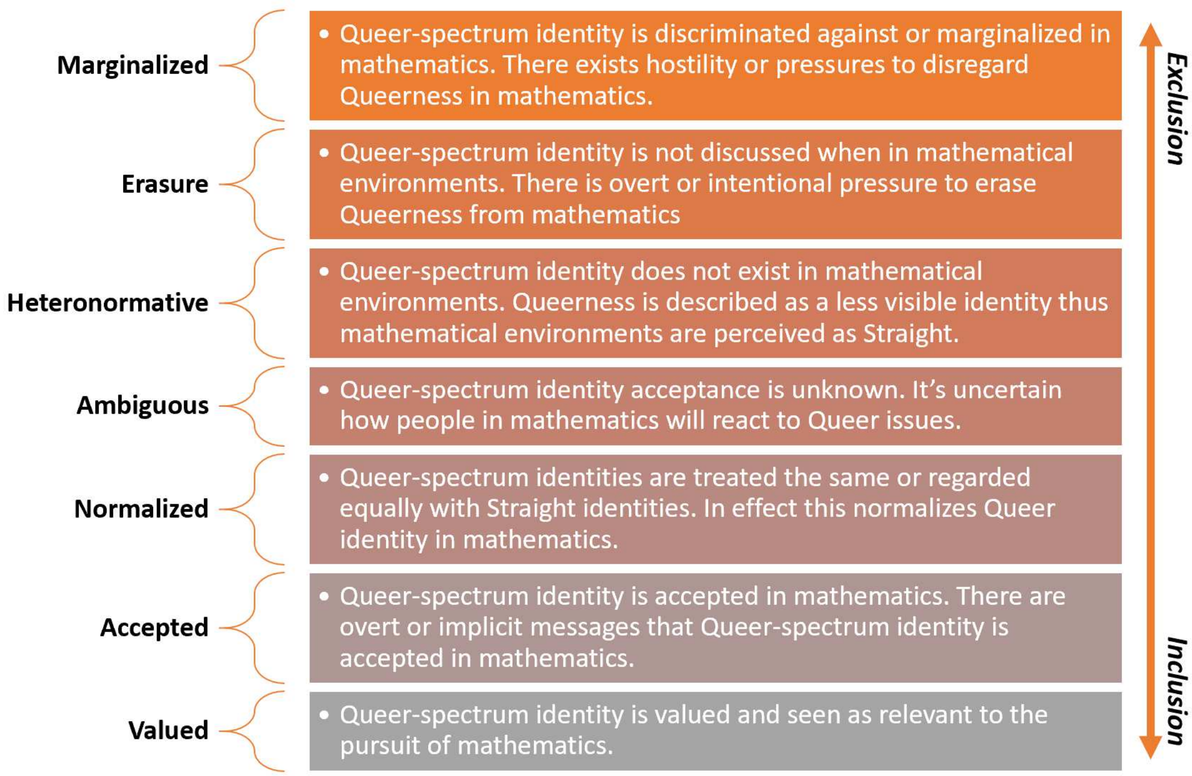


Figure 5.1. Mathematics discourses related to Queer identity from most exclusionary to most inclusionary.

Marginalized Discourse

The marginalized discourse conveys a belief that Queer identity is discriminated against or marginalized in STEM environments. Students described overt pressures or intentional hostility towards Queerness in STEM from peers and instructors. As such

Queer identity is castigated as inferior to heterosexuality and relegated to a lesser position within STEM environments. In general, this discourse captured a belief that Queer-spectrum students will be excluded in STEM.

Evidence of a marginalized discourses included hearing discriminatory language in STEM courses and microaggressions in the form of students using “that’s so Gay” or describing their instructors as “Gay.” Fran discussed how these types of remarks tend to “snap” people out of the mathematics they were working on when in STEM environments. She said that hearing such remarks can be “very jarring” and that “I’m in class to learn about math, I’m already struggling, you’re making me struggle more by hearing your hateful comments.” Ronald, Corine, Adam, Martha, and Erin also all reported hearing such comments in their classes but had differing degrees of how problematic they viewed such comments.

Additional evidence of marginalized discourses included instructors’ dismissal of non-binary demographic data in mathematical computations, a disregard for using pronouns, or assuming a student’s pronouns based on gender presentation. For instance, Azra stated, “I think it's much more likely for people to misgender other people in math and science than other classes.” Additional evidence included hostility towards Queer-spectrum students presenting in non-heteronormative ways (e.g., transgressing against dress codes) and a belief that the field of STEM has been oppressive to Queer-spectrum people. Azra put it in the following way, “no one likes to talk about how science has been oppressive to Queer people and Intersex people particularly.” Wren discussed how a peer in her mathematics class was treated harshly because they outwardly presented as Queer and students used that label in conjunction with calling them irritating. Indicators of a marginalized discourse also includes references that other disciplines outside STEM are more accepting spaces to Queer-spectrum individuals.

There were some indicators that the marginalized discourses positioned Queer-spectrum people as less successful in mathematics. These were mostly linked with students described being perceived as less capable if they advocated for social justice. Wren was the only students who shared a belief that there exists, “a stereotype that Gays can't do math.” However, overall most Queer-spectrum students did not convey that Queer identity was closely associated with perceptions of mathematical success. This stands in contrast to gendered and racialized discourses in mathematics that are highly tied to mathematical capability (Shah, 2019a; Trytten et al., 2012).

Navigating a marginalized discourse

The primary navigational response to the marginalized discourse was predominantly that of disengagement. As such, when Queer-spectrum students’ own identity is treated with hostility the most readily available response is to disengage from that environment for self-preservation. Additionally, students navigated this discourse by not disclosing (closeting) their Queer identity and situating it within the context of other intersectional identities and forms of oppression in STEM.

Disengaging through internalized exclusion.

Queer-spectrum students discussed the ways in which their view of a marginalized discourse contributed to disengaging or becoming distracted by Queer issues in STEM. These disengagement responses manifested in the curriculum, their interactions with peer or instructors, and their views of the STEM discipline.

In terms of the curriculum, students had negative reactions to mathematics problems that featured Queer context and suggested they would become distracted or upset if they saw them in their courses. For instance, Gavin said encountering a problem in a mathematics class that featured a Queer context would be a stressful experience. He said, "I'd probably be stressed, I don't know why. Like just cuz it could make me uncomfortable because I knew it would make other people uncomfortable." Gavin went on to say that although he wouldn't have an issue working on such a problem himself, he would want to avoid conflict, and such a problem would create unnecessary conflict. He said having a Queer problem on an exam would be especially problematic since he would be "stressing out because there's always the thought in the back of my mind that a student's gonna go to their parents and like complain." Additionally, he said that "If I saw the word Gay in a word problem in math on an exam, I would be shocked." Gavin said that other students likely wouldn't have an issue, but there are so many stories in the media about parents complaining about having Queer issues in the classrooms. Gavin's response to Queer issues in the curriculum shows how he internalizes the perceived issues others might have, and casts Queer identity as problematic in mathematics.

In contrast to worrying about the reactions of others, Azra had a reaction to the specific language used in a problem that would prompt her to be distracted or become disengaged. They said that the fact that the problem used the word "homosexual" would make them upset and they expressed a desire to not have Queer issues in mathematics.

> I would feel really icky, because they're saying the word homosexual because for me that's not a word that anyone needs to use now, because

> that's been used as a slur throughout history and it's time that we move on from that and start respecting people.

Azra said that mathematics problems need “to be better [with] language” and that they would feel better about this problem if it used, “Queer or Gay or Lesbian.” Ninah also shared how using such problems would be problematic in a mathematics setting, since they serve to trigger the ways that society discriminates against her,

> I don't like being reminded of my identity, cuz it's like hey here's some solid you know quantitative proof that like you know you're considered lower in the society…I'm forced to be reminded of like the fact that I'm basically oppressed. It is almost a slight trigger. it's a sudden reminder of my place in this world. As an LGBT person I'm like not allowed to forget what, who I am or like where I am in this world just by a math problem.

Gavin, Azra and Ninah’s response to having Queer issues in the curriculum (e.g., icky, stressed, and trigger) shows the ways in which the marginalized discourse positions Queer issues as problematic to the goals of a mathematical task. Even though students don’t take offense to the inclusion of these types of problems themselves, the marginalized discourse presents a shared understanding that the presence of Queer issues has and would be problematic. Thus, they internalize these pressures and disengage from the mathematical tasks. Additionally, the responses from each of the students shows how historical oppression and societal issues related to Queer issues can manifest themselves in mathematical settings.

In relation to peer and instructor interactions, both Gavin and Azra described experiences where they were discriminated against or marginalized because of their Queer identity, resulting in their desire to not disclose their Queer identity. Gavin stated that disclosing his Gay identity to those in mathematics class would make him feel awkward because he wouldn’t know how others would react. This impacts his experience in classes since he monitors what he says when talking about “LGBT community exclusive” events or will “dumb it down” to not make others feel awkward. Its notable that Gavin’s concern for not disclosing his Gay identity is focused on not making others uncomfortable, as compared to his own discomfort. Again, we see Gavin internalizing pressures from the marginalized discourse. Gavin described two incidents where he encountered bias and marginalizing experiences from other classmates. During his first semester in his precalculus class he had a lab partner who “turned into my worst nightmare” and “was clearly homophobic.” That turned out to be a “really awkward” experience for Gavin, but he stopped sitting near the person so that he could stop the daily reminder of why he did not like the person. A second incident Gavin described was working on a group project in his engineering class. He said the group was comprised of three other Middle-Eastern students who were all friends. He said they would not speak English during group work and did not respond to group texts that he would send. Gavin said this resulted in him questioning if they were excluding him because he was Gay. Gavin described having “two selves” that reacted to this situation. “Paranoid me would say that it was because I was Gay and they didn't like that, but rational me would say they were just ignoring me.” Gavin’s experience highlights how Queer-spectrum students can experience internalized discrimination, and question why one is not fully included in the learning experience.

Similar to Gavin, Azra doesn’t want to disclose their Queer identity unless they know someone well enough. Azra stated that if they had disclosed their Queerness early on at university, it likely would have made things worse. By disclosing your Queer identity, Azra said you may open yourself up to someone who is not accepting, who may say something upsetting, and that may require emotional labor that you don’t want to invest in that person. Azra's stated that in their experience in sciences classes, "I'm Queer but I'm not presenting in a way that people read me as Queer, sometimes they do but sometimes they don't. So, my teachers just assign me a pronoun by themselves." Azra said that this happens in all of their science and mathematics classes where teachers do not make an effort to ask for pronouns, "I mean it will be great if any teacher start the class by asking pronouns in science, they don't. Every other class that I've taken besides my science classes they do." In social science courses, they start class with pronouns, and Azra said this has created a more welcoming and friendly space for them as a student. Azra conveyed that in general their mathematics instructors "don't care about my identity" and furthermore don't express an interest in their life. Azra stated that,

> if you are a Queer person there will be times when you want the teacher to say something, just like say a blanket statement...like take a stance, but they don't in my experience, they haven't. So, there's always like that feeling of like oh I don't feel validated here I don't know what they think. I don't know if they were ever to find out that I was Queer if they would even respect me as a human being.

Both Gavin and Azra's responses to the marginalized discourse illustrates the way it results in disengaging by not wanting to disclose one's Queer identity and informed by specific discriminatory events with peers and instructors.

The marginalized discourse also manifested in students' views and beliefs about the field of STEM. Azra said that within science and mathematics classes there are not discussions around issues of Queerness or social justice. Azra said that, "in science like no one really...likes to talk about Queerness in general" and they have not seen any inclusion of social justice issues. This is especially problematic within science since, "science has been like awful to Queer people, and still is… no one likes to talk about how science has been oppressive to Queer people and Intersex people particularly" in terms of the surgeries that have been performed on Queer bodies and an approach to teaching science that fails to address the difference between sex, gender identity, and gender performance. Azra stated that in STEM there seems to be a general avoidance of talking about ethical issues, which may put Queer people at a disadvantage, since they are often more aware of and have respect for human beings. Azra mentioned how the science department at their school ignores and erases the history of oppression within science. For example, the Biology department celebrates "Darwin Day" but fails to acknowledge exactly how racist and transphobic and sexist he was. For Azra, it is as if STEM has no space for social justice. Gavin described STEM students as being "more dry" and might not care about issues of identity. Gavin said that STEM in general is a field that is not concerned with Queer issues or rights, and thus why would a STEM student find those topics interesting. As Gavin said, "I think for me like all this kind of boils down to like how open or closed you are to new things, new viewpoints. So, I just generally feel STEM majors, so people in math classes are just more closed-minded to some degree period." Gavin and Azra conceptualize STEM as a close-minded and hostile field towards Queer identity.

Understanding intersecting systems of oppression.

Navigating a marginalized Queer discourse was often viewed through a lens of intersectionality and how STEM and society treat other marginalized groups (e.g., women, students of color). Azra for instance said, "I'm not just brown and I'm not just a girl I'm also an international student. I'm also a particular type of brown. I'm also dark-skinned and now I know that I'm also Queer." Azra said that in their mathematics class there are few people of color and even the two friends they have in that class are likely not aware that they are Queer, because “it’s not something that I think people ask you.” Azra’s experiences with their intersectional identity was impacted when their university closed a single identity center and decided to open four new identity specific centers (Latinx center, Black center, Asian Pacific-Islander Desi American center, and LGBT student resource center). This decision and the implementation had a very negative impact on Azra’s connection and support at the university. At the old center it was a place where, “I was expressing all of me all at once. I was Queer, I was brown, I was also an international student.” A major concern that Azra stated is that these new centers did not allow for a complete acknowledgment of their intersectional identity. Azra said, “I'm all of these things at once, I can't choose to be one part and not be the other. I may present that way but that doesn't mean that I'm just one thing.” For Azra, the Center was an important part of their support and community connection with others who share their identity, since in their mathematics and science courses there have been fewer of those connections. Azra described their sense of exclusion in mathematics courses by highlighting having multiple marginalized and underrepresented identities.

Gavin, who has a different gender and racial identity compared to Azra, discussed the ways in which his race and background contributed to his orientation and understanding of Queerness in STEM. Gavin said that being a white man can make it harder sometimes to find a community to fall into as compared to other marginalized groups. He said that being Gay is the easiest community to fall into, but that he hasn’t pursued those connections while in college. At the time of the interview he was actively seeking community connections with other Queer people through student organizations. Another impactful identity for Gavin was growing up in Missouri, which he said gave him less exposure to diversity and has made him more sensitive to issues of race and sexuality. Gavin throughout the interview often contrasted his STEM experiences in Missouri to his experiences in San Diego, which he described as a more liberal and supportive environment. Gavin said that in San Diego, he feels “more myself here than I could in Missouri, which is exactly why I came here.” Gavin discussed that his reaction to Queerness in mathematics would depend heavily on whether he was in Missouri or another place and would feel more limited in Missouri. Although Azra and Gavin have different intersectional identities, they both drew on their identity and the systems of oppression related to those identities to inform their experience as a Queer person at their university and sought out community and supports outside the STEM classroom.

Erasure Discourse

The erasure discourse conveys a belief that Queer identity should not be discussed when in STEM settings. There is implicit or intentional pressure to erase or silence Queerness from STEM, such that it is deemed as an inappropriate topic in STEM. As such, Queerness is seen as irrelevant to the goals of mathematics. In contrast to the marginalized discourse, erasure is about pressure to not talk about Queer issues, versus a disregard or hostility towards Queer identity when in STEM.

Evidence of the erasure discourse included students highlighting a normative practice in STEM courses of only discussing content-related topics. For example, Aidan stated, “I'm in a calculus class and we just talk about calculus” or as Martha said, “yeah like I'm not just gonna walk in my math class and be like hey guys I'm bi[sexual], like it's not relevant there." Fran described almost the exact same scenario of walking into a STEM space, "it's not like I'm gonna go into a lab and be like yeah guys I am like Queer! Like what does that have to do with anything, we are trying to learn here. Alright nobody cares." Notice how Martha and Fran's language positions Queerness in opposition to learning in STEM. The erasure discourse also included examples of students responding to mathematics problems with Queer issues by disregarding the relevance and context of the problem and saying they would focus only on the mathematical material. For example, Robert believed problems that featured a Queer topic (e.g., Freshman attitudes towards homosexuality) would seem "inappropriate," "odd," and "propagandistic" in a mathematics classroom or textbook. Evidence of this discourse also included responses to the mathematical vignettes such that students would not disclose their Queer identity or discuss Queer issues because they were not seen as relevant.

Navigating an Erasure Discourse

In response to an erasure discourse, students would most frequently not disclose their Queer identity, downplay the importance of their Queer identity, or divide their STEM and Queer identities. Students also responded to this discourse by redirecting the focus of the interactions to the mathematical task, giving the justification that mathematics was a neutral discipline and one that is solution oriented.

Not disclosing Queer identity in STEM.

Given that the erasure discourse supports a belief that Queer identity should not be discussed in mathematics, it is not surprising that the most common response by students is to not disclose their Queer identity in those environments. Three contributing factors emerged for why Queer-spectrum students did not disclose their identity in STEM: 1) not having close friendships in mathematics, 2) a personal orientation about not disclosing their identity, and 3) believing it to be irrelevant to mathematics.

Disclosing one's sexuality can be a personal and emotional process, and the risk of reprisal is often mitigated when a Queer-spectrum individual has connections with the recipient of that information. As such, students discussed how they were less likely to disclose their Queer identity in their mathematics classes because they have fewer close connections in that environment. For instance, Martha said, "I usually don't have my friends in them [mathematics classes] it's like strangers, or they'll be like my class friends but they're not like my out of class friends." She went on to state that for those reasons she is not comfortable sharing about her Queer identity. Likewise, both Corine and Fran stated how working together in a new group they would not go into the details related to their personal life if it would reveal their Queer identity. Fran elaborated saying that in mathematics class it is not very personal, and you are not personal to each other when working in the class, so it creates even more distance.

Disclosing one's sexual identity is a personal choice and several of the students described an orientation where they seldom disclosed that information in general. Azra discussed how students in their mathematics class "don't really know that I'm Queer" mainly due to the fact that, "I don't really talk about it," and "it's not something I don't think people ask you." Adam described himself as a "pretty private person in general" so he often felt "awkward" and "discomfort" when disclosing his sexual identity. Ronald felt disclosing such information would put a target on him, so, "this is information they [other students] do not need to know…I would just not bring it up." The ability to capture this personal philosophy of not disclosing one's queer identity, was made possible through the study design, which recruited students through the general classroom survey, as compared to soliciting through Queer organizations where the students may be more likely to disclose and share about their Queer identity.

One of the most discussed factors, mentioned by nine students, for not disclosing Queer identity was that it was viewed as irrelevant in mathematical environments. Martha and Fran discussed how they wouldn't share this information because it's not relevant to learning mathematics. Wren described it as it "feels really pushy to bring up something that's *not really related*." Similarly, Swappi said, "it's not very pertinent to the matter of my sexuality, it's just *not relevant* to the course." Even though Jesse considered his sexuality to "define a lot about me but not everyone thinks that, and so maybe kind of weird if I were to share that just because they might have to be like, what? like *what's the relevance*?" Ninah's description of this belief adds nuance where she described,

> a difference between like hiding my identity because I feel unsafe and then like not bringing it up because *it's not relevant,* you know or I just like don't feel the need to and that's like how I feel in the math space is like it's like not relevant like it's not like a huge thing that like needs to be brought up or like mentioned really.

Fredo and Swappi also discussed not disclosing their identity, especially to faculty who are older, but cast this as needing to keep it professional and not personal. Viewing sexuality as irrelevant to mathematics casts Queer identity in opposition to the goals of mathematics.

The ways in which Queer-spectrum students described pressures of non-disclosure were not monolithic and varied by individuals and context. For instance, Erin shared how they would navigate situations in STEM by omitting certain details about themselves or “telling a little white lie.” Similarly, Fran shared how she would often omit certain details in group interactions. Robert shared his personally philosophy that he described as a “gradient of dishonesty” whereby he might hide certain facts about what he did over the weekend but would not commit a “transgression against my mode of being” which he described as denying he was Gay or that he had a boyfriend. These approaches to not-disclosing highlight the pressures to “stay in the closet” but also the ways in which coming out are not binary mechanisms of being “out” or “closeted.” Students make daily decisions about disclosure based on the environment, people, and context.

Redirecting to the mathematical content.

In response to an erasure discourse, several students made sense of this by viewing and describing STEM as a neutral discipline, where Queer topics would be at odds with the field. For instance, Wren said that mathematics is not supposed to be political and said seeing a Queer-themed mathematics problem in their classroom or textbook would appear political, invasive, or social-justice oriented. Wren said that including a single Queer problem likely wouldn’t be problematic but if it were continuous, “it would just seem too in your face, like if you're trying to include something that isn't related then it probably shouldn't be the main focus.” Wren went on to say that “math isn't supposed to be focused on having a side” and that Queerness, “it's still something that has controversy attached to it.” Robert said that mathematics is and should be a-political, “mathematics exists on its own terms.” He said mathematics is a subject that has a rich history and is so permanent that is transcends cultural influences. Robert viewed mathematics as being less sociological driven as compared to economics or statistics where you may explore psychological phenomenon or subpopulations. In his experience, he has never encountered Queer issues in a mathematics classroom, and doing so would convey some political, moral, or cultural debate. Robert said mathematics should not serve another purpose as it loses its beauty. Both Wren’s and Robert’s descriptions positions mathematics as a neutral discipline, and at the same time this positions Queer issues as outside the realm of neutrality or normalcy such that they should not be included or discussed in a mathematical environment.

A second approach to redirecting the focus to the mathematics was to orient the mathematics classroom as place whose primary goal is to arrive at an answer. Notice how this form of redirecting the mathematics does not cast Queer issues in contradiction to mathematics, but as ancillary to the goals of the mathematics classrooms. For instance, Martha said in regard to Queer issues in mathematics,

> I don't think that would be my focus. I feel like I would just be trying to get the work done rather than focusing on what the work is. I might like register and be like oh that's cool, but I don't think that would be my main focus when doing these math problems.

Martha said that when working with other students, she would be focused on getting the work done, and thus wouldn’t be concerned about either disclosing her Bisexual identity or asserting herself in mathematical conversations because “we all want to get the right answer.” Leigh described a similar orientation of her mathematics class that was focused on arriving at the answer, “we are trying to get our math done. Our focus is math like that's the total [focus].” Robert suggested that students in mathematics are direct and forward since the goal is to get stuff done, in comparison to a course like economic literacy where they talk and debate. Since students’ primary focus is to get the work done, they are less likely to discuss or bring up Queer topics. Fran said that mathematics is all about formulas and “it’s all about the numbers…everything's just like focused on one thing, nothing else no fluff and no personal things, just like [the] job.” Adam, Ninah, and Swappi also made similar comments about arriving at the answers and being more focused on the pure mathematical side of things.

Viewing mathematics as a field that promotes quick solutions has been shown in the literature to be associated with masculinity in mathematics (Mendick, 2006a). This alignment with masculinity, taken together with the strategies that view Queer issues in opposition to the neutrality of mathematics, showcases the ways in which mathematics as a field is more closely associated with Straightness. The response of redirecting to the mathematical content stands in contrast to the marginalized discourse whereby students disengage and understand STEM as oppressive. Thus, as the discourse shifts to be more inclusionary students are able to engage with the mathematical content.

Hindering a Queer STEM identity.

Given a belief that Queer identity should not be discussed, students responded by downplaying the importance of their own Queer identity. Martha said that she does not think about being Bisexual all that often since, “I still live my life as if I were Straight, as if I were Gay…I feel like it doesn't affect my day-to-day life.” Overall, she said that being Bisexual and being a student do not interact and that, “If I wasn’t Queer, I would go to class in the same way, I would do the same work.” It’s possible that because Martha doesn’t have a strong affiliation with the mathematical community that she is able to conceive of her Bisexual identity apart from her experiences as a student, “I just go to my math classes as me and then I leave and it its fine.” According to Adam he doesn’t fit the stereotype of being Gay very well, which he described as being more effeminate, high-pitched voice, girly, ditzy, and into art or fashion. Due to not fitting the stereotyp,e Adam said that being Gay doesn’t really have an “impact on my social life,” because he doesn’t value or emphasize that part of his identity and instead puts more emphasis on beliefs and values, as opposed to social identities. Adam instead holds a stronger STEM identity, suggesting that this is what impacts his experiences more often. Wren said, “so I don't feel like it's a big part of my past, I don't feel like it's a huge part of my identity, it's just something that's there, and I also happen to look the part.” Ninah said that, “I don't feel any different. I think like being a woman of color has like a way bigger effect than me being you know Queer at all.” Aidan, Adam, and Swappi said that the focus should be more on the ability to perform STEM than on identity characteristics. Aidan put it the following way, “so you're Gay? you can still do math? Great!” Notice how the ability to do mathematics is disconnected from Queer identity. Swappi suggested that being Queer was only as relevant as you personally wanted it to be.

> It is only a big deal if you make it a big deal. And so, if you don't make it a big deal, it's never going to be a big deal…Oh, don't make a big deal about it. Student’s Gay? Cool. Move on. He, he broke up with his boyfriend. Oh, that sucks. Well, breakups are bad. Move on. You have your research to do. Um, so I guess, but for me it's not important for me.

Thus, the ways in which students respond to a discourse that emphasizes not disclosing Queer-identity is by diminishing its impact and overall importance.

As opposed to downplaying the importance of one’s Queer identity, some students compartmentalized their STEM identity with their Queer identity. Fran and Swappi both exhibited these tendencies in response to the erasure discourse. Fran discussed how when you are in the mathematical setting, you need to separate out between your academic self and your personal self. “We're talking about math and we’re not gonna talk about ourselves now, because you have to keep those separate.” Swappi stated, “There's not going to be an involvement of your Gayness in that math class. So, you kind of have to separate them out...there is no need for my Gayness to be involved there.” Swappi elaborated saying that there is “space for my Gayness to be involved in the class,” but in STEM courses its more “independent of Gay and Straight…my sexuality is not at all relevant.” Swappi said that this independence of Queer and STEM is not helpful nor harmful but just the way the field exists. He expressed that some people might consider the independence as restricting but he doesn’t see it that way. Swappi believed that dividing these identities was not problematic, “I can have a really successful academic life and finding a career without my Gayness being involved in it and I can really have a Gay ass life without my science being involved in it.” He stated his Gayness and STEMness only have as much importance as he gives to them. He went on to say I, “keep them separate so that they both have their degrees of freedom. I can be whatever Gay I want and I can be whatever science, STEM I want, they don't have to relate to each other.”

Although students viewed downplaying and dividing their Queer and STEM identity as beneficial it nevertheless fails to support a Queer STEM identity. This discourse likely reveals the underlying power structures at play that relegate Queer identity as inferior by positioning it as irrelevant to STEM. This discourse may deny the epistemic agency of students to declare their Queer identity in STEM spaces (Mollet & Lackman, 2019). As such, this discourse resulted in the most hindering navigational strategies to Queer STEM identity than any other discourse, with 78% of the strategies considered hindering towards a Queer STEM identity.

Heteronormative discourse

The heteronormative discourse describes an orientation such that Queer identity does not exist in STEM spaces. Queerness is described as a less visible identity, which is accompanied by the fact that people assume everyone in STEM is Straight. This discourse supports the idea that STEM spaces are presumed to be Straight environments. This is often an implicit assumption due to lack of visibility or the underrepresentation of Queer-spectrum individuals in STEM. In contrast to the erasure discourse, where Queerness exists with pressures to not talk about it, the heteronormative discourse views Queerness as not even existing in STEM environments.

Instances of the heteronormative discourse included describing mathematics curriculum as having only Straight issues, ignoring or not seeing Queerness in mathematics problems when it existed, and a viewpoint that most individuals' default to assume heteronormative relationships and identities in STEM. For example, students saying, "physics seems really really Straight" or "people perceive everything as Straight," and, "your [STEM] class is centric around Straight stuff." This also included students describing their interactions in STEM such that people assumed they were Straight. For instance, Magda said, "everyone always assumes I'm a Straight, which is very upsetting a lot of times," and that these assumptions occur "definitely more so in STEM spaces." Evidence of the heteronormative discourse also included students referencing the hidden or less visible nature of their Queer identity. Students described this in the following ways, "no one would just like know unless I told them,", "but people might not necessarily know I'm Queer," "your identity is like hidden…you're almost like holding on to a secret," and "people don't really know you're Queer." Evidence of the heteronormative discourse also included references to the underrepresentation of Queer-spectrum people in STEM. For example Swappi said, "I know for a fact that there are more LGBT people in non-stem courses," and Ronald even referenced the study by Hughes (2018) on the 7% switching rate for Queer-spectrum students in undergraduate STEM.

Navigating a Heteronormative Discourse

Queer-spectrum students navigated the heteronormative discourse by engaging through an advocacy for role models and increased representation of Queer topics in the curriculum. Additionally, there were ways in which students challenged heteronormative assumptions through visual and performative acts of transgressing against normative portrayals of Straightness in STEM.

Engaging through role models.

In response to a heteronormative discourse, eight of the Queer-spectrum students specifically discussed the needs and benefits of having Queer-spectrum role models in STEM. The theme of Queer-spectrum role models is also discussed in Chapter 6 as an identity resource. Expressing a desire for Queer-spectrum role models was a navigational strategy that engaged students as STEM individuals. Ninah thought having Queer-spectrum STEM faculty would be "awesome! I would love that." She went on to describe how that would be a more comfortable relationship,

> We would just bond. Like you know like pretty bond. Like it would be more comfortable. I feel like sometimes there's this like a beneath the surface level understanding between like two Queer people in the same place, you know? So, I feel like it would just it would be like I would just be more comfortable.

Leigh similarly discussed the importance of having Queer role models and the ability to connect with them, especially for people who are coming to understand their sexual identity. She said she generally gets along with other Queer-spectrum people more, and having representation helps support notions that Queer-spectrum people belong in STEM, “if someone who was Queer could see a professor in that position of like very high standing and be like, their Gay. like I got this. you know representation is so so important.”

Aidan and Martha expressed how it would be “cool” to have Queer faculty, but Martha said she probably wouldn’t seek out a relationship with them. Corine and Jesse each shared the difficulty in finding Queer-spectrum role models. Corine shared how she would “love” having a Queer-spectrum instructor since most of the mathematics faculty have been, “men and they all just like that stereotypically masculine...So I feel like the fact that they're so overtly masculine sometimes kind of also scares me, cuz then I just associate that in my head with heteronormativity.”

