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"Like I Was an Actual Researcher": Participation and Identity Trajectories of Underrepresented Minority and First-Generation STEM Students in Research Training Communities of Practice

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“Like I Was an Actual Researcher:” Participation and Identity Trajectories of Underrepresented Minority and First-Generation STEM Students in Research Training Communities of Practice

by

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Abstract

Although calls for a more diverse workforce in biomedical fields have been widespread, racial and ethnic gaps in biomedical degree attainment remain. Contextualist perspectives seek to understand persistent STEM inequities by examining person-in-context experiences and how systemic factors filter into students' proximal contexts shaping their participation and science identity trajectories. Research training communities of practice aim to offer underrepresented minority and first-generation students support, guidance, and opportunities to learn the practices of science and construct their science identity. However, many students still choose to leave these programs. There is limited research on these students' science identity construction process and their identity trajectories. This study fills this gap by examining contextual factors shaping participation, identifies essential experiences shaping student science identity construction, and explores the link between science identity and decisions to leave research training communities of practice. Semi-structured interviews were conducted with 23 underrepresented racial and ethnic minority and/or first-generation students participating in a research training community of practice. Twelve participants completed the program, and eleven left the program. Through thematic analysis, several themes were identified. Study results revealed the central role of contextual factors including college affordability, racialized dynamics in STEM, scientific norms that

impact student well-being, narrow pedagogical approaches, and the program's motivational climate in shaping students' participation and departure decisions. Study results also highlighted the importance of explicit inclusion in meaningful science practice, legitimate peripheral participation, and scaffolded mentoring as they learned scientific practices. Additionally, the study highlighted the importance of performance, competence, recognition, within the research training community of practice and the centrality of marginalized identities in the science identity construction process. This study provides critical insight into the underrepresented racial and ethnic minority and first-generation STEM student experience, the science identity construction process, and contextual factors contributing to choices to depart from research training programs and/or STEM career pathways.

Dedication

To Ben, Esme, and Kellan. You make me a better person and make this wild, precious life worth living.

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Chapter 1 : Underrepresented Students, Undergraduate Pathways, and STEM

Although calls for more diversity in the biomedical workforce have been widespread, little has changed in the overall demographic makeup of research scientists in the United States over the past several decades. Instead, our nation's scientific community has been slow to diversify, and particular groups remain underrepresented in the biomedical research workforce. Those underrepresented include individuals from particular racial and ethnic groups, including African American/Black, American Indian, Latinx, and Pacific Islanders, along with people who have disabilities, women, or individuals who come from socioeconomically disadvantaged backgrounds (Valantine & Collins, 2015). Becoming a biomedical researcher requires successful completion of a lengthy and challenging post-secondary pathway and, as a result, trends in college entrance, choice of college major, and degree attainment remain some of the most pertinent topics for researchers across many disciplines who are interested in increasing diversity in the biomedical workforce. In particular, who attends college and is most likely to persist to degree completion have been areas of focus for researchers over the last several decades. This literature review will begin with a brief overview of the undergraduate landscape for underrepresented minority and first-generation students across all disciplines and then focus on these groups within STEM majors, considering trends in enrollment, choice of major, degree attainment, and the unique experience of underrepresented minority and first-generation students in STEM.

College Attendance

To understand why particular groups remain underrepresented in the biomedical research workforce, overall trends in college attendance, including if particular groups are more likely to attend college than others, and how college attendance differs by region and type of institution, must be considered. According to the Bureau of Labor Statistics, in October 2019, 66.2% of 2019 high school graduates ages 16 to 24 were enrolled in colleges or universities (Bureau of Labor Statistics, U.S. Department of Labor, 2019). Notably, there was a 1.3% drop in college enrollment from the fall of 2018 to 2019, which follows the trend of small annual decreases in college enrollment rates over the last decade. When considering college enrollment by gender, although female and male enrollment trends have been similar over the last decade with a peak enrollment in 2010-2011 and then a steady decline since that time, an average of 3,000,000 more female students than male students enroll in college each year (DeAngelo et al., 2011). In the fall of 2018, nearly 20 million students enrolled in colleges and universities in the United States, equating to 41% of 18- to 24-year-old individuals in the United States. Notably, college enrollment rates for this group were higher for Asian students (59%) than those who identified as White (42%), Black (37%), and Hispanic (36%) (National Center for Education Statistics, 2020). In these national studies, race and ethnicity categories allow for a mutually exclusive selection of one race, one ethnicity, or a "more than one race" category. As a result, a complete picture of the trends in college

attendance is hard to uncover. During the 2015-2016 academic year, 56% of undergraduates nationally were first-generation college students and 59% of these students were also the first sibling in their family to attend college (Kena et al., 2016)

Historically, there has been a large discrepancy between the number of students attending public and private colleges such that many more students attend public 2 and 4-year universities than private institutions. The Bureau of Labor Statistics (2019) also noted that during the fall semester of 2019, of the approximately 18.2 million students enrolled in college, 7.9 million enrolled in public 4-year colleges, 5.3 million enrolled in public 2-year colleges, 3.8 million enrolled in private non-profit 4-year colleges, and 50,000 enrolled in private, for-profit 4-year colleges. Although overall, more students enroll in 4-year universities, Latinx students are overrepresented at 2-year community colleges, and African American/Black students are more likely to attend private for-profit universities than either of the public alternatives (Ma & Baum, 2016).

Past studies have revealed that many students choose to postpone attending college. These rates have been mostly stable over time, with about one-third of students delaying college enrollment for at least one year (Bozick & DeLuca, 2005; Riccobono et al., 2001). Research has also demonstrated that students who delay college enrollment are 64% less likely than those who go straight to college to complete their bachelor's degree (Bozick & DeLuca, 2005). Notably, the rate of students who enroll in college immediately after high school differs by race and ethnicity with White students at 41%,

African American/Black students at 36%, Hispanic students at 36%, Asian Pacific Islander students at 21%, and American Indian Alaska Native students at 19% (Bureau of Labor Statistics, U.S. Department of Labor, 2019). First-generation college students are more likely to delay college entry or need remedial coursework before entering college (Engel, 2003) and often begin college less academically prepared than other students (Choy, 2001).

There is a wide variation in enrollment patterns in the U.S. across different states and regions. In the state of Oregon, where the present study took place, in the fall of the 2018 academic year, 418,430 students enrolled at a college or university (Higher Education Coordinating Commission, 2019). Men made up 47.2% while women were 52.8% of the total undergraduate population. In the 2018-2019 academic year, Oregon community colleges awarded a total of 20,143 associate's or bachelor's degrees, while Oregon public universities awarded around 20,000 bachelor's degrees. At the community college level in Oregon, in 2019 the enrolled students were 49% White, 15% Hispanic/Latinx, 4% Asian American, 2% Black/African American, 1% Native American, and 0.5% Native Hawaiian/Pacific Islander. At Oregon universities, the 2019 student enrollment was 59% White students, 12% Hispanic/Latinx, 7% Asian American, 2 percent Black/African American, 1% Native American, and 0.6% Native Hawaiian/Pacific Islander. At present, White students account for less of the total college population than in the past in Oregon, down from 68.7% in 2010 to 58.7% in 2019, while

Hispanic/Latinx and African American/Black student attendance have stayed relatively stable over the last decade (Higher Education Coordinating Commission, 2019). These statistics, when taken together, provide essential context regarding who attends college and how attendance rates and trends differ based on group membership, region, and type of institution.

Degree Persistence

Overall statistics on degree attainment reveal demographic patterns in college completion based on race, ethnicity, and first-generation status. Students from minority racial and ethnic groups persist to degree completion at a lower rate than their White counterparts with graduation rates fluctuating by up to 25% (Shapiro et al., 2017). These gaps are more pronounced in particular fields (Libassi, 2018). The National Student Clearinghouse Research Center (Shapiro et al., 2014) reported that although college student persistence and retention rates are on the rise, there remain significant differences in these rates between racial groups with a particularly large gap between White and African American/Black students. This report found that while the overall persistence rate for White students at college was 78.1 %, this rate was 70.7% for Hispanic students, 66.2% for African American/Black college students, 36% for Asian Pacific Islander students, and 21% for American Indian Alaska Native students. Notably, some research suggests that Native Hawaiians and Pacific Islanders may be the least acknowledged of the underrepresented groups because they are often placed in categories with Asian

students (Kerr et al., 2018). One report found that Native Hawaiian and Pacific Islander students attend college at notably lower rates than that of the general U.S. population (54.9 percent) and nearly half of these students did not complete their degree (Teranishi et al., 2020).

First-generation college students are also less likely to persist to degree completion than their peers whose parents graduated with at least a bachelor's degree. For first-generation students, 23% obtain an associate's degree and 24% achieve a bachelor's or higher at some point after starting college (Teranishi et al., n.d.). In one study, researchers found that while 42% of continuing generation students graduated within four years, only 27% of first-generation students graduated in that same time frame (DeAngelo et al., 2011). Another study found that more than 25% of students who are both first-generation and low-income leaver college after only one year (Skomsvold, 2017). This could be, at least in part, because these students are more likely to have jobs while in college and live off-campus which can negatively affect their social integration on campus and academic success (Saenz et al., 2007).

Although overall rates of degree attainment differ in most disciplines based on demographic factors, research highlights that these gaps are more pronounced in STEM fields (Riegle-Crumb et al., 2019) and while underrepresented minority students make up 31% of the college population, they attain only 13% of STEM degrees awarded (National Science Foundation, 2017). In a study that considered disparities in degree attainment

across many disciplines, researchers found that even when considering various personal factors such as academic preparation and socio-economic status, STEM disciplines still had significantly fewer students from minority backgrounds completing degrees than in non-STEM fields (Riegle-Crumb et al., 2019). First-generation college students are a significant portion of the overall college student population but their challenges in STEM are of concern to higher education institutions (Capriccioso, 2006; Soria & Stebleton, 2012). A report by the National Science Board regarding National Science and Engineering Indicators highlighted the underrepresentation of first-generation students in STEM disciplines and their reduced likelihood of attaining STEM degrees (National Science Board, 2012).

When initial efforts to decrease gaps in biomedical workforce diversity failed several decades ago, researchers began positing that there was a "leak in the pipeline," with preventing certain underrepresented groups from progressing through their education to advanced degrees in biomedical fields (Olson & Riordan, 2012). This metaphor has been criticized for implying that the goal is to funnel students through a pipeline to a predetermined destination (Cannady et al., 2014), it seeks to capture the pervasive issues that continue to puzzle higher education researchers and college administrators (Allen-Ramdial & Campbell, 2014). Of course, many underrepresented minority and first-generation STEM students have been successful in attaining degrees and previous research has examined institutional affordances and supports that may have

contributed to these students' success. One significant finding is that students of color tend to have higher levels of engagement and degree completion when attending minority-serving institutions (MSIs) (Espino et al., 2012). Along these same lines, in a 2017 report that considered graduation rates of low-income, Black students, researchers found that Historically Black Colleges and Universities (HBCUs) graduated these students at higher rates, with 38% of these students attaining degrees versus 32% at Predominantly White Institutions (PWIs) (Nichols & Evans-Bell, 2017). One study suggested this may be because the student and faculty interactions at these campuses occur more frequently and are of higher quality, which may positively shape students' experiences (Hutto & Fenwick, 2002). Other research on this topic points to the importance of having supportive networks with same-race faculty and peers, both of which are more prevalent at MSIs (Espinosa et al., 2017), and the higher levels of belongingness students feel on these campuses (Strayhorn, 2008).

While first-generation students may not be members of a racial or ethnic minority group, these students regularly experience barriers to success including financial stress while in college and challenges integrating into college environments (Falcon, 2015). Studies have identified particular supports and services that may assist first-generation college students including government assistance programs for financial aid, support with school integration, and attending schools with higher levels of underrepresented minority students (Pitre & Pitre, 2009).

When taken together, these statistics and study results reveal patterns in college completion based on race, ethnicity, and first-generation status suggesting that many colleges and universities are more successfully supporting students from majority racial and ethnic groups and those who are not the first in their family to attend college. This raises questions about how institutional affordances may be differentially benefiting White, continuing education students. In contrast, institutional constraints may negatively shape the college experience for underrepresented minority and first-generation students.

Choosing a STEM Major in College

Given the previously discussed differences in STEM degree attainment rates by race, ethnicity, and first-generation status, past research has examined who chooses to major in STEM positing that underrepresented minority and first-generation students not choosing STEM disciplines may account for why fewer of these students are graduating with these degrees. This literature review considers research on STEM majors that include both the natural sciences such as chemistry and biology as well as social sciences such as psychology and sociology. In a large study that included 91,000 students attending 43 different institutions, researchers looked at how various background factors and previous educational experiences linked to a student's declaration of a STEM major. Researchers found that the only demographic factor that was significantly related to choosing to major in a STEM discipline was family income. Race, ethnicity, and first-

generation status did not appear to be linked to students' decisions (Chen, 2005). In a large longitudinal study with a national sample of 12,000 college students, Chen (2009) examined background factors that might influence whether a student would choose a STEM major in college. Similarly, the study concluded that students from lower SES communities were less likely to enter STEM fields suggesting that being from a family with limited financial resources may be a factor in whether students choose to major in a STEM discipline but that students from all racial and ethnic backgrounds choose STEM majors at similar rates. These study findings, when taken together, suggest that the gaps in degree attainment in STEM fields are likely not attributable to students from minority or first-generation groups not choosing to pursue these degrees when entering college.

Underrepresented Minority and First-Generation Student Experiences in STEM

Students from underrepresented minority backgrounds report negative social interactions with faculty and peers, and feelings of isolation because of limited access to faculty and classmates from minoritized backgrounds. In one study, students reported regular clashes between themselves, faculty, and White students and shared that these negative interactions left them feeling alone, confused, and isolated (Johnson et al., 2007). Students of color report having little access to faculty of color (Hurtado et al., 2011) and a lack of same-race peers in their classes and other research settings (Strayhorn, 2015), highlighting the reality that many underrepresented minority STEM students do not have peer mentors or more senior mentors in their major who come from

similar cultural backgrounds. In a study by Hurtado and colleagues (2011), underrepresented minority students in scientific disciplines reported having negative and impersonal interactions with many STEM faculty. Subsequently, they viewed the college science classroom environment as being overly competitive. In the same study, college administrative staff were interviewed about the reasons these negative classroom environments persist despite more student-centered approaches in pedagogies becoming popularized. Administrators reported that they believe faculty members are reluctant to introduce new supportive mechanisms in the classroom even if they might enhance classroom learning for diverse students. In this mixed-method study, researchers identified their key finding as the significant role of the institutional context in ensuring high quality student-faculty interactions at the classroom level.

Underrepresented minority and first-generation students in STEM often experience a disconnect between the dominant cultural values and norms espoused by many scientific disciplines and those from their cultural backgrounds. Previous research has suggested that biomedical disciplines at college operate using ideals and narratives from White, dominant culture which often creates tension when paired with the lived experiences of underrepresented minority and first-generation students (Snively & Corsiglia, 2001). As a result, students from dominant cultural backgrounds often find "cultural continuity" between their communities of origin and campus contexts while many underrepresented minority students do not have this experience (Padilla et al.,

1997). For instance, in a study conducted by Strayhorn and colleagues (2015), researchers used both quantitative and qualitative data to examine the experiences of 38 underrepresented minority students in STEM. Students shared that in these environments they felt socially isolated and alienated in STEM disciplines at college. Other research has suggested that underrepresented minority students struggle to transition from their family and social environment to academic contexts (Giroux & Kincheloe, 1992). Cooper and colleagues (1999), building on previous work by Phalen (1991) posited that many students must put in significant effort to coordinate their cultural and family traditions and norms with academic environments. In higher education STEM settings, students often enter an unfamiliar, intimidating, and even unwelcoming "world" into which they are expected to quickly and successfully integrate with little or no support in this process. This poor institutional climate has a well-documented negative link to students' sense of belonging which often leads to lower levels of student persistence (Purdie-Vaughns et al., 2008).

When taken together, these challenging experiences are barriers to student success and provide a picture of the unique struggles faced by underrepresented minority and first-generation students in STEM. They also highlight the foundational injustices in higher education STEM contexts that equity Scholars and researchers are seeking to address. Although these studies shed light on the everyday experiences of underrepresented minority and first-generation STEM students, they provide limited

insight into root causes for gaps in persistence and degree attainment. Many scholars seeking to better understand these persistent inequities have examined how learning, social processes, and students' identity construction may be shaping the college STEM experience and contributing to challenges for these students.

Understanding Underrepresented Minority & First-Generation Students in STEM: Learning and Identity Construction as Key Processes

STEM disciplines have a long history of top-down hierarchical classroom environments where learning is viewed as a students' ability to understand, memorize, and regurgitate information on a given topic. Not surprisingly, many students in these disciplines struggle to succeed with this approach to learning (Olson & Riordan, 2012; Seymour & Hewitt, 1997). Although there has been a growing focus on more inclusive and innovative pedagogical approaches, the implementation of new ways of teaching has been slow (Borrego & Henderson, 2014). There is concern among education researchers and educators focused on equity that these traditional approaches, which often mirror dominant cultural values, may also perpetuate inequities for minoritized groups (Malcom et al., 2016).

Experiences in science classrooms and lab environments are at the core of how students see and understand themselves and their abilities in these domains (Kim & Sinatra, 2018). Traditional approaches to teaching science often create environments where student learning and subsequent identity construction rests on students'

demonstration of competence in the classroom, an experience often limited to students from dominant cultural groups who have been socialized to succeed in these spaces (Ballenger, 1997). This pedagogical approach fails to see students' identity construction as a process that occurs *while* engaging in scientific learning and how students' self-appraisals within these domains are the result of opportunities for learning and practice in the classroom.

Identity construction has played a central role in attempts to understand student engagement and achievement for underrepresented minority and first-generation students in higher education (Syed et al., 2011). Students' ability to see themselves as "science people" in STEM spaces is central to their likelihood of success, particularly for underrepresented minority and first-generation students in these disciplines (Chemers et al., 2011; Robnett et al., 2015). Traditional theories of identity focus on individual cognitive processes of identity and fail to adequately explain how the contextual realities of STEM disciplines and classrooms can support or impede students' identity formation based on their experiences and interactions in these environments. In the next section, traditional conceptualizations of identity as a process of formation and a sociocultural alternative for considering underrepresented minority and first-generation college student identities as construction process will be reviewed. Additionally, the processes of identity construction and learning through practice in educational contexts will be explored.

Traditional Conceptualizations of Identity and a Sociohistorical View of Underrepresented Minority & First-Generation Student Identities in STEM

Developmental psychologists have historically drawn heavily from Erikson's (1968) psychosocial theory of lifespan development to describe and explain identity development across the lifespan. Erikson conceptualized identity as a developmental process involving building a personal sense of coherence across time and multiple contexts. In his view, this universal and formative task is most prominent during adolescence but continues into adulthood. This perspective focuses predominantly on the role of the sociocognitive in developing one's sense of self and emphasizes the importance of individuals' earlier life experiences in how people understand themselves in the world. Although this sociocognitive view of identity development is foundational developmental psychology, more recently researchers have forged new pathways to conceptualize identity that aim to recognize the complex and dynamic process of identity construction as firstly a social process over the lifespan. For instance, building on Erikson's focus on the innate inner conflict for those in adolescence grappling with their unique personhood after a lifetime of experiences and messages about who they are, some researchers have taken a narrative approach to identity formation in which individuals retroactively reconstruct their past in efforts to integrate their life into a more coherent sense of self (e.g. McLean, 2016; Syed & Azmitia, 2008). This narrative approach, expanded and refined later by McLean and Syed (2016), recognized that

individual understanding of one's story differs between individuals and is significantly linked to cultural context.

Although the Eriksonian perspective emphasizes the role of social contexts and interactions within these spaces as key in identity development, this perspective has been criticized for failing to consider how broader cultural forces shape these contexts, impact social interactions, and lay the foundation for how individuals build a personal sense of self. More recent conceptualizations of identity as construction reject the notion that identity development happens within a person, as an intraindividual and cognitive process, arguing instead that identity construction happens through social processes as individuals interact with social partners across various contexts (Martin, 2003). Martin and colleagues (2003) posited that what matters most in identity construction is the living, breathing person who is acting in a social world to understand themselves and their role, thus becoming an independent and self-reflective individual. In this view, one constructs their identity continually throughout life while making meaning of interactions with social partners, objects, and symbols. Martin implored the field of developmental psychology to make "the person acting in the world the primary concern of psychological theory and inquiry" (2015, p. 31). Along similar lines, Gergen provided a clear critique of the widespread assumption in Western psychology that the individual is the "fundamental atom of society" (2011, p. 281). Instead, Gergen proposed that relationships between people lie at the center of understanding human development and

social interactions are responsible for how individuals think and act in the world. Stetsenko (2012), providing a sociohistorical perspective within the sociocultural family of theories on identity construction, points to the foundational notion in Vygotsky's psychology that views social activity as central to human development. Stetsenko accordingly includes the historical and collective nature of relational processes, individual roles, and social interactions in identity construction. These sociocultural perspectives emphasize that identity does not emerge as the result firstly of an intrapersonal, cognitive process of reconciling identities across domains but rather as a dynamic, perpetually emerging process that depends on how individuals make sense of their social interactions, how they interpret the meanings of these interactions in regards to their personhood, and the broader cultural, social, and historical forces that are creating the environments in which these social exchanges take place.

Although identity construction has been at the forefront of much research on underrepresented minority and first-generation college student success, the dominant model in higher education research until recently applied a cognitivist perspective to conceptualize student identity as a process that takes place primarily at the intraindividual level. Some exceptions include work that has used a sociohistorical perspective to understand how college students form an understanding of themselves in learning contexts (Mitescu, 2014), research on supporting doctoral students from a diverse background with a sociohistorical lens (Crossouard & Pryor, 2008), and research that has

examined how different sociohistorical contexts were instrumental in shaping student experiences within the same program (Englund et al., 2018).

Sociocultural perspectives on identity construction implore us to consider the social processes that define students' environments and how ongoing social interactions are contextualized in historical realities. In this view, social interactions in educational settings may result in unique processes of identity construction for students from particular groups, such as those that have been minoritized in higher education settings. To adequately explore how identity construction may be shaping the underrepresented minority and first-generation college student experience in STEM disciplines, we must consider identity construction as a dynamic, social process dependent on social interactions across multiple domains and recognize the centrality of social interactions in STEM contexts in higher education in shaping students' sense of self in these environments.

Accordingly, learning is a fundamentally social process and identity construction is the result of understanding roles within a sociocultural context and navigating the values, norms, and cultures of various contexts through social interactions with others (Lave & Wenger, 1991; Wenger, 2008). This view of learning sees the individual and social processes as mutually constituting with social interactions at the core of how knowledge is co-constructed in any learning-related context (Park, 2015). Notably,

students have many different identities that co-exist and are made more salient based on their activities, social partners, and other contextual factors (Bricker & Bell, 2012).

Taking a sociocultural perspective on social interactions in context as key to identity construction, Wenger's (1998) Communities of Practice framework aimed to better conceptualize the centrality of learning and practice in identity construction. Communities of practice must have a domain, a community (more than one person), and practices that are being learned. These communities can vary widely in size and purpose and are co-constructed based on the participants' social interactions where individuals are negotiating meaning and using their interpretations to move their understanding of their identities forward.

This view of learning may prove useful in considering how underrepresented minority and first-generation students are navigating their pathways in STEM majors at college because it considers how identity construction is the result of intertwined and overlapping social processes that occur as individuals are given opportunities for learning through practice in various environments. The communities of practice model provides an ideal theoretical framework to consider the underrepresented minority and first-generation STEM student experience in higher education as it examines the process of gaining new knowledge in social contexts through reciprocal interactions and continuous negotiation that shapes students meaning making and identity construction.

Using the conceptual framework of communities of practice, Wenger focuses on four major components of learning and identity which include that students learn through doing, the importance of meaning-making in the learning process, the role of belonging in a community while learning, and how learning is the process of becoming a particular kind of person who can be recognized as such by oneself and others. Importantly, for Wenger, identity is not only formed by the practices we engage in but also the practices we do not engage in and is "a constant becoming" that defines whom we are by "the ways we participate and reify ourselves; our community membership; our learning trajectories (where we have been and where we are going); reconciling our membership in many distinct communities into one identity; and negotiating local ways of belonging with broader, more global discourse communities" (2003, p. 149).

Wenger's conceptualization of learning and practice posits several core beliefs about how students navigate the process of constructing their identity. First, identity is a negotiated experience and students define themselves by their experiences in learning environments. For underrepresented minority and first-generation STEM students, how they see themselves comes through participation in both STEM and non-STEM spaces. Second, identity is linked to community membership and students define themselves by considering their mutual engagement, joint enterprise, and shared repertoire in communities of practice. In other words, underrepresented minority and first-generation students construct their identities based on whether they see themselves

as community members, when they know what is expected, they have opportunities to engage with others in the community, and they have the competence to complete required tasks. Third, identities formed through practice exist in trajectories, which are the accumulation of formational experience and events, and students' perceptions about where they are now and where they are going in the future. Fourth, identity is the nexus of memberships in many different groups. Students belong to multiple communities of practice and work to maintain a coherent identity between these contexts, reconciling tensions in the different forms of membership and participation. Finally, each learning environment is a relationship between local contexts and global realities and the conditions in which social processes take place are the result of large and systemic forces.

Conclusions about Underrepresented Minority and First-Generation STEM College Students' Pathways, Learning, and Identity Construction

National trends reveal different college enrollment and degree completion rates for underrepresented minority and first-generation college students in STEM disciplines. Although students from different racial and ethnic groups appear to have similar levels of interest in science, underrepresented minority students are less likely to succeed on their STEM pathway. Prominent approaches to science education are thought to perpetuate these inequalities. Although many innovative approaches to teaching and

learning have been developed, implementation at universities and colleges has been slow.

Traditional ways of understanding identity construction focus on identity as an individual, cognitive process. This falls short by not acknowledging the centrality of social processes in identity construction and many psychologists have taken a sociocultural approach that sees identity as a process that unfolds over time through interactions and negotiated meanings in learning spaces. Notably, the ongoing social interactions within STEM classrooms and environments lay the foundation for underrepresented minority and first-generation students' science identity construction and provide important information about what identities are available to them.

Wenger 's concept of communities of practice weaves together learning, identity, and practice to provide a relevant framework for considering how STEM contexts are shaping students' identity processes and their subsequent opportunities for success. Wenger's identity-in-practice perspective is particularly useful for equity-minded scholars and practitioners because it focuses on how institutional contexts create or inhibit student success based on if these environments allow for and support the construction of science identity for underrepresented minority and first-generation students. This sociocultural view of identity should inform how we understand underrepresented minority and first-generation student participation and success in STEM disciplines. We must look beyond a cognitivist lens concerned only with

individual thoughts and behaviors to instead consider the social, cultural, and historical factors that create the environments in which students learn.

In the next section, this literature review will delve into traditional explanations for gaps in STEM degree attainment as well as contextualist and sociocultural perspectives on why these inequities persist. This will be followed by an in-depth discussion of campus programming aimed to support these students and how a broader conceptualization of identity dimensions, and consideration of the many contextual factors shaping these student trajectories, may provide important insight into persistent STEM inequities.

Chapter 2 : Theoretical Perspectives on STEM Inequities in Higher Education

Persistent gaps in STEM degree attainment for underrepresented minority and first-generation students have prompted widespread efforts to examine and understand the factors that may be responsible for these ongoing inequities. Approaches to studying relevant phenomena and delve into the wide range of possible explanations are significantly shaped by researchers' perspectives on student learning and identity construction. As previously discussed, the dominant view of identity in developmental psychology is as a series of cognitive processes, occurring at the intraindividual level, with the individual cleanly separable from constructs that are easily relegated to the social world. This view explains inequitable outcomes in STEM by examining differences in individual-level factors such as a student's academic abilities, their commitment to science, or their access to others who place a high value on education suggesting that if students altered their mindset, deepened their interest in science, or had higher levels of social support these gaps would not exist (Schmidt, 2008). Ultimately, these explanations focus on students' deficits and deficiencies, putting the responsibility for their persistence and degree attainment on the students and their families while failing to consider historical and systemic realities that limit access and exposure for these students and shape these students' trajectories.

Other researchers, who take a contextualist view, are focused on the nature of the context within which students develop and how these environments either support or

hinder students' learning and subsequent ability to succeed in college. For researchers using this sociocultural lens, the process of human development consists of ongoing social interactions between humans, and the focus of their study is these social interactions and how larger, systemic forces shape the contexts in which these interactions occur. This approach considers a broad range of complex and interconnected social, cultural, and historical factors. A more in-depth exploration of these approaches, including deficit-based explanations and those which look at person-in-context and systemic factors to understand and explain student outcomes follows along with arguments against the deficit-based approach.

Deficit-Based Explanations for Gaps in STEM Degree Attainment & A Contextualist Alternative

Psychological research has a long history of attributing gaps in achievement and persistence of minoritized students to the deficits of individuals from these groups. According to Valencia (2012), the deficit thinking model is a foundationally endogenous theory that posits that students fail in school because of individual shortcomings including flawed moral character, intellectual limitations, and low motivation levels. These approaches, which suggest that individual deficiencies are responsible for students' lack of academic achievement or persistence, are also widespread in researchers' attempts to explain educational inequities between groups in higher education.

During the first half of the twentieth century, researchers posited that differences in academic achievement between racial groups could be attributed to race-based biological attributes. In the early 1900s, Lewis Terman and Henry Goddard conducted intelligence tests and compared scores between racial and ethnic groups concluding that the low performance on these tests by some racial, ethnic, and linguistic minorities reflected these groups' genetic inferiority (Valencia, 2012). These initial deficit-based attempts to explain differences in student outcomes posited that minority students have limited cognitive and intellectual abilities based on their biological inferiority to White students which could not be altered. More recently, educational environments operate under the assumption that students' intelligence is an unchangeable, fixed internal characteristic (Dweck, 2008). The idea of fixed intelligence, or entity theory, is tethered to the notion that certain individuals have predetermined levels of intelligence and more aptitude to succeed at academically challenging work. In college STEM classrooms, faculty who believe that student intelligence is fixed have larger racial gaps in academic performance in their classrooms and students of color are less motivated in these environments than in classes with faculty who see intelligence as malleable (Canning et al., 2019).

Although a significant body of research has discredited the idea that racial inferiority exists (Gould, 1981), modern-day deficit-based approaches still suggest that underrepresented minority students' challenges in science-related disciplines stem from

individual-level factors (Valencia, 2012). These deficit-based approaches have transitioned from biological inferiority to focus on cultural deficiencies of minority groups attributing gaps to factors such as a lack of curiosity about science topics from underrepresented minority students or families that do not place a high value on education. Although previously discussed research has revealed that students of color are no less likely to choose a STEM major in college than White students, some researchers still assert that students from minority backgrounds may not have the innate interest in the sciences needed for a STEM-related career (Anderson & Kim, 2006; Cullinane, 2009). However, this assertion is not supported by research as studies have shown that students from underrepresented minority backgrounds have similar levels of interest and excitement about science-related content to those from non-underrepresented backgrounds (Riegle-Crumb et al., 2019). Additionally, this perspective fails to consider how the broader opportunities and affordances in educational environments, such as access to high-quality STEM instruction and regular exposure to racial and ethnic role models in science textbooks, may play a role in how students understand their relationship with science and their role in scientific communities.

Another culturally focused, deficit-based explanation to STEM inequities posits that a lack of family support is responsible for differential outcomes for underrepresented minority students in STEM. In this view, students' challenges may be the result of lower levels of parental involvement in academic work, a lack of value of education by

families, or limited provision of role models pursuing college degrees (Lott & Rogers, 2011). These perspectives put the responsibility for students' challenges in higher education on their families and communities which are seen as problematic, unsupportive, and damaging to their college experience. However, research has demonstrated that although parental support for educational pursuits may manifest differently across racial and ethnic groups, parents of underrepresented minority students value education and want to support their students as they pursue post-secondary degrees (Azmitia & Brown, 2002).

Ultimately, these perspectives fail to recognize how institutional and educational policies, access to resources and support, and systemic racism and oppression impact student's college experiences and shape their trajectories. Explanations that consider student success in STEM cannot be isolated to individual-level factors but must be examined in a much larger context that considers how societal and cultural factors shape students' adjustment to college, on-campus integration, academic performance, and persistence.

Lemke (2001) posits that a sociocultural approach to understanding science education considers it as a collection of social interactions and activities conducted within institutional and cultural frameworks. This view provides rationale for considering both structural and person-in-context factors that may play a role in STEM inequities and impact underrepresented minority and first-generation STEM college

students. Successful efforts to diversify the STEM workforce will require researchers to shift the narrative of the cultural inferiority of underrepresented minority and first-generation students to focus on a contextual, sociohistorical approach that delves into the larger social, cultural, structural, and historical contexts in which these student experiences are situated.

Contextualist Perspectives: Person-In-Context Factors Contributing to STEM Inequities

Research attempting to understand the underrepresented minority student pathway in STEM has long considered the experiences of these students and examined their access to opportunities and resources, perceptions of social interactions, and the instructional practices used in various contexts on college campuses. Sociocultural approaches to this work take these considerations even further by looking at individuals and context as co-constitutive and thus, examining social interactions rather than solely individual's perceptions about their interactions with others. This approach does not attribute gaps in degree attainment to personal deficiencies, as the previously discussed deficit-based perspectives might suggest, but rather focuses on how interactions in proximal environments, along with the provisions or exclusions from learning and participation opportunities within these environments, may be responsible for students' decisions to leave the sciences or college altogether.

Missing from many traditional approaches to studying human development are the contextual realities that create differential access to resources within these environments for certain groups. According to Garcia-Coll (1996), mainstream developmental sciences have not looked at unique normative developmental processes among minority children because they are not considering the way that social stratification and its derivatives may be shaping students' experiences and the subsequent processes driving student development. As an alternative, Garcia-Coll created the Integrative Model for the Study of Developmental Competencies in Minority Children that puts these influences at the core. The model posits that macro-level mechanisms such as racism, prejudice, discrimination, oppression mediate between an individual's social position and various other contexts directly affecting student outcomes. This is significant when considering underrepresented minority STEM students because it provides a foundation for understanding how the broader social forces filter into students' ecological systems, shape their proximal environments, and influence their attitudes and behaviors in educational contexts.