The need for representation transcended faculty role models and is also desired among peers. Gavin said that he doesn’t know any other Queer-spectrum STEM students in his class. Magda said that she only knows of one other Queer-spectrum student who is not even in her classes but works in the same lab. Similarly, Corine said she only knows two other Queer-spectrum students in STEM and that those connections only developed through involvement with the LGBT student resource center on campus. Corine said that, “I feel like if I knew more Queer individuals in my field of study I would probably like um do more outside class work with them.” In reflecting on her own experience Corine saw the ways in which she could serve as a role model for other peers.

> I feel like that could be a benefit. I could just kind of help out you know Queer-spectrum students of color who are also like well I see someone like me doing this so maybe I can do it too. Because I know that was my biggest thing as I was like I didn't see anyone of color or anyone from the LGBTQ community as far as I know. So, I was like are they out there? Are we out there? Are we a thing?

Gavin, Magda and Corine's experiences highlight the potential for near-peer role models and support developed through connections outside the classroom environment. Students not knowing other Queer-spectrum STEM peers when coupled with the 10% of students identifying as Queer-spectrum on the classroom survey, highlights how the lack of visibility of Queerness leaves students feeling isolated and under presented.

Advocating for curriculum representation and normalcy.

Examples of the heteronormative discourse emerged through the presentation of Queer themed mathematics problems, which none of the students could recall seeing in their prior mathematics courses. Students discussing the heteronormative nature of mathematics curriculum, expressed a desire to see more representation of Queer identities. Aidan and Magda both suggested that having problems that feature Queer-spectrum individuals helps promote a sense of "normalcy," and it would help "normalize" Queer couples. Magda elaborated saying that she has never seen any in her textbooks, but "wish there were more representation." Fredo also shared how such problems are beneficial. "Normally if there's a couple in there [mathematics problems] it's normally Straight couples. It is something that's in my opinion, is refreshing to see, in a way. Like, oh you know, it's not just Straight couples." Martha also said it would be "nice to see representation in questions…too see LGBTQ+ examples in math.” Leigh discussed why representation is important in STEM for helping Queer-spectrum students understand their identity.

> Representation is so important and just like you see Straight couples all the time so that's probably a big factor in what made me think that I was Straight and so if I had seen this it definitely would have…like this should be implemented into schools… I like that a Gay couple is being represented even if I'm in a Straight relationship, because I know that for someone they're going to read this problem, and I think about other people, they're going to read this problem they're going to be like oh my god.

Fran discussed the benefits of having such problems because they seem more “relatable” that would “pertain to us.” Students desire for more Queer themed mathematics problems in response to a heteronormative discourse, stands in contrast to the marginalized discourse which viewed the curriculum through disengagement strategies. In the marginalized discourse, having Queer themed problems would be a reminder of societal discrimination or an opportunity for marginalizing acts to occur when working on mathematics problems. I hypothesize that when discourses shift to less exclusionary messages, the curriculum can then be viewed as an opportunity for representation.

Coming out as performative identities.

Given a discourse that heterosexuality is the normative identity in STEM spaces, Queer-spectrum students would often not disclose their identity but would engage with Queerness in STEM by visually conveying their identity. Jesse had one of the most descriptive ways this occurred in his physics class and how it impacted his beliefs about the heteronormativity of the course. Jesse said his physics class, “gave off a vibe to me that was really really Straight, and really really like heteronormative.” His viewpoint of this class eventually changed after an incident where they were learning about angular momentum and the instructor wanted every student to come up and stand on the stool as part of the experiment. On that day Jesse was wearing his five-inch red boots inspired by the play *Kinky Boots*. Jesse said, “I was so nervous, I was sweating in my chair,” but he got on the stool with the help of the instructor. Jesse said that he apologized to the instructor because he was “disrupting class” by wearing the boots. Jesse said the instructor was cool about it and said that he could wear whatever he wants in the class. Jesse said that it ended up being one of his best classes and his best professors for the semester after getting to know their personalities and feeling comfortable. He went on to convey his shifting opinion of the discourse, “it's not it as heteronormative as I thought it was, just like coming in it gave the impression of being really heteronormative. And as I got to know people in there better it got to be less heteronormative, but yeah.” Jesse experience highlights how discourses about his identity were able to shift once Queerness was made visible in the STEM environment.

Swappi and Fredo also discussed the ways in which their dress conveyed their sexual identity, but at the same time, they may alter their appearance based on the particular STEM environment. Swappi said he conveys his sexuality through his fashion choices.

> I make sure that I dress different from other people just because it's self-expression…it's also that you know that I'm not Straight when you see me. It's information which is important to the other people when you're talking to me, I guess.

Swappi said that, “I do limit my eccentricity in my dress code when I'm going to a lot of STEM classes and I'm going to interact with a lot of professors because I know professors like sobriety and maturity in what they see.” While Swappi does limit his dress, he expressed he “has to be who I am but that doesn’t mean that I have to be stupid about it.” For example, when interviewing for a chemistry lab he said that he would be “dressed normally.” Fredo described how he wears a pride necklace, and students in his engineering program asked if it meant he was Gay. Fredo indicated that yes, he was Gay, and the other individual was accepting of Fredo. Although Fredo said he wouldn’t take off his pride necklace when visiting a professor, he has subconsciously put it under his shirt in similar situations. Swappi and Fredo’s experience show case how dress can mitigate against the heteronormative assumptions of STEM.

Erin, Azra, Leigh, and Wren shared the ways in which they transgress against typical gendered performance which helps to conveys their Queer identity. For Leigh and Wren doing so helps build connections with others in STEM. Azra shared how they don’t consider their Queerness visible, but they straddle visual presentation, “I don't dress very fem[inine], I have short hair, maybe like I don't know I don't think I look super masc[uline] but it kinda a little bit ambiguous.” Leigh said a strong identity for her was being a woman with short hair. For Leigh, this visual display of her appearance afforded both connections to other women with short hair but was also the “one give away” that allowed people to “assume that I’m not Straight.” Leigh communicated that Engineering courses have more men, and men don’t like girls, since they perceive them as a threat. Leigh is able to mitigate these tensions by being a girl with short hair since she said she presents less stereotypically as a woman. Wren’s said that her androgynous presentation helps her seem more approachable to others. She said that, “I feel like some people who don't present as androgynous would be perceived as less approachable in some way, just like wouldn't want to be talked to or touched.” In fact, the student that Wren tutors, first approached her because, “she kind of identified with me originally because she's LGBT and she thought it was cool that I could wear androgyny so confidently and so she immediately thought it was cool.” Additionally, Wren said that because of the way she looks it makes coming out not that big of a deal because, “people kind of expect it cuz I look the part for the most part. Yeah, it's just not a big deal.” She says that she defies that stereotype but because of the way she presents, people often assume that she is an art major or question the fact that she is interested in mathematics. Wren said there is a belief that the kind of person who does mathematics is a “nerdy dude in glasses or a girl who wears modest clothing.” These performative identities highlight the ways that students can challenge the heteronormative assumptions in STEM without having to verbally come out to others.

Ambiguous discourse

The ambiguous discourse describes an environment where it is unknown or unclear how people in STEM will react to Queer identities or issues. There is not explicit messaging about the inclusion of Queer identity in STEM spaces and any emerging beliefs often varied by environmental and personal factors.

Evidence of the ambiguous discourse included direct responses that students were uncertain how people in STEM spaces would react to Queer identity or issues. For instance, Swappi stated, “I do not know how me being Gay fits into that [STEM discipline] because I've never experienced that before.” Corine shared that even though professors have safe-zone placards, she wasn’t sure how accepting they really were. “I don't know exactly how LGBT friendly they are, or how inclusive they're gonna be.” It also included students use guarding terms such as, “I am not sure,” “I think it would be ok," when describing how others would respond to Queerness in STEM. The uncertainty of this discourse was influenced by the fact that several stated they were only in introductory mathematics courses and were uncertain how accepting the environment would be as they progressed further towards their degree in STEM.

Navigating an Ambiguous Discourse

Queer-spectrum students navigated the ambiguous discourse through an almost equal mixture of not disclosing their Queer identity (20% of the strategies) and disclosing their Queer identity (14% of the strategies). This is not surprising given the nature of this discourse having uncertain messaging and beliefs about the inclusion of Queer identity in STEM. Students gauged the acceptance of Queer identity by reading environmental factors in STEM settings. The ambiguous discourse was also impacted by the fluid and changing nature of one's own Queer identity.

Reading the environment for contextual factors.

Students navigated unclear or unknown STEM situations by evaluating the environmental factors that might convey the acceptance of Queer identity. These factors included the general perceptions of the university and location, beliefs about particular STEM courses, and individual characteristics of the student body in the STEM courses.

Several students used their perceptions about the campus climate to make inferences about the nature of discourses in STEM environments. Ninah stated that Cardinal University is a "pretty accepting environment" and "liberal" yet went on to discuss that within her STEM classes that doesn't mean her identity is automatically accepted. Ninah described how others would respond to her Queer identity in STEM classes at Cardinal University,

> But in terms of like just talking with people or like meeting people like no one's gonna be like ‘ewww.’ Like no one's overt about it is what I mean. Like at the very least they're like too scared to insult me to my face so I can get away with saying whatever the hell I want about myself. If that makes sense?

Ninah’s experience at Cardinal University shows how the campus climate and the changing social acceptability of homophobia results in their not being overt exclusionary messages but also no messaging about inclusion of Queer identity in STEM environments. Adam shared a similar experience where he wasn’t sure how accepting students in mathematics would be, but since they are at Blue University, “I don't think people are gonna be overtly against anything. There's a very like accepting politically correct culture on campus.” Jesse also discussed how the environment at Blue University gave him indicators of the overall acceptance of Queer identity, but it was not universal. “Normally at [Blue University], I would feel comfortable sharing but if…I was not feeling comfortable at the moment I would leave it as vague and as broad as possible.” Gavin and Leigh discussed how the location of the university in a progressive state was an indicator of the overall level of acceptance within STEM environments at Black University. This attention to the university climate and location emphasizes the importance of situating future work with Queer-spectrum students in the context of the environment.

Queer-spectrum students discussed the variation among the STEM disciplines in how accepting Queer identity was perceived. For instance, Gavin felt introductory mathematics courses which serve as a general education requirement were more accepting since they have a range of STEM students. Yet he worries about what will happen in upper division courses that have less non-STEM majors and more mathematics majors. Erin suggested that mathematics courses having a variety of people meant it was unclear how accepting they would be of Queer identities.

> I think mathematics is a very basic course in that there's not a specific type of a person who's going to take mathematics. I feel like it's more open to the general public as in like there's not a stereotype of the person who takes basic level mathematics because it's a prerequisite for so many other things

Erin said that given this mixture of people, the acceptance of Queer identity in mathematics would vary highly based on the enrolled students and professor of the class. Erin went on to say that that students in “psychology or environmental classes…are going to be a little bit more open minded to variances within personalities, sexualities, and gender identities.” Ninah discussed that having “a mix of people” in the general mathematics sequence meant there were a “variety of archetypes” making it unclear how people will respond to Queer identities. She compared this to science courses where everyone is more similar in a way and would have a more cohesive and supportive attitude towards Queer identities. These responses capture the unique nature of mathematics within STEM for Queer-spectrum students, since these courses have a variety of STEM majors and are also the first pipeline into the STEM discipline.

Queer-spectrum students calculated the acceptance of Queer identity in STEM spaces by assessing the characteristics of the students enrolled in the course. In general, students felt women, students of color, students from urban and coastal areas would be more accepting and indicators of acceptance. Jesse shared that he uses identity markers such as being a woman or from California as positive indicators of acceptance. Leigh shared that younger students of color are typically more accepting because they have also experienced discrimination towards their racialized identity. Corine uses information about students’ major, whether they are religious, part of Greek life, or from Texas, as indicators that those students are less inclusive. Corine went on to share how STEM being a white-male dominated field impacts their beliefs about acceptance.

> I feel like especially in certain classes where it's a white male dominated, I feel like that one being a minority and then being Queer on top of that it's like I'm already like you know I kind of already stick out. So, I feel like that when I say something, they're kind of just gonna base it off of my appearance and my identities and what not first before actually taking into consideration what I said.

These findings are consistent with Cooper and Brownell's (2016) study in the context of Biology that students used identity markers of others to gauge the acceptance of peers in STEM. Given the under-representation of women and racial minorities in STEM, these serve as indicators for the lack of inclusion of Queer-spectrum students in STEM. The perception that STEM is a Straight white male dominated field is further explored in Chapter 6 regarding resources to support Queer-spectrum students.

Understanding the fluidity of Queer identity.

In addition to reading the external environment to understand discourses about Queer identity in STEM, students also communicated how individual characteristics, namely their gender performance and romantic involvement, shaped their understanding of Queer identity in STEM.

Leigh who identifies as a pansexual woman, discussed how her current relationship status with a man impacts her behaviors and her understanding of how accepting STEM is to Queer identity. Leigh communicated her perception that the current generation of students are more accepting of Queer issues, but that there has still been perceived resistance in STEM towards Queer individuals. For instance, Leigh was able to bring her boyfriend to study session for engineering. In this situation, she was able to introduce him as her boyfriend as well as be flirtatious and display affection. Leigh reflected that if she had a girlfriend, “I don’t know if I would have felt comfortable bringing her.” Leigh said she would not be sure of the reaction of other students, and that since these courses are for her major, there are also career considerations when interacting in these spaces. Leigh’s current relationship status contributes to an ambiguous discourse as she is unsure how STEM peers would respond to her having a Queer-spectrum relationship.

Corine’s experience highlights the nature of how their gender performance impacted their perceptions of the level of acceptance of Queer identity. Corine said some days they will wake up more on the “masculine side” of things in terms of dressing, pining up their hair, and giving a manly persona. On other days, Corrine will be the complete opposite where they are feminine all day. Corine said some students have questioned their “weird identity thing” with being gender fluid. This has been especially problematic as Corine described it.

> I don't know I just feel like sometimes people look at me differently almost because I started off college like completely like all feminine and then I transitioned into this sometimes masculine sometimes feminine so in the days when I present a little bit more masculine people are kind of thrown off and then they're like well you know ‘kind of what are you?’

Corine went on to further say that this impacts her classroom experience because students question her ability to make up her mind about her identity, and then do not trust her on other content-specific things. Corine said that, “I'd always be super nervous going into math class and be like, okay, don't look at me” and because of the demographic of the classroom (masculine and white) they were “harsher on me to accept how I present myself.” Corine said that worrying about whether people were going to accept her or make negative comments was such a constant thought that they would often tune out and not be able to pay attention. Corine further illustrated how this unfolded and the impact it had on her ability to feel comfortable in mathematics.

> It's just really nerve-racking to kind of walk into my math class one day and look different from what I did the previous day. Almost like when you get a new haircut, are people gonna like it? It's kind of like when I present myself differently it's like well are people gonna understand? Are people going to judge me for it? I just kind of have this constant like nervousness and fear that the people around me aren't going to accept it and then that in turn kind of just makes it harder for me to feel comfortable learning.

Corine said that because there is a stereotype that woman don't understand mathematics, often times her ideas will be discounted, and those subtle pressures influence Corrine's masculine presentation in mathematics. Corine said,

> I feel like my opinions value a little bit less sometimes or people are more shocked if I have the right answer compared to like if my male counterpart were to have the right answer. So, I feel like that's why I kind of just subconsciously like put on a more masculine front when I go in, so I don't seem like a damsel-in-distress.

Corine said that its often a subconscious effort but that they do notice they present more masculine in mathematical environments. Even though Corine exhibits more masculine traits in mathematics, this does not lessen the cognitive burden they experience in navigating these spaces. Corine said that other students,

> they assume that I am a female who's just having this sort of butch outer appearance, so I feel like that's probably why like I feel like if I identify as a man and I look like a man and then I was masculine then they wouldn't have a problem with it, but the fact that I outwardly appear female more often than not and then I'm just have this masculine persona and it kind of just throws everyone off, and then they're like woah, what? yeah it's just really nerve-wracking to think like someone's gonna say something one day or like you know comment about me.

Corrine's experience highlights the interwoven and connected nature of gender and sexuality and how an ambiguous discourse impacts their performative identities in STEM environments. Furthermore, it highlights the cognitive resources exhibited by

Queer-spectrum students to respond to ambiguous discourse that can negatively impact the learning experience.

Normalized discourse

The normalized discourse describes an environment where Queer-spectrum identities are treated the same or regarded equally with Straight identities when in STEM. In effect, this normalizes Queer identity in STEM such that it is not viewed as abnormal in comparison to Straight identity. The Normalized discourse is viewed through a lens of equal treatment which often included minimization of all forms of sexuality in STEM. Evidence of this discourse included explicit beliefs that Queer-spectrum students are treated the same as their Straight peers (e.g., “no one notices me any different” or “everyone doesn't really treat you any different”) or describing other students having minimal reaction to Queer identity in STEM.

Navigating a Normalized Discourse

The normalized discourse conveys a belief that Queer identity is treated equally with Straight identity in STEM. This discourse was less prevalent in student responses but was primarily met with students downplaying the importance of Queer-identity coupled with not disclosing their Queer identity. In downplaying the importance of their Queer identity students also referenced the independence of their success in STEM from their sexual identity.

Downplaying the importance of Queer identity.

Responding to a normalized discourse was navigated by students’ through downplaying the importance of Queer identity towards their pursuit of STEM. This is similar to the navigational strategies used in the erasure discourse; however, the difference here is that Queer identity is accepted but not seen as relevant. Fredo, who primarily exhibited a normalized discourse, discussed how his Queer identity hasn't been important to his success in STEM. “I feel like anything that like I've gotten to this point has been through like, just kind of like really working at it. Um, I don't, I don't think my sexuality has really impacted any of my experiences.” Fredo also held a belief that Queerness is the same as heterosexuality. For instance, Fredo briefly mentions how he feels his Queer identity might lead to different experiences, but he quickly followed this by a statement that he doesn't differentiate his sexuality from anyone else's.

> I don't really like think about it…for the most part, I feel like it doesn't really play a factor because I think I've gotten to the point where I don't really differentiate my sexuality from that of anyone else's.

Fredo said that he would be “indifferent” or have minimal reaction to seeing Queer issues in mathematics and would approach “it the same way I go through any other problem.” Fredo's experience showcases the ways in which a normalized discourse equates Queer identity with Straight identity, both having minimal impact on STEM experiences. Fran similarly discussed that being Queer-spectrum hasn't' had “any affect personally” because no one “really treats you any differently.” Fran reflected on how they would interact with Queer issues in mathematics by treating it the same as any other issue.

> I think the same. It's just kind of indifferent. Especially now and just going to go through it the same way I go through any other problem. I think that's probably the best course of action – treating as if it was any other one. It just kind of, in my opinion, really helps to just normalize it.

Fran went on to discuss that this equal treatment is a positive aspect of STEM.

> I think that was cool about like when it comes to like math and like science classes, we're all just like the same. We are all just treated the same, we aren't given bias because we are this, or discriminated because of that

> because we are all just students and it doesn't matter our background, which is kind of nice.

Likewise, Adam discussed how his success in STEM has been more the result of what he has put into the courses (his effort) than it has about his Queer identity which, in his view, “doesn’t hold like any significant weight.” Swappi and Ronald held a similar belief about the unimportance of Queer identity and discussed how this also applied to instructors in the field. Ronald said that in regard to an instructor, “their sexual orientation does not affect their academic performance, their teaching skills, or anything about it, so there is really no point to factor that in when you are choosing your instructor.”

Ninah and Magda shared how a normalized discourse influenced not needing to disclose your Queer identity. Ninah viewed not disclosing as a positive saying, “I would bring it up to it'd be like okay, like because it's so normalized. And I love that, like I love that I don't need to bring it up.” Magda said that the reaction she has received when coming out has been minimal. “I dated a girl and I think it was very like normal reaction. No one like said anything. Like no big reaction.”

Each of the student’s navigational responses to a normalized discourse resulted in minimizing or downplaying the role of their Queer identity. This is not inherently problematic, since they were able to attribute their success to their own efforts and not a result of their identity. At the same time, a normalized discourse cast Queer identity as irrelevant to STEM and thus was not an asset, nor did it promote an integration of STEM and Queer identities.

Accepted and Valued Discourses

The accepted and valued discourses are discussed together in this section due to their similar nature and relative infrequency during the interviews. The accepted discourse describes and environment such that Queer identity is accepted in STEM. There are overt or implicit messages that Queer identity is accepted in STEM and not viewed in opposition to the goals of STEM. In contrast to the normalized discourse where Queer identity is treated the same yet irrelevant, there are explicit messages about it being accepted.

Evidence of this discourse included students' beliefs that their Queer identity has been accepted by peers, and a description of their classrooms environments as especially accepting. It also included a description of science and mathematics as disciplines that are open-minded, or exploration-focused, which lends themselves towards acceptance. Additional evidence of acceptance discourse were indicators such as other Queer-spectrum students in the course and explicit messaging from STEM faculty about acceptance. Students also drew on societal discourses that Queer identity is becoming more accepted, especially with younger individuals, to frame an accepted discourse in STEM. Leigh for instance stated that someone in their STEM course expressing discriminatory beliefs would be "behind the curve" and that most people in the class are very accepting. Fran said that the climate is "changing from being more accepting so everyone's most people like nowadays especially in my class were they're more like, oh yeah, like cool, pansexual, that's awesome."

The valued discourse conveys a sense that Queer identity is not only accepted but it valued and especially relevant to the pursuit of STEM. Queer-spectrum students believe those within the STEM community need to know their identity to understand who they are as people. In contrast to the accepted discourse where Queer identity is accepted, there is an additional element where Queer identity is seen as important and contributes value to the pursuit of STEM. Its presence highlighted in this study and noteworthy since it promotes an asset-based view of Queer identity in STEM; however, given the relative frequency of this discourse it is combined with the accepted discourse for analysis.

Navigating an Accepted and Valued Discourse

The most prevalent navigational strategies to these discourses are disclosing Queer identity, forming relationships with STEM individuals, and integrating Queer identity with STEM identity. Factors related to disclosing and building relationships with STEM individuals include the role of faculty in communicating acceptance, experiences with STEM peer acceptance, and the presence of other Queer STEM students.

Forming relationships within STEM.

Erin, Jesse, Corine, and Fredo all expressed the important role that faculty have in communicating and establishing an accepted or valued discourse in STEM. Jesse’s earlier experience in his physics class with the instructor acknowledging and stating it was ok to wear whatever in their class helped shift Jesse’s view of the class and the professor to an accepted discourse. “Yeah, I've ascertained some norms and what the professor, at least that the professor is really accepting and that the class is generally pretty accepting too.” Corine also stated the explicitly knowing that Queer identity was accepted would be important in feeling safe and comfortable in the class. “I would feel a little safer in classrooms knowing that my teacher is accepting of all identities.” Erin was able to establish that her calculus professor was accepting and “open-minded” of their

Queer identity because they had talked about mental health and anxiety issues, and that served as an indicator that, in her experience, made the instructor, “more open to talking about you know, identities and so on and so forth.” Fredo had one the most illustrative examples of an instructor communicating directly about the need for acceptance in their linear algebra course.

> Our professor for [linear algebra] is super, um like, he is very strong, strongly against like bullying or harassment of any kind. Um, he like pointed out to start of the quarter. Like, if anyone, if I hear about anyone like crossing any other student for any reason, like I will drop you from the class. That really makes you feel…more encouraged to call people out on what they're doing wrong. Yeah. cause it makes you really feel like oh the professors on my side or like the professors…is also against what these people are doing or saying.

Each of these student experiences highlight the role that instructors play in communicating a discourse. This is not surprising given that instructors, as representatives of the discipline, have greater amounts of power to communicate the normative discourse within the environments. It also highlights the impact that being explicit about acceptance in a course has for Queer-spectrum STEM students.

Queer-spectrum students discussed how prior experiences and relationships with STEM peers helped contribute to this sense of inclusion. Aidan, reflecting on her current mathematics class stated, “in my math class everyone is pretty accepting…I know that like my friends in my math class who are my group mates, I would have no problem telling them...they would just say it was cool.” Aidan was able to develop these connections due to the fact that she has had the same peers and instructor for two continuous terms. Erin communicated that having a strong STEM affiliation contributes to a belief that their identity is accepted and valued. As Erin stated it,

> I feel comfortable like talking about it in any class. I'd say even maybe more comfortable talking about it in stem just because I know more people

> in stem. And I guess I identify generally more with the people in stem. And those are the people I hang out with more. So those are the people I want to know I'm not Straight.

In a similar fashion Fredo drew on his STEM affiliation and his beliefs about the nature of STEM to cast peers as more accepting and “open minded”, which “is a characteristic that comes alongside of just wanting to learn and wanting to expand your knowledge because I know that you kind of have to be open minded if you want to do [STEM]”. Magda highlighted the role that instructional practices in the classroom serve to foster peer connections. She stated that the role of group work in developing those peer connections helped in her environmental class. “I feel like with my the people who I take my environmental class I was I'm closer to them a little bit just because we do a lot more group work in there than in my previous math class, so I would feel maybe a little bit more comfortable like expressing.” This theme of small group work is also discussed in Chapter six as a contributing identity resource.

The presence of other Queer-spectrum individuals and building relationships with those individuals contributed to an accepted or valued discourse. Ninah, Erin and Wren all mentioned the presence of other Queer-spectrum people and how that helped them feel more included in STEM. Ninah said that at Cardinal University, there were a large number of Queer-spectrum students, and in their classes, “just the number of like LGBT people…you know LGBT people everywhere. Like you know, and that's what made me more comfortable.” It not surprising that the presence of other Queer-spectrum people contributed to a belief in an acceptance or valued discourse, as more representation is an indicator of inclusion. What is noteworthy however, is that given the less visible nature of Queer identity, the development of this representation was facilitated outside the classroom through LGBT student resources centers. This theme is further explored in Chapter 6 as an identity resource.

Summary and Conclusion

In this section, I summarize across the discourses to highlight key findings that were illustrated previously through the students' lived experiences in STEM environments. In particular, I identify three key findings related to mathematical discourses for Queer-spectrum students in STEM environments. The first highlights the identification and range of discourses that were shared by Queer-spectrum students. The second key finding is that the discourses relating to Queer identity were predominantly about presence and visibility of Queerness in STEM, as compared to attributions of perceived ability or success. The third key finding is a framework that networks the underlying structure of the discourses to concepts of exclusion and irrelevancy.

Key Finding 1: A Range of Discourses and Navigational Strategies

Prior to this study, there was limited research documenting the existing mathematical discourses or navigational strategies in STEM environments related to Queer identity. As such, this study offers an initial window into the understudied nature of this topic. One result of this study is the development and identification of the types of navigational strategies used by Queer-spectrum students and how these promote or hinder the development of a Queer STEM identity. As seen in Figure 5.2 the navigational strategies included: how Queer-spectrum students position their Queer identity in STEM, how they connect their Queer identity and STEM identity, how they disclose their Queer identity, how they react to Queer topics in STEM, and how they develop relationships in STEM.

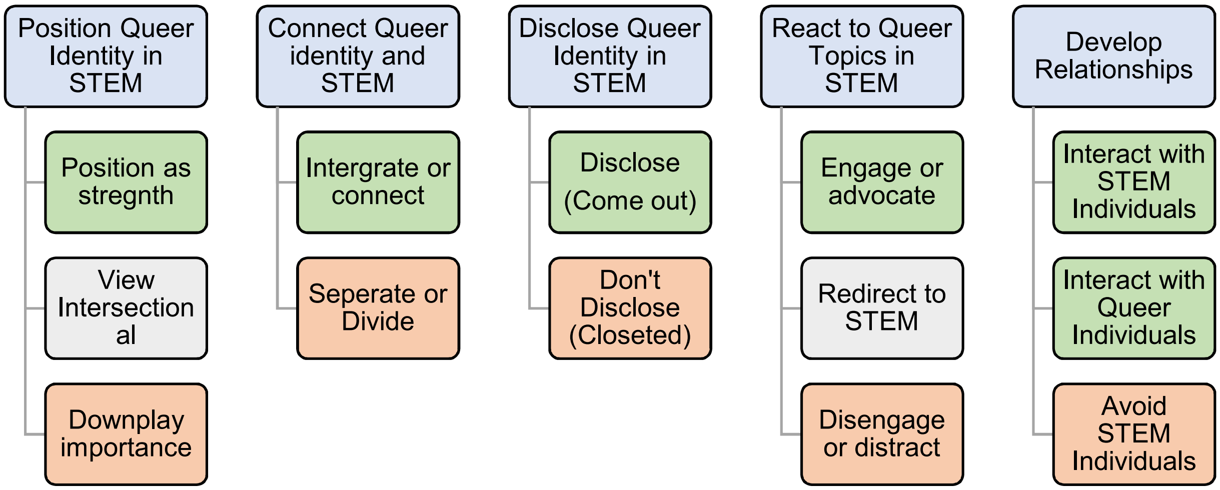


Figure 5.2. Navigational strategies used by Queer-Spectrum students in STEM environments.*
*Green boxes represent strategies that promote a Queer STEM identity, gray boxes represent neutral strategies, and orange boxes represent strategies that can hinder the developments of a Queer STEM identity.

The navigational strategies used by Queer-spectrum students arose through beliefs and messaging about Queer identity and mathematics. This study identified seven mathematical discourses shared by Queer-spectrum students that related to how their Queer identity arose and were constituted within social discourses in STEM environments. Navigational strategies are thus embedded within and informed by mathematical discourses, which is visually depicted in Figure 5.3. The most prevalent mathematical discourses cast Queer identity as being irrelevant (erasure), unseen (heteronormative), or discriminated against (marginalized) in STEM environments. At the same time there were some beliefs that Queer identity acceptance was unknown (ambiguous) was treated equally (normalized), was accepted and even valued in STEM environments; however, these discourses were less likely to be shared by Queer-spectrum students.