Research has identified several ecological background factors unique to underrepresented minority students in STEM that may relate to students' choices to continue pursuing STEM degrees, their ability to succeed in STEM disciplines, and their likelihood of persistence to degree attainment. In a comprehensive review of the literature on college success and retention, Kuh and colleagues (2006) concluded that

underrepresented minority students are significantly more likely to come from lower-income households, be first-generation college students, and experience financial strain while attending college suggesting that these background factors, which have documented negative relationships with college success, disproportionately impact underrepresented minority students. In another study, researchers found that the financial and family concerns of underrepresented minority students had a negative relationship with students' social self-concept and their academic and social adjustment on campus (Hurtado & Carter, 1997). Given what is known about the critical components of student success, these results suggest that the ongoing stressors that many individuals from minority groups face may be hindering their ability to be successful in higher education and provide evidence that the ecological contexts in which students develop may be influencing their persistence in college. Next, several lines of research that consider person-in-context focused explanations will be reviewed.

K-12 Preparation for Underrepresented Minority Students

Students enter college after over a decade of academic experiences in educational settings. Thousands of interactions with teachers and peers, along with years of academic coursework, contribute to students' identity construction and impact how they appraise their academic capabilities when entering college. Research has shown that college success in STEM disciplines relies, at least in part, on positive self-appraisals about one's abilities in these disciplines (Britner & Pajares, 2006). Because of this, understanding

how these previous academic environments and experiences shape students' academic self-concept has been of great interest to those studying underrepresented minority students in STEM.

Across primary and secondary educational contexts, research has demonstrated that students of color are disproportionately placed into less academically challenging classes even when controlling for students' academic abilities (Oakes, 1990). In a mixed-methods study that looked at factors contributing to college enrollment for students of color, Allen and colleagues (2003) found that the placement of students in courses based on teacher's perceptions of their academic abilities, also known as ability tracking, results in school staff and administrators designating students in more academically challenging courses as a more appropriate fit for college. These students are subsequently prepared for college entrance with mentors and college tours, while students outside this group often receive very little assistance planning for postsecondary education. Research has also suggested when students from underrepresented minority groups receive instruction in science and math topics in K-12 settings, the curriculum is often not congruent with students' cultural identity and this lack of culturally responsive pedagogy can undermine the benefits of exposure to STEM topics in primary and secondary educational environments (Wang, 2013).

For underrepresented minority students in biomedical disciplines, the evidence is mounting that these pre-college academic experiences predict students' self-appraisals of

their scientific abilities as they pursue STEM degrees. It is crucial, then, to consider the frequent negative and damaging experiences of underrepresented minority students in pre-college science-related classes. In a longitudinal study, Cherng (2017) found that math teachers were more likely to perceive their classes as too difficult for students of color compared to White students, even after controlling for homework completion rates and test scores suggesting that race may play a role in how teachers perceive students' abilities. Given the known link between pre-college academic experiences and success in college, the experiences of underrepresented minority students in primary and secondary academic environments may be contributing to the challenges they face in degree attainment at the higher education level.

Other studies have looked at the relationship between K-12 STEM education and success in STEM disciplines at college. In a study by the National Commission on Teaching and America's Future (1996), students from lower SES schools who are disproportionately from racial and ethnic minority groups, were significantly more likely to be taught STEM classes by teachers who had little or no training in science disciplines. Pre-college STEM experiences were also the focus of a study conducted by Chang and colleagues (2014). The results of this study suggested that being from a minority group may not only be negatively related to persistence in a STEM major but that this negative link may be the result of inadequate preparation in high school science courses and a lack of access to high-quality educational opportunities. These results suggest that the gap in

STEM college degree attainment for underrepresented minority students may, in part, be the result of the inequities in secondary schooling options for these students.

Institutional Climate and a Sense of Belonging in STEM

Beyond its importance for college student success generally, a sense of belonging is particularly crucial for underrepresented minority STEM students on college campuses. The combined experience of being a minoritized student on campus and majoring in a scientific discipline, where students often feel isolated or like an outsider, creates a psychologically challenging environment for students. In one study, conducted with 1,722 women majoring in STEM disciplines, women of color reported a significantly lower overall sense of belonging than White women (Johnson, 2012). These results suggest that being a member of a minority racial or ethnic group may significantly determine the extent to which students experience a sense of belonging. In a second study, researchers found that Black male engineering students were more uncertain about the quality of their social bonds with other students and faculty in their discipline than those from the majority group. Additionally, these students had a lower sense of belonging than White students within the engineering department (Walton & Cohen, 2007). In the third study, which included 201 college seniors who were all STEM majors, researchers found that students of color who major in STEM were significantly less likely to report a high sense of belonging than White students in STEM majors (Rainey et al., 2018). When taken together, these studies provide a sobering picture of

the lack of belongingness that many underrepresented minority students pursuing STEM degrees are experiencing and suggest that underrepresented minority students likely have lower overall levels of belonging than students from majority populations within these disciplines.

Researchers posit that a sense of belonging is an important resource for underrepresented minority students who successfully attain biomedical degrees. Past studies have isolated a sense of belonging for underrepresented minority STEM students to consider its relationship with achievement, persistence, and academic engagement. Garcia and Hurtado (2011) conducted a quantitative study to explore the predictors of persistence for Latinx undergraduate STEM students and found that a sense of belonging was significantly and positively related to persistence for Latinx students in STEM majors suggesting that when a student feels a greater sense of belonging, they will be more likely to persist to degree completion in their discipline. Strayhorn (2015) conducted a mixed-methods study to examine how demographic factors, STEM interest, pre-college self-efficacy, and a sense of belonging might be shaping the adjustment to college and academic success of Black undergraduate males in STEM majors. Zero-order correlations revealed a significant and positive association between a sense of belonging and several student success measures for the sample's STEM students including college GPA, satisfaction with college, overall satisfaction, and intent to persist. Qualitative data from 38 in-depth one-on-one interviews with participants corroborated these findings,

further supporting the notion that belonging may take on heightened importance for Black male students in STEM majors and departments, where they often feel alone and isolated. Wilson and colleagues (2015) examined the role of a sense of belonging in predicting academic engagement for STEM students. The sample was recruited through STEM courses and science-focused activity groups and included 1,507 sophomores, juniors, and seniors in STEM majors from five different types of higher education institutions. These five institutional types included a private institution, a women's college, a research-intensive university, a teaching university, and most relevant to the current study, a Historically Black College (HBCU). The three measures of a sense of belonging were the only predictors in the model and the results from the multiple regression analysis showed that for the African American/Black STEM students, there was a significant and positive relationship between students' belonging to their STEM courses and student engagement in academic activities required to complete their class.

In sum, research to date suggests that underrepresented minority STEM students experience lower levels of belonging within their disciplines and institutions, resulting from hostile campus climates and ongoing experiences of bias and discrimination for underrepresented minority students. However, underrepresented minority STEM students likely have a need greater belongingness as it may be an essential ingredient that allows them to persist through the challenges they encounter.

Pedagogical Norms, Stereotype Threat, and Microaggressions in STEM Disciplines in College

Past research on underrepresented minority student success in STEM has suggested that the experiences of individual students within classrooms and in their disciplines are an important component of their success (Booker, 2016; Cohen & Garcia, 2005; Gasiewski et al., 2012; Solorzano, 2000). For instance, many students, shortly after beginning in a STEM major, must take foundational courses designed to "weed out" students whom programs fear may not be successful, leading to doubts about the competence and belonging within STEM disciplines that can be particularly devastating for underrepresented minority and first-generation students who already may be wondering if they have what it takes to succeed in science (Chen, 2009). These courses illuminate the prevailing pedagogical norms in many STEM courses where many professors utilize approaches that are seen as cut-throat, competitive, and highly intimidating, particularly for those who may already doubt their fit in STEM.

Underrepresented minority students in scientific disciplines have reported negative interactions with both faculty and peers and studies have highlighted the potential role of faculty's pedagogical practices in persistent negative experiences in these learning environments (Hurtado et al., 2011; Johnson et al., 2007). Many minority college students report frequent and persistent experiences with stereotype threat, implicit bias, and microaggressions with classmates and professors (McGee & Martin, 2011;

Solorzano & Yosso, 2001). Unsurprisingly, these experiences of discrimination can lead to hostile academic environments in classrooms and lab settings for underrepresented minority STEM students (Hurtado & Ruiz Alvarado, 2015). Research has also shown that faculty often have lower expectations for the academic performance of underrepresented minority students (Hurtado et al., 2011). Notably, discrimination, microaggressions, and low faculty expectations widespread occurrences on college campuses for underrepresented minority students. These experiences have well-documented negative relationships with a sense of belonging for underrepresented minority students (Chang et al., 2014; Hurtado & Ruiz Alvarado, 2015).

Conclusions about STEM Inequities and Underrepresented Minority and First-generation Students-in-Context Explanations

Underrepresented minority and first-generation students experience several challenges as they traverse through their educational pathways and must engage with faculty and peers in classrooms and research lab settings. These students develop in ecological contexts shaped by the realities of systemic oppression and racism. This can result in a lack of access to the resources and support accessible to their dominant culture, continuing education classmates. For instance, underrepresented minority and first-generation students often attend less-resourced schools and are not adequately provided with ample opportunities to be taught science-related classes by teachers trained in the

sciences (Chang et al., 2014; National Commission on Teaching & America's Future (U.S.), 1996).

When underrepresented minority and first-generation students choose to pursue a STEM degree in college, they report lower levels of a sense of belonging in these spaces and frequently experience discrimination, bias, stereotype threat, and microaggressions making success in these disciplines difficult. Taken together, it is clear that these person-in-context factors are contributing to STEM inequities. However, it is imperative to consider how the structural realities that allow such contexts to exist perpetuate these inequities. Next, several systemic and structural factors shaping the underrepresented minority and first-generation student pathways in STEM will be discussed.

Contextualist Perspectives: Structural Factors Contributing to STEM Inequities

A brief review of several person-in-context explanations for STEM inequities exposes that the underrepresented minority STEM student experience is situated in a complex system of proximal and distal contexts that shape students' access to resources, sense of belonging, and discriminatory experiences in the classroom, among other things. When considering the lower rates of persistence of these students, crucial considerations include the many cultural, societal, and systemic forces that impact students along their academic pathways (Lemke, 2001). Equity scholars argue that STEM education is culturally mediated and socially constructed, emphasizing that our

collective drive to understand the nature of the world is complex and dynamic. Therefore, we must engage with the larger "political, ideological, and racialized context of STEM education" to understand the experience of underrepresented minority students in STEM (Vakil & Ayers, 2019).

Studies have suggested that STEM higher education is currently stratified by race with African American/Black, Latinx, and Native American students at the bottom of a racialized STEM hierarchy (Nelson et al., 2007). In one study, students from Black and Latinx groups were found to experience lasting psychological strain as the result of ongoing racism within institutions and other structural barriers faced by these students (McGee, 2016). Notably, missing from this research is the experience of Asian American and Pacific Islander (AAPI) students in STEM, as they are not consistently considered an underrepresented minority group in educational reform and research (Park & Teranishi, 2008). This may be because of deeply held stereotypes about this group as a model minority (Park & Chang, 2010) borne out of the consistent lumping together of all Asian identifying students and not disaggregating by ethnicity or income. As a result, Filipinos, Vietnamese, Cambodian, and Pacific Islander groups, who are underrepresented in the biomedical workforce, are not included in studies regarding underrepresented minority student success. This results in the belief that many Asian American and Pacific Islander students may not need the same assistance as underrepresented minority students from other groups despite the reality that AAPI students face significant challenges both on

and off-campus in STEM including similar racialized experiences such as stereotypes and microaggressions with other racial/ethnic minorities (Yeung & Johnston, 2014). Given what is known about these realities in higher education for African American/Black, Native American, Latinx, and AAPI students, considerations of the cultural norms and practices, along with the consequences of systemic racism and oppression of underrepresented minority and low-income students must be considered. Next, several explanations for how these structural factors may impact student trajectories in STEM disciplines will be reviewed.

STEM Disciplines, Culture of Power, and Science Capital

Some researchers have posited that inequities in STEM disciplines may be the result of students' ability to deploy various forms of social and cultural capital in exchange for opportunities for social mobility within these spaces. Archer and colleagues (2015) extended previous work on capital by Bourdieu (1986) to consider the social and cultural dimensions of cultural capital. In particular, they provided insight into the structural factors that create systems where particular groups are at a disadvantage because they do not have the cultural capital needed to gain opportunities in these environments. This idea of science capital produced a conceptual model that proposes that scientific forms of social and cultural capital are used by students to successfully navigate these disciplines. Archer posited that when students have cultural capital such

as having a cultural appreciation of science, scientific literacy, and practices such as consumption of science-related media, along with social capital such as knowing people with science-related jobs, this creates a "science capital" that has significant value and can be exchanged for opportunities within these realms. DeWitt and colleagues (2016) further extended this research to consider how science capital may shape science participation for underrepresented minority and first-generation students. Using data from two surveys completed by students from underrepresented minority and first-generation backgrounds researchers found that science capital was closely connected with science-related aspirations for future education and careers. Additionally, they found that particular dimensions of science capital including family influences, science literacy, and student's perception of the utility of science were more closely linked to science identity and student's anticipated future participation in science.

Past research has posited that a culture of power exists in STEM majors on college campuses and that this culture perpetuates inequalities and is responsible for gaps in STEM degree persistence and attainment (Barton & Yang, 2000). This "culture of power" represents a set of values, beliefs, and behaviors that unfairly celebrate and reward White, upper and middle class, male, and heterosexual groups. Individuals from these groups are elevated to positions of power and authority and get to determine values and norms in these contexts (Delpit, 1988). In Delpit's (1988) view, this "culture of power" affects every part of educational institutions and manifests through interactions in

the classroom, the existing norms for participating in power, that rules are accepted and created only by those in power, and the explicit instruction to those without power that if they play by the "rules," they will have a higher likelihood to acquire power. Delpit argues that without making these "rules" explicit, those who are not familiar with the culture of power, namely underrepresented minority students, will not be afforded opportunities for upward mobility and may be perceived as inferior, deficient, and the root of many societal ills. Research findings have corroborated this in higher education STEM contexts such as in a study by Hurtado and colleagues (2009) which emphasized the pervasiveness of unwelcoming and competitive cultures in STEM disciplines that are borne of the hierarchical nature of power distribution within these majors.

The implications for the student experience within this "culture of power," given the varied level of science capital that students may have based on their position within these stratified environments, occurs in student and faculty interactions in the classroom, grading practices and policies, student participation in research experiences, and more. In their work, Barton and Yang (2000) explore how the experiences and values that are viewed as the "ideal" within the educational system shape individual opportunities and impact individual trajectories into or out of STEM careers. Using a case study approach to dissect how a culture of power in science education shaped the college and career choices of one individual, they explored the experience of a Latinx male individual who was not afforded opportunities to pursue his interest in a science-related

career. Ultimately, Barton and Yang call for a new conceptualization of science curriculum and teaching practices that allow underrepresented minority students to simultaneously engage in scientific learning and imagine future STEM careers while preserving their sense of cultural identity.

Researchers examining whether racial and ethnic degree attainment gaps were more pronounced in STEM disciplines suggested that the sociological phenomena of "opportunity hoarding" may be prohibiting the success of some underrepresented minority students in STEM. The framework comes from Tilly (1998) who proposed that "opportunity hoarding" is foundational to understanding inequality and is seen whenever members of an in-group secure and then maintain access to a resource that is both highly valuable and limited. Riegle-Crumb and colleagues (2019) conducted a study using the lens of opportunity hoarding and positing that this phenomenon may be responsible for the overrepresentation of White students in STEM postsecondary degree attainment relative to their minority peers. They attributed their findings, which revealed that gaps between underrepresented minority and non-underrepresented minority students are much larger in STEM fields, to White individuals working to create social advantages with these disciplines so that outsiders are less likely to be successful in these fields. This notion of opportunity hoarding highlights an oppressive culture in some STEM disciplines where faculty, staff, and peers from the majority, privileged groups may

create conditions where underrepresented minority students feel unwelcome or don't have access to the same resources or support needed to be successful.

Tensions Between STEM Norms and Underrepresented Minority and First-generation Student Cultural Identities

Underrepresented minority and first-generation students often have to navigate unfamiliar cultural values, expectations, and norms on college campuses. Previous research has suggested that the academic environment, and biomedical disciplines in particular, operate using norms and values from the dominant culture which often creates tension when paired with the lived experiences of underrepresented minority students. Past research has placed significant focus on the notion that there may be a cultural conflict between the normative culture of science and the culture of many underrepresented minority students including Latinx students, Africans and African-Americans, Pacific Islanders, and Native Americans (Aikenhead, 1996; Allen & Crawley, 1998) while majority students often find "cultural continuity" between their communities of origin and the campus contexts (Padilla et al., 1997). Culture plays an important role in the various institutions and disciplines that students encounter on their paths to STEM degrees as college campuses and departments have their own unique organizational settings with cultures that are shaped by social norms, values, practices, and policies (Malcom et al., 2016). Some researchers posit the underrepresented minority students choose to not persist to STEM degree completion based on what they see as

irreconcilable differences between the values and expectations in these fields and their own cultural identity and experiences. Furthermore, the social, psychological, and structural dimensions of STEM disciplines in higher education influence how students understand their academic self-concept, affecting their academic performance (Cabrera et al., 1999; Eccles et al., 1998; Perez et al., 2014).

In a study that considered the experience of 38 high achieving Black and Latinx STEM college students, McGee (2016) found that students reported burnout and psychological stress from the effort of navigating subtle and blatant racial bias, and modifying their behavior as a protection against it. These students engaged in "stereotype management" to respond to, but not eliminate stereotypes. Participants reported that they used "frontin'" by minimizing and not overemphasizing various characteristics that might be attributable to their racial or cultural identity. This illuminates the ongoing cultural tensions many students from underrepresented minority backgrounds face, along with the psychological damage incurred as they navigate these tensions.

As previously discussed, students report feeling isolated as the result of clashes with faculty and peers (Johnson et al., 2007), limited access to students and faculty of color (Hurtado et al., 2011) and feeling socially isolated as they travel long "cultural distances" to succeed and stay in school (Strayhorn, 2015). In another study, researchers suggested that although background factors, challenges on campus, and other factors have been studied as potential causes for STEM inequities at college, underrepresented

minority student success may be linked to the disconnect between their social justice focused value systems and the STEM field, which is focused on individual pathways to success and high paying jobs (McGee & Bentley, 2017). The authors conducted 38 structured interviews with Black and Latinx students to better understand how and why students pursue STEM pathways. Authors concluded that reshaping STEM education, focusing on issues of social justice and equity, rather than just financial success may better support diverse students and increase their likelihood of pursuing degrees in STEM fields

Ways of Knowing in Science

Research has suggested that STEM disciplines in higher education contexts have narrowly acceptable ways to teach and demonstrate competence in science-related material. Much of the underrepresented minority and first-generation college student experience in STEM takes place in formal classroom and lab environments designed to teach students the core knowledge required for proficiency in their discipline. However, the acceptable ways of sharing and understanding "knowledge" in these environments, which stem from western ideals and beliefs about what counts as knowledge, often marginalizes underrepresented minority and first-generation students (Newberry & Trujillo, 2018; Tuhiwai-Smith, 2016).

Decisions about what constitutes as "truth" in scientific fields stem mostly from the positivist tradition, which takes a dualistic viewpoint in which objective and

inarguable truths and knowledge are a matter of unfiltered observation (Bredo, 1994; Guba & Lincoln, 1994). For instance, Tuhiwai-Smith (2016) suggests that positivist perspectives on knowledge may conflict with the core of many indigenous peoples that there are many different traditions of knowledge and moments of history where ideas have been reformed or transformed into new truths and calls for a critical examination of traditional scientific approaches and methods which could expose underlying assumptions that serve to conceal unjust power dynamics.

The perpetuation of this positivist approach to knowledge so prevalent in STEM fields may marginalize and exclude minoritized groups because it fails to recognize how their collectivist cultural roots shape their engagement with content in the classroom. Research has shown that Native American and Alaska Native students in particular, who are significantly underrepresented in STEM disciplines and the biomedical workforce, may feel marginalized within STEM classrooms as they are instructed that scientific knowledge is value-free and objective, notions that are in direct conflict with their cultural norms and ways of knowing (Aikenhead & Ogawa, 2007). Taking things even further, Aikenhead (2001) argues that very few underrepresented minority students have cultural identities and worldviews that are not in conflict with the predominant ways of knowing and knowledge production found in most STEM classrooms and curriculum.

Students from minority populations are more likely to align with cultural identities that prioritize interdependent knowing over individualistic knowing (Triandis,

1993) and value altruistic reasons for pursuing science careers over individualistic ones (Thoman et al., 2015). This leads to challenges within STEM classrooms where dominant practices recognize and celebrate individualistic knowing and individual-level accomplishments or failures. Research has demonstrated that students from first-generation backgrounds often suffer from an overly individualistic focus in college classrooms (Chang et al., 2020) and that students from underrepresented racial and ethnic groups also are negatively impacted by the cultural mismatch they encounter in STEM classes where individual knowing is elevated over more collectivist learning experiences in the classroom (Smith et al., 2014).

When taken together, research suggests that for many underrepresented minority and first-generation students, the learning environments they find within STEM disciplines are alienating and provide limited pathways to producing knowledge and demonstrated competency in science-related subjects. Furthermore, these classroom experiences impact student outcomes and subsequent decisions to pursue further education in STEM disciplines.

Conclusions about STEM Inequities and Structural Explanations

Many contextualist approaches to understanding gaps in degree attainment for underrepresented minority and first-generation STEM students consider systemic explanations such as the underlying epistemological perspectives that dominate STEM fields, the nature of science education, and a culture in STEM that perpetuates these

inequities. These structural explanations provide crucial information about the underrepresented minority and first-generation student experiences and perpetual inequities in STEM because they recognize that student outcomes are not the result solely of individual experiences, as the person-in-context explanations might suggest, but that STEM contexts are created by decades of complex and intertwined forces.

Decades of social stratification have resulted in the oppression of minority and low-income students across educational settings and created power dynamics in science disciplines that mirror inequities in society. White, dominant cultural values have prevailed in STEM disciplines creating contexts where underrepresented minority and first-generation students feel out of place. Furthermore, the acceptable ways of knowing in STEM limit the full participation of many underrepresented minority and first-generation students. In sum, consideration of systemic factors including social, cultural, and historical forces at play provides essential information about the student experience. This must remain the focus of efforts to understand and explain higher education STEM inequities.

Conclusions About Approaches to Understanding Higher Education STEM Inequities for Underrepresented Minority and First-Generation Students

This section has provided an in-depth consideration of numerous contextualist and sociocultural perspectives seeking to explain why STEM degree attainment gaps persist. In stark contrast to deficit-based approaches, which attribute student challenges

to student-level deficiencies or deficits, contextualist and sociocultural perspectives consider the environment in which students learn and the broader, systemic factors that determine whether these environments will support or inhibit students in their efforts to succeed in college. An in-depth review of previous research on underrepresented minority STEM student experiences suggests that students do not attain degrees at lesser rates because of individual-level failures or lack of familial support, but rather that these inequities persist because of a collection of systemic realities deeply embedded in STEM disciplines in higher education.

There is a significant body of work considering the impact of both person-in-context factors such as students' K-12 science preparation and their sense of belonging in STEM disciplines and structural elements such as the culture of STEM education and ways of knowing in science. To date, much of the research on this topic prioritizes either the student experience in context or the structural factors shaping these experiences. When viewed together, findings from this research suggest that there is no single most important factor contributing to persistent gaps in degree attainment but rather, there is a large system of complex and deep-seated contextual, historical, political, social, and cultural realities that together, are perpetuating an unequal and inequitable playing field in STEM disciplines for underrepresented minority and first-generation students. Given the intertwined nature of these factors and how they reciprocally shape each other, both person-in-context and systemic contextual factors must be considered in research on this

topic to ensure understanding of the ongoing inequities in outcomes and persistent marginalization of particular groups in STEM disciplines. Efforts focused on narrowing STEM inequities must simultaneously focus on hearing from students about their experiences in classroom interactions with faculty, mentors, and staff while also looking at broader forces shaping these spaces.

Given the previously discussed central role that identity plays in student persistence and achievement and how environments for practicing science are a key component of success for underrepresented minority and first-generation students on STEM pathways, this literature review will now consider institutional programming designed to provide communities of practice for these students to develop their science identity and succeed in these disciplines.

Chapter 3 : Underrepresented Minority and First-Generation STEM Student Identity Construction Through Research Training Communities of Practice

As previously discussed, researchers have sought to understand STEM inequities in higher education by considering the person-in-context and systemic factors. From this perspective, these factors together create environments that both constrain and support underrepresented minority and first-generation students as they construct science identities, successfully attain STEM degrees, and pursue their graduate education in STEM fields. Many institutions recognize the importance of giving students opportunities to engage in the practices of science in order to build an identity as a scientist, such as working in a lab environment to conduct meaningful research and engaging as an active member of a research team (Hurtado et al., 2009; Seymour et al., 2004). As a result, many institutions have created inquiry-based programs that are highly scaffolded, where students can gain proficiency with scientific methods and procedures, engaging in scientific practices so that they might begin to see themselves as scientists. The final section of this literature review will provide an overview of the prevalence and efficacy of these research training programs and how they operate as communities of practice for underrepresented minority and first-generation STEM students. A sociocultural approach will be used to conceptualize science identity for underrepresented minority and first-generation students within these research training contexts, and what is known about students who choose to leave these programs before completion will be reviewed.

Given the important role of social processes in identity construction and the persistent STEM inequities impacting underrepresented minority and first-generation students, higher education institutions have focused on creating and sustaining social environments within STEM disciplines to better support a more diverse range of students. These efforts include providing a range of opportunities for learning and practice that may assist these students in building a science identity and completing their STEM degree.

Undergraduate Research Training Programs and Scientific Practice for Underrepresented Minority and First-Generation STEM Students

Recognition of the many barriers and the importance of practice opportunities for underrepresented minority and first-generation students in STEM has prompted widespread efforts to support these students with campus programming designed specifically for underrepresented minority students seeking STEM degrees. At a programmatic level, universities have attempted to create formalized communities of practice through hands-on research experiences which are now present at nearly all four-year institutions in the U.S. (Tsui, 2007). These programs, often referred to as STEM Intervention Programs (SIPs), Undergraduate Research Experiences (UREs), or undergraduate research training programs, focus on support at the individual level by working to increase student engagement and success in STEM learning and also address the larger historical and structural issues that have led to the ongoing underrepresentation

of certain minority groups in biomedical majors and professions (Tsui, 2007). At present, the functional program components and implementation of undergraduate research training programs vary widely and are impacted by institutional context, funding sources, and several other factors. As a result, there is significant diversity in the design and implementation of these programs on campuses across the United States (Hunter et al., 2007; Linn et al., 2015; Seymour et al., 2004). Well-known research training programs include Meyerhoff Scholars Program, McNair Scholars Program, Bridges to Howard Hughes Medical Institute Research Scholars, Bridges to the Baccalaureate Research Training Program, and Maximizing Access to Research Careers programming. A common denominator across campuses is the overarching and long-term goal to increase diversity in the research workforce through deliberate programmatic efforts at the undergraduate level and to address the larger historical and structural issues that have led to the ongoing underrepresentation of certain minority groups in biomedical majors and professions (i.e., clinical research, engineering, chemistry, social work).

Tsui (2007) comprehensively reviewed the literature to examine the empirical evidence regarding the effectiveness of strategies that undergraduate research training programs employ in efforts to increase minority participation in STEM fields. After reviewing articles related to the operationalization of these programs on campuses, Tsui identified ten strategies that are commonly used across different programs and have well-documented evidence supporting their effectiveness to support underrepresented minority

STEM student success. These strategies included summer bridge programming in which students engage in summer on-campus enrichment workshops, mentoring relationships with faculty and peers, hands-on research experience, tutoring and learning opportunities, career counseling, academic advising, curriculum reform, and financial support. This is corroborated by other research that suggests that building programs that include structured environments for students to engage in research and be mentored by faculty may be at the core of creating successful program-based interventions that can provide tangible benefits to underrepresented minority STEM students (Archer et al., 2010; Collea, 1990). This research also highlights that the essential program elements give students opportunities for social interaction with faculty and peers through mentorship and the chance to engage in the practices of science in hands-on research.

Research considering the importance of opportunities to practice science for students is robust and has considered the many benefits for students that result from these opportunities (Lopatto, 2004; Robnett et al., 2015; Shaffer et al., 2014). For instance, for underrepresented minority and first-generation students, opportunities to practice science have been identified as central in their construction of a scientific identity (Hurtado et al., 2009; Seymour et al., 2004) which in turn, increases their likelihood of success in these disciplines (Archer et al., 2010). Providing students practice-based STEM experiences has been linked to several positive outcomes for underrepresented minority students including increased retention in biomedical fields and increased likelihood of attending

graduate school (Lopatto, 2004; Nagda et al., 1998). Studies that have considered the relationship between identity construction and research practice experiences have found that these experiences have a positive impact on students' ability to see themselves as scientists (Hurtado et al., 2011; Lopatto, 2007). In Seymour's (2004) review of studies considering the positive benefits of undergraduate students engaging in hands-on research practice, 91% of students' evaluative statements across studies provided evidence for specific positive benefits gained from hands-on research experience including providing real-world work experience, providing the opportunity to network with faculty, peers, and other scientists, getting exposure to new opportunities, and enhancing graduate school and career preparation. In a study by Hurtado and colleagues (2009), researchers conducted focus group sessions with 65 underrepresented minority STEM student participants and results indicated that students who participated in hands-on research experiences felt more efficacious about their abilities and they attributed this to feeling like they were "doing science" in their research placements within programs. These findings provide insight into the importance of opportunities to engage in research activities for students to construct science identities.

Undergraduate Research Training Programs as Communities of Practice

The focus on scientific practice and disciplinary norms within these programs provides a lens to examine how social processes between students, faculty, and peers may be shaping students' perspectives on their identity as a scientist. It is not often explicitly

stated, but these programs function as spaces where students are apprenticing while learning how to be a scientist and construct their science identity through ongoing interactions and science-related practices in these spaces. We can extrapolate Wenger's conceptualization of communities of practice, defined as spaces where people regularly interact with a shared set of practices that define an identity of membership in the community (Wenger, 2008), to consider student experiences undergraduate research preparation contexts. The literature on communities of practice in STEM higher education thus far has focused mainly on communities of practice for faculty aimed at transforming classrooms with innovative teaching strategies and more inclusive pedagogy (Kezar et al., 2018). However, communities of practice theory would suggest this is also relevant to students given its emphasis on social interactions and engagement in relevant practices as key in identity formation.

Past research on the importance of science identity highlights the centrality of social interactions that allow students to recognize themselves and be recognized by others as researchers and scientists (Barton et al., 2008; Carlone & Johnson, 2007; Jackson et al., 2016). For students in these settings, being able not only to practice science but also to be recognized as one who does science, is a key to feeling like becoming a scientist is possible. Notably, positive social processes that make students feel recognized as scientists may be even more salient for underrepresented minority and first-generation students who often encounter bias and discrimination in STEM-related

spaces (Brickhouse & Potter, 2001). Given that these programs are created with the opportunity for social interaction and hands-on experience, looking at these programs as communities of students and future scientists who "practice science" together, may provide great insight into understanding how identity construction and subsequent success in science are connected to the ongoing social processes occurring within these programs.

Although there is evidence that research training programs support students on their pathways, there is limited research demonstrating precisely *how* participation in research training communities of practice affords science identity construction for underrepresented minority STEM students. Chemers and colleagues (2011) conducted a study that determined that giving underrepresented minority STEM students hands-on research experiences positively impacted their science identities. In a study by Hurtado and colleagues (2009), researchers looked across four universities with "structured science research programs for undergraduates" that provided students with a range of research and mentoring opportunities. The study, which took a phenomenological approach, conducted focus groups with students and among the many findings about their experiences, results revealed that a majority of students in these research programs believed that they were being mentored by faculty who encouraged them to take on increasingly challenging research tasks they would not otherwise have attempted which led them to more strongly identify as a scientist. Other research has highlighted that

program benefits include the social connections and interactions students have with faculty and their peers. In a study by Maton and colleagues (2000), one of the most commonly reported benefits for participants in research training programs was getting to be a part of a community and having the chance to develop connections and interact with other underrepresented minority students and faculty.

Most of the studies to date considering program efficacy have examined whether participating in these programs increased the likelihood of success for underrepresented minority and first-generation STEM students and the potential relationship between undergraduate research training program participation and graduate school aspirations and/or entrance. In a study by Chang and colleagues (2014), researchers found that underrepresented minority students who participated in an undergraduate research program increased their chances of progressing towards or obtaining a biomedical degree by 17.4%. Although explanations for this link were not explicitly examined in this study, researchers posited that science-related practice might increase student's identification with science disciplines with more opportunities for "performance and competence" in these subjects (Carlone & Johnson, 2007) and that the faculty connections in these programs might encourage students to engage in increasingly complex research tasks thus shaping their science identity (Hurtado et al., 2009).

In a longitudinal study with a sample of 4,152 undergraduates pursuing science-related degrees, students who participated in hands-on research experiences had greater

intentions to pursue graduate school than those in a matched control group. This was particularly pronounced for Latinx and Black students (Eagan et al., 2013). Two other studies found that by participating in programs that provide opportunities for undergraduate research, students significantly increased their chances of completing their undergraduate STEM education and pursuing an advanced science degree (Barlow & Villarejo, 2004; Lopatto, 2004). For African American STEM students, two studies demonstrated that participation in undergraduate research activities increased retention and graduate school attendance as compared with African American STEM majors who did not engage in these programs (Hunter et al., 2007; Nagda et al., 1998), These studies showcase a potentially strong link between student participation in undergraduate research training programs and graduate school aspirations and/or participation suggesting that students may gain essential skills and perspectives from these programs that enhance their ability to pursue advanced STEM degrees.

These study results, when considered together, provide evidence that there are positive benefits for underrepresented minority STEM students who engage in undergraduate research training programs including a greater sense of science identity and intent to pursue graduate school. However, although these programs are generally thought to be effective, there are still large gaps in researchers' understanding of the specific mechanisms that are responsible for positive student outcomes (Leggon & Pearson, 2006; Seymour et al., 2004; Tsui, 2007). Furthermore, despite significant

programmatic efforts to build communities of practice in which students can successfully increase their identity as a scientist, overall gaps in biomedical degree attainment do not appear to be decreasing at a significant rate (James & Carlson, 2012). This suggests that the widespread prevalence of undergraduate research training programming alone is not sufficient to achieve the goals of increasing underrepresented minority and first-generation student persistence in STEM disciplines. By considering how students' identity trajectories relate to their experiences in research training communities of practice, essential information about who is successful in these programs and why could shed light on the causes of persistent gaps in STEM degree attainment. Next, the process of identity construction within these programs will be explored along with what is known about student departures from these programs.