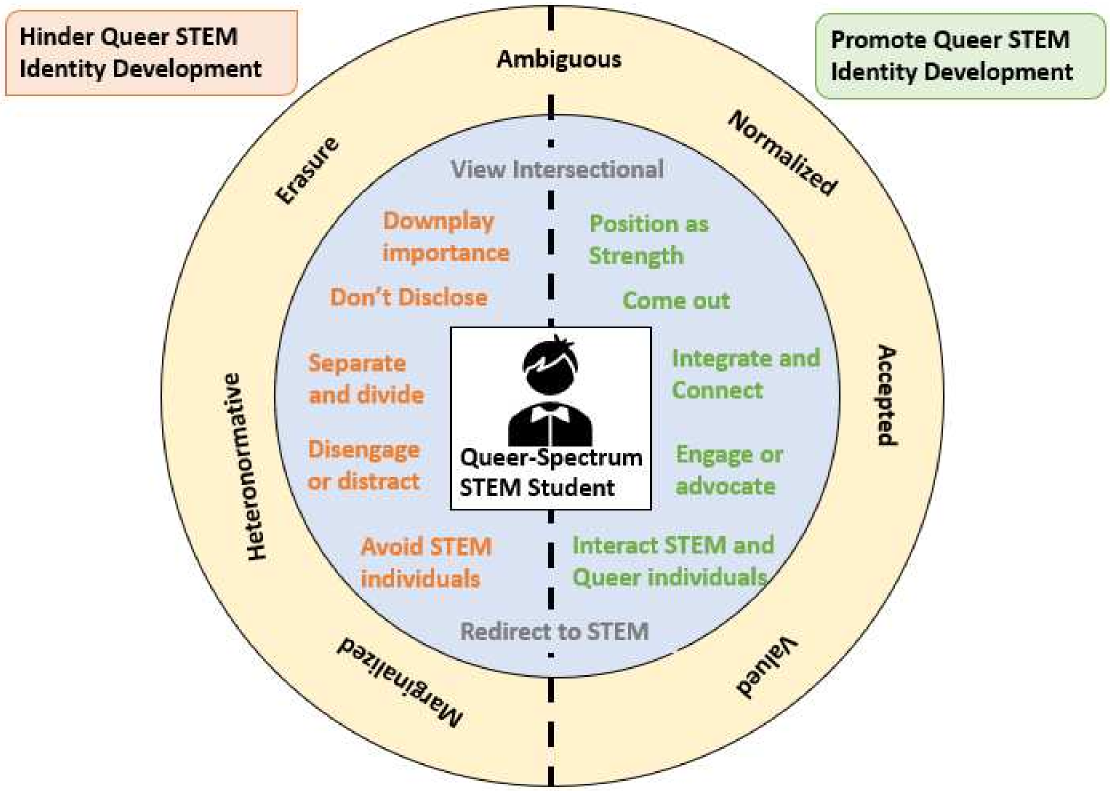


Figure 5.3. Visual representation of the navigational strategies used by Queer-spectrum students in STEM environments embedded within the mathematical discourses about Queer identity.

The identification of positive discourses and navigational strategies that promoted the development of a Queer STEM identity is noteworthy as most of the emerging literature on Queer-spectrum students in STEM has highlighted the hostility and exclusionary pressures experienced by Queer-spectrum students (e.g., Fischer, 2013; Toynton, 2016). In fact, navigational strategies that promoted a Queer STEM identity arose within all of the mathematical discourses even the marginalized discourse. At the same time, certain discourses were more productive in promoting a Queer STEM identity than others, with the erasure discourses exhibiting the most hindering strategies to a Queer STEM identity (see Figure 5.4). These hindering strategies played out in the lived experience by feeling pressures to not disclose one's Queer identity, downplaying the importance of Queerness, and compartmentalizing one's Queer identity with STEM identity. As such, erasing Queer identity from STEM is one of the largest barriers in supporting Queer-spectrum students in STEM. This discourse promotes a more fractured Queer STEM self, thus hindering the opportunity to develop a Queer STEM identity.

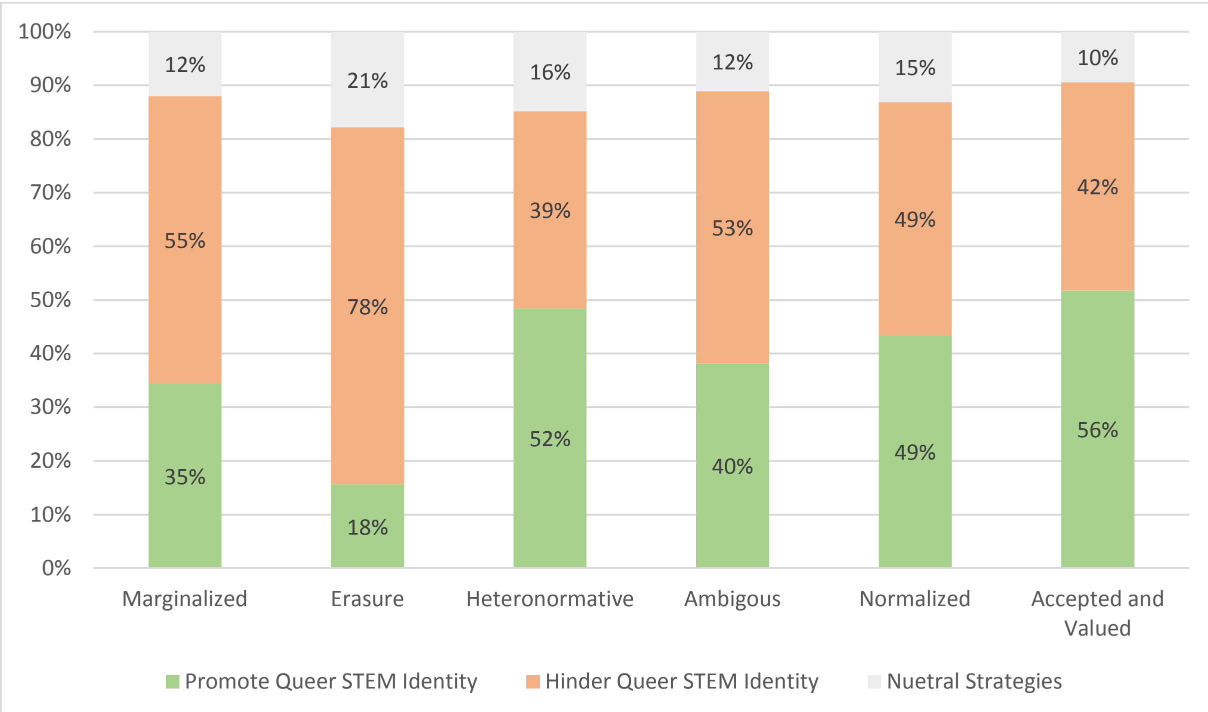


Figure 5.4. Mathematical discourses and the percentage of navigational strategies that promote, hinder, or are neutral to Queer STEM identity.

The range of discourse that were identified likely arose given the number of Queer-spectrum students interviewed, the variety of institutional settings, and the diverse representation of Queer identities and STEM affiliations. Furthermore, the variety of discourses and the presence of the ambiguous discourse suggest that there are not master narratives (McGee, 2014) or broadly accepted societal beliefs about Queer identity and mathematics. This suggests future research and policy can help promote productive asset-based views of Queer identity and must attend to the localized context to understand mathematical discourses for Queer-spectrum students.

Key Finding 2: It's Not About Success; It's About Presence

There exist dominant discourses that often position women and students of color as less mathematically capable than compared to men and white students (Leyva, 2016b; Shah, 2019a; Trytten et al., 2012). These discourses associate mathematical ability with gendered and racialized identities. In this study, Queer identity was not associated with mathematical ability in the same way that gendered and racialized identities have been linked to success narratives in the literature. In fact, only a single student communicated a belief that Queer-spectrum individuals were bad at mathematics. Instead, the dominant discourse attached to Queer identity is about irrelevancy and inclusion of the identity to the pursuit of STEM. The absence of success narratives is likely due to the lack of gap-gazing on success outcomes for Queer-spectrum students, which has occurred and furthered gender and racial narratives. Furthermore, since Queer identity is less visible, the power structures at play that exclude identities from normative spaces, cannot as easily associate Queerness with mathematical inability. Instead, the power structures at play cast queer identity as irrelevant as a way to erase and minimize the presence of the identity in STEM environments.

Key Finding 3: The Exclusion and Irrelevancy Space

The seven identified mathematical discourses are not disjoint constructs but instead represent a system of beliefs about Queer identities in mathematics. One important feature previously discussed in relation to the mathematical discourses was the level of inclusion/exclusion of Queer identity in STEM environments. The discourses range from the most exclusionary towards Queer identity (marginalized) to the most inclusionary (valued). The relationship between the discourses and their level of inclusion/exclusion is further depicted in Figure 5.5.

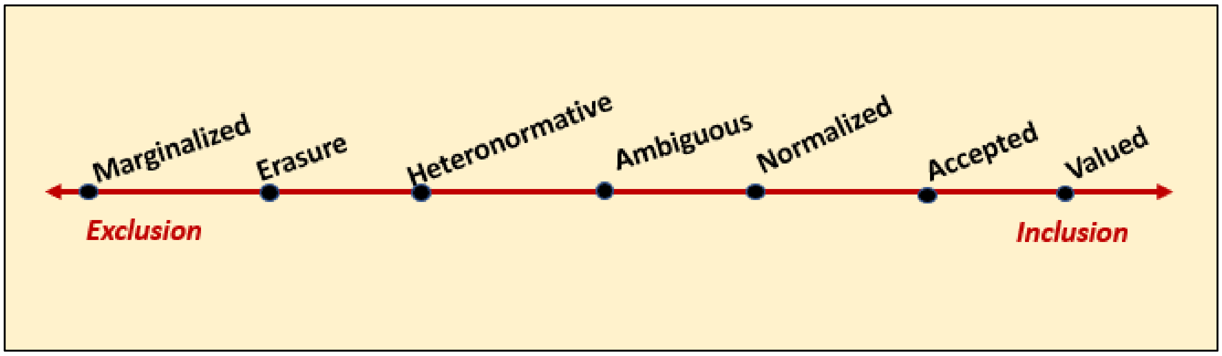


Figure 5.5. Visual representation of the levels of inclusion and exclusion for mathematical discourses.

Throughout the analysis, I identified a second cross-cutting feature of the beliefs system about Queer identity in mathematics which is the level of relevancy/irrelevancy of Queer identity in mathematics. The level of relevancy/irrelevancy are the messages and personal beliefs that Queer spectrum students communicated in how Queer identity was not connected to the goals of the mathematics classroom. Towards the developments of a mathematical discourse framework, I combine the levels of inclusion/exclusion with the levels of relevancy/irrelevancy to develop a conceptual space which helps network the relationship between the discourses together. This conceptual space is referred to as the exclusion-irrelevancy space and is shown in Figure 5.6. This planar space helps illustrate how the discourse relate to beliefs about exclusion of Queer identity and the irrelevancy of Queer identity towards the goals of STEM. As seen in the exclusion-irrelevancy space the marginalized discourse is excluded and somewhat irrelevant, whereas the erasure discourses although less excluded from STEM has far more messaging about the irrelevancy of Queer identity towards the goals of STEM. The heteronormative discourse while still exclusionary is not about it being irrelevant. In fact, in many ways the heteronormative discourse makes Queer identity more relevant through the lack of Queer people in STEM. The ambiguous discourse is at the origin of these two scales as the messaging is unknown. The normalized discourse while included, was equated with straightness, both being seen as irrelevant to the pursuit of STEM. The valued discourse conveys a greater sense of relevancy than the accepted because it was seen as an asset. The ways in which these discourses map onto the space represents a theory-building endeavor, based on the interviews and how they discourse were operationalized. These discourses are also not stable points on the space, but are shifting and moving belief systems given the settings, context, and environment. Further research will help define where and how mathematical discourses map onto the exclusion-irrelevancy space.

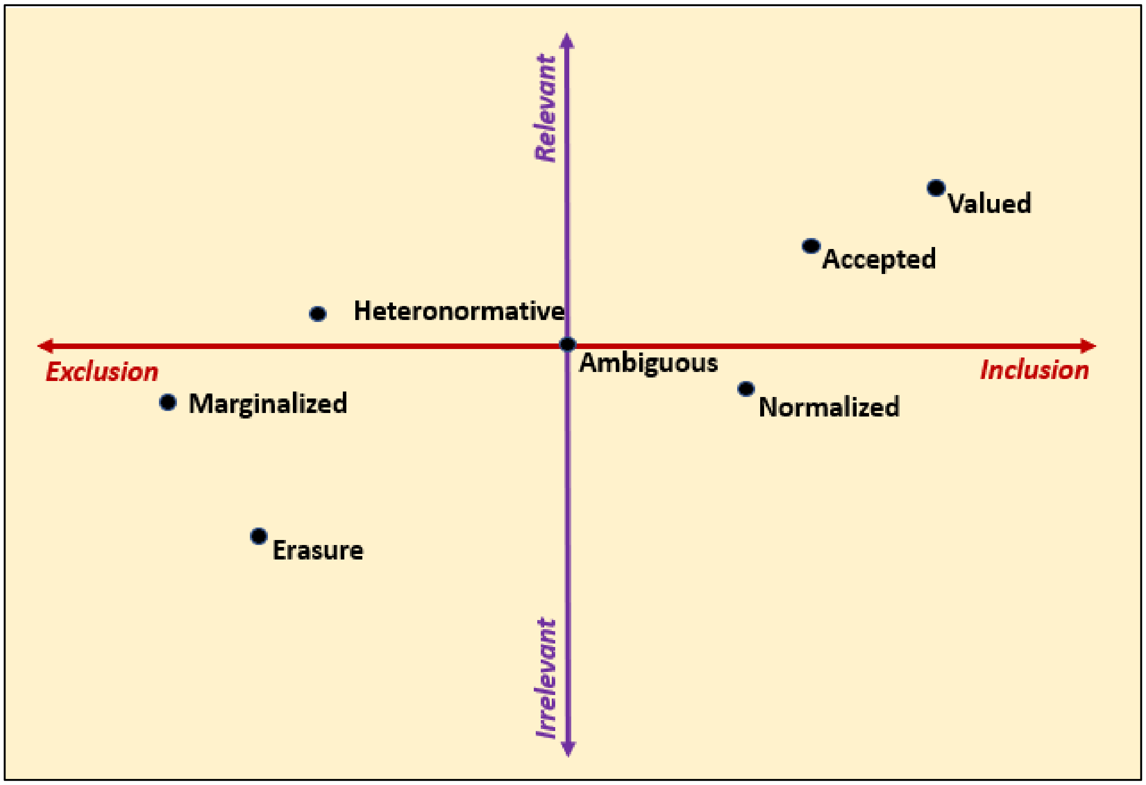


Figure 5.6. Exclusion-irrelevancy space of mathematical discourses.

The development of the exclusion-irrelevancy space not only serves to build a framework that networks the relationship between these discourses together but also has utility for communicative and research purposes. For example, I can utilize the exclusion-irrelevancy space to visually display the prevalence of the discourses within the interviews showcasing the overriding belief systems that are driven by irrelevancy (see Figure 5.7). Furthermore, the exclusion-irrelevancy space can be utilized in future research to have student's self-identity their own belief systems in various environments, and moments in time.

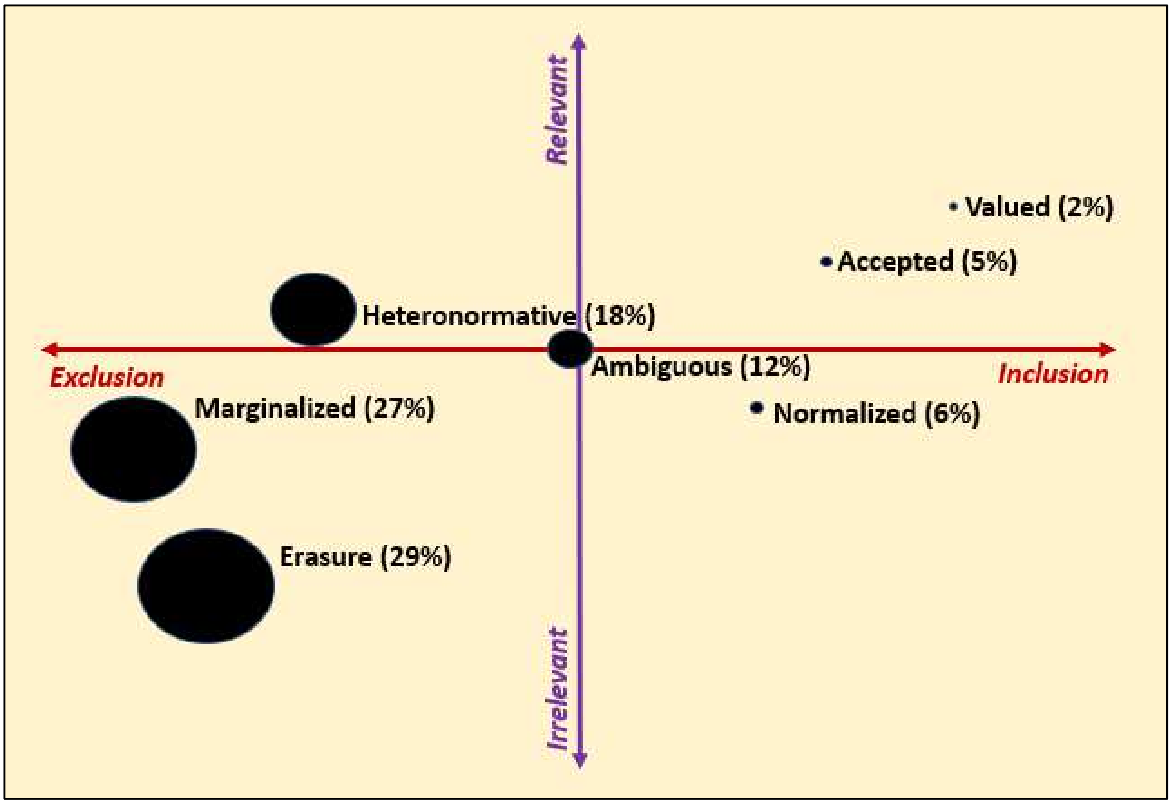


Figure 5.7. Prevalence of mathematical discourses depicted on the exclusion-irrelevancy space.

Chapter 6: Resources to Support Queer-Spectrum STEM Students

This chapter focuses on addressing research goal 3, *to identify the resources that impact Queer-spectrum students,* which ask the following research question:

- In what ways do curricular, interpersonal, and institutional factors impact Queer-spectrum students' participation, perceived capability or success, and sense of belonging in mathematics?

I delineate the resources described by Queer-spectrum students in the four focus groups, resources that they identified as beneficial or negative in their experiences as Queer-spectrum STEM Students. Focus groups consisted of 3-5 Queer-spectrum students whose pseudonyms and relevant information is represented in Table 3.9 for the ease of the reader. The analysis was guided by Nasir's (2011) identity resources constructs, which serve to highlight how educational settings make particular identities available while constraining others. There are three types of identity resources*: material, relational, and ideational*. In addition to coding for each of the types of identity resources, I further coded excerpts as a classroom-related resource or as an external resource occurring within the broader educational setting.

The analysis resulted in the identification of 25 identity resources, which was composed of 9 material resources, 10 relational resources, and 6 ideational resources. Each of the identified resources, their type, and where they occurred are presented in Table 6.1. In the remainder of the chapter, each resource is discussed along with relevant literature to help frame and contextualize the impact of the particular resource. In the conclusion, I draw cross cutting comparison around the types of ideational resources, where they are occurring, and possible resource types that were not reported or experienced by the students.

Table 6.1. 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

Material Resources

Material resources refer to the physical environment, its organization, and the artifacts that support a students' 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). This analysis draws on this broader conceptualization of material resources to include the physical spaces and structures that support a student's connection with mathematics. As stated earlier, resources (material, relational, ideational) can overlap in how they foster a student's connection with the discipline of mathematics. The emphasis here is on the materiality of the resources, as compared to how these resources foster relationships or ideas about mathematics. In the next two sections, I highlight the classroom-related material resources followed by the external material resources reported by Queer-spectrum students.

Classroom-Related Resources

There were four material resources from classroom-related environments which included: class size and the existence of recitations, the sequential nature and sequencing of mathematics courses along with scheduling times, curriculum and terminology in STEM, and the use of dress and decals to signify Queer identity.

Class size and structure.

There exists well-documented research showing the benefits of small classes, including improved academic success, higher teaching evaluations, and greater course engagement in K-16 environments (Class Size Matters, 2019; De Giorgi et al., 2012). Small class size also helps close the opportunity gap by supporting students of color, low income students, and English language learners (Konstantopoulos & Chung, 2009; Krueger & Whitmore, 2001). A review of the literature did not reveal any published studies suggesting the impact of class sizes for Queer-spectrum students. In the focus groups, Queer-spectrum students unanimously discussed the benefit of having smaller classes size in STEM. One might hypothesize that larger classes would provide anonymity and safety for Queer-spectrum students, but students in the focus groups instead highlighted how small classes provide a structure to develop peer connections and better understand the content. For example, Fran said she wanted small classes in order to “find people to know,” making it a more comfortable learning environment.

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 each 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 mathematics class, she was able to get 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. James and Flora discussed how larger classes limit their learning because STEM is already difficult, so adding more students only makes it harder to succeed and stay in STEM. Students had mixed opinions about the use of labs or breakout sections in mathematics. Some students pointed to the benefits of labs or breakouts due to their affordance of smaller size and interactions with a teaching assistant, while Cat said labs were pointless, but she did not elaborate further. These results provide evidence that small class sizes can support Queer-spectrum students comfort in mathematics and their perceived sense of ability.

Course sequencing and scheduling.

Students identified both beneficial and detrimental impacts of the scheduling and sequencing of mathematics courses. Undergraduate mathematics courses, especially introductory courses, are typically sequential in nature and each course depends on the previous course for requisite knowledge. 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. Cat said she has had two sequential mathematics courses with the same teacher and in the first course didn’t know or talk with other peers but in the second course she “eventually developed more of a relationship” with two other Queer-spectrum students. James didn’t elaborate on the benefits of sequential courses but did share that he has taken three mathematics courses with the same professor who discussed LBGT issues in the course. James’s decision to enroll in the course with this particular instructor may highlight how once a Queer-spectrum student identifies a supportive and inclusive instructor, sequential courses may facilitate course enrollment decisions. There were also identified risks of having sequential courses for Queer-spectrum students. Erin and Meh discussed that, due to the sequencing of courses, they are taking longer to obtain their degree. At the same time, they have also experienced pressure in people rushing them to graduation. 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. Although there is no documented evidence of the time to degree for Queer-spectrum students, there is some evidence in secondary school that Queer-spectrum students experience tensions in the normative timeline of education (Stiegler & Sullivan, 2015).

An identified structure that hindered Queer-spectrum students was the scheduling of STEM courses in the evening. 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?'

In sharing this story Naseem said that this experience and 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." Erin said she has a lot of night courses, but generally feels safe walking back to her apartment because it's on campus which is outside where all the reported incidences are for campus crimes. Erin said that having night courses were problematic because this prevented her from enrolling in an LGBT course that she was interested in taking. 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.

Curriculum and terminology.

The use of some STEM terminology served as a play on words that allowed for students to come out and connect with other Queer-spectrum students. Meh discussed an instance working with a study partner in biology when the term cleavage (division of cells in the early embryo) was mentioned, "And I was like, oh, cleavage. And he started laughing and he's like, oh wait, is that offensive? And I was like, no, it's okay. I love the word tits." In this instance, Meh was able to joke and connect with her study partner due to the use of the terminology. Chelsea shared a similar joke that occurred because she studies libra vaginas, and a woman graduate student joked that, “vaginas are the only thing important to me,” which she described as beautiful and fun, thus creating a positive experience. In both incidents, the Queer-spectrum individual is the one initiating the humor in the use of the terminology. In contrast, James shared how in his mathematics course, an instructor who he perceived as Straight, was discussing homogenous equations and throughout the lecture would joke about “homo” and “no homo.” James described this as an overall negative experience and said he wasn’t sure how to react in that situation.

Several students mentioned the degree to which Queer issues were discussed as part of the curriculum in STEM. For example, Fran and Isabella shared that in their global health courses, Queer topics are discussed more than any of their other courses. They both shared how they love that aspect of the global health courses and it helps inspire them because they want to pursue research in Queer issues and global health. Isabella shared that her biology and anthropology courses bring up Queer issues since they talk about the variation in life, and that even though the courses are centered around those issues, “we at least acknowledge it and it feels more accepting.” Isabella shared that in other STEM courses it doesn’t really come up in that context. Fran said that having discussion about Queer issues in STEM was important because it provided representation where she could hear other parts of her identity being present in STEM courses. This promoted a sense of belonging and representation for Fran. Jesse discussed that having discussions about Queer issues was a way in which he didn’t have to come out personally, but “people get the message” based on his discussion of the topic. James was one of the only students who experienced Queer issues being addressed in his mathematics courses in relation to statistics. When asked about how this impacted his experience he said,

> Like I don't think it made me more comfortable because I was already comfortable, but it made me feel less hopeless. You know like, oh my God, people are actually doing stuff. And since I want to teach, I feel like it just made me give him, gave me like a role model or you can do this, you know, so I feel like I was already comfortable, but he gave me hope like basically so, yeah.

Chelsea was the only one to share an incident in which discussion of Queer issues in STEM was problematic. Chelsea said that in her biology course they had a unit on sexual paraphilia (necrophilia, pedophilia) and in the same section they discussed homosexuality. She said that in class, it was even more problematic because the instructor’s slides included statements such as “Gay men are more likely to be promiscuous” and kept repeating the term “homosexuals.” A student in the class asked if they had sources for these claims and the instructor responded defensively. According to Chelsea, this demonstrated the lack of effort towards inclusivity or diversifying STEM curriculum, “like teachers aren't putting in the effort to like update their terminology in order to like be inclusive and they're like inadvertently giving the message that like, like really bad and homophobic messages.”

Appearance and decals.

As discussed in Chapter 2, appearance and dress are important mechanism that Queer-spectrum individual use to convey a sense of group belonging to those “in the know” (Hutson, 2010; Rothblum, 2014). Students in the focus groups described the ways in which appearance and dress served as material resources in STEM environments to gauge the lack of acceptance of peers or to establish connections with supportive allies. Jesse, who was also a participant in the individual interviews, recalled the following story of wearing his red “kinky boots” to his physics class: “I remember like telling you that like Oh yeah, the professor's response was great but then I was thinking back and the student's response, like my peers was not like that great. Like I just kept getting weird looks.” Jesse said that this contributed to feeling intimidated by his peers “and so like I could definitely feel like a very like this dis… like uncomfortable like air throughout the room like I could just like, and like I felt uncomfortable.” 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.” James and Jesse’s experience combined with the individual interviews of Swappi and Fredo suggest that Gay men have more negative experience during visual performances of Queer identity than other Queer-spectrum students. Such a result would be consistent with exclusionary pressures that privilege masculinity in mathematics (Mendick, 2006a).

Dress and attire are documented mechanisms in the literature related to Queer performative identities, but less present in the literature is the use of visual indicators or decals not worn on the physical body. For example, the focus group at Black University discussed the benefits of having Queer decals, pins, and stickers that served as beneficial resources in STEM environments. 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.

Flora’s described how material resources can signal to those ‘in the know’ of identity belonging. “It was so nice just to have like a little visual identifier, like if you know what this is, great!” The visual indicators included the pansexual flag, rainbow safety pins, rainbow flags, and an especially important physical resource was the use of oSTEM stickers on phones and water bottles. Meh, Katherine, and Flora described their appreciation for the 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?” The use of the oSTEM stickers as a visual indicator deserves further research to understand how it can promote both a Queer and STEM identity. This is especially important given the exclusionary pressures discussed by Gay men in gender transgression performance, since such decals might aid in promoting a sense of belonging and safety in STEM.

External Resources

There were five material resources from external environments which included: LGBT students resources centers, STEM research lab spaces, mathematical learning centers, building facilities especially gender-inclusive restrooms, and the context of the university climate and location.

LGBT student resource centers.

The establishment of LGBT student resource centers on college campuses has increased in recent years to over 450 institutions in 2018 (Consortium of Higher Education LGBT Resource Professionals, 2018). The main purpose of LGBT student resource centers is to support students with diverse gender and sexual identities. Although each center varies by institution they commonly offer resources related to academic advising, leadership development, education, and training and outreach for the larger campus community (Pitcher et al., 2018). Additionally, and particularly important to this study, is that LGBT student resource centers provide a physical space on campus to foster a supportive and inclusive environment for Queer-spectrum students, commonly referred to as a “safe spaces.” These physical centers are often supported by the institution with monetary support for paid directors or staff members and facilities (Sanlo, 2000). LGBT student resource centers are different than LGBT student organizations (which are discussed in the relational resource section), since LGBT student organizations are often less institutionalized and focused on peer community support (Nguyen et al., 2018; Pitcher et al., 2018). LGBT student resource centers have been shown to support Queer-spectrum student retention and a sense of belonging by providing a physical “first stop” for problem resolution, providing community and professional support, and serving as a symbol of Queer support and inclusion at the institution (Pitcher et al., 2018). At the same time, LGBT student resource centers are less likely to be used by women (Westbrook, 2009), are often not meeting the needs of Transgender individuals (Marine & Nicolazzo, 2014), and less likely to exist at small, private, or two-year colleges (Fine, 2012; Nguyen et al., 2018). LGBT student resource centers existed at each of the four universities in this study and each had a designated physical space and paid staff member(s).

LGBT student resource centers were discussed as a positive material resource through the physical space they provided to develop connections with others, as a study space, and as tool to network with other STEM resources. At the same time, not all Queer-spectrum students were comfortable accessing LGBT students resource centers.

LGBT student resource centers helped develop connections with peers and staff members for the participants. Naseem and Katherine, who frequently utilize the LGBT student resource center at Black University, described how they were able to connect with first-year students because the center was responsible for teaching an LGBT course for first year commuter students. Naseem said that being at the center, helped her develop connections with peers, who he now recognizes inside her STEM classes and is more comfortable interacting with them. At Blue University, Jesse and Alexis described the benefits of the LGBT student resource center as a physical space to “relax when not in class.” Alexis said she spends a lot of time in the LGBT student resource center “ranting to one of the staff about my classes.” Although the topics discussed are not LGBT or STEM exclusive Alexis said,

> It tends to be just be more welcoming and easier to relate to people and to then genuinely be comfortable with them and to share things in a way that makes you feel better instead of just like kind of sitting there twiddling your thumbs.

Aidan said that having a safe space to have discussion about your daily activities inevitably includes STEM related things since these are part of your daily activities for Queer-spectrum STEM students.

The presence of an LGBT student resource centers also provided a study space for students in STEM. 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. Jesse, who also studies in the same space, highlighted how the individuals he sees in the center are not the people in his mathematics courses, suggesting that either people in STEM are Straight or they do not leverage the LGBT student resource center. Aidan illustrated why such spaces support Queer-spectrum students through academic and social integration that elevate the academic experience outside the classroom (Tinto, 1975, 1987). Aidan shared how the LGBT student resource centers, "just create a safe space where I could identify as myself and it wasn't in the classroom" and thus she didn't feel judged. Aidan said having this space enabled her to find friends who understood what was happening in her life outside of school, which made it easier to study with them. Likewise, Isabella said having a set aside safe space was important to her academics, because she hasn't had these in her past educational experiences, and it was "encouraging just to simply know that they are there."