Identity Construction Within and Student Departures From Research Training Communities of Practice

Among the hypothesized benefits of participation in research training programs is an increased science identity. Researchers have pointed out that having the skills to perform scientific acts is not sufficient for success in STEM and that students also need to form a social identity as a scientist to be successful in STEM fields (Carlone & Johnson, 2007; Gasiewski et al., 2012; Johnson et al., 2011; Syed et al., 2011). Although developing this science identity has been linked to positive outcomes for students in some studies (Hurtado et al., 2011; Williams & George-Jackson, 2014), most of the studies that

consider the benefits of science identity for underrepresented minority STEM students focus on attitudes such as intent to pursue a graduate degree or career in science rather than actual entrance into a graduate program or STEM career (Lee, 2002; Merolla & Serpe, 2013).

Science identity construction is a complex and multi-faceted process. Conceptualizing science identity in a way that allows researchers to look at it as an ongoing process occurring in socially mediated contexts has been difficult and resulted in varying perspectives and approaches to understanding this phenomenon. Carlone and Johnson (2007), extrapolating from a sociocultural perspective, argued that in order to understand student identity construction, identity must be considered as an analytic lens to view the underrepresented minority STEM student experience. They argued the necessity of this approach because it allows questions about who gets recognized and marginalized by present-day science teaching and learning practices, how students come to see their place in science, the socialization of students into the norms and discourse practices of science and ultimately has the power to prioritize a more equitable science education.

To this end, Carlone and Johnson developed a grounded model of science identity based on qualitative research with STEM female students of color. This model considers student's racial, ethnic, and gender identities as important in the shaping of science identity and includes both how individuals make meaning of their science experiences

and the broader constraints on identities for particular students in these contexts. In this view, students with a strong sense of science identity have a knowledge and understanding of their discipline such that they can demonstrate competent performance in relevant scientific practices and have meaningful knowledge and understanding of related content. These students also have skills needed to adequately perform the practices required for success in their discipline such as discussing relevant articles or participating in various steps of the research process. This competence and performance lead to a recognition that is both internal and external, including a person seeing themselves as a scientist within their discipline and feeling that they are seen by others as a "science person" within these contexts. In sum, the model posits that science identity is the overlap of competence, performance, and recognition by self and others (Carlone and Johnson, 2007).

Embedded in the intersection of competence, performance, and recognition is the importance of practicing science in underrepresented minority science identity construction because, in these practice-based settings, students believe they can be scientists because they can do the tasks involved in being a scientist. In this view, explicitly telling students that "this is what a scientist does" and then supporting them as they do those activities, can help them see themselves as scientists. This approach also acknowledges that the proximal science environments in which identity is constructed are created by large, global forces in which power and privilege determine who gets to

contribute to science and how. Importantly, this view also considers how the sociohistorical legacies of science and the meanings of these legacies create STEM-related environments in which students are afforded or not afforded opportunities to develop particular identities.

There is limited research to explain how research training programs connect to students' identity construction as scientists. Notably, student departures from these programs have not been widely studied and little is known about why students choose to leave these programs. Given that these programs provide ample opportunities for social interactions with STEM faculty and peers, along with hands-on experiences doing science, much could be gleaned about persistent STEM inequities by understanding how student identity construction unfolds when provided intentional communities of practice. As previously discussed, research on student departures from STEM suggests that underrepresented minority students leave these disciplines at faster rates than their non-minority counterparts (Riegle-Crumb et al., 2019). Given that underrepresented minority students report lower levels of belongingness (Strayhorn, 2012) and frequent experiences of bias and discrimination (Hurtado et al., 2010), there may be overlap between departures from research training programs and students' choices to leave STEM but this has not been widely researched. Understanding why students choose to leave these programs, and sometimes STEM or college altogether can provide essential information

about the ways that students make meaning of their identities in science contexts and make subsequent decisions based on their perceptions of available identities.

Conclusions about Underrepresented Minority and First-Generation STEM Research Training Communities of Practice

A sociocultural approach to understanding identity goes beyond viewing identity as a cognitive process occurring within each individual to highlight how systematic and person-in-context factors jointly shape students' ability to identify with science disciplines and future science careers. Students' identities play a central role in how they navigate educational pathways. Yet, when thinking specifically about science identities as the intersection of performance, competence, and recognition, there also may be a central role for social interactions within communities of practice (Carlone & Johnson, 2007). Together, these three dimensions capture how identity construction for underrepresented minority and first-generation students is an ongoing and complex process that unfolds as students make meaning in various contexts to determine which identities are available, or accessible, to them.

Given the connection between learning, identity, and practice, the experiences of underrepresented minority and first-generation students participating in research training programs are important to consider if we want to understand how their science identities develop and how these experiences shape students' subsequent education and career pathways. By carefully considering participation in research training programs using the

lens of communities of practice, we can better understand how underrepresented minority and first-generation students develop identity trajectories inbound (i.e., toward science careers) and outbound (i.e., away from science careers). Given that little is known about why students leave research training programs, further research must examine the particular person-in-context and structural forces that are shaping these spaces and how subsequent identity construction may influence students' decisions to leave research training communities of practices.

Chapter 4 : The Current Study

Understanding Trajectories out of Research Training Communities of Practice through Qualitative Inquiry

The literature review of this study provided the rationale for considering experiences that shape underrepresented minority and first-generation identity trajectories in research training communities of practice to better understand persistent STEM inequities. The first section gave an overview of trends in higher education enrollment and degree attainment and provided a glimpse into the underrepresented minority and first-generation experience in STEM disciplines. Chapter two of the literature review examined how person-in-context factors *and* structural forces shape how these spaces afford and constrain opportunities for positive science identity construction for underrepresented minority and first-generation students and subsequently affect their success. Results from previous studies on STEM inequities suggest that gaps in degree attainment for underrepresented minority and first-generation students are the result of dynamic forces rooted in both systemic causes and person-in-context experiences. The literature review concluded with a review of research on how research training programs serve as communities of practice in which students construct their identity through ongoing opportunities to engage in the practices of science.

Past research has revealed that complex layers of multiple contexts are shaping the underrepresented minority and first-generation student experience in STEM

disciplines. However, there is limited research on underrepresented minority and first-generation student departures from undergraduate research training programs and STEM disciplines. A deeper understanding of the lived experiences of students who have successfully completed a research training program, along with others who have left these programs, can provide valuable information needed to explain and address STEM inequities. The current study seeks to fill gaps in the literature by giving in-depth consideration to the student experience in research training communities of practice, focusing on key experiences and factors that impact program participation, how social interactions and opportunities to practice science shape science identity construction within research training communities of practice, and how science identity trajectories, and other factors, influence students' choices to depart from these programs and disciplines.

Studying Underrepresented Minority and First-Generation Identity Construction Through Communities of Practice

For underrepresented minority and first-generation students in STEM, research training programs serve as communities of practice and are designed to provide students with an in-depth, scaffolded, and apprenticeship-focused experience and strive to increase their potential for success in future biomedical research careers. In response to persistent STEM inequities in higher education, these programs intentionally target their support for underrepresented minority and first-generation students, in hopes that positive

relationships with those within the scientific community, along with opportunities to engage in the practices of science, will increase the likelihood of these students attending graduate school in a biomedical field. Although research suggests that these programs are effective in increasing students' graduate school and science career aspirations, very little is known about the students who depart from these programs and their reasons for leaving. Failing to examine the potential factors and experiences leading to student departures from research training communities of practice leaves essential information about the root causes of STEM inequities unexamined and misses crucial insight about student identity construction within these spaces. The current study seeks to address this gap by considering the experience of students who have left and others who have completed a research training program, focusing on factors that contributed to their ability to participate in the program, key social interactions, opportunities for practice while participating, and science identity construction processes.

Benefits of a Qualitative Approach to Understand the Student Experience

To consider underrepresented racial and ethnic minority and first-generation student experiences and understand why students may leave research training programs, an approach is needed that captures students' reflections and provides a thick, rich description of these students' experiences. Human development takes place within a world that is dynamic, complicated, interdependent, and requires in-depth consideration of an individual's experiences and reflections on their experiences (Patton, 2015). This

study used qualitative inquiry to better understand how underrepresented minority and first-generation students construct scientific identities in research training communities of practice. Specific attention was paid to the role that systemic and person-in-context factors, along with their science identity pathways, played in their decision to stay or depart from these programs.

Qualitative inquiry is the best fit for this study for two reasons. First, given that equity in science education is a primary goal of advancing this research agenda and studies of students' own meaning-making about their departures from STEM are few, focusing on how students understand their lived experiences within these programs must be central to this research. Previous research on STEM education for underrepresented minority and first-generation students reveals a complex picture of the possible factors responsible for shaping inequitable learning contexts. Although studies have posited many possible explanations for these persistent gaps in STEM degree attainment, research has fallen short in providing the information needed to address these inequities. Qualitative research allows for an in-depth explanation from participants about the unfolding nature of their decisions and identity trajectories. This methodology also allows a focus on understanding students' perspectives and considering patterns as they unfold across students' stories. Second, underrepresented minority and first-generation student outcomes have been the focus of much research on STEM inequities and yet little is known about the social processes within these programs and how they unfold for

students. The qualitative approach is particularly appropriate given its usefulness when trying to understand social processes (Rubin & Rubin, 2005) and because it puts the attention on understanding the holistic and systematic nature of phenomena, favoring richness of data over the ability to zoom in and single out a particular mechanism.

The primary data collection tool was semi-structured interviews which are best suited for this study because they allow researchers to ask students directly about their experience and follow up about the particulars that may be valuable or important. These interviews offer crucial information because they focus on students' reflections on social interactions and how they make meaning of social processes as they construct their identity.

The Study

In sum, research broadly considering the root causes of STEM inequities for underrepresented racial and ethnic minority and first-generation students considers a range of explanations for gaps in STEM degree attainment. Although a multitude of systemic and person-in-context factors have been considered in past research on the topic and institutions have worked out to implement findings from these practices on campus to support students, gaps in STEM degree attainment have persisted over many decades. Undergraduate research training programs seek to address these inequities for underrepresented racial and ethnic minority and first-generation students in STEM with

where they can engage in the practices of science through structured mentoring and apprenticeship. However, the research to date lacks adequate information about how social interactions within these research placements and mentoring relationships may contribute to students' understanding of their identities as scientists. Additionally, although research training programs may be linked to positive student outcomes, little is known about students who leave these programs.

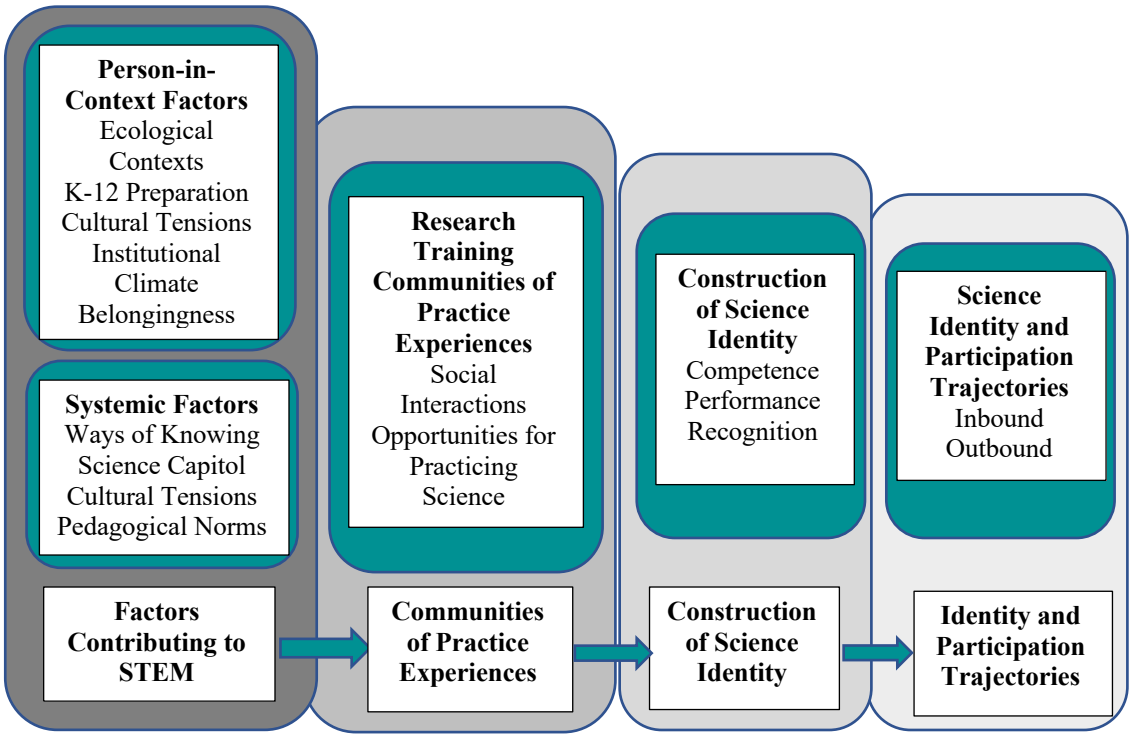
The current study takes a qualitative approach to gather information about the complex factors contributing to students' ability to succeed in STEM by looking at both person-in-context factors and systemic factors. The current theoretical model proposes that person-in-context and systemic factors both play a role in how social interactions and opportunities for practice in research training communities support or hinder identity construction for students and thus shape their decisions to stay in or leave these programs (see Figure 1). Science identity is conceptualized using Carlone and Johnson's (2007) model as the intersection of competence, performance, and recognition which views the science identity construction of STEM college students both in how students make meaning of their own engagement in science activities and how society structures possible meanings in these contexts.

This study addresses the following research questions:

1. What are the key experiences and structural factors that contribute to underrepresented students' (first-generation and students of color) decision to leave research training communities of practice and/or STEM altogether?
2. What are the key student experiences within research training communities of practice and STEM disciplines that shape a student's science identity?
3. What is the relationship between a student's science identity and their decision to leave the research training community of practice and/or STEM altogether?

Figure 1

The Theoretical Model



Chapter 5 : Research Design and Methods

Overview

This study examined the experiences of underrepresented racial and ethnic minority and first-generation college students participating in a structured research training program at a large urban university in the western United States. Semi-structured interviews were conducted with 23 students. Of these participants, 12 completed the research training program and 11 participants left the program before completion. A qualitative approach was used to answer the three previously discussed research questions and focused on identifying themes across participant interviews. Research questions examined contextual factors impacting student participation, key experiences shaping identity construction, and the connection between identity construction and trajectories. Throughout this study, I remained committed to reflexivity, regularly considering how my own identities and experiences shaped my approach to the study, interviews, and interpretation of the findings. At each step, I continually asked for guidance from mentors and colleagues to engage in this process openly and transparently. Next, I will discuss my positionality, the study context, steps taken to ensure rigor, details on the study participants, data collection, and the analysis used for this study.

Researcher Positionality

A rigorous process requires a level of transparency in which researchers work to

be open-minded and impartial, carefully describing their inquiry, positionality, and approach to the study (Patton, 2015). I worked to take a reflexive stance with transparency and approachability for all participants while carefully reflecting on my positionality through each step of the process (Ravitch & Riggan, 2016).

I identify as a White, middle-class, cisgender, straight, non-disabled female. I was adopted as an infant, so much of my birth family history is unknown, but I grew up in the U.S. Midwest, in a working-class family, and have multi-generational roots in Upper Michigan. I spent the first decade of my adult life living in a racially, ethnically, and socioeconomically diverse urban neighborhood in the Midwest and have resided in the Pacific Northwest for five years. I was a first-generation college student and the first in my family to attend graduate school.

After my undergraduate degree, I spent over a decade as a practitioner and trainer in the youth development field. After working for a mentoring program and then a capacity-building organization, I received a fellowship to address issues of equity and autonomy in youth work. I found myself fully engaged in a conversation centered around how educational institutions' oppressive practices and policies negatively impact marginalized young people. This work left me troubled, energized, curious, and committed to learning more about these student experiences.

I began working for BUILD EXITO as a research assistant in the spring of 2015. My primary responsibilities have been to work on project coordination tasks, including putting together communication pieces for key stakeholders, updating the website, assisting with events, and work on program dissemination efforts. Most of my work is behind the scenes and does not involve significant amounts of direct contact with Scholars. However, I have formed relationships with many Scholars over the past five years. Throughout my time with EXITO, I have seen how elements within the current higher education context have hindered the healthy identity construction of EXITO students, particularly those in STEM disciplines. I have become extremely interested in their perspectives on their program participation in EXITO and the how they construct their identity during and after their time in the program.

At the core of my dissertation work are important ethical considerations connected to collecting qualitative data about the student experience directly from students. I have remained strong in my commitment to a transparent process, recognized the importance of acknowledging the power dynamics in the researcher/participant and staff/student relationship, and understood the need to offer additional support to students should difficult or triggering topics emerge during their interviews.