The LGBT student resource center also supported students by connecting them with other STEM-specific recourses. At Blue University, students referenced resources on the website of the center that aided in their pursuit of STEM. For example, Alexis accessed a listing of STEM mentorship programs for women posted through the LGBT student resource center. Jesse described an "Out and Ally Faculty list" that was posted on the website that he used to search for STEM faculty; however, he also said, most of the faculty were either Allies or not in STEM. The lack of out STEM faculty is discussed further in the relational resource section. Naseem said that she originally wasn't active in the Queer community, but through her involvement in a STEM club, she was drawn to using the LGBT student resource center because it's a safe space on campus that is "motivating." Additionally, Naseem's involvement in the focus group was attributed to being advertised at the LGBT student resources center. Meh shared how, through attending an event at the LGBT student resource center, it served as a connection to oSTEM, which had a table with members and information. oSTEM then served as an important relational resource (discussed later). These experiences demonstrate the way that STEM involvement and Queer community involvement can mutually influence each other.

Not all students in the focus group were comfortable accessing the LGBT student resource center. Meh discussed the hesitancy of using the LGBT student resource center in her first year because she was shy and didn't hang out their much. Erin similarly conveyed her anti-social dispositions prevented her from frequently using the LGBT student resource center, but that she would go occasionally. Fran cited different reasons for not accessing the LGBT student resource center, which were mostly attributed to feeling like an imposter in that setting. As Fran described it,

> Am I like, Queer enough to be in this space right now? Even though I have visited there, like constant I'm always like, okay, like I feel like sometimes someone will judge you, like you shouldn't be here. And I'm like, but I swear, I'm a part of you guys. So, like when it comes to stem, it's more of a comfort, like I don't have to worry about that

Fran's description highlights how in Queer spaces she questions her identity affiliation, but that such pressures are not experienced in STEM environments. Additionally, the lack of accessing these resources due to their social nature, but leveraging them for study spaces and connections to other resources, indicates that Queer-spectrum STEM students are utilizing these spaces to advance their academic interests.

STEM research labs and research opportunities.

Research Experiences for Undergraduates (REUs) have been shown to increase student interest in STEM fields (Lopatto, 2003, 2004; S. H. Russell et al., 2007) and are especially impactful for the retention of underrepresented students in STEM (Chang et al., 2014; Pfirman et al., 2014). In a longitudinal study of Queer-spectrum undergraduates in STEM, Hughes (2018) showed that not only was student participation in undergraduate research the largest predictor of being retained in STEM, but that Queer-spectrum students were 10 percentage points more likely to participate in undergraduate research than their heterosexual peers. Hughes (2018) suggests that this result is likely due to Queer-spectrum student's being more committed to STEM fields due to expecting a heteronormative environment. At the same time, mathematics is the least likely of any of the STEM fields to report the existence of undergraduate research opportunities (Lopatto, 2004; S. H. Russell et al., 2007). For this reason, in the analysis that follows I examine the ways that the physical space and material structure of having a dedicated STEM lab outside of mathematics impacted Queer-spectrum students.

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 and post-docs, and supporting a stronger STEM affiliation. Two potential issues with STEM research labs is having to interact with less-inclusive lab members and an overall difficulty in obtaining a research position. Meh, Alexis, and Chelsea were the most involved in STEM research labs and their experiences are discussed below.

Meh was motivated to be part of a research lab due to attending community college and being told about the importance of such experiences. Meh described her STEM lab as a "safe space" that she would hang out in and leave only when she had other meetings. 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 student 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. It also led to a positive interaction with another undergraduate researcher in her lab, when the other student used the wrong pronouns to refer to the postdoctoral student. Meh said because they were close with the other student, due to working in the lab with them, she was able to correct them, and the student appreciated knowing this new information. As Meh described it, “sometimes negatives can turn into positives.” 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 “on like my side of the desk” and when the postdoc left the lab Meh kept a flyer “what is trans and how to be a trans ally. And I left that on my side of the desk.” Meh mentioned how having these decals and flyers, promoted discussions with other classmates when they would study together in her lab, often leading to positive conversations.

Chelsea has been involved in undergraduate research since her first-year at the university, leading to “ample opportunities to get involved with like various different aspects of research or different labs.” This variety of experiences helped contribute to Chelsea’s view that the ability to talk about Queer issues depended on the particular STEM lab. In her current lab, Chelsea said that because they talk about sex and sexual behavior, it’s easier to be open about your own sexual identity. In fact, there was another graduate student in her lab who identified as a Lesbian and invited everybody in the lab to her upcoming wedding with her future wife. Chelsea said she has been positively impacted by “seeing other LGBT [people] in my lab” and that discussions of Queer issues have not been negative in that space.

Alexis described her experiences in STEM labs as more neutral and that she often doesn't mention "social issues" because it would take "an hour-long conversation" to explain it to her other lab members. Alexis described how the principal investigator of the lab acted as a mediator in that space when a "staunchly Republican" student was making others uncomfortable. The principal investigator intervened and discussed with that student to "tone it down" because they were "making people uncomfortable." This form of intervention from the supervisor of the space might be more likely in STEM labs as compared to classrooms where the relationships are more loosely formed. Alexis said that she "accidentally come out to people in my lab as ace [Asexual]" because she mentioned she was attending an event that was targeted for Asexual individuals. She said the reaction was mostly that people were confused and didn't ask about it, which contributed to her sense that the STEM lab was more neutral.

Fran, Timmy, and Cat all shared how they would like to participate in STEM research opportunities, but they have been difficult to obtain at the university. Fran discussed how research opportunities are especially challenging to get as a global health major and hence she feels excluded from such opportunities compared to other STEM majors. Timmy said he hasn't had the chance to be part of research opportunity yet, but thinks it would be a positive experience. Cat shared that opportunities for undergraduate research have been hard to get, hence she has not been able to experience them. As Hughes (2018) documented, Queer-spectrum students are more likely to participate in STEM research opportunities and be retained in STEM. Based on this research, one reason to explain the higher levels of involvement in STEM research is that they provide safer physical spaces for Queer-spectrum students than other learning environments. Additionally, the presence of other out members in the lab may promote STEM retention and greater sense of belonging for Queer-spectrum students.

Mathematical learning centers.

STEM research opportunities and dedicated lab space are less likely to occur in mathematics; however, an analogous space of interest is that of mathematical learning centers. Mathematical learning centers have been shown to support student success and promote a sense of community in a non-classroom environments (Grove & Croft, 2019; Solomon et al., 2010). Description of mathematical learning centers varied across Queer-spectrum student participants. James discussed the benefits of having a mathematical learning center, but that he didn’t utilize the services it provided. Katherine, who had a strong mathematical identity, was excited that she will soon be employed at the mathematical learning center as a tutor. Cat and Jesse discussed that their mathematical learning centers were unhelpful because the tutors lacked the necessary mathematical understanding and there were often too many students for the number of available tutors. Jesse shared that as he has progressed past the introductory mathematics courses, there were more dedicated mathematics tutors for the course. This smaller setting with dedicated tutors was the only time in all of Jesse’s undergraduate studies that he met another Queer-spectrum mathematics major. Jesse’s experience suggests that mathematical learning centers may be able to emulate the benefits of STEM lab spaces if they can provide smaller physical spaces to allow networking opportunities between Queer-spectrum students compared to a larger service model.

Facilities and gender-inclusive restrooms.

Gender-inclusive restrooms have received recent notoriety with several "bathroom bills" being passed in state legislatures, which mandate restroom use based on sex assigned at birth (Schilt & Westbrook, 2015). Research in educational settings suggest that, the lack of inclsuve restrooms for Transgender students act as environmental microaggressions, that are associated with increased risk of poor academic outcomes (Woodford et al., 2017). As such, best practices at universities suggest providing readily available gender-inclusive restrooms (Beemyn & Sanders, 2005). The presence of gender-inclusive restrooms not only benefits individuals who are Transgender but has been shown to signal safety and institutional fairness for women and racial minorities (Chaney & Sanchez, 2018).

While none of the students in the focus groups shared that they were Transgender, students at Gold University and Black University discussed how the lack of gender-inclusive restrooms in STEM buildings contributed to a sense of exclusion and injustice on campus. At Black 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 Gold 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." Isabella had more positive experiences with the use of gender-inclusive restrooms within her college[4] since they were available in both her residence hall and where she worked; however, when she walked around other parts of campus she was aware and bothered by the lack of inclusive restrooms outside of her college. 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.

University climate and location.

Prior research suggest that Queer-spectrum individuals face a chilly campus climate, experience greater rates of harassment, and perceive the campus as less comfortable than their heterosexual peers (Rankin, 2003; Rankin et al., 2010). At the same time, there is great deal of variability between institutional support for Queer inclusive environments (Garvey et al., 2017). The four universities selected in this research all provided a suite a resources and policies to support Queer-spectrum students. As such, students described how the university climate and where it is located, served as resources to support positive experiences in STEM. The abundance of available campus resources, was an indicator to students, that the university climate was supportive. At Gold University, Fran and James shared the positive climate at the university was due to "all" the resources available. Fran said this had helped her find out

[4] There were six undergraduate colleges within Gold university. Each college is designed to foster undergraduate student community through general education requirements and designated locations on campus.

“more about me.” At Black University, Flora similarly shared that the abundance of resources in comparison to her high school had a large impact in her positive experience as a Queer-spectrum student in STEM.

In addition to the availability of various resources, the characteristics of the university also contributed to students’ positive experiences. James shared how the racially diversity at Gold University contributed to seeing more diversity in his mathematics and chemistry courses. Although Cardinal University is a private university that is religiously affiliated, each of the students discussed that in practice they felt the university was liberal and supportive. Luciana shared how the faculty priests are supportive and “really cool about finding yourself and not knowing exactly where you lie in the spectrum.” Aidan agreed with this sentiment that there are so many diverse students and professors that don’t fit the traditional model you would anticipate at a religious university. John shared that technically the institution is religious, but the university has an LGBTQI minor, so that shows its level of institutional support.

Students at Cardinal University and Gold University discussed how the locality of the university contributed to an overall positive sense of acceptance in a liberal city or state; however, Fran and James provided some nuance saying that the university is in a more conservative part of the city within the region. Although institutions can’t alter where they are located to provide supportive climates, one must attend to the location of the university in considering how it may impact Queer-spectrum students experiences in the learning environment. Attending to the local context may inform the types of resources best suited to support a positive climate for Queer-spectrum students in STEM at the university.

Relational Resources

Relational resources refer to ways in which positive relationships with others afford a connection to the practice of mathematics. Relational resources capture the characteristics and aspects of the relationship and not the relationship itself. For instance, one can draw on multiple relational resources from a single relationship with a instructor. Thus, in the following sections, although particular individuals are listed (e.g. teaching assistant, peers) the analysis and identification aims to highlight the aspects of those relationships that support Queer-spectrum students in STEM.

Classroom-Related Resources

There were five classroom-related relational resources described by Queer-spectrum students that captured characteristics of relationships with classroom peers, Queer-spectrum peers, teaching assistants, instructors, and student-initiated study partners.

Classroom peers.

Developing relational resources with peers in STEM classes was often difficult given the perceived nature of STEM courses as non-social environments; however, students expressed an overwhelming desire for small group interactions and social environments in their STEM classes. The development of social interactions in STEM classes when they did occur, was aided by the perception that Queer-spectrum students are more social in nature and, due to the rigor of STEM courses which necessitated interactions in order to support each other.

Several of the students discussed that, in their experence, STEM courses have not been social environments. Naseem described her mathematics courses as not socially oriented, and “not supposed to be a social environment,” resulting in not really making any friends in the courses. Erin described her courses as mostly boring lecture where you are told what to learn and then tested on it. She said she would prefer to have small group interactions. 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.

All the students who discussed classroom interactions preferred small group discussions with peers. Some of the stated benefits of having small group interactions are that they were perceived as “safer” environments, allowed one to be more open, and it was easier to connect with people. Naseem described that small groups are safer because, if you know there are allies in the group, then “I know that there's someone I know who's there, who's going to like protect me.” Finding allies was described by Erin as easier in small groups because you can gauge their level of acceptance and mention Queer things that will identify those “in the know” and accepting. Isabella said that Queer-spectrum people tend to be more open and working in small groups is beneficial for them because it allows for more meaningful interactions. Meaningful interactions are also facilitated in smaller groups because it’s easier to listen to others and understand their viewpoints according to Tim. Similarly, Swappi shared that Queer-spectrum people are more open and have nonconventional ideas, which are then easier to share in smaller groups than in larger groups, where you may worry about how you will be perceived. James discussed how being in smaller groups doesn’t make you feel spotlighted if you are the only Queer-spectrum person, but if you are the only Queer-spectrum person in a group of 15 it feels feel “weird” and not “normal.”

Two factors contributed to the development of peer interactions in STEM classes. The first was a perception that Queer-spectrum people are naturally social, and the second was that the rigor and setup of the course necessitated peer support. 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.

The rigor of the course was described by several students as helping to facilitate peer interactions. As Flora described it,

> Like in the really difficult classes, like you need to feel like you're a part of it. Like you need to feel like I am in a community where I can be successful…if it's going to be hard, then you need people who are similar to you who can like help you out and like prove that you can be successful. So, I like, like in a math class, if I'm not with other people that I like, I will just drop out of math.

Luciana described having a “ridiculously” hard course allowed for everyone to talk to each other and relate. Meh described it as “freaking out together and struggling” that provided that social interaction. Aidan and John discussed how certain instructional practices, such as applied labs and peer-teaching, also facilitated peer interactions that made them more comfortable with individuals in their class. These results indicate that peer connections and small groups contribute to a sense of belonging and support for Queer-spectrum students in STEM.

Queer-Spectrum peers.

The presence of other Queer-spectrum peers was described as mostly a beneficial resource by several of the students, but there were challenges in finding such peers in STEM courses. In contrast, two students did not view having Queer-spectrum peers as especially impactful or important to their pursuits of STEM. The benefits of having Queer-spectrum peers contributed to an overall sense of feeling comfortable. James described it as “reassuring” and “comfortable” when he sees Queer-spectrum students in class that he has seen at Queer events on campus not related to STEM. Erin said that because being Queer-spectrum is a major part of her identity and one that is the newer, it helps to have other Queer-spectrum students to be “vulnerable about it” and “I don’t feel like I have to hide part of who I am.” Erin described an experience in her class where a student came out as Transgender and brought her girlfriend to class, which then allowed Erin to “piggyback off of that” and also come out. Erin described this as making the class “infinitely more Gay.” Luciana had one STEM class where she met several Queer-spectrum STEM majors, which she described as a positive experience because she had never had that in any other class. Aidan enjoyed having Queer-spectrum peers in class, and when choosing partners, she noted that there was a bit of tendency to seek out people who are similar, which has resulted in having queer partners in her STEM classes.

Some of the students discussed the challenges in finding Queer-spectrum peers. Erin and Flora commented that Queer-spectrum people tend to have more invisible identities so it’s hard to find them. Likewise, Jesse said he has only ever met two Queer-spectrum people in his major and Cat has only meet one during orientation. Even when students knew of other Queer-spectrum peers from different classes or events, some described the pressures to not be out in STEM settings leading to guarded language like “partners” instead of “girlfriend.” Aidan shared how the mathematics courses, with instructors who are teaching up until the last minute, don’t provide time to express one’s Queer identity. Aidan went on to say that, “given the chance people do express their LGBTQIA identity in STEM classes, but we're not really given the chance.” Isabella and John said that having Queer-spectrum peers was not impactful in their experience. Isabella attributed this to feeling like she could fit in anywhere. John attributed it the fact that he doesn’t have many Gay friends and thus relates more to his STEM identity. As such, the benefit of having Queer-spectrum peers in STEM classes is impacted by students’ perception of the importance and relevancy of their Queer identity.

Teaching Assistants.

Student experiences with teaching assistants (TAs) relationships were influenced by the TAs ability to help with the course content and the TAs perceived or known Queer identity. Naseem, Jesse, Cat, John, and Aidan all discussed relationships with teaching assistants that were not beneficial, often because they would not help them with the content. Naseem described her teaching assistant in computer science that “ran away and pretended that they couldn’t see me,” which resulted in Naseem discounting them entirely and suggesting she would utilize other resources, such as peers in her study group. Jesse shared similar experience, such that teaching assistants were not very helpful because they spent most of their time in the back of the classroom, so they weren't developing relationships. Cat discussed how the lack of training for teaching assistant often meant the TAs weren't able to help with mathematical assignments. John and Aidan had a shared teaching assistant that they described as patronizing and not helping learn the course content.

Beneficial aspects of teaching assistant relationships were often described based on the nature of their near-peer status and perceived or known Queer identity. Chelsea shared that teaching assistants are often near peers and thus it makes it easier to ask questions of this person than your professor because they are in your "sphere of people." Alex, John, and Luciana all described positive relationships with teaching assistants with a Queer identity. For example, Aidan shared that her teaching assistant wore rainbow earrings, which she assumed meant she has a Queer identity. It was with that teaching assistant, that Aidan experienced the introduction of pronouns, which was the only time in STEM class she had experienced using pronouns. Aidan believed that teaching assistants could provide great mentorship, which she was actively seeking out on campus. Alex, John, and Luciana all had the same teaching assistant, Henry, which they described in very positive terms. John discussed how he made, "fake sexual advances" at Henry in class and even the instructor made jokes about John loving Henry. As a result of this joking, Henry "started blushing and so did I. It was very uncomfortable but really funny actually in a weird way." Based on John's experience, he described a mixed reaction of both being uncomfortable but humorous. Furthermore, it allowed John to discuss sexual attraction to the teaching assistant, who he may or may not have perceived as having a Queer identity. Luciana shared how she is uncomfortable going to the professor for assistance, but is more comfortable getting help from the teaching assistant given the near peer-status. Luciana had a Transgender teaching assistant she described as “really helpful” because they “related in a different way on like we're both really into STEM, I'm actually doing research with her right now.” In addition to being able to talk about STEM, Luciana discussed the benefits of having a shared identity,

> Um, and our identities kind of, you know, like, I don't know, I could just talk more freely about who I am and what I'm struggling with outside of class. Not only what is inside of class. Um, so yeah, I think TAs are, especially with diverse TAs are very helpful.

Even the idea of having Queer-spectrum teaching assistants was a comforting notion, as Cat described, “I had a dream that all my other TAs were Gay, and like it was very, they were really nice, and I felt better about that class after that.” None of the students in the focus group shared that they had a Queer-spectrum instructor, only teaching assistants, suggesting that TAs might be more comfortable being out in that role, or it may reflect a generational difference in Queer visibility. These findings are consistent with research demonstrating the positive academic outcomes of having a teaching assistant with a shared racial identity (Lusher et al., 2018) or gender identity (D. M. Butler & Christensen, 2003).

Instructors.

Positive instructor relationships were characterized by instructor took a holistic approach to student interactions, were personable, mentored students, and utilized inclusive teaching practices. Luciana described an instructor she had for discrete mathematics that was “caring,” “non-judgmental,” and “tried to relate” to the students. For her personally, he was able to relate with her as someone who was Mexican because he had an appreciation for Mexican culture and would talk with her about this. As she described it, he would “talk about STEM things but also like personal things.” He also described mathematics differently from other instructors, emphasizing that it was okay to be an outcast and that struggling in mathematics didn’t mean you were bad at mathematics. This approach allowed for Luciana’s personality to emerge in the classroom because it was a “very inviting place for me at least.” She said that such an approach “resonated with like people who are LGBTQIA.” It was in this class, that she came to know other Queer-spectrum students in STEM, and it was the only professor she felt comfortable attending office hours. This instructor was so impactful on Luciana’s experience, that she switched from a computer science major to a joint mathematics and computer science degree.

Jesse said for Queer-spectrum students it can be hard to find instructors who are “willing to like see you as like a whole person…and not just like your major or like your academic interests” because for him, his Queer identity and work at the LGBT student resource center are important aspects of his identity. Jesse was able to find an instructor who provided this mentorship,

> It's been a great, like there's so many times where I like the question my, my mathematical ability and If I didn't have a faculty member who like understands where I'm coming from. he's worked with me, worked with me from like calc one and like helped me to like see that like I have passion in math and not even if I'm not necessarily like the best person that I'm not looking like a math genius that I can to do math. Um, that's really helpful.

John and Aidan had instructors that they described as life coaches. John said that his instructor knows more about him than most of his friends, and he was able to share about the dramatic events in his life related to an ex-lover. Aidan said her mathematics instructor is on a first-name basis, her family knows about him, and he has helped plan out her academic courses. Furthermore, her instructor reassures her that, even though she is struggling, she is still going to be fine. Aidan said “he genuinely cares about me and mental health.” Each of the previously described instructor relationships highlights not only the impact that a single instructor can have on the success of Queer-spectrum students, but how a holistic caring disposition resonated with these students. This finding mirrors research on the impact of “perceived caring” of instructors which are associated with immediacy, responsiveness, and assertiveness (Teven, 2001; Teven & McCroskey, 1997); yet, extends this relationship further to a more personable and mentoring relationship for Queer-spectrum students.

In addition to a holistic mentoring disposition, there were particular instructional practices that STEM instructors did (or did not do) that impacted students’ relationships. Isabella had one instructor who directly said they “support trans rights” during a time when Transgender rights were being rescinded in national policies. Isabella said this was impactful and contributed to sense of safety and belonging in the classroom. This mirrors results from the individual interviews in phase two, where instructor made explicit statements of acceptance, which students interpreted as an accepted discourse of Queer identity in STEM. Swappi conveyed that seeing a flexible instructional approach, in terms of deadlines and homework, sends messages that the instructor might be more approachable and less conservative. For Swappi this meant that he would be more likely to attend office hours and assume that the instructor was potentially supportive of Queer issues. Alexis had one instructor who would intentionally feature researchers from diverse backgrounds and display their pictures. Alexis really appreciated this because,

> "it's just cool that it's not just students who are not seeing people like themselves and being upset about it. It's also the professors are acknowledging, okay, I'm like a white woman, let me show my students that other people exist. And I think that's been really helpful. It's been cool for me to know that like she actually intended to do that…really helped me like get to where I am is seeing people that are like me and being able to emulate them."

One of the most discussed and cross-cutting instructional practices was the use of pronouns in STEM. Aside from one cited example with a Transgender teaching assistant, none of the students had experienced STEM instructors using pronouns in classes. A few of the students had experienced pronouns in other non-STEM classes (History, Gender Studies, Cultural Studies, Writing), and students were upset at the disparity of not using them in STEM classes. Using pronouns to introduce yourself was described as a relatively easy practice for instructors, which sets a "different tone" and makes an instructor become an "active ally." Tied to pronoun use, Erin and Naseem talked about being misgendered in STEM and why it bothers them because it highlighted inherent sexism. As Erin described it,

> I think it still speaks to like the whole like equality thing between men and women because it's like if men and women were actually equal in our society then like it wouldn't be a big deal if you mis-gendered someone but like, oh if you like miss gender a man, it's like, oh that's like an attack on his person.

The use and attention to appropriate pronouns was described as a relatively easy to implement inclusive practice that would bolster relational resources with instructors. Research on pronoun use is emerging in the literature, mostly documenting the negative psychological impacts on Transgender and non-binary students being misgendered (MacNamara et al., 2017; Pryor, 2015). Results here suggest that attention to pronoun use is less present in STEM environments.

Student-initiated study partners.

Prior research on student-initiated study groups in STEM have documented their formation based on student needs (Sandoval-Lucero et al., 2012), the development of group roles and technological facilitation (Sandoval-Lucero et al., 2012), their ability to co-construct meaning (Dalitz & Australasia, 2014), and the impact they have on learning outcomes after long-term formation (McCabe & Lummis, 2018; Micari et al., 2010). Educational specialists suggest the ideal study group sizes should range from three to five peers (Gokhale, 1995). Students in the focus groups readily shared about their use of study groups in STEM with two emerging themes: study groups were often described as impersonal and study dyads with a close ally were preferred over larger study groups.

Jesse, Alex, and Flora all discussed how their past study groups have been impersonal and not fostered social connections. Jesse has experienced a need in mathematics to develop study groups and study sessions, but these are usually people separate from who he interacts with socially and usually are "specifically focused on the math work." As Aidan described it, even though she has gotten "really close" with a peer in her mathematical reasoning class and they study together, "it's not a personal connection because we just do the math together." Aidan described the relationship that even though they can talk about other things they don't share secrets and are not "buddy buddy." Flora was recently a part of three different study groups where the focus was to "get it done and that was it" and furthermore she could not recall the names of any of the people in those study groups. Katherine somewhat agreed with the experiences of Flora, but she has been in a study group for combinatorics where they talk about study habits and mental health. Talking about non-mathematical topics has mitigated against the impersonal nature of environment. In fact, Katherine said that because they are struggling in the course and talk about mental health, people have "correctly guessed" that she is part of the Queer community because, as she described it, Straight people are not usually knowledgeable about mental health. Katherine's experience may suggest that study groups for upper-division or more rigorous courses allow for deeper peer connections out of necessity, and that mental health and self-care strategies facilitate those interactions.

Given the impersonal nature of study groups, students at Black University shared their preference and use of study dyads with a close ally. Meh described that in her biochemistry class, they have a shared google document where 60 people are taking notes and then that will lead to study groups of 6 to 15 people forming in the library. Meh said that she doesn't like that size of study groups and instead prefers small groups or dyads. She described her interactions with a single peer that she studies with in biochemistry as follows:

> I have like this one like friend who isn't, even though [he] used to be my physics lab partner and now we're in biochem together, but he doesn't interact with any other of like my friend groups. It's kind of just like us like solo study or like solo hang out…and he's like the one person that's like not in any of those groups that like I have told like within the first time of us like hanging out outside of class about my Queer identity

Meh said that it's been an interesting experience working with this one peer because they are "super Christian" and she expected him to be rude, but it has been a productive study dyad where he will ask questions to better understand her identity as Pansexual. Meh said she could study with other friends in that course, but they intimidate her because she doesn't feel confident in her ability. She said that she and current study partner "were on the same level of like struggle."

Naseem agreed with Meh's description of the study dyad and shared that in her computer science course she studies with one individual who she described as "not even LGBT, he's one of those Straight people that's an alliance." Naseem went on to further share that not only is he one of the good ones, that is funny and nice, but "he only hangs out with Lesbians." Flora agreed with the discussion, "I have a very similar like one person" who she "trusted outside of the Queer space." The use of study dyads with an Ally may be a mitigating strategy to provide safety for Queer-spectrum students when study STEM topics, versus larger groups which foster greater opportunities for interacting with a disapproving peer.

External resources

There were five relational resources identified from environments external to the classroom, which included those formed through: Queer and STEM groups (e.g., out in STEM), STEM groups, Queer groups, out role models, and other relationships.

Queer and STEM groups.

Queer and STEM student groups are steadily forming at institutions of higher education. The largest network of such student groups is Out in STEM (oSTEM), which has chapters at 107 institutions across the United States. Undergraduate student chapters of oSTEM existed at Black University and Gold University, and a graduate student chapter existed at Blue University. All students in the focus group at Black University were members of oSTEM, and at least two of the students from Gold University had attended oSTEM events. Three of the students at Blue University were aware of the existence of oSTEM but were disappointed that it was focused on graduate students. At the time of this study, there was not an oSTEM chapter at Cardinal University.

Students in the focus groups at Black University and Gold University described the impact of being a part oSTEM as contributing to overwhelmingly positive experiences in STEM. The benefits of the oSTEM relational resources included education about Queer issues, fostering social relationship within the group, providing networking of known allies outside the group, and empowering students through role models.

Flora and Erin discussed how they learned terminology and current issues related to the Queer community through oSTEM relationships. For Flora, oSTEM was especially impactful, since she attributed her involvement with oSTEM as the only reason she was out in college. She was able to spend a year interacting with the members and the founder of oSTEM until she was able to, “feel safe in this space and like feel comfortable with like my identity.” As such, Flora described the impact of oSTEM as, “everything came from oSTEM and all of my knowledge about everything.” 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. Naseem said that over the last year being in oSTEM she has become more educated and an activist in the Queer community. Naseem and Flora’s experience connecting with the oSTEM community through a disciplinary connection helped create a space and connection to their Queer identity and 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. Erin said if oSTEM didn’t exists she would not have as many friends but would still try and foster a Queer and STEM community. Meh, Naseem, Erin, and Flora all described the nature of the group as social and provided comfort and created what they called “oSTEM friendships.” The fostering of social connections was linked with students forming study groups, helping each other with internships, and even deciding to pursue a STEM degree. Naseem said the main reason she joined oSTEM, “was because of a literal support group because I was like really afraid to get into computer science. So, it's kind of a motivation for me.”

In addition to the fostering of social relationships within the group, being part of oSTEM facilitated networking of known allies or Queer-spectrum individuals outside the oSTEM setting. During the focus groups there were several times that students inquired about the names of individuals that were described as Queer-spectrum or allies in order to relate and network them within their own system of supportive individuals. Students also talked about how knowing oSTEM members impacted their ability to identify overlaps in courses and other STEM clubs. Meh discussed having friends that were in both oSTEM and Society for Advancement of Chicanos/Hispanic and Native Americans in Science (SACNAS). Naseem was pleasantly surprised to have oSTEM members in her computer science course and in her other STEM club. Flora said that all the communities she has formed in STEM classes have come from oSTEM, and this is especially so in large lecture courses, since she can form smaller groups and "dissect some of the STEM stuff."

At Gold University, the impact of oSTEM was discussed more in terms of empowerment and the presentation of successful role models. Swappi said that oSTEM has "positively impacted me" and he was able to make a few friends from attending the meetings. Swappi joined oSTEM in his first year while exploring his Queer identity, which he described in the following way, "I had never been Gay and a student before and so it was really, really like empowering for me to see that there are so many good like people who are, who are LGBTQIA plus who are or excelling in STEM." One of the most impactful experience for Swappi was a meetins where they had out professors sharing their experience and research with the oSTEM group. He said this gave him a lot of confidence in his identity. 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 has become more comfortable, she said oSTEM helped provide a sense of empowerment because "I can just be who I am." Fran's experience highlights possible oSTEM limitations in helping to develop relationships if students are not comfortable with their Queer identity at the time of accessing these resources.

STEM groups.

STEM groups are student clubs that are designed for STEM-interested students. Examples of clubs discussed were math club, marine biology club, engineering build club, and video game design club. STEM groups were often described as a place where

Queer-spectrum students didn’t belong or “fit the mold” of a STEM person. Such effects were mitigated in STEM diversity groups such SACNAS and Society of Hispanic Professional Engineers (SHPE). Aidan and Luciana discussed the math club at Cardinal University as exclusionary and they don’t have friends in the club. They said math club events primarily consist of being lectured at for another hour. 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.” Aidan said this hindered her experience in STEM because she has tried to attend these events, but then questioned if she should even be pursuing mathematics. Luciana and Aidan said they didn’t “fit the mold” because of their personality, their gender, and their sexual identity. James at Gold 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 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.

Meh is involved in SACNAS, oSTEM and the marine biology club. Meh described how she can be out in oSTEM and SACNAS, but that she is not out to anyone in her marine biology club. She said that in her marine biology club it's mostly cisgender white people, and she is the only person of color, which she described as leading to a sense of imposter syndrome. These results suggest that STEM clubs might highlight the lack of diversity in STEM through self-participation, and how they hinder Queer-spectrum students' participation and sense of belonging.

Queer-spectrum groups

Queer-spectrum groups are student clubs and organizations that are designed to serve the needs of Queer-spectrum students on campus. These include Queer student alliances, Queer people of color groups, Queer Greek organizations, and other Queer related groups. Such organizations have been shown to provide a safe and comfortable environment for peers to connect and help to retain Queer-spectrum students on campus (Pitcher et al., 2018). Additionally, the presence of such organizations on campus are positively associated with the psychological well-being of Queer-spectrum students (Woodford et al., 2018). Surprisingly only one student in the focus group (Alexis) referenced attending a specific Queer-spectrum student group designed for Asexual individuals. Most of the students discussed having a divide in STEM friends and Queer-spectrum friends, or not having any Queer-spectrum friends (e.g., Tim, John). Instead, students seemed to describe Queer-spectrum friends that they would hang out with socially but not through organized groups. Fran suggested that one of the reasons behind this divide is that she doesn't feel "Queer enough" within Queer spaces. 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-spectrum 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.

Out role models.

Having out role models in STEM was important to students; however, most discussed not knowing any Queer-spectrum STEM faculty or only knowing Queer-spectrum faculty outside of STEM. Luciana, John, and Aidan all said they didn't know any Queer-spectrum mathematics faculty, but it would be helpful to know they existed. At Blue University, they have an "Out and Ally Faculty list," but as Jesse described it most of the faculty listed are allies, and he still hasn't found a Queer-spectrum faculty member in either of his two STEM departments. John understood why out faculty were less visible since their job was to talk about math, "I don't think if I were a professor I probably wouldn't like come out in front of a class." Luciana said that faculty don't need to necessarily come out saying "I'm Gay," but that it would be helpful to have someone who "you could relate to…someone that's openly Gay."

Having out role models was as a mechanism to support Queer-spectrum student success to challenge normative assumptions of who is in STEM. Chelsea expressed this in the following way,

> (It's) really important and helpful and when you are seeing these departments that are really homogenously like cis hetero white guys, old white guys most of the time, it sends kind of an implicit message that like you can't succeed or you can't make it to that level so it can be discouraging.

Having out role models provide a vision of success for Isabell, "it is important to see people who you can identify with and look up to and say like, I could do that too." James shared a similar sentiment that when you are told you don't belong in the STEM field because you are Gay or Mexican, that seeing that representation can make a big difference. James discussed how having a mathematics instructor who included Queer issues in the curriculum, was one of the reasons he decided to double major.

There were a few instances of out faculty that contributed to students' positive experiences. As discussed earlier, Swappi was able to meet out faculty through oSTEM that provided models of success. Aidan discussed having out faculty in philosophy and religious studies that was "eye-opening" to see a faculty talk about those issues in the classroom. She attributed this to the dynamics of the classroom since it was more discussion oriented as compared to STEM courses. Flora knew one of the faculty members in health communication was Gay and she actively sought out this professor to develop a relationship. As a result, she is working on a research project with the faculty and described the department as "tight knit.". At the same time, Flora said her field of health communication was on the periphery of STEM, and more similar to a social science, allowing it to be more inclusive. The lack of out role models, combined with the positive impact they can have, speaks to the need for more visibility campaigns to provide role models for Queer-spectrum STEM students (Barres et al., 2017; Freeman, 2018; Knezz, 2019).

Other relationships.

Other relationships that were discussed in external learning environments were familial relationships and strangers or ambiguous individuals. Familial relationships were discussed by Erin, Naseem, and Tim. Erin and Naseem discussed how their parents supported them in STEM by countering the stereotype that women don't do STEM and actively encouraged them to pursue STEM. Tim said his parents also encouraged him with the dominant racial narrative that "Asians are good at math"

(Shah, 2019a; Trytten et al., 2012). Both familial supports highlight how they are based on racialized and gendered discourses about STEM, but not based on sexual identity discourses. This is likely due to the fact that, as seen in the previous chapter, there does not exist a single dominant narrative about Queer-spectrum students in STEM, and that often times it is erased or not assumed to exist in STEM learning environments. Additionally, familial relationships for Queer-spectrum students are unique from gender and race, since there is not necessarily a shared identity and one's family may not be aware of their children's Queer identity. This highlights the unique nature of Queer identity in STEM and its relation to (or lack of) familial relational resources.

Strangers or ambiguous individuals were discussed in the context of hearing slurs or disparaging remarks towards Queer-spectrum people. Students discussed that they had heard slurs on campus, but these remarks were not happening in the classroom. The levels of remarks ranged from protesters on campus saying Gay people would go to hell, hearing the word faggot, or off-hand jokes such as "that's so Gay." Some students linked these messages with STEM environments because they occurred in STEM buildings or because the campus generally prioritizes STEM majors. Several of the students said hearing slurs didn't really impact them personally, they felt it wasn't a big deal, and questioned whether they should even be offended. John described not being impacted when hearing disparaging remarks since it's the 21st century and so they really shouldn't have that opinion. Swappi said that because his STEM identity is more important, hearing such remarks didn't matter, and that he chooses not to be oppressed. This response highlights how a STEM identity can mitigate against oppressive relational resources towards one's sexual identity.

Ideational Resources

Ideational resources refer to the ideas about oneself and one's relationship to the practice of mathematics. This 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.

Classroom-Related Resources

There were three ideational resources from classroom-related environments. These were: perceptions that STEM is primarily White Straight men, STEM courses are designed to be rigorous and challenging, and STEM courses value technical solutions and neutral contexts.

STEM people are White Straight men.

Students described the identities of a typical STEM person that often positioned their own self outside the realm of what was valued in STEM. Ten of the students made mention to the cultural perceptions of a STEM individual being a multifaceted combination of White, Straight, cisgender man. These dominant identities were linked together and discussed in combination when describing a STEM person. Students described these identities in both the instructors they have had in STEM and the other students in the courses. As stated earlier in the role model section, Chelsea described the discouraging notion of seeing STEM professors as "really homogeneously like cis hetero white guys, old white guys most of the time." These notions of the typical STEM identity contributed to students saying they didn't feel like they "fit the mold," being “intimidating,” exclusionary and feeling pressures of being pushed out of the field. Isabella said these exclusionary pressures were experienced in interactions she had with peers, “because it's even been shown like as like someone who comes off as like a cisgender woman. Like I'm more likely to be excluded from like conversations I have to like work harder to prove myself for like STEM classes.” James and Erin provided some counter evidence saying that due to the context of the university being ethnically diverse there were more students of color in their STEM classes.

Students also talked about the impact of a singular identity, mostly in terms of either women or students of color being under presented in STEM. Erin, Katherine, and Meh all discussed the reduced number of women in their STEM classes. Katherine said sometimes you might be the only woman in the course. Erin does computations in her class that have shown the ratio of men to women is five to one. Meh described being the only woman places pressures on you and can be exclusionary. “And I think that's why it becomes like part like that exclusion experience. It's like being the only woman. Like, like uh, like I know the dropout rates for women.” Meh also mentioned the lack of students of color in her major, and Luciana mentioned the lack of Latinx role models in STEM. Katherine was the only student to talk about the lack of Queer individuals while not evoking other identities. As she described it, “Most of the people I meet in STEM are not Queer like straight up that is just how it is. They don't identify as Queer even if maybe they're hetero flexible.” As demonstrated in the previous excerpts, Queer-spectrum students draw on the underrepresentation of multiple identities to make sense of Queer-spectrum representation and inclusion in STEM environments.

STEM courses are rigorous and challenging.

Students described the idea that STEM courses are designed to be rigorous, challenging, hard, or competitive. When these notions were not countered with ideas of productive struggle, this triggered imposter syndrome for several students. Swappi said STEM courses tend to be more stressful than other courses given the challenge of the course topic, which he said, might be more overwhelming for Queer-spectrum students. Aidan said most people in the mathematics courses are struggling and these struggles have made her question if she should continue to pursue mathematics. Cat shared a similar idea that mathematics classes are "very competitive" and that if you are Queer-spectrum you might be impacted more from that type of struggle. As cat explained,

> [It] takes a lot of energy to want to be in STEM. It's a lot of like having to practice every single day and keeping up your motivation to go to class. And if you're dealing with external stress, I think that can definitely reduce your ability to commit to all of that…So if you're at all vulnerable just by existing, you're going to feel that magnified.

Flora, Erin, Meh, and James all shared that Queer-spectrum students need to succeed in STEM courses to "prove that you understand this concept" to yourself or so that you are seen as "valid in this space" in order to challenge imposter syndrome. As James stated it,

> Because we already had this idea that stem is not for us or that is harder to succeed in stem as a LGBTQ person even if we haven't really experienced that at all yet. But I feel like there's already this idea that you will struggle I feel like, doesn't this have something more to do with like maybe stereotype threat and imposter syndrome.

Luciana shared that she too was currently struggling in mathematics courses but has had a course that emphasized productive struggle. She described this as leading to a viewpoint that "struggle comes first and then your identity comes." Luciana described how framing STEM courses as productive struggle could be especially impactful for Queer-spectrum students.

> Once we realized that the struggle is, you know, good and that everyone was struggling, like somehow it our personalities just came through… if you struggle in math doesn't mean you're a bad mathematician. I think that like somehow it resonated with like people who are LGBTQIA

James and Tim communicated similar ideas that they appreciated the challenges in STEM when they were given the resources to be supported. The ideational view that STEM courses are rigorous or challenging had the potential to exclude Queer-spectrum students by triggering imposter syndrome, yet a framing of STEM as productive struggle could resonate more with Queer-spectrum students who may have personal history of resilience.

STEM values technical and neutral contexts.

Students in the focus groups described how STEM courses emphasize technical computations and neutral contexts, as opposed to emphasizing personal connections or including social justice issues. For some students, this view of STEM was a beneficial resource that allowed them to focus on course content. Other students described this emphasize in STEM as a false representation since science is influenced by individuals. Students described STEM as “not social,” “getting a solution,” and “detached” from discussion of identity. Isabella and Fran described STEM as detached, mainly because the goal was to get an answer to a particular problem and getting a passing grade and moving on to the next course. Tim and Swappi suggested that STEM was removed from one’s identity, that you could solve problems without a need to consider issues of identity, and this was generally a positive approach of the courses. Flora also appreciated the view of STEM courses as taking an objective stance,

> I really liked the objective or neutral discipline, like the idea of having like an escape because I'm not necessarily like comfortable being out, but that's not like in like math class kind of circumstances, but that's not always a bad thing. I kind of like having an instance where I don't have to

> like, ‘hello, I'm flora and this is all of my things. Here are all of the things that you need to know about me.’ I like just having like an objective with people and not having to talk.

Flora acknowledged that although anyone can succeed in STEM as an objective field, if you are not inherently gifted, and the environment excludes Queer-spectrum people, that is when it can “damper your” experience. James expressed a similar tension of enjoying STEM because it doesn’t have to include issues of social justice but feeling expectations that because of his Queer identity he should desire such topics.

> So, I feel like in stem I don't have to worry about all these issues, and it does bring some comfort. But the same time…maybe I should be doing more, you know, maybe I'm just too comfortable… So, it's like a combination of like confusion of like whether it's a good field or a bad field because it's like you're getting what you want, but at the same time it's not having the effect that you expect.

Alexis and Jesse expressed an interest in wanting to see more social justice applications in their STEM fields because they thought the objective nature of STEM was a false representation. Alexis said not having social issues in STEM means that issues of your identity don’t seem related and can’t as easily come up. She described how, although STEM was viewed as objective, it’s heavily influenced by the individuals who perform STEM

> You can't just separate objective quote unquote scientific work from the people doing that work. That's not, that's not possible. Um, and like even with the supposedly objective work, you've still got analysis involved and the people doing that analysis matters. And then like how you look at that analysis matters and that can be effected by everything. Like the assumption is that your identities don't matter and sometimes that can be true in certain contexts, but it like identities matter to people and people are the ones doing the work.

Jesse also wanted more connections within mathematics to social justice issues because this work was necessary to combat biases that existed in the field. Jesse said there is a hesitancy in STEM to do anti-discrimination work

> It's seen as like, that's not something that's needed. But also, like systems that thrive on like the norm and so they keep like snowballing, I guess. If you don't actively combat them, they're going to happen. So, I think that that's like a, something in STEM that like people don't think that they need to do anything, but by not doing anything, they're actually furthering like these like "isms".

The description of STEM as a technical and solution-oriented field aligns with engineering research that has cast engineering education within a technical/social dualism (Cech & Waidzunas, 2011; Leyva et al., 2016). In this alignment, technical skills are valued in engineering, while social skills such as communication and management are not given the same importance. This can result in Queer-spectrum issues being cast as “political” or “social” and thus being deemed irrelevant to serious discussion in the field. This view is in alignment with the erasure discourse discussed in the previous chapter and can result in Queer-spectrum students being marginalized in STEM environments.

External resources

The three ideational resources from external related environments are: the role of diversity initiatives within STEM, the impact of historical discrimination on students’ ideas about marginalization, and the variation in Queer-spectrum exclusion within STEM.

Diversity initiatives.

Although efforts to diversify STEM fields were described as needed, based on the perceptions of STEM individuals as White Straight men, current diversity initiatives were viewed problematically because they excluded Queer-spectrum individuals. As Chelsea put it, programs exist related to “women in STEM and people of color in STEM, but there’s not a lot of LBGT in STEM.” This conveys an ideational resource that diversity was being valued in STEM, but only regarding gender and race. The students in the focus group at Black University had a prolonged conversation about diversity initiatives in STEM. Meh raised the notion that such efforts emphasize that

> we want women, yes, we want people of color and those are the minorities, and they don't consider different genders or sexualities as part of that minority. I feel like it's not considered a minority.

Erin agreed with this sentiment, suggesting she had never seen a push for Queer-spectrum engineers, but has seen lots of effort around women and students of color. Meh did a presentation on available internships in STEM. She was able to find internships targeting gender, race, and even first-generation status, but

> there's like no mention of like anything Queer and that like, that irritates me. It's just like, well, we're also a minority. Like, why are you ignoring like this aspect of like minorities? Like I don't get that.

Naseem and Flora said that the lack of including sexual identity in diversity efforts, may suggest STEM is okay with having homophobic and transphobic individuals apply for such positions. Each of the students agreed that it was “annoying” that Queer identities were not even acknowledged in these initiatives. There were also tensions in appearing to support diversity but not fully appreciating the need. For example, 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.

Historical discrimination.

Students 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 acceptance 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 also brought up Alan Turing being chemically castrated and persecuted. Even though she said that wouldn't happen today, she still wasn't sure "what you are dealing with" in STEM. Given this discrimination, she also expressed that she wishes she could hide her gender in STEM spaces. 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.

Queer exclusion.

The experiences of Queer-spectrum students in STEM are not universal, and certain Queer identities illicit different levels of perceived privilege and exclusion. One of the most notable and discussed differences in identity is that of Asexual students. Luciana, Isabella, and Flora each identified as Asexual and all of them expressed hesitancy of whether they were "allowed" to participate in this research because of their Asexual identities. Each communicated a sentiment that Asexual identities weren't considered part of the Queer community, even though recruitment emails expressly listed Asexual identities. Luciana initially wasn't going to attend the focus group, but through email correspondence with me, she agreed to participate. She described her hesitancy to attend for the following reasons:

> Like basically I'm Asexual on the sexual spectrum and I was like, I feel like I get too much privilege from being, you know, like I don't tell people basically and I get too much, you know, Straight privilege. I get too much like, like people don't assume I'm LGBTQA and I don't like to identify myself as a part of it.

Luciana went on to say that at times she doesn't feel comfortable using the Asexual label because so many people have denied it being real, and this has led her to not disclose her Asexual identity, "I don't even tell people like I'm very close friends that don't know I'm in the Asexual spectrum." Luciana said it easier in STEM to not come out as Asexual because you are not hiding a Queer partner or relationship, which is something that would be harder for someone who is Gay or Lesbian. Flora shared similar sentiment that people deny the existence of Asexuality even within the Queer community there are exclusionary pressures.

> I can't fight their perception of my sexuality. Like as ingrained as I am within the Queer community. Like it's just tricky. Like if other people don't view me as Queer, I don't know what to tell them. So, I feel it's just like the double whammy that almost gets like if people do feel excluded by other Queer individuals and then by like people in the Straight community, then that gets really tricky. So, I think Asexual people just in general just avoid coming out just to avoid that exclusion altogether.

Isabella highlighted that although she questions her presence in Queer spaces, in STEM spaces she often feels included. She said that she feels accepted and doesn't modify her behavior among her STEM friends because there is less stigma attached to being Asexual compared to other minoritized sexual identities. "I feel included with my STEM friends. I feel like they're very open people…I mean, I feel comfortable with them." As such, Isabella feels comfortable coming out to her STEM friends who will respond usually with a science joke, “Oh, do you Asexually reproduce? I'm like, oh my God, that's something that happens a lot.”

Lucina, Flora, and Isabella’s experiences highlight that although they may experience “Straight privilege,” which allows for easier interactions with individuals in STEM, this might also create dissonance where they still experience exclusionary pressures that deny their Queer identity. This result is consistent with the quantitative findings from chapter four, showing Asexual students expressing more interactional patterns but having fewer differences in affective beliefs about ones STEM self.

Summary and Conclusion

Drawing on the identity resource constructs from Nasir (2011), I identified the material, relational, and ideational resources that Queer-spectrum students identified as either contributing to or hindering their experiences in STEM. Each of these resources are depicted in Figure 6.1, showcasing whether they promoted or hindered the development of Queer STEM identity. These identity resources do not represent the totality of available resources to Queer-spectrum students in STEM, but merely those mentioned and provoked within the focus groups. For instance, in the individual interviews, Jesse mentioned the material resource of following twitter handles of scientist in his field that were Queer-spectrum. These twitter handles provided him with a sense of visibility and belonging in pursuing his STEM field. Additionally, there are resources that are likely not salient to the student perspective, such as policy documents that express anti-discrimination stances towards sexual identity or “safe space” training programs used by faculty and staff to promote inclusive environments. Further research is needed with various stakeholders to understand the potential identity resources made available to Queer-spectrum students. Additionally, each of the focus groups occurred at institutions that were, by and large, Queer inclusive and provided a suite of resources for students. Future research is needed at various institutions to document how identity resources are made available within less inclusive environments.

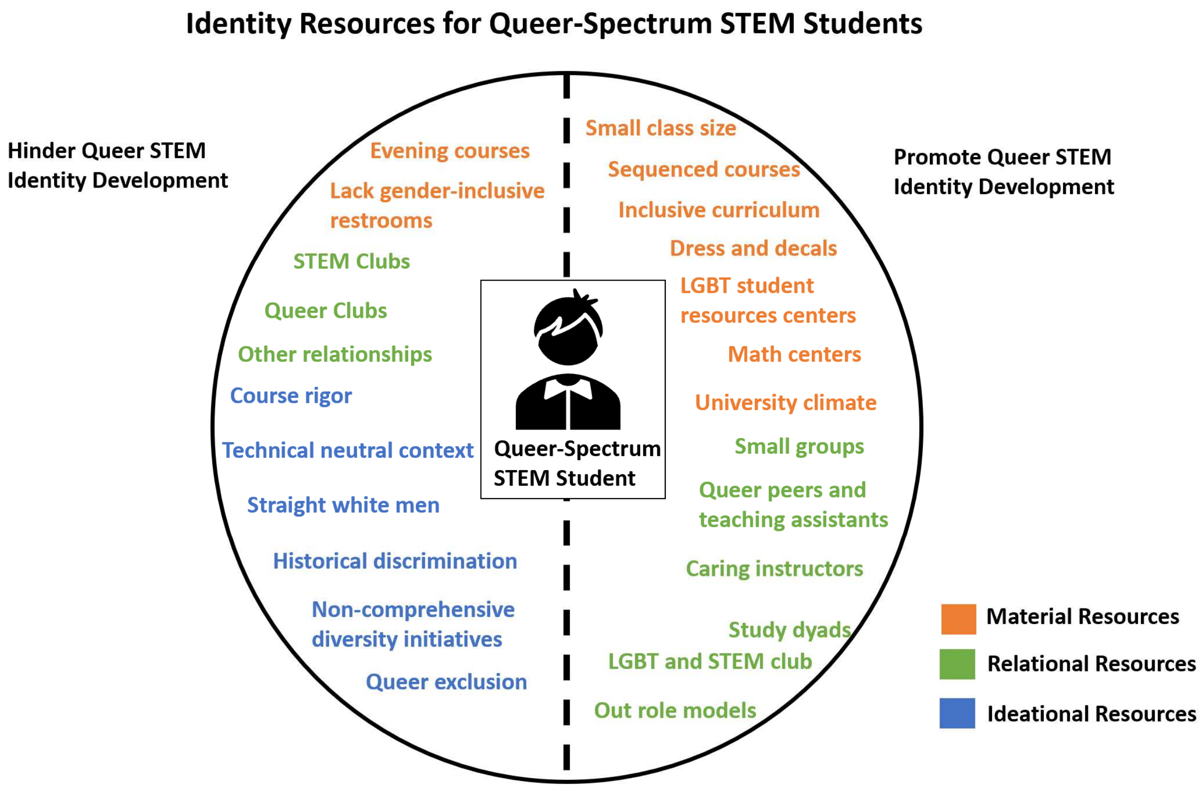


Figure 6.1. Visual representation of identity resources (material, relational and ideational) that promote or hinder a Queer STEM identity.

Three key findings were identified in addressing the research goal to understand how resources impact Queer-spectrum students' participation, perceived ability, and sense of belonging in mathematics. 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, the lack of positive ideational resources contributed to a lessened sense of both belonging and perceived ability. Next I elaborate on each of these three key findings.

Key Finding 1: Creating Smaller "Safe Spaces" and Relationships

Queer-spectrum students are forging and creating their own "safe spaces" within the STEM environment in order to allow for more robust positive participation. The idea of "safe spaces" have been well used within the Queer community to define a designated physical location where individuals who feel marginalized can associate freely and communicate about their experiences. However, safe spaces as a construct extend beyond the physical spaces. 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.

Key Finding 2: Fostering Academic and Social Integration

Queer-spectrum students conveyed the greatest sense of belonging in STEM when engaged with resources that supported academic and social integration. One of the key examples of this was in discussion of oSTEM, whose design was to foster a connection between the STEM discipline but also support networking and social support among students. Students in the focus groups discussed how oSTEM supported them in deciding a STEM minor, learning terminology, understanding their own Queer identity, and providing connections with others when in STEM classes. In contrast, STEM clubs which fostered the connection to the discipline, but not supporting students' Queer identity, were described as isolating. Queer clubs, which were designed to support Queer identity but not connect to the STEM discipline, were not utilized by the students in this study. As such, oSTEM, which seeks to foster this connection between STEM and Queer identity, was more well received and helpful in supporting a sense of belonging in STEM.

Additionally, positive instructor relationship that were described as caring and mentoring fostered a connection between the academic and social spheres of the students. For example, John being able to discuss with his advisor his ex-lover and Aidan describing her advisor as a life coach. Academic and social integration is also manifested in relationships with Queer TAs and Postdocs. Luciana described relating to her Queer-spectrum TA on a different level, and Chelsea described being invited to the Lesbian Postdoc's wedding. Future research is needed to fully understand the formation, development, and role that these relationships play for Queer-spectrum students, but by connecting the academic and social self, these relationships helped support a sense of belonging in STEM for students.

Key Finding 3: Lack of Ideational Resources

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. This will require rethinking what is valued in STEM and promoting more communicative and supportive environments that value productive struggle. Additionally, there is a need to confront both the historical discrimination within STEM and the underrepresentation of multiple marginalized identities without forgetting about Queer-spectrum students.

Chapter 7: Conclusion and Implications

The aim of this sequential transformative mixed methods study was to provide a broad window into the understudied nature of Queer identity in mathematics. I was motivated to undertake this study in order to further expand the research literature and to provide voice to the experiences of Queer-spectrum students in mathematics. Additionally, as a gay mathematics educator, I was personally motivated to conduct this transformative study to advocate for fostering inclusive environments for Queer-spectrum students in STEM. In this chapter, I begin with a review of the findings, looking across the three phases to provide a more connected view of Queer-spectrum student experiences in mathematics. I then discuss the limitations of this study as it was designed and enacted. I then highlight the direct implications this study has for practice and policy in STEM education. Next, I discuss future areas for research. I conclude this chapter with some final thoughts and reflections.

Summary of Findings

> *"We can only see a short distance ahead, but we can see plenty there that needs to be done."* - Alan Turing, Gay mathematician, and computer scientist

Queer identities can be broad, fluid, complex, and enacted in different ways by individuals. This complexity was partially illustrated in the methods chapter which included the rich and nuanced participant descriptions of students' Queer identity. Queer identity for these STEM students, was not just a label, but represented physical, emotional, and sexual attractions. It even went further for many students, such as Jesse, who described being Gay as a guiding orientation to the communities and views he holds about masculinity. For some of these students, having a Queer identity was important, salient, and impacted many decisions they made in life. For others, they described a Queer identity that was not impactful and only played a small role in their daily decisions. This variation of the impact of queer identity is one of the strengths of this study, which cast a broad net to understand the experiences of Queer-spectrum students in STEM. By recruiting students from mathematics classrooms, as opposed to oSTEM centers, I was able to reach students who did not place a large emphasis on their Queer identity. This helps contributes to the literature by adding the voices and experiences of Queer-spectrum students who did not place significant weight in their Queer identity and who expressed inclusive mathematical discourses towards their Queer identity.

The variation in Queer-spectrum experiences was also captured in the first phase of this dissertation study, which illuminated the differences within certain Queer-spectrum identities. Namely, the result that Asexual students report having more frequent or robust social interactions between their instructors and peers in mathematical environments. This stands in contrast to Bisexual and Queer+ students who report fewer social interactions with their instructors and peers in mathematical environments. I conjecture this difference in the interactional patterns within Queer-spectrum identities, is due to the mathematical discourses that position Queer identity as excluded and irrelevant in STEM environments which were identified in phase two of this study. More specifically, it is the pressures and belief system that cast sexuality as irrelevant to the goals of mathematics that are likely contributing to these difference in social interactions. This belief system appears to alienate Queer-spectrum students who have a more fluid identity, thus disengaging them from the social interactions within the classroom. At the same time, this discourse aligns more so with Asexual individuals, who may be more inclined to draw on social interactions in educational environments, as compared to achieving them in romantic encounters.

The exclusion-irrelevancy space further helps to understand the factors impacting the mathematical discourses that exists in STEM and why those are experienced differently by Queer-spectrum students. What is interesting in the identification of these two factors is that mathematical discourses were not driven by beliefs about success and mathematical ability. In developing this study, I drew largely from literature on racialized and gendered identities in mathematics (Martin et al., 2010; Trytten et al., 2012). I anticipated similar themes emerging around success or ability narratives and marginalized identities for Queer-spectrum students. Instead, what emerged were narratives around rightful presence and representation in STEM. I conjecture that because Queer identity is less visible to those not “in the know,” this makes it harder to leverage power structures that link marginalized identities with mathematical success. For instance, it’s more socially accepted to ask about race and gender on standardized exams, which have led to gap gazing in success outcomes. Instead, marginalizing power structures are leveraged towards Queer identities in order to treat them as irrelevant to the goals of mathematical, and thus erasing them from STEM settings. As the notable political AIDS advocacy group ACT UP famously captured in their advertisement to combat the AIDS epidemic, “Silence=Death.” While this might seem extreme, the silencing pressures of not talking about queerness in STEM is diminishing the capacity of Queer-spectrum students in mathematics. This was evidenced both in the regression models presented in phase one with negative indicators for each outcome variable and through the discussion of exclusionary mathematical discourses in phase two. These diminishing pressures likely contribute to the higher rates of Queer-spectrum students switching out of a STEM major (Hughes, 2018). Furthermore, the pressures to not talk about queerness in STEM likely contribute to findings in phase three, such that students are attending to the physical environment and material resources in order to gauge the acceptance of Queer identity in STEM.

As I identified in phase one this study, Queer-spectrum students overall report a diminished sense of belonging and engagement in mathematical classrooms. The greatest of these effects was in reported sense of community and positive math affect. Both of these measures capture a sense of whether one considers themselves a STEM individual. Both in terms of the positive affect (e.g., being interested, confident, able, and enjoying mathematics) and whether one considers themselves a part of the mathematical community. These quantitative results indicate that Queer-spectrum student are less likely to hold robust mathematical identity or a sense that one is a mathematical person. One of the reasons for this diminished sense of mathematical identity among Queer-spectrum students is likely due to the lack of visible role models that were identified in phase three of this study. How can we expect Queer-spectrum students to build a Queer STEM identity when they have never seen examples of its existence?

Consider the following thought experiment drawing on mathematical induction. In such proofs one must show the existence of the base case (n=1), assume that it holds for *n* and show that it works for *n+1.* What was learned from phase three of this study was that Queer role models provide the base case of a Queer STEM identity. Having a community of peers, such as out in STEM relationships assumes that it holds for *n*, and each student personally persisting is evidence of the *n+1* Queer STEM identity existing. What this thought experiment highlights is that a multifaceted approach is needed to support Queer STEM identity. Phase three identified these approaches to include material resources, relational resources, and ideational resources about what it means to be a STEM person. Some of the factors to support the development of Queer STEM identities are discussed in the implications for practice and policy section in this Chapter.