Complete transparency in the qualitative inquiry process remained a central concern. Recognizing how my own experiences, identities, and paradigmatic

assumptions shape how I see the world, I used electronic field notes to regularly reflect on my interpretations of interactions and other relevant information regarding how my unique perspective continually shapes my understanding (Emerson & Shaw, 1995). Throughout this study, I worked to remain aware of my positionality and its impact on the process in my efforts to most accurately represent the student experiences that emerge from these interviews.

Although the focus of this study is uncovering information about the challenges students face in higher education STEM contexts, there are inherent power imbalances that result from my role as a staff member on the EXITO project, the lead researcher on this study, and a person who identifies as White. If not checked, these imbalances could maintain the status quo and keep disenfranchised populations, such as underrepresented racial and ethnic minority and first-generation students who have left STEM disciplines, from having a voice and agency in spaces where power differentials already exist (Riger, 1993). I remain aware of these power dynamics and how the imbalance of power in the researcher-participant relationship may impact the study process (Reid et al., 2018). To actively work against this power imbalance, I approached these conversations as a learner (Miller & Shinn, 2005) and considered ways to disrupt the oppressive conditions perpetuated by those in power by creating spaces for students to freely share their program experience in safe and confidential ways (Stein & Mankowski, 2004).

My third ethical commitment was to ensure that additional resources were available for participants should difficult or even traumatic, events come up during the interview. In qualitative interviews, the researcher and participant engage in a dialogic process that may bring up memories or stories about difficult topics regarding family, finances, discrimination, and other topics that could be triggering to discuss (Eide & Kahn, 2008). Researchers must be sensitive to participants' experience, not pressure them to discuss topics that may be triggering for them, and provide resources should they be looking for additional support. Students had access to various resources to support their mental health and well-being as needed after the interview.

Study Context

Program: National Institutes of Health Building Infrastructure Leading to Diversity

In their efforts to diversify the biomedical research workforce, the National Institutes of Health (NIH) provided grants to ten undergraduate institutions to design, implement, and study new and innovative approaches to recruiting and training students from diverse backgrounds interested in biomedical research careers. To apply for the BUILD grant, institutions must have less than $7.5 million in NIH research project grant funding and at least 25% of students had to be Pell Grant recipients. Ten institutions were selected and serve a racially and geographically diverse population, including Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions

(HSIs), Asian American/Native American/Pacific Islander-Serving Institutions, and other programs with targeted outreach to underserved populations. The overall goal of these programs is to support students on their pathway to contributing to NIH-funded research in the future and the proposed outcomes for BUILD training grants have specific aims at the student, faculty, and institutional levels.

BUILD programs were designed and implemented across the Diversity Program Consortium to address the student challenges and remove barriers to STEM degree completion. Programs utilize several intervention components including mentorship, mentored research skill-building, and hands-on research apprenticeships in real-world settings. Across the BUILD consortium, there are collective efforts to disseminate effective interventions and strategies to support students on these pathways, focusing on institutional transformation and sustainability. The grant was awarded in 2014 and will expire in 2024.

BUILD EXITO: A Multi-level Model to Increase Biomedical Persistence for Underrepresented Minority Students

The study participants were all students previously enrolled in one of the 10 BUILD programs, BUILD EXITO, which takes place at a large, urban university in the western United States. The EXITO project seeks to provide extensive support and training for undergraduates from traditionally underrepresented student populations, focusing in particular on students who identify as Alaska Native, American Indian, and

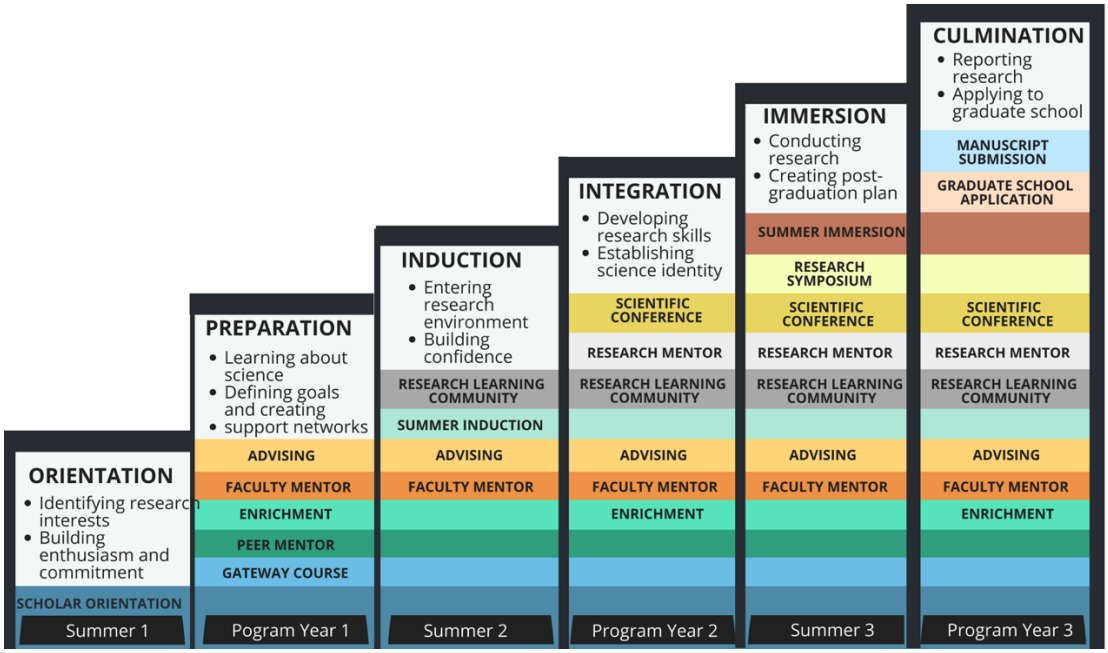
Pacific Islanders who are pursuing health-related research careers. The lead university serves as the lead institution of EXITO and a local medical school and hospital serves as a research-intensive academic health center for the project. The EXITO network links nine higher education institutions across the Northwest Pacific region including 2-year colleges and 4-year universities which are in Oregon, Washington, Alaska, the Northern Mariana Islands, Guam, and American Samoa.

EXITO is a three-year program that supports students on their pathway to pursue biomedical research careers by focusing on four critical elements: a supportive environment, integrated curriculum, developmental mentoring, and research experience. All institutions in the EXITO network share these foundational components of the EXITO model but precise implementation differs based on the needs of the particular institution and its unique student population.

The program model is complex and involves a series of supportive mechanisms scaffolded together for students throughout their engagement in the program. Some components are consistent throughout the program while others occur in a particular program year. A detailed illustration of the program components that constitute the EXITO Scholar Pathway and when they are implemented can be found in Figure 2.

Figure 2

The BUILD EXITO Scholar Pathway



EXITO provides students with a supportive environment by offering tailored academic advising, a student lounge and computer lab dedicated for EXITO student use, and connections to campus opportunities and services. The integrated curriculum of BUILD EXITO includes a required foundations of research course that students take their first year in the program. This course is designed to teach students about research methods and the responsible conduct of research. Additionally, Scholars engage in regular enrichment workshops and training seminars designed to socialize Scholars into science careers.

The EXITO model uses a three-tiered approach to mentoring. Students are matched with a faculty career mentor at the beginning of their time in the EXITO program. This faculty member advises students on academic and career planning, helps them set goals, and provides additional support as they navigate the many demands of their coursework and discipline. Currently, EXITO students also get matched with a peer mentor who is an advanced undergraduate student. Peer mentors help students with academic and personal issues and assist them in gaining access to campus resources. After being placed in their Research Learning Community students get a research mentor who provides training for their research placement, guides them as they get acclimated to their role and responsibilities, and provides ongoing oversight as they learn the fundamentals of working on an established research project.

A cornerstone of the BUILD EXITO program is the 18-month hands-on research experience in a Research Learning Community (RLC). Students engage in meaningful research activities on an externally-funded research team and often have the opportunity to contribute to scientific posters, presentations, and publications. During the summer before their second year in EXITO, Scholars participate in a 4-week Summer Induction which includes professional development workshops twice each week and time getting acclimated in their lab. Then, they spend 10 hours each week throughout the school year working in their RLC. The following summer, which is their final summer in EXITO, students participate in a 10-week long Summer Immersion, which includes a weekly

journal club, ongoing professional development sessions, and approximately 16 hours each week working on research in their lab. At the end of this summer, students present their research at a Summer Research Symposium for the broader EXITO community. During their final program year, students work 10 hours a week in their lab.

Program Profile

Students join EXITO when they have approximately three years left until graduation. To be eligible to complete the EXITO Scholar application students must be full-time enrolled at a BUILD EXITO institution, have a GPA of at least 2.5, intend to major in a biomedical discipline, and be a U.S. citizen or permanent resident. EXITO supports students from diverse backgrounds and academic pathways who are majoring in various disciplines including biological sciences, social work, chemistry, and psychology. A new cohort of students starts the program each fall with cohort one beginning in 2015.

Students self-report their racial and ethnic identity using the National Institutes of Health categories of race and ethnicity. This includes six categories for race: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, and Other (see Appendix A for detailed descriptions of each racial group). Students can also select "more than one race," without providing any detail about their particular racial identities. Additionally, students report their ethnicity using three categories; Hispanic or Latino, not Hispanic or Latino, or other. Students are given three gender options to select from including male, female, and non-binary/other.

Students in cohorts 1-5 were 68.9% female, 29% male, and 2.1% non-binary. A majority of this group of students (86.4%) are considered disadvantaged by NIH standards (see Appendix B for NIH definition of disadvantaged) and 59.7% were the first in their family to attend college. Complete and detailed demographic information for cohorts 1-5 can be found in Table 1.

The retention rate for BUILD EXITO across cohorts 1-5 is approximately 89%. At present, students from cohorts 1-3 have had the opportunity to complete the program. At present 196 students from those cohorts have completed the program and 101 did not complete the EXITO program. Detailed demographic information by program completion status can be found in Table 2.

Table 1

EXITO Cohorts 1-5 Student Demographics

Demographic	Cohort 1 began fall 2015 (n=74)	Cohort 2 began fall 2016 (n=94)	Cohort 3 began fall 2017 (n=96)	Cohort 4 began fall 2018 (n=96)	Cohort 5 began fall 2019 (n=67)	Total (n=427)
Gender						
Female	63.5%	75.5%	64.6%	64.6%	77.6%	68.9%
Male	36.5%	22.3%	35.4%	31.2%	17.9%	29.0%
Non-binary/Other	0.0%	2.1%	0.0%	4.2%	4.5%	2.1%
Age						
19 or younger	37.7%	53.9%	46.3%	58.3%	64.1%	52.3%
20-25	29.5%	27.0%	35.8%	22.9%	25.0%	28.2%
26 or older	32.8%	19.1%	17.9%	18.8%	10.9%	19.6%
First-Generation Student						
Yes	73.0%	57.4%	61.5%	52.1%	56.7%	59.7%
No	27.0%	42.6%	38.5%	47.9%	43.3%	40.3%
Disadvantaged Status						
Yes	94.6%	85.1%	83.3%	83.3%	88.1%	86.4%
No	5.4%	14.9%	16.7%	16.7%	11.9%	13.6%
Need-based Financial Aid						
Yes	79.7%	66.0%	69.8%	70.8%	68.7%	70.7%
No	20.3%	34.0%	30.2%	29.2%	31.3%	29.3%
Ethnicity						
Hispanic or Latino/a	16.2%	29.8%	19.8%	25.0%	23.9%	23.2%
Not Hispanic or Latino/a	62.2%	54.3%	59.4%	56.2%	58.2%	57.8%
I decline to answer	21.6%	16.0%	20.8%	18.8%	17.9%	19.0%
Race						
Am. Indian/Alaska Native	4.1%	3.2%	2.1%	3.1%	0.0%	2.6%
Asian	17.6%	10.6%	20.8%	12.5%	26.9%	17.1%
Native Hawaiian/Pac Islander	9.5%	9.6%	16.7%	7.3%	11.9%	11.0%
Black/African American	10.8%	4.3%	5.2%	5.2%	6.0%	6.1%
White	29.7%	33.0%	25.0%	30.2%	28.4%	29.3%
More than one Race	18.9%	19.1%	14.6%	19.8%	10.4%	16.9%
Unknown/ not reported	9.5%	20.2%	15.6%	21.8%	16.4%	17.1%

Table 2

EXITO Cohorts 1-5 Student Demographics Completers vs. Leavers

Demographic	Completed Program (n=196)	Left Program
Cohort		
Cohort 1 (began in fall 2015)	55 (28.1%)	19 (18.8%)
Cohort 2 (began in fall 2016)	70 (35.7%)	22 (21.7%)
Cohort 3 (began in fall 2017)	70 (35.7%)	24 (23.7%)
Cohort 4 (began in fall 2018)	1 (.05%)	30 (29.7%)
Cohort 5 (began in fall 2019)	N/A	6 (5.9%)
Gender		
Female	133 (67.8%)	68 (67.3%)
Male	60 (30.6%)	31 (30.6%)
Non-binary/Other	3 (1.5%)	2 (1.9%)
Age		
19 or younger	100 (51%)	37 (36.6%)
20-25	60 (30.6%)	40 (39.6%)
26 or older	36 (18.4%)	24 (23.7%)
First-Generation Student		
Yes	126 (64.3%)	59 (58.4%)
No	70 (35.7%)	42 (41.6%)
Disadvantaged Status		
Yes	171 (87.2%)	89 (88.1%)
No	25 (12.8%)	12 (11.9%)
Need-based Financial Aid		
Yes	137 (69%)	75 (74.3%)
No	59 (30%)	26 (25.7%)
Ethnicity		
Hispanic or Latino/a	44 (22.4%)	21 (20.8%)
Not Hispanic or Latino/a	147 (75%)	72 (71.3%)
I decline to answer	5 (2.6%)	8 (7.9%)
Race		
American Indian/Alaska Native	7 (3.6%)	3 (3%)
Asian	35 (17.9%)	12 (11.9%)
Native Hawaiian/Pacific Islander	20 (10.2%)	14 (13.9%)
Black/African American	15 (7.7 %)	5 (4.9%)
White	80 (40.8%)	43 (42.6%)
More than one Race	31 (15.8%)	19 (18.8%)
Other	3 (1.5%)	1 (1%)
Unknown or not reported	5 (2.6%)	40 (39.6%)

Conceptualizing Rigor in Qualitative Research

Rigor in qualitative research speaks to the quality of the research process and the subsequent trustworthiness of the findings (Lincoln & Guba, 1985). For study results to offer theoretical generalizations that are useful for future inquiry, careful considerations of ensuring a rigorous process are followed through each step of the study. Researchers need to consider constructs within complex webs of relationships bringing qualitative inquiry into "a complexity that resembles reality, unpacking the social theory that shapes the world" (Morse et al., 2002, p. 804). Creswell and Miller (2000) propose a two-dimensional framework to help researchers select the best procedures for rigor. The researchers get to determine the study's credibility and their own paradigmatic assumptions and philosophical perspective on quality inquiry. Using this framework, they propose various validity procedures including collaborating with a research team, reflexivity, member checking, and creating a detailed audit trail to build a rigorous qualitative study. My paradigmatic assumptions stem from understanding truth as socially constructed and shaped by interactions within context. Thus, credibility in this study is not beholden to the researchers involved but will be determined by all key stakeholders including program participants and those close to the study context. This study focuses on the lived experiences of students and how they make meaning of their own experiences. The goal of this study will be to accurately reflect the student

narratives from their perspective and recognize that for this inquiry, perception prioritizes over fact.

Lincoln and Guba provide a framework for considering the utility and trustworthiness of the findings from qualitative research studies which considers credibility, dependability, confirmability, and transferability (Lincoln & Guba, 1985). A rigorous research process must produce credible findings, dependent on the richness of the data gathered rather than just the quantity of data. To ensure credibility in this study researcher triangulation, peer debriefing, and member checking were used. Triangulation was used to verify the accuracy of results and I worked to cross-check the information from multiple perspectives to ensure there was agreement on themes and their meaning. I used peer debriefing, by conferring with my advisor and colleagues to get feedback on emerging themes. I also used member checking to ensure that my understanding of students and their perceptions aligned with their own. As codes were generated, an audit trail was kept and all peer debriefing notes were documented.

I continue to ensure the transferability of the results so that it is clear how the results may be generalizable and if they can be applied to other similar contexts and situations. In this study, a thorough description of the study context is used to assist readers in generalizing findings and potentially applying them to other contexts. To further support readers in this process, in the results I will give sufficient detail to describe the process of coding transcripts and analyzing for themes.

Participants and Sampling

Eligibility

Participants were selected from a sample of 427 students who were in the BUILD EXITO program. This sample included students from five separate cohorts: cohort 1, who began in the fall of 2015; and cohort 2, who began in fall of 2016, cohort 3 began in the fall of 2017, cohort 4 began in the fall of 2018 and cohort 5 began in the fall of 2019. To be eligible for this study, students had to have completed the EXITO program or left the program prematurely, and identified as an underrepresented minority or first-generation student.