Another factor contributing to Queer-spectrum students having a diminished mathematical identity is the lack of ideational resources that promote Queer STEM identity development. All of the ideational resources that were discussed in phase three did not aid in the development of a Queer STEM identity. Instead, students held beliefs that mathematics was a field composed of mostly Straight, white, men. This ideational resource contributed to a sense that STEM is exclusionary to marginalized identities. This was mirrored in phase two of this study where a marginalized discourse was navigated by understanding STEM through the intersecting nature of oppression that exist towards various identities in STEM. These exclusionary pressures are not only drawn from current societal narratives and experiences in classrooms, but also historical events. In order to support Queer STEM identities, we as field need to address the historical exclusion and marginalization that has happened throughout history. This was evidenced by students referring to the discrimination of Alan Turing as markers for STEM discrimination towards Queer-spectrum individuals.

One of the key findings that emerged in phase three was the way in which smaller "safe spaces" were created and preferred by Queer-spectrum students in STEM environments. This included small classes, groupwork, study dyads, STEM research labs, and LGBT student resource centers. These resources helped promote a Queer STEM identity. At the same time, these resources might not be universally beneficial but instead represent mitigating strategies given the dominant discourses that exists that position sexuality as irrelevant (erasure), unseen (heteronormative), or discriminated against. What I mean by that is the beneficial resources identified in this study may change based on the environment and the discourses within STEM. For example, the need to create smaller “safe spaces” may not be necessary in a STEM environment that promotes an accepted or valued discourse.

This study compliments the few existing studies examining Queer-spectrum students in STEM which have highlighted the exclusionary pressures and expressed desires to not disclose identity while in STEM settings (Fischer, 2013; Smith, 2014). This study also complicates these notions by adding to the literature students who expressed inclusionary discourses and discussed their ability to disclose their Queer identity in STEM settings. Fischer (2013) puts forth the notion that supporting a student’s leading Queer identity can support their mathematical identity. Yet this study included students who did not have a leading Queer identity. As such, what resulted is that Queer-spectrum students were drawn to identity resources that supported the fusion of both identities. We see this in the desire for Queer STEM role models and out in STEM groups, while Queer student groups and LGBT student resources centers were not a productive or utilized to support students in this study.

Limitations

"Many LGBT people in my generation share growing up with a shameful secret and consequent low self-esteem. Perhaps this may drive us to work hard to succeed in order to prove our self-worth." – Ben Barres, Transgender neurobiologist

There are many affordances that this study provided in order to understand the experiences of Queer-spectrum students in mathematics. The multiple universities provided variability to understand the context of resources available to students. The relatively large number of student interviews, both individual and as part of the focus groups, allowed for a variety of experiences to be shared. The mixed methods design added power to this study by providing voice and explanatory reasoning behind the statistically significant differences that were identified in the quantitative analysis.

However, as with any research, there were also limitations in the design and enactment of this study. First, the recruitment efforts and context of this study were focused on introductory mathematics courses. There are reasons to focus on this important transitional period in undergraduate education, which is a pivotal juncture in the decision to pursue a STEM major. At the same time, this design decision was primarily driven by this study being supported within existing NSF-funded studies (PtC and SEMINAL), which were focused on introductory mathematics courses. As was expressed by some students, they were unsure how the mathematical discourses and experiences in mathematics would change as they progressed into upper-division courses. Further research is needed in this area to understand how mathematical discourses evolve over time and are shaped by the level of mathematics courses.

Second, another recruitment consideration in this study is that all the students who agreed to participate were "out" and willing to indicate on a survey that they were Queer-spectrum. This undoubtedly shaped the beliefs and resources that were captured from the interviews. There were students who participated who were only out to a few friends, several who were not out to family, and others who considered themselves out to almost everyone. What is missing from this study are Queer-spectrum students who have not come to define themselves as Queer or those not feeling comfortable to disclose their sexual identity on an academic survey in their mathematics course. For instance, Fran discussed how she initially attend oSTEM when she first started coming out, but because she wasn't yet comfortable with her sexuality, she stopped using that resource. In this way, the resources identified in phase three of this study represent identity resources best suited to individuals who have come to define themselves as Queer.

Third, although students were interviewed at a variety of universities, they were, for the most part, Queer-inclusive institutions. Three of universities were in large urban centers, all had an LGBT student resource center, and all had other services and programs for Queer students on campus. Several of the students pointed to the location of the university and broader campus climate as indicators for Queer acceptance in STEM. Additional research is needed at various institutional contexts, especially those that are perceived as less Queer-inclusive.

Finally, one of the goals of this research was to recruit students using the mathematics survey and not recruitment through LGBT student resources centers, as this presents a self-selection bias to those who may find more relevance in their Queer identity. This was accomplished in phase two of the research examining the discourses and navigational strategies, which is likely why a variety of discourses and strategies were shared by students. However, in phase three of this research, the lack of student response rates to the survey necessitated broadening my recruitment efforts to include LGBT student resources centers and oSTEM groups. The necessity to broaden recruitment for participation likely elevated resources that catered to the importance of Queer identity (e.g., oSTEM relationships, Queer STEM role models). Similar to the pilot which recruited through oSTEM, such students were more attuned to issues within Queer spaces regarding privilege, discrimination, and representation. However, the themes that were identified in phase one and two were drawn from mathematics classes. These themes were used in phase three and could have mitigated against some of these influences by providing contrasting experiences.

Implications for Practice and Policy

"All young people, regardless of sexual orientation or identity, deserve a safe and supportive environment in which to achieve their full potential." –Harvey Milk, openly Gay American politician

There are many implications for practice to support Queer-spectrum students that have been identified in this study, many of which were presented in Chapter 6. These included a need for Queer role models, oSTEM groups, small groupwork, community building through sequential courses, caring instructor dispositions, and inclusive curriculum. The use of inclusive curriculum was also explored in phase two through the presentation of Queer-themed mathematics problems. Students had various reactions to these problems, but most had never seen any Queer-themed problems in their mathematics classroom. The lack of Queer-themed mathematics problems thus represents a great opportunity to support Queer-spectrum students.

When reacting to Queer-themed problems students viewed the problems as relating personally to their Queer identity, making it more relevant and interesting for them. For instance, Ninah stated that the freshman attitude problem was, “like real data that also affects me directly as someone that's Queer.” This perceived benefit is consistent with the curriculum as a mirror metaphor put forth by Style (1988). In this metaphor, Style states that, “education needs to enable the student to look through window frames in order to see the realities of others and into mirrors in order to see [their] own reality reflected” (Style, 1988, p. 6). Through the inclusion of Queer mathematics problems, students described the curriculum as reflecting their own identity, and as such it produced positive reactions from most students. One of the features of the Queer mathematics problems that students viewed as beneficial, is that they depicted a progress orientation towards Queer themes, such that society was becoming more accepting or tolerant of Queer issues. For instance, the freshman attitude survey problem (see Appendix C) showed that opposition to homosexual relationships has been declining. The don’t ask don’t tell mathematics problem both showed an eventual decline in military discharges but also the historical end to the DADT policy. The desire for a progress orientation of Queer-inclusive curriculum helps inform instructional design principles moving forward. Incorporating Queer-inclusive curriculum in mathematics can happen at the classroom level tomorrow through modifications to already adopted curriculum or can be systemic through policy adoptions. The Gay Lesbian Education Network (GLSEN) has resources available for creating such curriculum (https://www.glsen.org/inclusive-curriculum).

Fostering instructor caring relationships and providing role models for Queer students means communicating an awareness and openness to Queer issues and language. For instance, although the use of pronouns was not ranked highly as a beneficial resource in the identity resource matching activity in phase three, it was mostly because students conveyed that their STEM instructors never used pronouns. This sentiment was supported in the individual interviews where students conveyed a marginalized discourse because STEM instructors disregarded or assumed students' pronouns based on gender performance. Queer spectrum students communicated that the practice of using pronouns was small, simple, but had a large impact on knowing that an instructor was inclusive. As Bisexual comedian Margaret Cho stated, "sometimes when we are generous in small, barely detectable ways it can change someone else's life forever." The use of pronouns is one such technique that can shape students' lives by promoting an inclusive Queer STEM environment. As these issues are constantly evolving and adapting to societal pressures, this guidance of pronoun use is situated in a particular time and context. Instructors can exhibit a caring disposition through ongoing professional development and learning. A first place to start is through partnerships with oSTEM student organizations (www.ostem.org), the gay and lesbian education network (www.glsen.org) or through the national gay and lesbian task force (www.thetaskforce.org). These organizations can provide resources for instructors that help support students' Queer identity formation. Such resources include best practices with the use of pronouns when introducing oneself, supporting gender-nonconforming students, and creating anti-discrimination policies.

I started this dissertation study by highlight how policy statements from professional organizations have failed to explicitly include sexual identity or sexual orientation. As shown in Chapter 6, students' attend to the lack of inclusion of sexual identity in diversity efforts, which they interpret as messages about Queer exclusion in

STEM. Policy documents need to be updated to explicitly address sexual orientation. Since Queer-spectrum individuals are the “invisible other” (Toynton, 2016), Queer identity risks erasure by not explicitly addressing it in policy documents and statements.

Future Research

“My silences had not protected me. Your silence will not protect you.” – Audre Lorde, Lesbian poet

Throughout this manuscript I have highlighted future areas of research. For instance, broadening the setting to include upper-division mathematics courses and conducting this research at less Queer-inclusive universities. Another area for future research is understanding how teacher relationship and role models can support Queer-spectrum students in mathematics. Unlike other shared visible identities, queerness, as the “invisible other” manifests itself differently than gender and racial relationships with instructor role models. As such, there is a need to document the impact of visibility and non-heteronormative performances by instructors in mathematics classrooms. It is especially important to understand what environmental and social features allow Queer-spectrum instructors to “come out” in the classroom without fear of reprisal or accusations of “sexualizing” their classrooms. Additionally, future research is needed to understand the impact of inclusive practices of Straight ally teachers, such as using pronouns, confronting microaggressions, or displaying ally signs in mathematical settings.

A second area for future research is understanding the impact of Queer-inclusive curriculum in classroom settings. While there are existence proofs of Queer-inclusive curriculum, there are relatively few rigorous or thorough studies to understand the use of these curriculum in classroom settings. For instance, in this study students were presented with the Queer-themed mathematics problems in an interview setting and asked to speculate how they would react in a classroom setting. Additional research can develop principles for curriculum creation that appropriately center Queer identities in mathematics. Furthermore, classroom studies and professional development are needed to understand how to enact this curriculum in the classroom. It is possible that without careful consideration and guidelines, implementing Queer-inclusive mathematics curriculum, may create a less inclusive environment through students or parents marginalizing such ideas when encountered.

A third area for research focuses on the need to revise and expand the use of the student survey that was implemented in this study. Future revisions of the survey should include items related to “outness,” “visibility,” and the importance of Queer identity. These measures will shed light on the various experiences within Queer-spectrum identities. For instance, these factors will help unpack why Bisexual and Queer+ students are reporting fewer social interactions and if those are in fact tied to heightened visibility or identity mismatch. This study only examined sexual identity in the quantitative analysis in order to limit the scope of this dissertation. This is problematic as it excludes examining the outcome for Transgender and Non-binary individuals in the analysis. This decision was also driven by the fact that gender identity was accounted for in a separate item on the survey. Future research is needed to understand the impact and intersection of gender and sexual identity in STEM. Lastly, expanding the use of this survey in other introductory courses outside of mathematics and science will help to understand the unique nature of STEM as compared to factors that may be cross-cutting for Queer-spectrum students in education overall.

Final Thoughts

"I'm not missing a minute of this. It's the revolution!" – Sylvia Rivera, Latina LGBTQ Stonewall activist

My hope is that one will not walk away from this study with a deficit or pessimistic view of Queer-spectrum students in mathematics. It is critical that we recognize and build upon the unique strengths of Queer-spectrum students in mathematics, rather than focusing only on the challenges they face. Ultimately, this is a matter of fixing the system, not fixing people. Being Queer and in mathematics need not be a disjoint set, and through further research and understanding we can begin to support the next generation of Queer mathematicians who will shape and influence the discipline of mathematics.

In doing this research, I have grown, I have hurt, I have cried, and I have felt a great sense of appreciation for the courage and resiliency that each of the students in this study have exhibited. When I first undertook this study, I was not sure of the outcomes or how it would be received within the STEM community. My aim was to conduct a transformative study to improve the lives of Queer-spectrum students in STEM. I hope that the results that I have presented in this study will begin that conversation. I also take solace in potential support that was provided to the students who were a part of this study, who were shaped and transformed by sharing their stories. Many of the students who I interviewed thanked me personally for having the space to share their experience in STEM. For many of them, this was the first time they had been asked about their Queer identity and its relation to STEM. My hope is that I shared each of their experiences as authentically as possible. Each of them are the true heroes that are leading the movement to create the space for Queer-spectrum students in STEM. To me this study is only one data point on the movement to making STEM and society a more inclusive space. With that, I end this study with the following quote from the first openly Gay United States Senator Tammy Baldwin from Wisconsin.

> *All of us who are openly gay are living and writing the history of our movement. We are no more – and no less – heroic than the suffragists and abolitionists of the 19th century; and the labor organizers, Freedom Riders, Stonewall demonstrators, and environmentalists of the 20th century. We are ordinary people, living our lives, and trying as civil-rights activist Dorothy Cotton said, to 'fix what ain't right' in our society.*

Appendix A: Pilot Survey Comparison Statistics

The following table displays the mean comparisons between Queer and Non-Queer-spectrum students on the pilot version of the SPIPS-M Survey.

Item	p-Value	Mean Queer Students	Mean Straight Students	Effect Size Cohen's d (Queer mean – Straight mean)
Helpfulness *(1= Very Helpful, 4=Does not occur)*				
Watching the instructor(s) solve problems	.039**	1.34	1.44	-.16
Participating in whole-class discussions	.081*	2.17	2.04	.13
Presenting my (or my group's) solution to others in class	.08*	2.53	2.39	.14
Exams	.026**	1.99	1.86	.18
Descriptiveness of Regular Class Setting *(1=Does not occur, 5 Very Much)*				
I work with peers outside of class on math problems	.084*	3.02	3.19	-.13
I listen and take notes as the instructor guides me through major topics	.074*	4.30	4.16	.14
I receive immediate feedback on my work during class (e.g., student response systems such as clickers or voting systems; short quizzes; etc.)	.018**	2.53	2.78	-.19
The instructor knows my name	.016**	3.55	3.24	.19
Frequency of Activities in Recitation Section (0% of time to 100% of the time)				
Working on problems in small groups	.082*	40.95	36.68	.18
Descriptiveness of Recitation Section *(1=Does not occur, 5 Very Much)*				
I listen and take notes as the instructor guides me through major topics	.051*	3.44	3.69	-.21
I receive immediate feedback on my work during class (e.g., student response systems such as clickers or voting systems; short quizzes; etc.)	.096*	3.02	3.6	-.18
I regularly talk with other students about course concepts during class	.069*	3.43	3.66	-.20
I present my ideas (or my group's ideas) to the whole class	.051*	2.59	2.85	-.22
I share my ideas and explain my thinking during whole class discussions	.045**	2.66	2.93	-.22

Item	p-Value	Mean Queer Students	Mean Straight Students	Effect Size Cohen's d (Queer mean – Straight mean)
I have enough time during class to reflect about the processes I use to solve problems	.068*	3.24	3.46	-.19
There is a sense of community among students in this class	.004**	3.09	3.46	-.31
The instructor calls on a wide range of students when asking questions in class	.047**	3.29	3.55	-.21
The instructor adjusts teaching based upon what the class understands and does not understand.	.066*	3.51	3.74	-.19
The instructor explains concepts in this class in a variety of ways	.013**	3.34	3.65	-.26
Included in Recitation *(1=Less than other students, 3 More than other students)*				
How much praise does your work receive?	.008**	1.92	2.02	-.26
Attitudinal Shifts *(1=Significantly Increased, 5=Significantly decreased)*				
My interest in mathematics	.033**	3.07	2.89	.16
My enjoyment of mathematics	.056*	3.16	2.98	.15
My confidence that I can do mathematics	.016**	3.05	2.82	.18
My ability to learn mathematics	.056*	2.76	2.60	.15
My belief that mathematical abilities can be developed through dedication and hard work	.036**	2.57	2.39	.16

*p < .1; **p<.05

Appendix B: Student Post-Secondary Instructional Practice Survey (SPIPS)

Welcome! The Progress through Calculus project is working with {Institution} to better understand precalculus and single-variable calculus courses at your institution and across the country. We have asked your instructor to award you course credit for considering participating in our study.

If your instructor is offering course credit, you must enter your school ID number, which course section you are enrolled in, and your decision about participating in order to receive it. You do not need to participate to receive credit, but you must submit these answers.

Please read the project description and informed consent that follows. Thank you in advance for your time, and your contribution to this work.

{Institution} Student ID:

Which course and section are you enrolled in?

Course name and number
Instructor
Scheduled time
Discussion/Lab Section

Results of this survey and the information we gather visiting {Institution} will be kept completely confidential. Participation is optional, but we hope you will contribute to our study, so that we may better understand your experiences with precalculus and/or single-variable calculus courses at {Institution}. In addition to questions about your experience in your current mathematics course, this survey contains a few mathematics questions and questions about your background and prior experience. A fuller explanation of the study and our data management procedures is available here. Please familiarize yourself with the information in that document, and keep a copy for your own record. For more information about the project, you can go to maa.org/ptc, and if you have any questions about your participation please contact Chris Rasmussen at crasmussen@mail.sdsu.edu.

Do you consent to participate in this survey and allow the researchers to access your transcript data (course history, grades, etc.)?

- Yes
- No

To participate in this survey, you must be 18 years old, or older. Are you?

- Yes
- No

Q11 What things (class activities, projects, campus resources, clubs, people) have you found to be particularly **helpful** to you as a student in {Course Name}?

Q12 What things (class activities, projects, campus resources, clubs, people) have you found to be particularly **unhelpful** to you as a student in {Course Name}?

Q13 Roughly how often have you missed class meetings for {Course Name}?

	(Almost) never (1)	Occasionally (2)	Frequently (3)	I've missed more than half the classes (4)
Regular class meetings	○	○	○	○
Recitation/lab section	○	○	○	○

Q14 What percent of **regular class time**, over the whole term, did you spend…
________ Working on problems individually
________ Working on problems in small groups
________ Participating in (contributing and/or listening to) whole-class discussions
________ Listening to the instructor lecture or solve problems

Q15 What percent of **recitation/lab time**, over the whole term, did you spend…
________ Working on problems individually
________ Working on problems in small groups
________ Participating in (contributing and/or listening to) whole-class discussions
________ Listening to the instructor lecture or solve problems

Q18 Indicate the degree to which the following statements describe your experience in {Course Name}.

	Very descriptive (5)	Mostly descriptive (4)	Somewhat descriptive (3)	Minimally descriptive (2)	Does not occur (1)
The test questions focus on important facts and definitions from the course	○	○	○	○	○
The test questions require me to apply course concepts to unfamiliar situations	○	○	○	○	○
I use technology or online resources in relation to this course	○	○	○	○	○
I make connections between related ideas or concepts when completing assignments	○	○	○	○	○
I receive feedback on my assignments without being assigned a formal grade	○	○	○	○	○
I see my instructor(s) outside of class for help	○	○	○	○	○
I work with peers outside of class on math problems	○	○	○	○	○
I attend tutoring sessions outside of class time	○	○	○	○	○

Q19 Which technologies and/or online resources do you use? Mark all that apply.

- Graphing calculator
- Clickers or other polling devices
- Computer algebra software (e.g., Maple, Matlab, Mathematica)
- Online search engines (e.g., Google)
- Online textbooks
- Online tutorials (e.g., Khan Academy, YouTube videos)
- Online computational or graphing tools (e.g., WolframAlpha, Geogebra, Desmos)
- Online homework (e.g., WebAssign, MyMathLab, Webwork)
- Online forums (e.g., Chegg, StackExchange, Slader)
- Learning management systems (e.g., Blackboard, Canvas, Piazza)

Q20 Where do you go for tutoring?

- Tutoring center at {Institution} (please identify the center): _____
- Office hours
- Friend(s)
- Private tutor
- Extra course sessions (e.g., supplemental instruction, extra lab)
- Review sessions
- Other (please explain)

Q 21 Indicate the degree to which the following statements describe your experience in **regular course meetings** of {Course Name} with {Instructor Name}.

[Question options for Q21 repeat with the following question]
Q24 Indicate the degree to which the following statements describe your experience in **recitation/lab sections** {Recitation Time} of {Course Name}.

	Very descriptive (5)	Mostly descriptive (4)	Somewhat descriptive (3)	Minimally descriptive (2)	Does not occur (1)
I listen as the instructor guides me through major topics	○	○	○	○	○
The class activities connect course content to my life and future work	○	○	○	○	○
I receive immediate feedback on my work during class (e.g., student response systems such as clickers or voting systems; short quizzes)	○	○	○	○	○
I am asked to respond to questions during class time	○	○	○	○	○
In my class a variety of means (models, drawings, graphs, symbols, simulations, tables, etc.) are used to represent course topics and/or solve problems	○	○	○	○	○
I talk with other students about course topics during class	○	○	○	○	○
I constructively criticize other student’s ideas during class	○	○	○	○	○
I discuss the difficulties I have with math with other students during class	○	○	○	○	○
I work on problems individually during class time	○	○	○	○	○
I work with other students in small groups during class	○	○	○	○	○
Multiple approaches to solving a problem are discussed in class	○	○	○	○	○
I have enough time during class to reflect about the processes I use to solve problems	○	○	○	○	○
A wide range of students respond to the instructor's questions in class	○	○	○	○	○

The instructor knows my name	○	○	○	○	○
Class is structured to encourage peer-to-peer support among students (e.g., ask peer before you ask instructor, having group roles, developing a group solution to share)	○	○	○	○	○
There is a sense of community among the students in my class	○	○	○	○	○
The instructor adjusts teaching based upon what the class understands and does not understand	○	○	○	○	○
The instructor explains concepts in this class in a variety of ways	○	○	○	○	○
I receive feedback from my instructor on homework, exams, quizzes, etc.	○	○	○	○	○
I share my ideas (or my group's ideas) during whole class discussions	○	○	○	○	○
A wide range of students participate in class	○	○	○	○	○
My instructor uses strategies to encourage participation from a wide range of students	○	○	○	○	○

Q22 For each of the following activities, please indicate how much each helps your learning in {Course Name}.

	Very helpful (3)	Somewhat helpful (2)	Not helpful (1)
I listen as the instructor guides me through major topics	◯	◯	◯
The class activities connect course content to my life and future work	◯	◯	◯
I receive immediate feedback on my work during class (e.g., student response systems such as clickers or voting systems; short quizzes)	◯	◯	◯
I am asked to respond to questions during class time	◯	◯	◯
I talk with other students about course topics during class	◯	◯	◯
I constructively criticize other student's ideas during class	◯	◯	◯
I work on problems individually during class time	◯	◯	◯
I work with other students in small groups during class	◯	◯	◯
The instructor knows my name	◯	◯	◯
Class is structured to encourage peer-to-peer support among students (e.g., ask peer before you ask instructor, having group roles, developing a group solution to share)	◯	◯	◯
I receive feedback from my instructor on homework, exams, quizzes, etc.	◯	◯	◯
My instructor uses strategies to encourage participation from a wide range of students	◯	◯	◯

Q23 To what extent are the following course elements helpful to your learning in {Course Name}?

	Very helpful (4)	Somewhat helpful (3)	Not helpful (2)	Not applicable (1)
Online homework	○	○	○	○
Written homework	○	○	○	○
Exams	○	○	○	○
Worksheets or handouts in class	○	○	○	○

Q26 Consider your **regular course meetings** ${Course Meeting Times} and primary instructor {Instructor Name} of {Course Name}. As compared to other students in class…

[Question options for Q26 repeat with the following question]
Consider your **recitation/lab section** and recitation/lab instructor ${Recitation Instructor}. As compared to other students in class…

	A lot less than other students (1)	Somewhat less than other students (2)	The same as other students (3)	Somewhat more than other students (4)	A lot more than other students (5)
How much opportunity do you get to answer questions in class?	○	○	○	○	○
How much attention does the instructor give to your questions?	○	○	○	○	○
How much help do you get from the instructor?	○	○	○	○	○
How much encouragement do you receive from the instructor?	○	○	○	○	○
How much opportunity do you get to contribute to class discussions?	○	○	○	○	○
How much praise does your work receive?	○	○	○	○	○

Q28 How would you describe the overall climate within {Course Name}?

	1	2	3	4	5	
Excluding and Hostile	○	○	○	○	○	Including and Friendly
Intellectually boring	○	○	○	○	○	Intellectually engaging
Academically easy	○	○	○	○	○	Academically rigorous

Q29 I believe that my math ability can be improved through dedication and hard work.

- Strongly agree
- Agree
- Slightly agree
- Slightly disagree
- Disagree
- Strongly disagree

Q30 Please indicate your level of agreement for the following statements from the beginning of the course and now.

	Beginning of course	Now
I am interested in mathematics	▼ Strongly agree (1) ... Strongly disagree (6)	▼ Strongly agree (1) ... Strongly disagree (6)
I enjoy doing mathematics	▼ Strongly agree (1) ... Strongly disagree (6)	▼ Strongly agree (1) ... Strongly disagree (6)
I am confident in my mathematical abilities	▼ Strongly agree (1) ... Strongly disagree (6)	▼ Strongly agree (1) ... Strongly disagree (6)
I am able to learn mathematics	▼ Strongly agree (1) ... Strongly disagree (6)	▼ Strongly agree (1) ... Strongly disagree (6)

Q64 The following demographic questions are intended to help us better understand the variety of student experiences at {Institution}. For more about why we ask these questions, click here.

Q65 (Select all that apply) Do you consider yourself to be:

- Man
- Transgender
- Woman
- Not listed (please specify): __________
- Prefer not to disclose

Q66 (Select all that apply) Do you consider yourself to be:

- Alaskan Native or Native American
- Black or African American
- Central Asian
- East Asian
- Hispanic or Latinx
- Middle Eastern or North African
- Native Hawaiian or Pacific Islander
- Southeast Asian
- South Asian
- White
- Not listed (please specify): ________
- Prefer not to disclose

Q67 (Select all that apply) Do you consider yourself to be:

- Asexual
- Bisexual
- Gay
- Lesbian
- Queer
- Straight (Heterosexual)
- Not listed (please specify): __________
- Prefer not to disclose

Q68 (Select all that apply) Do you consider yourself to be:

- International student
- First-generation college student (i.e., neither parent nor guardian completed a Bachelor’s degree)
- Commuter student
- Transfer student
- Student with a disability
- Student athlete
- Current or former English language learner (i.e., English was not the primary language spoken in your childhood home)
- Parent or guardian

- Prefer not to disclose

Q69 Did you use FAFSA to apply for financial aid?
- Yes
- No
- Prefer not to disclose

Q70 Did you receive a free grant (e.g., Pell Grant)?
- Yes
- No
- I don't know
- Prefer not to disclose

Approximately how many hours per week did you work at a job this term?
- 0
- 1-5
- 6-10
- 11-15
- 16-20
- 21-30
- More than 30
- Prefer not to disclose

Q72 What is your age, in years?

Q73 How many years have you been at {Institution}?
- 0-1
- 1-2
- 2-3
- 3-4
- More than 4
- Prefer not to disclose

Q74 What is your class standing?
- First-Year
- Sophomore
- Junior
- Senior
- Other (please specify)
- Prefer not to disclose

Q75 Have you declared, or do you intend to declare, a STEM (science, technology, engineering, or mathematics) major?
- Yes
- No

- Unsure
- Prefer not to disclose

Q76 Which major have you declared, or do you intend to declare?

Q77 Do you think your previous math courses adequately prepared you for {Course Name}?

- Yes
- No (please explain)

Q78 What grade do you expect to get in {Course Name} this term?

- A, A+, or A-
- B, B+, or B-
- C, C+, or C-
- D
- F
- Other (please clarify)

Q79 As of now, what math course (if any) do you plan to enroll in next?

- {List of Introductory Math Course}
- Other (please explain)
- I do not plan to enroll in another math course

Q80 Are there any aspects of your identity (or who you are) that have impacted your experience in mathematics at {Institution}? Please explain.

Q81 Is there anything else you would like us to know about you or your experience in mathematics at {Institution}?

Q82 May we contact you in the future, to further understand your experience in mathematics at {Institution}?

- Yes, here is my contact email:
- No, thank you.

Thank you for completing our survey! If you would like to revisit any of your responses, please use the back button on this page. Submitting this page will finalize your responses and complete your submission. If you have any questions about the project or this survey, please contact Chris Rasmussen at crasmussen@mail.sdsu.edu

Appendix C: First Individual Interview Protocol

Introduction
Thank you again for your willingness to participate in this study. As you may remember this is the first of two interviews and will last roughly 45 minutes to an hour. I am interested in hearing your story and background as someone who has taken a math course here at _____________and identify as _____________ or affiliated with the LGBTQIA community.

Anything you share with me today will be anonymized in my write-up, and I will send it to you to check-over to make sure I captured what we talked about.

[Have student sign informed consent]

Lastly, it's common in research to have a pseudonym or code name that is used if I refer directly to anything you have said. Would you like to select the pseudonym that is used, use your give name, or have I can select one?

Additionally, what pronouns do you use?

Pseudonym: ___________________________ Pronouns:__________________

The goal of this interview is to be as conversational as possible, but I do have some guiding questions and topics that I will refer to, I'll ask about how you identify, your background in STEM, your experiences in and outside of math classes. Before we start, do you have any questions for me?

Identity

1. As you may already know, the aim in this research is understand and advocate for the experiences of LGBTQIA or Queer-spectrum students in STEM fields, and particularly mathematics. Now, Queer and STEM are both rather large umbrella terms, can you share with me how you currently identify with being Queer? and your affiliation with STEM?

2. What does it mean for you to be _____________________?

3. Are there other identities or communities that you belong to or associate with?

Math and Educational Background

4. Can you tell me about where you went to school? Influential teachers? Peer groups? What other experiences were important to you in school?

5. How did you feel about math in school? What kinds of math courses were you able to take in your high school? What types of math-related activities were you involved in outside of school? During the summers? When did you first realize that you (didn't) liked math?

6. What does your family tell you about math or science? In what ways, if any, were you exposed to math in your household (relatives' households)? Describe how your family has or has not been supportive of your math achievements?

Coming Out

7. When did you first start coming out? What was that journey like for you? Are you out to most people you know?

8. How were you accepted in school/ at home/ friends?

9. Did coming out affect your direction in life? In what ways?

College Entrance

10. How did you decide that you wanted to go to college? What are your goals in going to college? Have they changed since you got here?

11. What about this university appealed to you? What other colleges or universities did you consider? How do you feel about your decision?

Major and Mathematics

12. What are you currently majoring in and how did you come to select that major?

13. What drew you to math or science as opposed to a different discipline like English or the Humanities?

14. How would you describe what math is?

15. How does knowing math impact your life, if at all?

16. How do you see yourself in relation to mathematics? Do you feel like part of a community or more of an individual

Math Problems

Present students with the following math problems A, B and choose one from C1, C2, or C3. Have the student read each problem out loud and then ask them the following question:

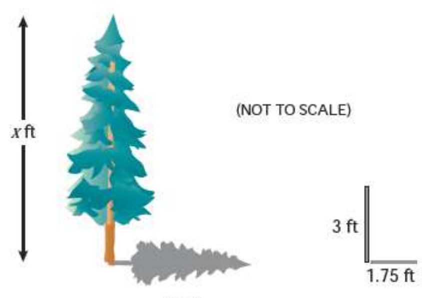
17. What is your initial reaction to this problem?

18. How might you go about solving it?

19. What would be your reaction if you were assigned to work on this problem? In class?

Mathematical Problem A

Billy wants to rent a lift to trim his tall trees. However, he must decide which lift he needs: one that will lift him 25 feet or a more expensive lift that will lift him 50 feet. His wife Lynda hammered a stake into the ground and by measuring found its shadow to be 1.75 feet long and the tree's shadow to be 19 feet. (Assuming both the stake and the tree are perpendicular to the ground.) If the stake was standing 3 feet above the ground, how tall is the tree? Which lift should Billy rent?



Math Problem B

A young couple, Javier and Raymond are planning a party at their local community center. The community center charges a flat rate of \$1000 to reserve the dance floor. The cost of food is \$35 per person for the first 100 people and \$25 per person for every additional person beyond the first 100. Write a cost function C(x) as a function of the number of people x attending the party. Javier wants to invite 75 people and Raymond wants to invite 50, how much will the party cost them?

Math Problem C1

Divorce rates are considerably higher for couples who marry in their teens. The line graphs in **Figure 1.11** show the percentages of marriages ending in divorce based on the wife's age at marriage.

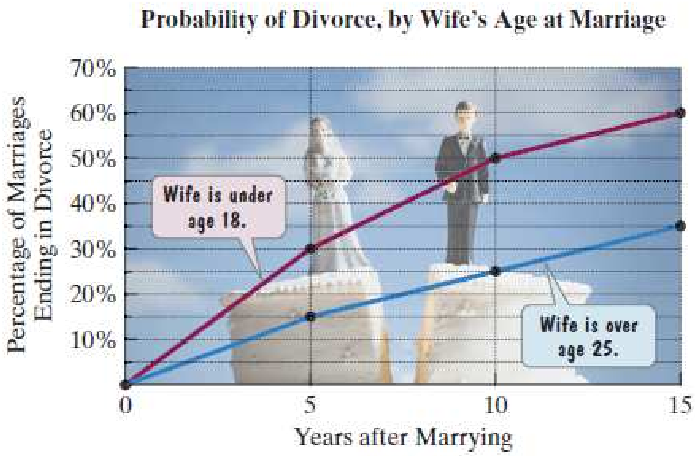


FIGURE 1.11

Source: B. E. Pruitt et al., *Human Sexuality,* Prentice Hall, 2007.

Here are two mathematical models that approximate the data displayed by the line graphs:

Wife is under 18 at time of marriage.

$$d = 4n + 5$$

Wife is over 25 at time of marriage.

$$d = 2.3n + 1.5.$$

In each model, the variable n is the number of years after marriage and the variable d is the percentage of marriages ending in divorce.

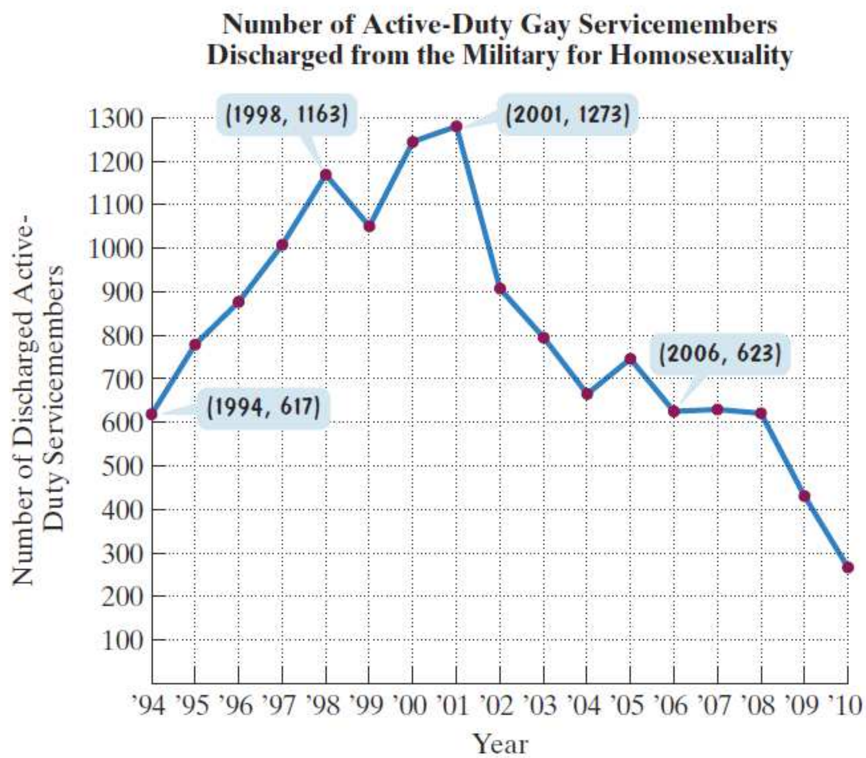
a. Use the appropriate formula to determine the percentage of marriages ending in divorce after 10 years when the wife is over 25 at the time of marriage.

b. Use the appropriate line graph in **Figure 1.11** to determine the percentage of marriages ending in divorce after 10 years when the wife is over 25 at the time of marriage.

c. Does the value given by the mathematical model underestimate or overestimate the actual percentage of marriages ending in divorce after 10 years as shown by the graph? By how much?

Math Problem C2

The stated intent of the 1994 "don't ask, don't tell" policy was to reduce the number of discharges of gay men and lesbians from the military. Nearly 14,000 active-duty gay servicemembers were dismissed under the policy, which officially ended in 2011, after 18 years. The line graph shows the number of discharges under "don't ask, don't tell" from 1994 through 2010. Use the data displayed by the graph to solve Exercises 29–30.



Source: General Accountability Office

29. Find the average rate of change, rounded to the nearest whole number, from 1994 through 1998. Describe what this means.

30. Find the average rate of change, rounded to the nearest whole number, from 2001 through 2006. Describe what this means.

Math Problem C3

Researchers have surveyed attitudes of college freshmen every year since 1969. The bar graph shows that since 1980, there has been a decline in first-year college students' opposition to homosexual relationships.

Opposition to Homosexual Relationships among First-Year United States College Students, 1980–2008

Statement: "It is important to have laws prohibiting homosexual relationships."

Source: John Macionis, *Sociology*, *Thirteenth Edition*, Prentice Hall, 2010.

a. The function

$$f(x) = -6.2 \ln x + 40.5$$

models the percentage of first-year college women, $f(x)$, opposed to homosexual relationships x years after 1979. If trends modeled by the function continue, when will opposition to homosexual relationships among first-year college women diminish to 16%? Round to the nearest year.

b. The function $g(x) = -7 \ln x + 59$ models the percentage of first-year college men, $g(x)$, opposed to homosexual relationships x years after 1979. According to this model, when did 40% of male freshmen oppose homosexual relationships? Round to the nearest year.

Closing

20. What are three words you would use to describe yourself? How do you think you are like other students at [Institution]? How do you think you are different from other students at [Institution]?

Thank you so much for sharing with me today, I am looking forward to our second interview.

Appendix D: Second Individual Interview Protocol

Thank you again for your willingness to participate in this study and meet with me again. Today's interviews should last roughly an hour and will focus on your day to day experiences, interactions around mathematics, and I will have you respond to some other student's stories.

[Remind student about informed consent]

Before we begin do you have any questions for me?

Experiences in courses

1. Can you describe a typical day for you as a math or science major? A typical semester? What sorts of math/science activities (Research experiences, clubs) have you been involved in while in college?

2. What has been your <u>favorite math or science class</u> that you've taken so far at {Institution}? Why? Tell me about a particular class/lab/activity that illustrates why you enjoyed it.

3. What has been your <u>least favorite math or science class</u> that you've taken at {Institution} so far? Why? Tell me about a particular class/lab/activity that illustrates why you did not enjoy it.

Institutional Supports

4. What resources on campus do you find particularly helpful?

5. Where do you go or what do you do when you need help with learning math concepts?

6. Do you ever attend the campus [teaching center] or [math tutoring] why or why not?

7. Are you part of any clubs? What about STEM or LGBT clubs, [oSTEM]?

Illustrative Examples

Now, I would like to turn and take a look at some descriptions and accounts of other Queer-spectrum students and their experience in Math classrooms. First, I will have you read this outload and then I would like to get your reaction to these stories.

Vignette # 1

You are working in small groups during your recitation section on problem computing the $\lim_{x\to\infty}\left(\frac{1}{2}\right)^x$. One of your group members says that it must go to infinity since ½ raised to a number returns another number and as x goes to infinity the result will also go to infinity. You explain that since ½ <1 this is a decreasing function and thus as x gets bigger, the results will tend towards zero as you are multiplying smaller numbers together. Your group accepts your answer and finishes the worksheet.

As you are waiting for the class to end, your group members talk about what they did over the weekend. One of them asks you what you did over the weekend, you don't feel comfortable sharing with them since over the weekend you hung out with some of your Queer friends at a LGBT movie night. Usually you try and slowly determine how accepting your group mates are by finding out certain information about them. Are they religious? Part of a fraternity? But this is a new group and you don't know how they will react.

How would you react in this situation?

Vignette # 1 (Response)

You deflect the answer, and say "oh nothing exciting," and disengage from the group conversation. It reminds you how much you dislike working in groups and wish the instructors would just lecture.

Towards the end of the class, the instructor asks each group to select one person to present their explanation to the problem. Your group mates nominate you, since you came up with the solution. You would rather not talk in front of the entire class, as it makes you nervous. You suggest one of your other group members and they accept. You are relieved you won't have to present in front of the class, and spend the remainder of the session taking notes.

- Do you see yourself doing something like this in your college mathematics course? Why or why not?

- If you behave differently in college mathematics lectures and/or recitations, how do you behave? Why do you behave this way?

- What about lecturing compared to working in groups, is your opinion similar to that conveyed in the story?

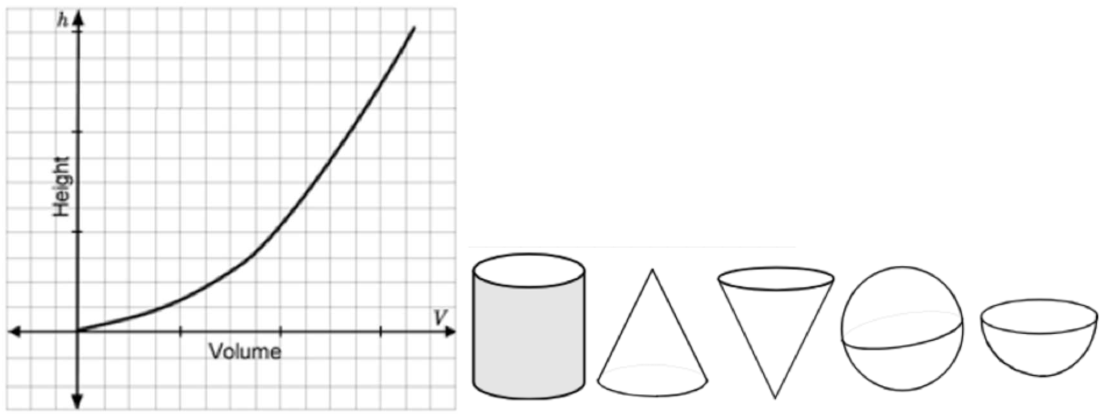
- If the group dynamic were different would you feel free to share? How would they need to be different? Is there anything about the make-up of the group that would make it easier to share?

- What about presenting your ideas in front of the class, do you see yourself doing something like that? What makes that more likely to occur?

- **Would you feel more open in sharing if this occurred in a different course?**

Vignette # 2

You are sitting in the library working on a group math project. For this project you each need to sketch the graphs that represent the height of water as a function of volume as water is poured into different containers. Your group is working well together, until one of them asks “where are the bathrooms on this floor?” Another group member tells them, “there’s an all-inclusive bathroom down the hall to the right.” Your groupmate responds, “pfffft, I am not using the tranny bathroom. I don’t know why they can’t just use the one they were assigned.”



How would you respond in this situation?

Vignette # 2 (Response)

You are upset, and not sure how to react. You decide that you have to say something. You tell your group member, “you are out of line, and I don’t appreciate you making derogatory remarks towards individuals who are transgender. Please keep those comments to yourself while we work together.” The group member agrees, and everyone returns to working on sketching the graphs. The group is trying to determine what the graph will look like for the sphere, and even though you know the correct answer you don’t want to seem pushy given the recent interaction. You can barely concentrate and wonder how the other group members reacted to your confrontation. You try and put it out of your mind and remind yourself that you won’t have to work with them after this project. Its alright, since you don’t associate with many of these group members outside of class.

- Do you see yourself doing something like this? Why or why not?

- Has anything like this happened to you before at [University]? Can you share any experiences where homophobia/transphobia played a major role within your experiences inside the STEM classroom or related contexts? How did you feel/respond?

- What sort of things would make it easier to confront a student comment like this**?**
    - What about the setting?
    - The person?
    - The other group members?

- Do you think something like this would occur while working on a different subject? How might it be different?

8. What about working with other math peers outside of class? Do you work with peers outside of class? Why or why not? Are you friends with many of the students in your math class? Do you feel like there is a community among the students in the class?

Vignette # 3
You are sitting in your college mathematics lecture. The instructor is taking the derivate of $\sin(x^2 + 2)$ which describes the motion of particle. The instructor says that the velocity of the particle is $\cos(x^2 + 2)$. You instantly notice that the instructor forgot to use the chain rule and the velocity of the particle should be $\cos(x^2 + 2)$ *2x.

What would you do in this situation?

Vignette # 3 (Response)

You interject with the correct solution and the instructor thanks you. After you correctly identify this error, the instructor references your contribution in other explanations during the recitation. The instructor cites you by first name while doing it (e.g., “Exactly as _______said…).

The instructor is someone with whom you frequently contact via e-mail with questions about assigned homework, grading and math topics. In addition, the instructor frequently calls on you during class discussions and praises your work. All of these interactions bring you to have a close relationship with the instructor, so it is not a surprise that the instructor acknowledges you on a first-name basis.

- Have you had a similar type of relationship with an instructor? What about a teaching Assistant leading your college mathematics recitation? With who was it?

- What was the nature of this relationship like? What allowed you to build this relationship with the professor or Teaching Assistant? Is there anything that you did? Is there anything that the professor or Teaching Assistant did?

- If you have not established such relationships, what kinds of relationships have you previously established with professors or Teaching Assistants in your college mathematics courses? What prevents you from being able to establish closer relationships with professors or Teaching Assistants?

- Have you ever had a professor or teaching assistant who was Queer?

Persistence and Success

9. Some people have difficulty succeeding as science or math majors, while others succeed fairly easily. How would you describe your experience as a science/math major? What/who has helped you to succeed as a science/math major? What difficulties have you faced as a science/math major?

10. Describe what is needed to be successful in math.

11. Did you ever think about changing to a non-science/math major? If so, why? Can you describe a particular time when you especially felt this way? If not, why?

Reflection and Closing

12. Tell me about being Queer in the math classroom, what is that experience like for you? Do you consider yourself "out" when in math settings?

13. In your experiences as a science/math major, do you feel that your status as a Queer student has presented any challenges or benefits? What kind? In what ways? If so, can you describe a particular time when you felt that this was happening? If not, do you know of other students who have faced difficulties as Queer-spectrum students?

14. Earlier you said that math was _______________, how does relate to your Queer identity?

15. Are there other identities you associate with or communities you belong to that have presented challenges as you pursue a degree in STEM student?

16. What do you want to do when you graduate from college? Where do you see yourself in five years? In ten years?

17. What advice would you give to others with a similar background as they consider whether or not to pursue a STEM degree? Socially? Academically? Economically?

Appendix E: Post Interview Contact Summary Form

Title:
The following document summarizes the key issues and themes that emerged based on an interview with __________ on ________________ and lasted for approx. ____ minutes.
This document was written by __________ on ____________.
Keywords:

1. What were the main issues or themes that struck in in this interview?

2. Summarize the information you got (or failed to get) on each of the interview topics listed below
   [Interview 1]

   - Individuals background
   - Career aspirations
   - Coming out process
   - Queer Identity
   - Experience in courses
   - Nature of Mathematics
   - Math Problem A
   - Math Problem B
   - Math Problem C

   [Interview 2]
   - Experiences in courses
   - Institutional supports
   - Vignette #1
   - Vignette #2
   - Vignette #3
   - Persistence and Success
   - Reflection and Closing

3. Anything else that struck you as salient, interesting, illuminating or important in this interview?

4. Were there other key factors of the individual's identity were mentioned during the interview? How did this factor into the responses provided by the individual?

5. How might you adjust the protocols for future interviews?

Appendix F: Sample Member Checking Document

The following document attempts to capture my understanding and interpretation of the experiences you shared with me as a Queer STEM student taking undergraduate mathematics courses. Please feel free to update, correct or change any of the information presented below.

Name:
Pseudonym: Azra (Researcher Assigned)
Pronouns: She, Her, Hers / They, Them, Theirs
Site: Cardinal University
Major: Biology
Salient identity: Queer, Asexual, Brown, Muslim, Low-income, International

Azra identifies strongly as a Queer, brown, South-Asian international student from Pakistan. In terms of being Queer, Azra said that she is still "figuring out the particulars," but ~~identifies as cis-gender~~is questioning their gender identity and identifies as Queer and might even consider herself to be on the Asexual spectrum. Azra specifically identifies as South-Asian, because to her Asian doesn't mean anything, and often people associate Asian with people f~~or~~rom East Asia and she doesn't look like people from East Asia.

Being at Cardinal University has presented both challenges and benefits to Azra's development and growth as a student in STEM. Azra described that by coming to Cardinal University and taking a broad array of classes, including those in the social sciences and gender studies, has provided her with the language to understand and talk about issues related to identity and social justice. Azra said that if it were not for those classes she, "would not be using the words that I'm using today" and has developed an intersectional understanding of her positionality in the world. She said, "I'm not just brown and I'm not just a girl I'm also an international student I'm also a particular type of brown. I'm also dark-skinned and now I know that I'm also Queer, and I'm also low-income." The use of language seemed to be an especially salient factor for Azra in relation to the world. For instance, when reflecting on the math problem related to freshman attitudes towards homosexual relationships, Azra had an immediate reaction to the word "homosexual" and later stated that if she were to complete this in class, "I would feel really icky, because they're saying the~~y~~ word homosexual because for me that's not a word that anyone needs to use now, because that's been used as a slur throughout history and it's time that we move on from that and start respecting people." Azra said that math problems need "to be better [with] language" and that she would feel better about this problem if it used, "Queer or gay or lesbian." Azra also reacted and highlighted the word expensive in one of the math problems saying without prompting, "I don't know why I did that probably because I'm a low-income student."

Another important factor related to the use of language that Azra mentioned several times throughout the interview was the use of pronouns. Azra's stated that in her experience in sciences classes, "I'm Queer but I'm not presenting in a way that people read me as Queer, sometimes they do but sometimes they don't. So my teachers just assign me a pronoun by themselves. There's no like, Oh what are you pronouns?” Azra went on to say that, “despite the fact that I'm not dressing like super fem-me that I have like shorter hair than most people they still assigned me a pronoun. Yes, I may use that pronoun, but you know that doesn't mean that everyone in that space uses the pronoun that you're assign them.” Azra said that this happens in all of her science and math classes where teachers do not make an effort to ask for pronouns, “I mean it will be great if any teacher starts the class by asking pronouns in science, they don't. Every other class that I've taken besides my science classes they do.” In the social science courses that she has taken they have started with pronouns, and Azra said this has created a more welcoming and friendly space for her as a student. Azra went on to further state that she would appreciate having math classes start by asking pronouns, especially if a math teacher, “if they're actually interested in the students’ lives they could start by asking pronouns which I think would be a monumental for a math teacher.” However, Azra cautioned that the instructor would need to take ownership for why they were doing such a practice, so that it doesn’t fall on her as a Queer student since, “if you start talking about my Queerness and that's just like extra emotional labor that I have to do and if not for anyone else but in my head and I don't have time for that.”

In general, Azra said that within science and math classes there are not discussions around issues of Queerness or social justice. Azra said that, “in science like no one really...likes to talk about Queerness in general” and she has not seen any inclusion of social justice issues. This is especially problematic within science since, “science has been like awful to Queer people, and still is… no one likes to talk about how science has been oppressive to Queer people and intersex people particularly” in terms of the surgeries that have been performed on Queer bodies and an approach to teaching science that fails to address the difference between sex, gender identity and gender performance. Azra stated that in STEM there seems to be a general avoidance of talking about ethical issues, which may put Queer people at a disadvantage since they are often more aware of and have respect for human beings. Azra also notices how the Science departments at her school, in her experience, ignore and erase the history of racism and oppression within science. For example, the Biology department celebrates Darwin Day but fails to acknowledge exactly how racist and transphobic and sexist he was. For Azra, it is as if STEM has no space for social justice.

In addition to math and science not discussing issues of Queerness, Azra conveyed that in general her math instructors “don't care about my identity” and furthermore don’t express an interest in her life. Although her math instructor knows her name, which is a good surprise, the only time that he has expressed an interest in her identity, was during a class session where she shared a technique for determining if a number was divisible by three by adding all the place values together and determining if that number is divisible by three. The instructor was curious where she had learned that mathematical technique and she shared that it was from her past educational experience in Pakistan. This experience highlights the notion that one entry point into students lives by math teachers is through the cognitive mathematical ideas possessed by students; however, this alone is not enough to develop connections with students. For instance, Azra stated that, “if you are a Queer person there will be times when you want the teacher to say something, just like say a blanket statement...like take a stance, but they don't in my experience, they haven't. So there's always like that feeling of like oh I don't feel validated here I don't know what they think. I don't know if they were ever to find out that I was Queer if they would even respect me as a human being.” As such Azra stated that knowing an instructor’s politic~~al stance (trump supporter or not?)~~s can be helpful to know whether her existence will be validated in that space and if the instructor cares about social change in a way that she does as well.

Azra has had a few positive role models or relationships with STEM instructors. In high school, Azra had a biology teacher that showed caring for her as a student. Although the instructor could be rude and called out Azra for disengaging with the classes and sitting in the back after getting a C grade, she also helped her plan for university and wanted her to succeed academically. Azra credits this relationship as one of the reasons why she wanted to be a biology major. Azra was also appreciative of her mathematics teaching assistant since this was a more informal relationship where she didn’t need to use formal titles and had more opportunities to ask questions. She expressed a similar benefit for attending supplemental instruction sessions for chemistry because there was more familiarity and knowledge from the part of the instructor as compared to the math center tutors who are disconnected from the daily working of the class. Azra has also had relationships with faculty that exhibited conflict often as a result of tensions related to her identity. For instance, one of her instructors made a xenophobic remark that, “international students sometimes have a hard time understanding instructions” and Azra was not in a position of power to be able to confront this remark. Additionally, Azra worked with a research faculty over the summer that proved to be difficult because the faculty member who was white was not able to understand the struggle Azra was going through as an international student from Pakistan.

Although Azra mentioned several ~~intuitional~~institutional resources that have been helpful for her as a STEM student (e.g., departmental advising, library space, Cardinal University Central) overall, she felt that Cardinal University has not been supportive of her as a Queer International South Asian person. One of the most prominent ways Azra has felt this was Cardinal University’s decision to close the ~~c~~Center for ~~i~~Identity, ~~culture~~Inclusion and ~~s~~Social ~~c~~Change and open four new identity specific centers (Latinx ~~c~~Cultural ~~c~~Center, ~~African-American~~Black ~~c~~Cultural Center, Asian ~~p~~Pacific-~~i~~Islander Desi American ~~c~~Center, LG~~Q~~BTQIA+ Resource Center). This decision and the implementation had a very negative impact on Azra’s connection and support at Cardinal University. At the old center she was ~~able to take part~~ employed as a Social Justice Advocate (SoJA) and was trained to ~~in SOJA training where she was able to~~ practice difficult conversations about marginalization, power, privilege and oppression. It~~and it w~~ was a place where, “I was expressing all of me all at once. I was Queer, I was brown, I was also an international student.” After the center closed, Azra said that the timing of the rollout was so close to midterms and the end of the year which seemed to be an attempt to silence students and resulted in the loss of employment for herself and other staff members who worked at the center. Additionally, the slow rollout of the new centers meant there was a time when there was no space to support her identity at Cardinal University. Another major concern that Azra stated is that ~~in addition to no longer having a space for Asian international students, the separate spaces~~ these centers did not allow for a complete acknowledgment of her intersectional identity~~.~~, and also ignored the existence of multiracial and indigenous students. Azra said, “I'm all of these things at once, I can't choose to be one part and not be the other. I may present that way but that doesn't mean that I'm just one thing.”

For Azra, the ~~cultural center~~ Center was an important part of her support and community connection with others at Cardinal University who look like her, since in her math and science courses there have been fewer of those connections. Azra said that in her math class there are few people of color, and she is primarily friends with two students in that class, one white student and one student of color. Azra is not sure if those two friends in her math class are aware that she is Queer, because “it’s not something that I think people ask you.” She speculated that they probably don’t know she is Queer because it’s not something they talk about, but on one occasion one of the friends mentioned that they were friends with lots of other Queer people. This statement appeared to be an indicator of the friend’s acceptance of LGBT~~ issues~~Q identities.

Azra stated that being Queer, although it has presented challenges, has given her a broader sense of injustice in the world and the other groups in society that are marginalized. Azra said being Queer, “helped me develop as a person, about the way I use ~~my words~~language, and about the way I look at life, and about the way that I like think about things.” Azra’s social justice orientation and advocacy for others came out several times during the interview. Azra said she has learned how to advocate for other people, and when given the example of hearing a transphobic remark stated that she would have to confront that person regardless of the type of day she was having because that kind of remark is “disrespecting and invalidating an entire human being.” Azra said that certain environments are easier to confront these types of issues such as when others in the group also seem supportive or look similar, smaller class settings, or when you can advocate for others.

One of the problems with not having representation of Queer people in STEM is that this can lead to a disconnect between STEM identity and Queer identity. For instance, Azra stated that her STEM friends and her Queer friends are disjoint categories. She stated that her Queer friends are mostly non-STEM majors (some psychology) and therefore they cannot relate to the stress and demands from the coursework she is taking. Yet at the same time Azra is aware that there should be more Queer people and representation in STEM, “Queer people are everywhere so why not math?” One possible reason is that according to Azra people’s default assumption is that you are straight until proven otherwise, but to disclose your ~~Queer~~non-cisheteronormative identity requires a certain level of comfort and trust. For her she doesn’t want to disclose this information unless she knows someone well enough, and that if she had disclosed her Queerness early on at Cardinal University it likely would have made things worse. By disclosing your Queer identity Azra said you may open yourself up to someone who is not accepting, who may say something upsetting, and that may require emotional labor that you don't want to invest in that person. However, having the visibility of a Queer instructor would be powerful since it would make it easier to connect and create a safer environment for disclosure.

Email Correspondence (Aug 30, 2018):

> Hi Matt,
>
> Hope you are doing well.
>
> Thank you for sending me this summary document! I have added and edited a little bit as I thought was necessary. I wanted to ask if you could replace she/her/hers used in the document with they/they/theirs. I do use she/hers but I feel more comfortable with the latter in this moment and would appreciate if you could change that.
>
> Let me know if there is anything else I can help you with.
>
> Best,

Appendix G: 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?

Appendix H : Individual Interview Codebook

The following is the codebook that has operational definitions of the mathematical discourses and the navigational strategies along with example students quotes.

Mathematical Discourses

What are the Discourses (implicit and explicit beliefs, values, norms, orientations) that students hold in relation to queer identity in mathematics? Evidence for these may exist at a global level for them as students and not confined entirely to what they say in STEM.