Sampling Strategy

This study used the nonprobability sampling strategy, purposeful sampling. Purposeful sampling, also known as purposive or selective sampling, was used to recruit participants who could provide in-depth and detailed information about science identity construction in STEM contexts in higher education settings. According to Patton (2015), this approach to case selection focuses on looking at "information-rich cases" that "yield insights and in-depth understanding" (p. 264). It also prioritizes selecting participants who are knowledgeable or experienced considering a particular phenomenon (Cresswell & Plano Clark, 2011), and those who are willingness and available to share their opinions and experiences reflectively (Bernard, 2017; Spradley, 2016). In particular, Patton (2015) discussed the purposeful sampling technique maximum

variation in which the researcher selects cases that maximize the diversity relevant to the research question. In this study, all eligible students were recruited but predetermined numbers were set regarding how many students should come from various subgroups. This approach was selected due to the study's intent to achieve maximum variability inside the whole sample.

In this study, students were selected based on meeting the basic criteria outlined above, along with their willingness to share their experiences in an interview format. I looked to ensure theoretically relevant diversity, such as prioritizing including students from diverse racial and ethnic backgrounds, STEM disciplines, and other demographic groups to increase the applicability of the results (Firestone, 1993).

All students who had completed or left the EXITO program were invited via email and through an alumni newsletter to complete an eligibility survey for this study. They survey asked basic questions on their program participation and completion, racial and ethnic identity, major, and first-generation status. Additionally, alumni with strong connections to the program were contacted and asked to reach out to individual students they believed might be willing to participate.

Fifty-seven students completed the initial survey. Five of these students were ineligible based on not identifying as an underrepresented minority or first-generation. Additionally, the decision was made not to include students who attended one of the other four-year institutions that offer BUILD EXITO due to concerns that looking for

themes across these different contexts would not yield the information needed to answer the research questions of this study. This resulted in an additional seven students determined to be not eligible to participate and left 45 students as possible participants.

Due to the need for theoretically relevant diversity and a final sample that included students who both left and completed the program, the remaining forty-five students were categorized in a nested table that considered their program status (completed the program vs. did not complete the program), race and ethnicity, first-generation status, transfer status, the institution where they started EXITO (main university, community college, pacific rim community college), and their major (natural science, social science, engineering and technology). The study participants were asked to describe their racial and/or ethnic identity in an open-ended format and students were grouped together into broader racial and ethnic groups to protect their privacy. The goal was to have a balanced representation of diverse backgrounds and disciplines in both groups. After completing this table, students within each subgroup were numbered using a random number generator and were contacted in order and asked to participate in an interview. Students were sent multiple invitations to schedule an interview, including three reminders, and there was some difficulty reaching several students who did not respond after opting into the study. If they did not respond, the next person on the list was contacted and invited to interview.

Study Participants

The final group of participants interviewed includes 23 students, 12 who had completed BUILD EXITO and 11 who had left the program before completion. The selection process yielded a diverse group of students. Details on the student demographics including their major, first-generation status, transfer status, length time in the program, and race/ethnicity by program completion status can be found in Table 3.

Details on how many students from each racial/ethnic group transferred while in the program and how many identified as first-generation college students can be found in Table 4. Additionally, students came from 15 unique disciplines. Students' majors were categorized into social science, natural science, or engineering and technology to protect their identities. Participant numbers based on transfer status, race, and first-generation status based on student major can be found in Table 5.

Table 3

Study Participant Demographics by Program Completion Status

Demographic	Left the Program (n=11)	Completed the Program (n=12)
Major		
Social Science	4	4
Natural Science	6	7
Engineering or Technology	1	1
First-generation College Student		
Yes	10	7
No	1	4
Don't know	0	1
Transferred		
Yes	1	6
No	10	6
Length of Time in the Program		
Less than one year	5	0
Between one and two years	5	0
Between two and three years	1	4
Three years	0	8
Race/Ethnicity		
American Indian/Alaska Native	0	0
Asian	3	2
Native Hawaiian/Pac Islander	0	2
Black or African American	3	2
White	2	3
More than one Race	0	2
Unknown or not reported	0	1
Latinx	3	0

Note. Latinx students did not indicate membership in a racial category (e.g., White or Black).

Table 4

Study Participant First-Generation and Transfer Status by Race/Ethnicity

Race/Ethnicity	First-Generation		Transfer	
	Yes	No	Yes	No
American Indian/Alaska Native				
Asian	4	1	2	3
Native Hawaiian/Pacific Islander	2	0	2	0
Black or African American	1	3	0	4
Latinx	3	0	0	3
White	6	0	2	4
More than one Race	0	1	0	1
Unknown or not reported	0	1	0	1

Note. Latinx students did not indicate membership in a racial category (e.g., White or Black).

Table 5

Study Participants First-Generation, Transfer Status, and URM Status by Major

Major	First-Generation		Transfer		URM	
	Yes	No	Yes	No	Yes	No
Social Sciences	6	2	1	7	3	5
Natural Sciences	11	2	5	8	11	2
Engineering and Technology	1	1	1	1	2	0

Data Collection

Qualitative Interviewing

Data collection occurred through a one-time semi-structured interview with each student that lasted 60-90 minutes. These interviews allow qualitative researchers to

produce a thick, rich description to increase the applicability of their findings to generalize to theory and allows for case-to-case reasoning (Firestone 1993).

Best Practices of Interview-Based Research. Previously identified best practices in interviewing include essential information for building rapport with interviewees and being careful to collect data thoughtfully. Patton (2015) emphasizes that interview questions must be open-ended, neutral, non-dichotomous, and asked one at a time to be clear. Patton also discussed the importance of building rapport in each interview by conveying respect to each interview and emphasizing the value of their experience, knowledge, feelings, and attitudes. Additionally, researchers should ensure participants are aware that the interviewer is striving for empathic neutrality and an understanding of the participant's situation without judgment. For this study, careful consideration was given to building rapport with each participant, carefully reviewing the confidential nature of the interview, asking questions as clearly as possible, and emphasizing the value of the participant's honest response to each question.

Procedures. Students were invited to participate via email using the EXITO Alumni quarterly newsletter, through flyers distributed via Facebook, Twitter, and Instagram, and by individual outreach to students via email. Students were offered an incentive of $40 for their participation in the study. Before the interview, students completed a brief survey which included basic demographic questions along with questions about the extent of their participation in the BUILD EXITO program and the

nature of their engagement with scientific practices while in the program (see Appendix C for pre-interview survey questions). All semi-structured interviews took place via Zoom.

Consent information was provided via an electronic form included with the initial survey and then key points were verbally reiterated at the start of the interview at which point verbal consent from each participant was attained. At this time, students were reminded of the study goals, research procedures and steps to ensure confidentiality, and their right to withdraw from the study at any time. Each interview was recorded and transcribed by an external transcription service for data analysis. Video and audio recordings were permanently deleted after transcription. Additionally, typed notes were taken during the interviews to document research insights that were not captured in the transcript, and in addition to transcripts, these notes were used during the data analysis process. The full interview protocol, including the language used to attain verbal consent, can be found in Appendix D.

Data Analysis

To analyze interview transcripts, a thematic analysis approach was used because it allows researchers to closely examine the data and find common themes including patterns of meaning from participants. This study took an inductive approach and used a latent approach in data analysis in which subtext and underlying assumptions in the data

were included in analysis considerations in addition to the explicit content of each interview. The steps of thematic analysis were primarily taken from Braun and Clarke's (2006) work on how to conduct a thematic analysis in qualitative research and steps to ensure rigor in the analysis will draw on recommendations from Nowell and colleagues (2017).

Data Preparation

All interviews took place over Zoom and a video and audio recording were captured for each. Once complete, each student participant was given an ID number and interview recordings were renamed with the participant ID and their program completion status to protect student's confidentiality. Interviews were transcribed verbatim using an external service.

Once the final transcription documents were available, I went through each transcript and corrected any mistakes by reviewing the text alongside the video recording and also looking through the text for individual name and program name errors. This review for accuracy allowed for a prolonged engagement with the data in which I was sure to document my reflections, thoughts on potential themes, and other thoughts through the process. Once this was complete, I downloaded each transcript as a word document and uploaded them as text files into NVivo 12, the software package used for the coding and analysis for this study. At this time, I created a case for each participant in NVivo and attached demographic and background characteristics, which were captured

in pre-interview surveys, for each participant, and attached the corresponding transcript file to each case.

Coding of Transcripts

To begin coding**,** in close collaboration with my advisor I chose two transcripts, one from a student who left the program and one from a student who completed the program, to use for an initial open coding process. I read through each transcript and assigned preliminary codes to these data to describe the content of the interviews as straightforwardly as possible. In this initial process, I took note of the context in which the students were situated, the social interactions students had with others and the nature of these interactions, student opportunities for science practice, their descriptions of science identity construction, and their reflections on future plans and pathways. Next, I shared these two pilot transcripts with my advisor without my codes and they went through and reviewed the transcripts, creating their own initial set of codes based on these data.

Next, we discussed our initial codes and worked to unify our ideas into a set of codes that could best make meaning of the information collected from the students and be used for the remaining interview transcripts. We developed a coding scheme that drew on my research questions and theoretical model and was helpful in capturing student experiences and responses to the interview questions. I served as the lead coder and was the primary person making decisions regarding the coding scheme. My advisor guided

the process, offered primarily knowledge of the research literature and phenomenon of interest, but deferred to my expertise with the data set on final coding decisions. The coding scheme included sub codes related to context, individual factors, scientific practice, science identity, tensions, and trajectories.

After this coding scheme was created, the two pilot transcripts were recoded and my advisor reviewed my codes to ensure they aligned with our previous conversation and coding decisions. Next, I began working through the ten additional transcripts from those who had left the program. Through this process I paid careful attention to how well the coding scheme worked in these subsequent transcripts and added new codes when a student experience was not reflected in the original coding structure. Next, I coded the remaining 11 transcripts for those who completed the program. As new codes were generated or two codes were combined, an audit trail was kept. Due to the focus on students in context, social interactions, and students' perceptions and interpretations of these experiences, text segments were often double coded to note the students' context and/or social partner along with how these experiences related to their ongoing participation in STEM and the research training community of practice, their science identity construction, their opportunities for science practice, and the nature of their trajectories. The full coding structure, including exemplary quotes and a brief description of each code can be found in Table 6.

Making Meaning Through Coding: Construction of Themes

Table 6

Final Coding Structure, Summary, and Exemplary Quotes

Code Name	Code Summary	Exemplary Quote(s)
Context		
College Classes	Took place in classroom or with faculty teaching classes and included grading practices, pedagogical norms, and social interactions	*-I ended up failing biology. Um, I did really good at the beginning and then it was like week four when I realized that.* *-There were definitely a few times when it was almost finals or it was finals week or midterms and I just mentally wasn't there, because I was like, "Oh my God, I have this exam. Like, I don't know how I'm going to do."*
College Institution	Student experiences with their college or university including navigating systems, college enrollment decisions, financial aid, and more	*-Some of it was, some of it was credits. Um, because I knew at [my community college], if I transferred to PSU, most of my credits would transfer, but I had no idea how they're going to transfer.*
Family	Included all mentions of immediate and extended family including family beliefs and practices, student conversations with families, and support from families	*-My parents were very hands-off in paying for school, you know, like, "You want it, you have to earn it. We're not going to help you."* *-[My family] were a big support, um, for me just being here in the program. Although they kind of didn't understand what I was doing out here (laughs), maybe they still don't know what bachelor's I'm doing, but that's fine (laughs).*
Peers	All interactions with peers inside or outside of the program, coded into negative and positive	*-We still have a pretty solid friend group, and I definitely think that, that was really important for me, um, was having that support and that friend group, and a few of them were also STEM majors*

	interactions with peers if expressed	*-My friends you know, I hate to say this but, like, so I have some of my friends that have pretty much all the financial assistance. So, their parents have more than money. They don't have to worry about working but just focus on their studies.*
Program (Outside Research Placement)	All student experiences in the community of practice that took place outside of the Research Learning Community including professional development workshops, advising appointments, and navigating program systems	*-I learned so much from [my career mentor] and like, just he's been absolutely amazing and we are still connected as well.* *-So, I really liked those fairs and events 'cause that's exactly what I was looking for. You know, like more career opportunity, more, yeah, just more exploration, more networking opportunities,*
Research Placement	All student experiences in the community of practice that take place inside of the Research Learning Community including interactions with mentors, lab mates, time working in lab, or lab related experiences and activities	*-And I had met my research mentor a few times about joining her lab, and yeah, she was just like super energetic and seemed excited to have me joining the lab.*
Context Motivational Climate	Captured within each context, as appropriate, and covered motivational climate within context such as provision of	*-There were definitely times where I found myself being like, "Oh, I don't want to get in trouble. Like, I know I need to go."* *-I'm like, I don't really have a choice. I think I got some sort of warning like one time.*

	autonomy support and structure	
Individual		
Mental Health	Mentions of depression, anxiety, and anything connected to mental health, treatment, and its impact on program or academic participation	*-I did struggle with my mental health, uh, a lot. And I was going to counseling for that at PSU.* *-I was feeling depressed, during that time.*
Affect (Positive/Negative)	Any time where student talked about affect, was coded for positive or negative	*-And so I just felt extremely overwhelmed on that. And so it was just a ton of that hit me at once.* *-I hit a point where I was really unhappy and I needed to figure out a way to be happy*
Motivation Related	Instances where students shared their intrusion and extrinsic motivation, barriers to motivation, and changes in motivation	*-And so I wanted to be able to be that person who's been there, done that, and can advocate on their behalf.* *-I've always wanted to go back home and open a mental health clinic there. And like do some kind of huge campaign to just kind of get people to, I don't know, to, to lower the stigma surrounding mental health, um, in, in their communities.*
Doubt About Abilities (Imposter Syndrome/Messages of Doubt)	Anytime student expressed doubt about abilities or experiences with imposter syndrome	*-It gave me a, like a more severe imposter syndrome because, you know, when you get exposed to so many like smart people, it just, um, yeah, it just makes you feel like, oh, shoot, I'm kinda lagging behind,*
Reasons to (Quit/Remain in) Program	Students' reasons to join or stay in EXITO both before joining the program and throughout the process of program participation	*-There was a lot of things about professionalism and et cetera that I didn't know, um, for example I had a hard time reaching out for opportunities, I didn't know how to send a cold email et cetera to people. So, that's the second thing, I learned that you know, EXITO helps with this matter, so I would love to join it.* *-I quit. The first thing I did not like how I was being treated and second, it was*

		affecting my grades and the way I study, so I dropped the program.
Science Identity		
Competence	Student descriptions of a sense of competence related to a specific science related task or knowledge in their research field or discipline	*-But then when you're actually doing this for someone and you're actually able to send it off to them and say, "Hey, this has a component which you need, you know, for a future publication," it was definitely like, "Okay, I didn't just say I understood this, but I really understood this."*
Performance	Student descriptions of preforming science activities including reviewing scientific literature, data collection, research design, data analysis, dissemination of research findings, and collaboration with scientists	*-But then when I was actually able to present it at a research conference, it was like, "And this is why you do it." You know, it's not just to do busy work, but actually show the world like, "Hey, this is the science I've been doing. This is what I can teach the world."*
Recognition by self	Student experiences of recognizing themselves as a scientist	*-It made me feel like I can be a researcher and just presenting whatever I was doing in my lab and just seeing how, you know, interested people were just, uh, the crowd asking questions and me fully knowing what, what, uh, purpose I had behind the research.*
Recognition by Others	Student experiences of being recognized by others as a scientist, as being good at science, or integral to research and science work	*-I was trained on how to do an experiment in a short period of time and it turned out perfect. And I got so many compliments by even people that were surprised that I was just an undergrad student at a conference and they're just like we're really amazed.*
Science Practice		