Code	Description	Example Quote
Queer identity is marginalized (Marginalized)	Queer identity is intentionally discriminated against or marginalized in STEM spaces. There is a belief that there is overt pressure of hostility or disregard of queerness in STEM. This can include hearing discriminatory language, disregarding non-binary demographic data, not caring about pronouns, exclusion of non-heteronormative performances, or a belief that Queer-spectrum students will not be accepted in STEM. This also includes references that other disciplines outside STEM are more accepting spaces.	"no one likes to talk about how science has been oppressive to Queer people and intersex people particularly." "so yes definitely I think it's much more likely for people to miss gender other people in math and science than other classes."
Queer Identity is not discussed or relevant (Erasure)	Queer identity is not discussed when in mathematical settings. It is seen as "off-topic" or irrelevant to the goals of mathematics. There is intentionality or pressure to erase queerness from mathematics. Students may point to Math as more abstract and not context specific and is not political as reason for this erasure. In contrast to the *heteronormative* code, queerness exists but it is not talked about. In contrast to the *Marginalized* code this is about a pressure to not talk about this issue, versus a disregard or hostility.	"maybe if we were talking about more aloof topics but I'm in a calculus class and we just talk about calculus." "yeah like I'm not just gonna walk in my math class and be like hey guys I'm bi, like it's not relevant there. cuz like no one else in my math classes is being like hey I'm gay or like hey I'm this or just in our math classes. you know like I'll be like hey I'm Mary nice to meet you"
Queer identity is invisible or doesn't exists (Heteronormative)	Queerness is a less visible identity, so people assume everyone in STEM is straight. Also, an assumption that queerness in math problems don't exist, students default to assume heteronormative relationships. This is implicit assumption due to visibility and lack of role models.	"cuz I feel like it's no one would just like know unless I told them." "when like your identity is like hidden like that, like you're thinking like but you're almost like holding on to a secret"

Queer identity is treated the same as heterosexual identity (Normalized)	Queer identity is no different than heterosexual identity in math settings. When Queer identities are present in STEM they are treated equally with straight identities. In effect this normalizes Queer identity in math. People have minimal reaction to others coming out.	"I think the same. It's just kind of indifferent. Especially now and just going to go through it the same way I go through any other problem. I think that's probably the best course of action – treating as if it was any other one. It just kind of, in my opinion, really helps to just normalize it"
Queer identity acceptance is unknown (Ambiguous)	It is unknown or unclear how people in STEM will react to Queer identity. When Queer identities are present in STEM it is unknown how they will be treated. Students often use guarding terms, "I am not sure," "I think it would be ok."	"I do not know how me being gay fits into that because I've never experienced that before. So, um, I'm first, I've seen situations where me being gay is actually effecting my life a lot."
Queer identity is accepted (Accepted)	Queer identity is accepted in STEM. There are overt or implicit messages that Queer identity is accepted in STEM. This is especially so since science and math are disciplines that are open minded, exploration focused. Queer identity is accepted because the people in STEM are accepting of this orientation.	"I feel like math is a very inclusive environment and like as long as you're smart enough you got it then you should flaunt it."
Queer identity is relevant or important (Valued)	Queer identity is relevant since STEM is seen as a students' place for community and others within that community need to know this information to understand who they are as people. Queer identity is important and relevant in STEM settings.	"well like I know that like my friends in my math class who are my group mates, I would have no problem telling them that I went to... they would just say it was cool." "I'd say even maybe more comfortable talking about it in stem just because I know more people in stem. And I guess I like identify generally more with the people in stem. And those are the people I hang out with more. So those are the people I want to know. I'm not straight."
Other	Other discourses	

Navigational Strategies

Given the above discourses how do students respond to these in mathematics and as students?

Who they are: The focus of the action relates to a students' personal identity. These would be actions taken by queer people.

Code	Description	Example Quote

Downplay importance of queer identity	Students downplay or minimize the significance of their queer identity in Math. Being queer it's not a big deal, don't consider it an impactful identity.	"it's not really like a very large aspect of my life so I don't really see that this type of situation arising."
Position queer identity as strength	View queerness as a strength. It makes one more creative, provides a different viewpoint, demonstrates resilience in struggle.	"I think it definitely, it just made me more aware of who I was as a person and like what I valued more than anything."
Reference nature of intersectional identities	Reference the nature of intersectional identities in relation to queerness in STEM. For example, reflecting on being a woman, man or a person of color, white.	"I think like being or being a woman of color has like a way bigger effect than me being you know queer at all."
Don't disclose queer identity (Closeted)	Desire or hesitancy to not disclose or come out in Math or educational settings (e.g., reservation to come out). This might also include filtering what is shared to not "come out" or gauging the acceptance of others before coming out. Having an awareness to constrain one's physical attire or gender performance.	"I just like I'm a private person, so I wouldn't necessarily bring that up into a conversation"
Disclose queer identity (Come out)	Desire to come out personally or not be hindered to discuss things that might "out" oneself in Math	"I feel like if the topic comes up, sure, I'll share it." "I'd rather have people know that I'm gay than not gay"
Separate or divide STEM and Queerness	There is a divide, separation or tension in students' views of STEM and Queerness. This plays out in different friend groups, compartmentalizing STEM self with queer self. Expression of not feeling queer enough because you are in STEM, or not feeling STEM enough because you are Queer.	"no I feel like those two things like are not really related for me. like I just go to my math classes as me and then I leave. They don't interact"
Integrate or connect STEM and queerness	Engage in activities that integrate queer identity with STEM. This also includes beliefs that STEM identity and Queer identity are related or complimentary. This also includes an integration of STEM and Queer friend groups	"I am part of oSTEM to be able to connect my interest in STEM with my queer interests"

What they talk about: The focus of the action relates to queer topics and issues. These are actions that could be taken by all students regardless of queer identity.

Code	Description	Example Quote
Disengage or become distracted	Having queer issues in mathematics would be distraction and would disengage from the mathematical objectives. Any evidence of them considering other problematic features. Pursue studies or interest outside of STEM. These could include taking courses in other fields that help position or understand STEM and who the student is in relation to STEM.	"why would they pick something this heavy, like this relatable for like you know lgbt+ people? like like why? I just think I don't know it like this like adds to like that like me being like desensitized to it." "I would be fixated on this, like I was just fine I mean I see it though because I could barely

	Students personally acknowledge a disagreement with a certain practice or interaction in STEM but don't have the agency power to alter this practice. For example, people may assume your pronouns and you disagree with that approach, but don't take other actions.	concentrate on like the group project, so it's just like like overthinking it a bit, which is something familiar."
Redirect to mathematical task	Put a primary focus on the mathematical objective, solving the tasks, often shifting away from possible discussion of queerness	"I mean I mainly would focus on the content, it would be I like the like the name thing, it would be something remarkable to like oh that's interesting like that's like good of people to start incorporating that, but I would more focus on the actual math side part of it probably."
Engage or advocate	Having queer issues in mathematics would be engaging and would be a chance to advocate. This also includes "taking up space" like asserting yourself and your opinions in relation to these topics. Students express wanting to see more representation of queer people and issues in Math. Evidence of enjoying queer representation in other subjects as a desire for wanting it in STEM subjects	"It's like spreading awareness, giving them … putting you in our minds and increasing like their knowledge on us, so what the community has actually been through." "I'd say like go for it because like we need more people in that community to represent us in, in, you know, stem majors and in the work industry"

How they interact with others: The focus of the action is on interacting with others

Code	Description	Example Quote
Interact with STEM individuals	Forming community with STEM people. This is often a view that people are bonded together in the experience of math as a difficult discipline.	"I bonded better with my calc friends because we all took it together and we all suffered together."
Interact with Queer Individuals	Forming community with other queer people. This includes forming connections through GSA, LGBT centers, and connecting with other known queer people in STEM.	"influence is like the community that I belong in, and just an extent...who and where I like to go in my free time. like for example I tend to hang out in the campus LGBT Center"
Avoid STEM individuals	Avoiding community with STEM. This also includes the empowerment or agency of not being friends with someone	

Appendix I: R Statistical Code

The following is the R source code used to analyze the quantitative data in this study. The formatting is intended to aid the reader under the constraints of the dissertation margins, this is best read with a copy-and-past into an R code editor.

```
#Libraries
library(ggplot2)
library(sm)
library(reshape)
library(QuantPsyc)
library(irr)
library(psych)
library(plyr)
library(rel)
library(car)
library(RcmdrMisc)
library(GGally)
library(psy)
library(lsr)
library(data.table)
library(doBy)
library(dplyr)
library(AICcmodavg)
library(MuMIn)
library('scales')
library(stargazer)
library(lsr)
library(MASS)
library(lme4)
library(lmerTest)
library(likert)
library(markdown)
library(rmarkdown)
library(readxl)
library(knitr)
library(ggpubr)
library(reshape2)
library(HH)
library(kableExtra)
library(dplyr)
require(grid)
require(lattice)
require(latticeExtra)
require(HH)
library(gvlma)
library(ordinal)
library(tidyr)
library(rockchalk)
library(pairwise)

###################################################
#Read in the dataset
###################################################
spips <-
```

```
  read_excel("C:/combined_dissertation_Final.xlsx")

####################################################
# Data setup, defining variables
####################################################

#create variable with all Queer-spectrum identities
spips$QueerSexualOrientaiton = factor(
  spips$QueerSexualOrientaiton,
  levels = c(
    "Straight",
    "Straight-Asexual",
    "Straight-Bisexual",
    "Straight-Multiple",
    "Asexual",
    "Bisexual",
    "Gay",
    "Lesbian",
    "Pansexual",
    "Queer",
    "Questioning",
    "Multi-Queer",
    "Not Disclose",
    exclude = NULL
  )
)

#Combine identities to form Straight+
spips$QueerSexualOrientaiton <-
  combineLevels(
    spips$QueerSexualOrientaiton,
    levs = c(
      "Straight-Asexual",
      "Straight-Bisexual",
      "Straight-Multiple",
      "Questioning"
    ),
    newLabel = c("Straight+")
  )

# Combine identities to form Queer+
spips$QueerSexualOrientaiton <-
  combineLevels(
    spips$QueerSexualOrientaiton,
    levs = c("Pansexual",
             "Queer",
             "Multi-Queer"),
    newLabel = c("Queer+")
  )

#Create variable with the Queer-Spectrum identities
spips$QueerSexualOrientaiton = factor(
  spips$QueerSexualOrientaiton,
  levels = c(
    "Asexual",
    "Bisexual",
    "Gay",
    "Lesbian",
    "Queer+",
    "Straight+",
    "Straight",
```

```
    exclude = NULL
  )
)

#Create variables that combines queer identities
spips$QueerSpectrum <- combineLevels(
  spips$QueerSexualOrientaiton,
  levs = c("Straight+",
          "Asexual",
          "Bisexual",
          "Gay",
          "Lesbian",
          "Queer+"),
  newLabel = c("Queer Spectrum")
)

#Create variables to compare Queer-Spectrum and Straight
spips$QueerSpectrum = factor(spips$QueerSpectrum ,
                             levels = c("Straight",
                                        "Queer Spectrum",
                                        exclude = NULL))

#Create variable of seuxalizxed minority (recategorizing Asexual)
spips$SexualizedMinority <-
  combineLevels(
    spips$QueerSexualOrientaiton,
    levs = c("Straight+",
            "Bisexual",
            "Gay",
            "Lesbian",
            "Queer+"),
    newLabel = c("Sexual Minority")
  )

#Create variable of seuxalizxed minority (recategorizing Asexual)
spips$SexualizedMinority <-
  combineLevels(
    spips$SexualizedMinority,
    levs = c("Straight",
            "Asexual"),
    newLabel = c("Non-Sexual Minority")
  )

#Create variable of seuxalizxed minority (recategorizing Asexual)
spips$SexualizedMinority <- factor(
  spips$SexualizedMinority ,
  levels = c("Non-Sexual Minority",
            "Sexual Minority",
            exclude = NULL)
)

#Create racial vairable (person or color)
spips$POC = factor(spips$POC,
                   levels = c("White",
                              "POC",
                              exclude = NULL))

#Create URM racial vairable (black, latinx, native American)
spips$URM = factor(spips$URM,
                   levels = c("Non-URM",
                              "URM",
```

```
                         exclude = NULL))

#Create first-generation variable
spips$FirstGen = factor(spips$FirstGen,
                        levels = c("Not First-Gen",
                                   "First-Gen",
                                   exclude = NULL))

#Create instruction interactions outcome measure
spips$InstructorInteractions = rowMeans(spips[, c(
  "PIPS - I receive feedback from my instructor on homework, exams, quizzes, etc.",
  "PIPS - I receive immediate feedback on my work during class (e.g., student response systems such as clickers or voting systems; short quizzes)",
  "PIPS - I share my ideas (or my group's ideas) during whole class discussions",
  "PIPS - I am asked to respond to questions during class time"
)], na.rm = TRUE)

#Create percieved equitable instructor interacitons outcome measure
spips$EquitableInteractions <-
  rowMeans(spips[, c(
    "Included_Class - How much encouragement do you receive from the instructor?",
    "Included_Class - How much praise does your work receive?",
    "Included_Class - How much opportunity do you get to contribute to class discussions?",
    "Included_Class - How much attention does the instructor give to your questions?",
    "Included_Class - How much help do you get from the instructor?",
    "Included_Class - How much opportunity do you get to answer questions in class?"
  )], na.rm = TRUE)

#Create peer interactions outcome measure
spips$StudentInteractions = rowMeans(spips[, c(
  "PIPS - I talk with other students about course topics during class",
  "PIPS - Class is structured to encourage peer-to-peer support among students (e.g., ask peer before you ask instructor, having group roles, developing a group solution to share)",
  "PIPS - I work with other students in small groups during class",
  "PIPS - I discuss the difficulties I have with math with other students during class"
)], na.rm = TRUE)

#Create sense of community and classroom participation outcome measure
spips$Community = rowMeans(spips[, c(
  "PIPS - A wide range of students participate in class",
  "PIPS - A wide range of students respond to the instructor's questions in class",
  "PIPS - There is a sense of community among the students in my class",
  "PIPS - My instructor uses strategies to encourage participation from a wide range of students"
)], na.rm = TRUE)

#Create responsive instructional environment
spips$Environment = rowMeans(spips[, c(
  "PIPS - In my class a variety of means (models, drawings, graphs, symbols, simulations, tables, etc.) are used to represent course topics and/or solve problems",
  "PIPS - Multiple approaches to solving a problem are discussed in class",
  "PIPS - The instructor explains concepts in this class in a variety of ways",
  "PIPS - The instructor adjusts teaching based upon what the class understands and does not understand",
  "PIPS - I have enough time during class to reflect about the processes I use to solve problems",
  "PIPS - The instructor knows my name"
)], na.rm = TRUE)

#Create positive mathematical affect outcome measure (not this was reverse coded)
spips$PosAffect <-
  7 -  rowMeans(spips[, c(
    "Attitude - Now - I am able to learn mathematics",
```

```
    "Attitude - Now - I am interested in mathematics",
    "Attitude - Now - I am confident in my mathematical abilities",
    "Attitude - Now - I enjoy doing mathematics"
  )], na.rm = TRUE)

#Remove NA and Not disclose sexual identity
spips <- subset(spips,!is.na(spips$QueerSexualOrientaiton))
spips <- subset(spips, spips$QueerSexualOrientaiton != "Not Disclose")

#####################################################
# Descriptive statistics
#####################################################
# Queer
spips %>% group_by(QueerSexualOrientaiton,   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,   .drop = FALSE) %>% tally
#Gender
spips %>% group_by(QueerSpectrum, `Gender-Composite`,  .drop = FALSE) %>% tally
# Race
spips %>% group_by(QueerSpectrum,
                   `EthnoRacial- Alaskan Native or Native American`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- Black or African American`,
                   .drop =  FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- Central Asian`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- East Asian`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- Hispanic or Latinx`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- Middle Eastern or North African`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- Native Hawaiian or Pacific Islander`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- Southeast Asian`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum, `EthnoRacial- South Asian`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `EthnoRacial- White`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `EthnoRacial- Prefer not to disclose`,
                   .drop = FALSE) %>% tally
#special populations
spips %>% group_by(QueerSpectrum,  `SpecialPop - International student`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `SpecialPop - First-generation college student`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `SpecialPop - Commuter student`,
                   .drop =  FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `SpecialPop - Transfer student`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `SpecialPop - Student with a disability`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `SpecialPop - Student athlete`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `SpecialPop - Current or former English language learner`,
                   .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  `SpecialPop - Parent or guardian`,
                   .drop =  FALSE) %>% tally
# SES
spips %>% group_by(QueerSpectrum,  FAFSA,  .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  PellEligible,  .drop = FALSE) %>% tally
```

```r
# STEM
spips %>% group_by(QueerSpectrum,  ClassRank,  .drop = FALSE) %>% tally
spips %>% group_by(QueerSpectrum,  STEM_Major,  .drop = FALSE) %>% tally

########################################################
#### Proportional testing
########################################################

#Proportion testing for missing class
class <-
  table(spips$QueerSpectrum,
        spips$`MissingClass - Recitation/lab section`)
class <-
  table(spips$QueerSpectrum,
        spips$`MissingClass - Regular class meetings`)
prop.test(
  x = c(class[2], class[1]),
  n = c(sum(class[2, ]), sum(class[1, ])),
  alternative = "less"
)

#Comparing equitable interactions for asexual and gay
#Proportion testing for working with peers
class <-
  table(
    spips$QueerSpectrum,
    spips$EquitableInteractions
  )

prop.test(
  x = c(sum(class[6], class[8], class[10]), sum(class[5], class[7], class[9])),
  n = c(sum(class[2, ]), sum(class[1, ])),
  alternative = "less"
)
prop.test(
  x = c(sum(class[6], class[8], class[10]), sum(class[5], class[7], class[9])),
  n = c(sum(class[2, ]), sum(class[1, ])),
  alternative = "greater"
)


########################################################
#### Comparing means and generating descriptive tables
########################################################

##This assigns one of the outcome measures to a field called outcome
#After assignment the functions are called for each one
spips$outcome <- spips$InstructorInteractions
spips$outcome <- spips$EquitableInteractions
spips$outcome <- spips$StudentInteractions
spips$outcome <- spips$HelpSeeking
spips$outcome <- spips$Community
spips$outcome <- spips$Environment
spips$outcome <- spips$PosAffect
spips$outcome <-

#generate the descriptive tables
dataTables(spips)

#Compare for differences within Queer spectrum
sigTests(spips)
```

```r

#Compare for differences between Queer Spectrum and Straight
sigTests2(spips)

######################################################
#### Generating plots
######################################################

label1 = "Instructor Interactions"
label1 = "Peer Interactions"
label1 = "Help Seeking Behaviors"
label1 = "Community and Participation"
label1 = "Instructional Environment"
label1 = "Positive Math Affect"
label1 = "Expected Grade"

#generate boxplot for a given outcome measure
PlotBoxData(spips,  "", label1)

#generate histograms
PlotCompareData(spips,  "", label1)

#generate histograms
PlotCompareData2(spips,  "", label1)

### Expected Grade need to remove (other)
spips <- subset(spips, spips$ExpectedGrade != 6)
spips$ExpectedGrades <- 6 - spips$ExpectedGrade
spips$outcome <- spips$ExpectedGrades
PlotCompareGrades(spips,  "", label1)

##############################################
#Code to run the inter rater reliability
##############################################

#Instructor Interactions
items = c(
  "PIPS - I receive feedback from my instructor on homework, exams, quizzes, etc.",
  "PIPS - I receive immediate feedback on my work during class (e.g., student response systems such as clickers or voting systems; short quizzes)",
  "PIPS - I share my ideas (or my group's ideas) during whole class discussions",
  "PIPS - I am asked to respond to questions during class time"
)

#Equitable Interactions
items = c(
  "Included_Class - How much encouragement do you receive from the instructor?",
  "Included_Class - How much praise does your work receive?",
  "Included_Class - How much opportunity do you get to contribute to class discussions?",
  "Included_Class - How much attention does the instructor give to your questions?",
  "Included_Class - How much help do you get from the instructor?",
  "Included_Class - How much opportunity do you get to answer questions in class?"
)

#Peer Interactions
items = c(
  "PIPS - I talk with other students about course topics during class",
  "PIPS - Class is structured to encourage peer-to-peer support among students (e.g., ask peer before you ask instructor, having group roles, developing a group solution to share)",
  "PIPS - I work with other students in small groups during class",
```

```
  "PIPS - I discuss the difficulties I have with math with other students during class"
)

#Help Seeking
items = c(
  "OverallExp - I attend tutoring sessions or seek help outside of class time",
  "OverallExp - I work with peers outside of class on math problems",
  "OverallExp - I see my instructor(s) outside of class for help"
)

#Community Participation
items = c(
  "PIPS - A wide range of students participate in class",
  "PIPS - A wide range of students respond to the instructor's questions in class",
  "PIPS - There is a sense of community among the students in my class",
  "PIPS - My instructor uses strategies to encourage participation from a wide range of students"
)

#Environment
items = c(
  "PIPS - In my class a variety of means (models, drawings, graphs, symbols, simulations, tables, etc.) are used to represent course topics and/or solve problems",
  "PIPS - Multiple approaches to solving a problem are discussed in class",
  "PIPS - The instructor explains concepts in this class in a variety of ways",
  "PIPS - The instructor adjusts teaching based upon what the class understands and does not understand",
  "PIPS - I have enough time during class to reflect about the processes I use to solve problems",
  "PIPS - The instructor knows my name"
)

#Pos Affect
items = c(
  "Attitude - Now - I am able to learn mathematics",
  "Attitude - Now - I am interested in mathematics",
  "Attitude - Now - I am confident in my mathematical abilities",
  "Attitude - Now - I enjoy doing mathematics"
)

#Call the function to run interrater reliability scores
alphas(spips, items)

################################################################################
### Code for the regression model
################################################################################

#Assign to a different dataset
spips_aov <- spips

# Remove NA and Not Disclose sexual identity
spips_aov <-
  subset(spips_aov,!is.na(spips_aov$QueerSexualOrientaiton))
spips_aov  <-
  subset(spips_aov, spips_aov$QueerSexualOrientaiton != "Not Disclose")

# Remove NA and Not Disclose gender
spips_aov  <- subset(spips_aov,!is.na(spips_aov$Gender))
spips_aov  <- subset(spips_aov, spips_aov$Gender != "Not Disclose")

#Combine Women and Transgender as Woman+
spips_aov$Gender <-
  combineLevels(
    as.factor(spips_aov$Gender),
```

```r
    levs = c("Transgender and Non-Binary", "Woman"),
    newLabel = c("Woman+")
  )

# Remove NA and Not Disclose race
spips_aov  <- subset(spips_aov,!is.na(spips_aov$POC))
spips_aov  <- subset(spips_aov, spips_aov$POC != "Not Disclose")

# Remove NA and Not Disclose first-generation
spips_aov <- subset(spips_aov,!is.na(spips_aov$FirstGen))
spips_aov <- subset(spips_aov, spips_aov$FirstGen != "Not Disclose")

#This assigns one of the outcome measures to a field called outcome
#After assignment the functions are called for each one
spips_aov$outcome <- spips_aov$InstructorInteractions
spips_aov$outcome <- spips_aov$EquitableInteractions
spips_aov$outcome <- spips_aov$StudentInteractions
spips_aov$outcome <- spips_aov$HelpSeeking
spips_aov$outcome <- spips_aov$Community
spips_aov$outcome <- spips_aov$Environment
spips_aov$outcome <- scale(spips_aov$PosAffect)
spips_aov$outcome <- spips_aov$ExpectedGrades

#Descriptive table to ensure large enough bin size
tab <-
  spips_aov %>% group_by(SexualizedMinority, Gender, URM  , FirstGen,  .drop =
                          FALSE) %>% tally

#Call the regresion funciton with the assigned outcome measure
RegressionCompare(spips_aov)

#####################################################################
#
# The following are functions that are called with passed in data
# and an assigned outcome measure.
#
#####################################################################
#Create the descritpive statsitcs tables for a given outcome measure
dataTables <- function(data) {
  # Compute the percentage per "bin"
  s <-
    subset(data,!is.na(data$outcome)) %>% group_by(bin = cut_interval(outcome, 5),
                                                  QueerSexualOrientaiton,
                                                  .drop = FALSE) %>% tally
  t <- cast(s, QueerSexualOrientaiton ~ bin, mean)
  z <- as.data.frame(rowPercents(t), row.names = NULL)
  z <-
    cbind(QueerSexualOrientaiton = levels(data$QueerSexualOrientaiton), z)
  # Run the functions length, mean, and sd on the value of "change" for each group,
  # broken down by sex + condition
  cdata <-
    ddply(
      subset(data,!is.na(data$outcome)) ,
      c("QueerSexualOrientaiton"),
      summarise,
      mean = round(mean(outcome), digits = 2),
      sd   = round(sd(outcome), digits = 2)
    )

  QSpec <- cbind(z, cdata$mean, cdata$sd)
  # Compute the percentage per "bin"
```

```
  s <-
    subset(data,!is.na(data$outcome)) %>% group_by(bin = cut_interval(outcome, 5), QueerSpectrum,  .drop =
                                                    FALSE) %>% tally
  t <- cast(s, QueerSpectrum ~ bin, mean)
  z <- as.data.frame(rowPercents(t), row.names = NULL)
  z <- cbind(QueerSexualOrientaiton = levels(data$QueerSpectrum), z)
  # Run the functions length, mean, and sd on the value of "change" for each group,
  # broken down by sex + condition
  cdata <-
    ddply(
      subset(data,!is.na(data$outcome)) ,
      c("QueerSpectrum"),
      summarise,
      mean = round(mean(outcome), digits = 2),
      sd   = round(sd(outcome), digits = 2)
    )
  QGroup <- cbind(z, cdata$mean, cdata$sd)
  QGroup <-
    subset(QGroup, QGroup$QueerSexualOrientaiton == "Queer Spectrum")
  combined <- rbind.fill(QGroup, QSpec)

  return(combined)
}

#Compute inter-rater reliability scores
alphas <- function(spips, items) {
  ? psych
  cronbach <- psych::alpha(spips[, items])
  print("Cronbach Alpha")
  print(cronbach$total$std.alpha)

  kappa <- cohen.kappa(spips[, items])
  print("Cohen's Kappa")
  print(kappa$av.wt)
}

#Sig test for mean difference looking within queer spectrum
sigTests <- function(data) {
  # Anova for within queer spectrum
  print(summary(aov(
    outcome ~ QueerSexualOrientaiton
    ,
    data = subset(data, data$QueerSpectrum == "Queer Spectrum")
  )))

  print(etaSquared(aov(
    outcome ~ QueerSexualOrientaiton
    ,
    data = subset(data, data$QueerSpectrum == "Queer Spectrum")
  )))

  # Post hoc t-test with Bonferroni
  Queer <- subset(data, data$QueerSpectrum == "Queer Spectrum")
  print(pairwise.t.test(Queer$outcome, Queer$QueerSexualOrientaiton, p.adj = "bonf"))
}

#Sig test for mean difference looking within all sexual identities
sigTests2 <- function(data) {
  # Anova for within queer spectrum
  print(summary(aov(outcome ~ QueerSexualOrientaiton
```

```
                    , data = data)))

  print(etaSquared(aov(outcome ~ QueerSexualOrientaiton
                       , data = data)))
  # Post hoc t-test with Bonferroni
  Queer <- data
  print(pairwise.t.test(Queer$outcome, Queer$QueerSexualOrientaiton, p.adj = "bonf"))

  #t-test for queer versus straight
  print(t.test(outcome ~ QueerSpectrum
               , data = data))

  #Effect size for straight versus queer
  print("Cohen's D")
  print(cohensD(outcome ~ QueerSpectrum
                , data = data))
}

#Generate boxplot for outcome measure
PlotBoxData <- function(data, xlab, ylab) {
  cbPalette <-
    c("#d73027",
      "#91bfdb",
      "#4575b4",
      "#fc8d59",
      "#fee090",
      "#e0f3f8")
  ggplot(data,
         aes(QueerSexualOrientaiton, outcome, fill = QueerSpectrum)) +
    geom_boxplot(alpha = .95) +
    xlab(xlab) +
    ylab(ylab) +
    scale_fill_manual(labels = c("Straight", "Queer-spectrum")
                      ,
                      values = cbPalette) +
    theme_bw(base_size = 14) +
    theme(legend.position = "bottom",
          legend.spacing.x = unit(.25, 'cm')) +
    theme(legend.title = element_blank())
}

#generate historgram for outcome measure as seperate and then overlayed
PlotCompareData2 <- function(data, xlab, ylab) {
  cbPalette <-
    c("#d73027",
      "#91bfdb",
      "#4575b4",
      "#fc8d59",
      "#fee090",
      "#e0f3f8")
  g1 <- ggplot(data, aes(x = outcome, fill = QueerSpectrum)) +
    geom_histogram(
      aes(y = ..density..),
      position = "identity",
      color = "black",
      alpha = 0.75,
      binwidth = .5
    ) +
    scale_y_continuous(labels = percent_format(accuracy = 1)) +
    scale_fill_manual(labels = c("Straight", "Queer-spectrum")
                      ,
```

```
                  values = cbPalette) +
    scale_color_manual(values = cbPalette) +
    theme_bw(base_size = 16) +
    theme(legend.position = "bottom",
          legend.spacing.x = unit(.25, 'cm')) +
    theme(legend.title = element_blank()) +
    facet_wrap( ~ QueerSpectrum) +
    xlab(xlab) +
    ylab(ylab)

  g2 <- ggplot(data, aes(x = outcome, fill = QueerSpectrum)) +
    geom_histogram(
      aes(y = ..density..),
      position = "identity",
      color = "black",
      alpha = 0.75,
      binwidth = .5
    ) +
    scale_y_continuous(labels = percent_format(accuracy = 1)) +
    scale_fill_manual(labels = c("Straight", "Queer-spectrum")
                  ,
                  values = cbPalette) +
    theme_bw(base_size = 16) +
    scale_color_manual(values = cbPalette) +
    theme(legend.position = "bottom",
          legend.spacing.x = unit(.25, 'cm')) +
    theme(legend.title = element_blank()) +
    xlab(xlab) +
    ylab(ylab)

  library(cowplot)
  plot_grid(g1, g2, labels = "AUTO")
 }

#Generate histogram for expected grade
#this is a single item with 5 point scale so new function needed
PlotCompareGrades <- function(data, xlab, ylab) {
  cbPalette <-
    c("#d73027",
      "#91bfdb",
      "#4575b4",
      "#fc8d59",
      "#fee090",
      "#e0f3f8")
  g1 <- ggplot(data, aes(x = outcome, fill = QueerSpectrum)) +
    geom_histogram(
      aes(y = ..density..),
      position = "identity",
      color = "black",
      alpha = 0.75,
      bins = 5
    ) +
    scale_y_continuous(labels = percent_format(accuracy = 1)) +
    scale_fill_manual(labels = c("Straight", "Queer-spectrum")
                  ,
                  values = cbPalette) +
    scale_color_manual(values = cbPalette) +
    theme_bw(base_size = 16) +
    theme(legend.position = "bottom",
          legend.spacing.x = unit(.25, 'cm')) +
    theme(legend.title = element_blank()) +
```

```
    facet_wrap( ~ QueerSpectrum) +
    xlab(xlab) +
    ylab(ylab)

  g2 <- ggplot(data, aes(x = outcome, fill = QueerSpectrum)) +
    geom_histogram(
      aes(y = ..density..),
      position = "identity",
      color = "black",
      alpha = 0.75,
      bins = 5
    ) +
    scale_y_continuous(labels = percent_format(accuracy = 1)) +
    scale_fill_manual(labels = c("Straight", "Queer-spectrum")
                      ,
                      values = cbPalette) +
    theme_bw(base_size = 16) +
    scale_color_manual(values = cbPalette) +
    theme(legend.position = "bottom",
          legend.spacing.x = unit(.25, 'cm')) +
    theme(legend.title = element_blank()) +
    xlab(xlab) +
    ylab(ylab)

  library(cowplot)
  plot_grid(g1, g2, labels = "AUTO")
}

# Regresion model for outcome measure
RegressionCompare <- function(data) {
  summary(lm(scale(outcome)  ~  QueerSpectrum + Gender + POC  + FirstGen
             , data = data))
}
```

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