Exclusion	Instances of exclusion from scientific practice either explicitly such as not being allowed or able to participate in a practice or implicitly such as by not being given a certain opportunity	*-Um, it kind of frustrated me, but I was just also, like, I think I was already frustrated at the fact that I had to, like, I felt like I had to beg for them to not, um, or like, just to give me, give me one of their studies to work on.* *-So I did work on a paper with uh somebody that I worked with at OHSU and was a co-author on that paper, and um so that was published.*
Inclusion	Instances of inclusion in scientific practice, mostly in RLC context, focused on intentional invitations	*-Yeah. So, I feel like that probably also mostly happened at conferences, like um, there's a few times where I would like sit in on conversations that [my mentor]was having with other like big names in the field, and that was really exciting.*
Support and Training (Present or Lacking)	With RLC contexts, PI, mentor, grad student, or peer support with scientific practice including verbal explanations, ongoing mentorship, and explicit training. Lacking was when students were asked to do something but without adequate support, instruction, or ongoing supervision	*-My PI gave me a lot of literature review work in the first, like um, while. So, and I did a lot of those with him, you know? And that helped me a lot, just like getting so efficient in literature review. Like, at one point, I got really so efficient at it that literally I did the literature review for my honor thesis in like three days. And I got all my resources down.* *-I found my own articles and then wrote about them and then gave it to my mentor.*
Tensions		
Finances	Any mention of financial hardship, struggle, need for more money, or challenges with money related to	*-I am first-generation, um, you know, going to college, going to university and I didn't really have a lot of loan options. I didn't really have a lot of options just to even pay for school.*

	paying for things including school, personal expenses, family or dependents	
Future Plans and Pathways	Discussions of future plans for career or education plans and challenges or barriers in reaching these goals or making these plans comes true	*-I would say probably that I didn't feel like I got any support in terms of when I thought about doing stuff besides graduate school in, like, a research pathway.*
Identity	Tensions, interactions, experiences, and perceptions related to students cultural, ethnic, racial, gender, or other identities or any intersection of two or more identities	*-So in our community college, or just like in our Island in general, everything is done as a community, as a group. Like we move forward as a group. It's not individual (laughs) individualized, like how it is like when I moved to the States,*
Competing Demands	Students' descriptions of demands in coursework, work outside of EXITO, research placements, EXITO program	*-At the same time, you're supposed to keep up with your classes and get a good grade. But what happened in my case was the time I was required to attend those workshops was when the professors were offering office hours or group studies. -And then, so then I was having to get really stressed and torn apart because I needed to keep up with the EXITO requirements, but at the same time, I also needed to keep up with my grades and so I got to a point where I was like, is this really worth it?*
Capacity	Students' examples of situations, actions, or experiences that were shaped by their personal capacity to accomplish tasks,	*-I don't know, like how I was doing in school and how I was like trying to... like, it was really, really hard for me to try to balance EXITO, my RLC and school and being a mom.*

	meet deadlines, and be responsible in many roles	
Inside/Outside Research	Descriptions of experiences with students looking at the difference between friends, family, or peers outside of the biomedical research world and their experience within. Instances double coded with context	*-Um, hmm. They know that I was moving out here and they were very supportive of what I was doing, but they kind of didn't understand what I was doing. It was just like a hard situation to explain.* *-I guess a little bit worried that if I sent [my paper] to her it would cause some distance between us, like she kind of felt like I was you know like doing things that she wasn't going to be able to understand, if that makes sense?*
Trajectories		
Trajectory Related	Comments about trajectories, decisions connected to student pathways that are not explicitly inbound or outbound but rather are connected to unfolding trajectories	*-Then when I got to EXITO and I knew that actually getting a bachelor's degree was an option, I was like, "Oh my God."*
Inbound Research	Descriptions of student intent, plans, or actions that lead toward advanced degrees or careers that relate to scientific research	*-When I went in, I was like, okay, I'm interested in this. I just don't know how I feel, like just testing the waters. And then I left knowing that I've, I could do work that I was really passionate about.* *-And I belong, I belong to this interesting world. And even though I had my own ideas and imaginations of what I wanted to do, but I actually feel like this is what I am supposed to do like no matter like how hard the journey was.*

Inbound STEM	Descriptions of students on trajectories related to science and STEM, but not explicitly connected to research	*-It made me I realized I loved science. Um, I always did in school, but then I never really thought of going into healthcare or into the STEM field.*
Outbound Research	Student descriptions of decisions to not pursue a degree or pathway that would lead to a research career	*-I'm actually in the [clinical training degree] program. Um, and with, through that you get another bachelor's so yeah, it's a two-year program and had to come in with prerequisites.*
Outbound STEM	Student explanation and descriptions of leaving STEM and science	*-After she had said she had agreed to let me join her lab, that I was just kind of like this is a mistake and I just kind of knew that if I didn't change course, then, that I probably wouldn't change course and then I would regret it.*

After coding each transcript, I created a summary for each case which included a rich, thick description of the case, the systemic and person-in-context factors that contributed to the student's participation, notable quotes from the student, a summary statement about their trajectory, and whether or not the student's trajectory was inbound or outbound in STEM and research fields. Throughout this memo creation process, I revisited the raw data to consider if my description of the case, meant to highlight the most important ideas and themes from each participant, was reflected throughout our conversation when I read through it again. A sample case summary can be found in Appendix E. Note that details have been changed and some content has been removed to protect the confidentiality of the student.

After all of the transcripts from students who left the program were coded and a case summary was complete for each, I began a document of overarching ideas and topics from these 11 student transcripts. I started with the broad categories included in my theoretical model: contextual factors shaping student participation, student experiences in research training communities of practice, scientific identity construction, and student trajectories to consider which ideas and experiences came up in multiple instances and were shared across participants along with student descriptions of various experiences. During this time, I looked at code frequencies, text content attached to each code, and reviewed notable quotes that captured these theme ideas in the raw data. The result was a large document with a long list of content areas and potential themes

captured in the transcripts of those who left the program. Next, I went through the same process for those who completed the program, I created a case summary for each and then created a document that cut across the completer transcripts and summaries to consider the most frequent experiences from the participants.

Emergence of Themes

After completing the separate theme summaries for those who completed and those who left, I created a unified, emerging themes document to capture the most prominent ideas that emerged from these data. For this step, I reviewed the two topic/theme documents and then reviewed each code and the text associated with related codes for all study participants. I considered different code patterns and frequencies between those who completed and those who left the program and created a summary for each construct including exemplary quotes, reflections on the distinctions between those who left and those who completed, and a summarized interpretation. An abbreviated version of one construct section of this emerging theme memo on mental health, can be found in Appendix F to showcase how exemplary quotes and my own reflections and interpretations were captured in the process.

Once this document was complete, I revisited the theoretical model posited for this study along with the literature review. This process, including in-depth conversations with my advisor surfaced several significant and emerging themes in the

data. At this time, the contextual factors shaping participation, science identity construction within research training communities of practice, and various trajectory relevant experiences, as shared by students in the sample became more apparent and were represented in several shared experiences and challenges for students. I did several concept maps and memoing to reflect on what was emerging, engaged in conversations with my advisor and spoke with EXITO colleagues on possible interpretations and perspectives on the themes. This allowed me to recognize and refine the emerging themes most relevant to my research questions.

Next, I went back to the raw data, with the emerging themes in hand, and reviewed each transcript to look for both confirming and disconfirming cases for each theme. The same strategies including researcher triangulation, peer debriefing, and consensus were used as themes were further refined. Finally, I wrote up the results of this study with careful consideration of articulating the student experience through emerging themes and providing evidence of each theme through sharing of student quotes and shared experiences and reflections across participants.

Chapter 6 : Results

This study examined the relationship between factors shaping students' participation in a research training community of practice, their construction of science identities, and their science identity trajectories. First, the study considered experiences and structural factors that contribute to underrepresented racial and ethnic minority and first-generation students' decisions to leave research training communities of practice or STEM disciplines altogether. Second, the study explored experiences within a research training community of practice and STEM disciplines that shape students' construction of science identity. Third, the study examined the relationship between identity construction and their decisions to stay or leave these programs and STEM environments.

Students provided detailed descriptions of their post-program plans throughout the interviews, and several trajectories related to future education and careers in STEM and research emerged. The distinctions in these trajectories surfaced as worthy of consideration in addition to students' program completion. A preview of the four distinct student trajectories, including inbound STEM research, inbound STEM non-research, inbound STEM with unclear research trajectory, and outbound STEM, are broken down by program completion status in Table 7. Students were categorized into the group that best aligned with their current status or near-term plans by creating a summary of each student's plans for continuing career and education, and then considering whether these steps led them closer to or farther from STEM and/or research careers. Students in the

Table 7

Science Identity Trajectories by Program Completion Group

Trajectory Type	Trajectory Summary	Left Program	Completed Program
Inbound STEM Research	Actively pursuing STEM and research pathway through current employment and/or graduate school enrollment (e.g., alumni working as a research assistant in a lab)	0	6
Inbound STEM Non-Research	Actively or intending to pursue a STEM career or working in a STEM field without intent or plan to do research (e.g., alumni attending clinical degree program)	7	5
Inbound STEM With Unclear Research Trajectory	Actively or intending to pursue STEM career but unsure if research will play a role in future career (e.g., working in a healthcare position and unsure of graduate school plans)	2	1
Outbound STEM	Actively pursuing a degree or career outside STEM (e.g., left college and working in non-STEM field)	2	0

first category, inbound STEM research, expressed a clear interest in research and had a pathway toward a future research career and are actively in a research job or attending graduate school in a relevant discipline. The second category, inbound STEM non-

research, includes students who are inbound in STEM but outbound in research. These students are pursuing STEM-related careers but do not plan to include research in their future careers. Some students in this group are on a clinical track, while others are entering a STEM field but do not plan to pursue a career closely tied to biomedical research. The third category, inbound STEM with unclear research trajectory, includes students inbound in STEM who may engage in research careers but lack clarity regarding if research will play a role in their future. Fourth and finally, outbound STEM includes two students pursuing degrees and careers outside STEM and research.

Across interviews, there was a significant focus on students' opportunities for scientific practice in the research training community of practice, social interactions with others, and the tensions and challenges students encountered on their pathways. This study surfaced several themes about the contextual factors that impact students' participation in higher education STEM contexts, the experiences that shape their construction of science identity, and the centrality of these processes in their science identity trajectories. The results will focus on the perspectives of students like Lily (Leaver, Inbound STEM Non-Research), who shared:

> I really didn't feel like a scientist. I never went to a conference for it. Maybe going to a conference would have changed it…I never really felt like a scientist and now I don't know if I am one or not, but I kind of want to be one.

This will be contrasted with students who completed like Tina (Completer, Inbound STEM Research), who shared:

> I think EXITO always called us scientists, and we all were just like, "You guys are lying to us. You have to tell us that so we feel cool." But I think once I started going to conferences, that's when I really like, "Wow, I am a scientist."

The following sections include the themes that emerged from these student interviews, including information on theme frequency and exemplary quotes. First, results regarding the contextual factors shaping student participation in the research training community of practice and STEM disciplines will be reviewed. Next, the emerging themes of students' science identity construction within research training communities of practice, emphasizing the role of competence, performance, and recognition, will be unpacked. Finally, an overview of students' identity trajectories and their pathways into and out of research careers will be discussed, along with the role of science identity construction and communities of practice in shaping these trajectories.

Contextual Factors Shaping Participation

The literature review of this study considered several previous explanations for factors responsible for inequities in STEM participation for underrepresented and first-generation students. Consistent with previous research on STEM inequities, study results revealed that a myriad of factors shape student participation in research training programs

and STEM disciplines. All 23 students who participated named at least one person-in-context and one systemic factor they felt impacted their participation.

Students Financial Challenges and College Affordability

Financial struggles, tensions related to money, or financial hardship came up in 20 of the 23 interviews. Financial challenges included determining how to pay for college, finding money to provide basic needs for themselves and dependents, dealing with limited financial assistance from families, and struggling to navigate financial systems within higher education institutions came up in eight of the eleven interviews with those who left the program. For six of these students, finances were a significant factor in deciding where they would attend college. These students attended community colleges before university because classes were more affordable than a four-year university or enrolled in their university because it was more affordable than other colleges or private schools. Liza (Leaver, Inbound STEM Non-Research) shared, "There wasn't any contribution from my family members or anything so I started off at [a community college] just to help myself save money for future educational purposes." Kayla (Leaver, Inbound STEM Non-Research) also chose where to attend because of finances: "I did apply to more schools, even out-of-state schools, they just financially didn't work out for me because the boarding is already around $10,000." Some students considered the financial implications of their degree pathway choices, such as Jamie (Leaver, Inbound STEM Non-Research), who said, "I found out basically that I was running out of

financial aid and I wasn't gonna have enough financial aid to cover the rest of [my degree]…and so I switched to [a different major]."

For students who left the program, determining how to pay for college was a source of stress and confusion. Seven leavers shared they did not receive money from family to help with college. Jamie (Leaver, Inbound STEM Non-Research) shared, "I didn't have any parents to pay my tuition or pay for my books or help me with rent or any of those things." Jackie (Leaver, Inbound STEM Non-Research) shared a similar experience, "I have no help from my family for finances and stuff." Additionally, five of the leavers had family-related financial responsibilities such as caring for dependents or extended family. This was true for Damien (Leaver, Inbound STEM Non-Research), who shared, "As a parent, your number one priority [is to] keep your kids safe and then be able to provide."

Students who completed also lacked support from families. Amy (Completer, Inbound STEM Research) shared, "I'm from a low-income family. So, we have to figure out where to get funds from ourselves. I know that I had to pay my own bills. I had no one else to rely on." Sofia (Completer, Inbound STEM Research) had a similar experience:

> I am first-generation going to college …my parents were very hands-off in paying for school So really I was trying to figure out my next steps "Okay, am I going to

> work full time and then goes to university part-time? Am I going to drown in debt?"

Students from the leaver group did not share any instances of getting assistance understanding how the program's financial support or navigating the institutional systems related to paying for college. In contrast, several students who completed the program had additional funding sources such as scholarships or family. Five of these students discussed scholarships such as Dominick (Completer, Inbound STEM Non-Research) shared, "I paid my school tuition through EXITO and I got like financial aid in another scholarship." Three students who completed discussed receiving significant financial support from their families to pay for college such as Rachel (Completer, Inbound STEM Non-Research):

> It wasn't until after college that I realized a lot of my friends had to work this many hours just to pay this amount of their tuition or they had to work so that they could help pay for family members' health expenses and stuff like that. And I didn't have to do all that. So, I just realize how privileged I was to just focus on school and not have to worry about much of anything else.

Students who completed the program also reported receiving staff or faculty support navigating financial aid. Maria (Completer, Inbound STEM Research) shared, "The EXITO financial aid counselor used to work with [the other scholarship I had], so she was able to help me out a lot with understanding what was going on." David (Completer,

Inbound STEM Non-Research) had a similar experience, " I actually sat down with [the financial aid staff] at one point and made sure that all of my documents were right and made sure all my finances were gonna keep going and that everything was okay." Sofia (Completer, Inbound STEM Research) had concerns about her financial aid and confusion about how much she would owe from term to term, "I didn't know, from one quarter to the next if I was going to have to drop out, because I didn't have enough financial aid." Sofia highlighted the importance of understanding how financial aid worked in the program and institution, "[The financial aid person] helped me a lot because it was, she wasn't just like, 'Oh, this is how much you owe,' but it was, 'This is why it is the way it is,' which ended up helping." But before that, it was months and months of trying to figure out an answer to one question.

The financial support from BUILD EXITO was the most cited reason for students' initial decision to participate in the program and this came up more in interviews with students who completed the program. Five leavers said they applied primarily because of the funding, while ten completers said that getting help paying for school was one of their top reasons for joining the program. Kelly (Leaver, Inbound STEM Non-Research) shared, "The fact that I had to have this amazing opportunity to pay for the majority of my schooling in my undergrad, that's huge." Some students who left had a complicated relationship with the funding support from the program. Jamie

(Leaver, Inbound STEM Non-Research) spoke of how the financial support impacted their participation:

> The money I was getting from EXITO positively and negatively impacted my participation. I was more likely to show up to everything because I was being paid to do so. And at the same time, it was kind of negative because I felt like without this program, I wasn't gonna be able to be successful because I needed the money so much, if that makes sense.

For many of the students who left the program, the benefits of the program's financial support did not outweigh the challenges and stress that accompanied their participation. Deidre (Leaver, Inbound STEM with Unclear Research Trajectory) said, "I quit. I did not like how I was being treated and, second, it was affecting my grades and the way I study, so I dropped the program." Kayla (Leaver, Inbound STEM Non-Research), when asked about factors impacting her decision to leave the program, shared, "I [knew] I should just stop it and then it would like ease my workload and I could focus on other things that matter more for me."

In contrast, some completers felt the program was a rare opportunity and worried they would not have other options for finishing their degree. Alice (Completer, Inbound STEM Non-Research) spoke to the importance of getting paid for research work, "I think that getting paid to do it was more important just because I have a family and I can't afford to put into research what research requires if I'm not getting paid to do it" These

students also explicitly stated that the money was a reason they would not quit the program such as for Dominick (Completer, Inbound STEM Non-Research) who shared, “the working stipend and the scholarships were like just really huge motivators to also continue on.” When asked why the challenges she was experiencing didn’t prompt her to leave, Ariana (Completer, Inbound STEM Research) shared, “I would never have the financial ability to rejoin an institution...an educational institution and complete my bachelor's degree.” These perspectives suggest that students who stayed in the program may have felt that the financial benefits were essential to their success. The benefits outweighed the challenges they faced due to program participation.

Although students appreciated the tuition support and monthly stipend, for many, it did not cover their rent, food costs, and other bills. Six students who left the program had to work in addition to their research experience and full-time course load, a decision driven by financial hardship. Damien (Leaver, Inbound STEM Non-Research) shared, "I got a job offer…and I knew that my financial aid wasn't covering everything, so I had to work, right?" For these students, working additional jobs negatively impacted their ability to succeed in classes and their research placement because it created extreme amounts of stress and made it difficult for them to fully engage in the program and their courses.

Some students did not think it made sense that everyone in the program received the same level of financial support, regardless of their situation. For instance, one participant pointed out that a student who lived with their parents a few miles from

campus had drastically reduced living expenses than students who moved to the university area from far away and had to establish themselves and pay for everything out of pocket. All three students with children in this study acknowledged the significant additional expenses of having one or more dependents. Kelly (Leaver, Inbound STEM Non-Research) shared:

> I think that there was like the whole month in the summertime that you were gonna be spending working, that was like, Oh, geez. I did not know that was gonna happen. I'm gonna have to arrange childcare for this and that's gonna come out of my pocket. So all the stipend that I would be getting for all of this would be paid to childcare.

When considered together, finances were a persistent and significant challenge for students in this study who left the program. These students experienced significant financial hardship, and many struggled to find affordable ways to pursue an undergraduate degree. Students who completed the program had more financial support from scholarships outside the program and more assistance navigating the financial systems in higher education. Those who left the program encountered challenges when working while going to school, which negatively impacted students and their academic and research work participation. They also reported no support in figuring out how to navigate the financial system.

Pedagogical Norms and Ways of Knowing in STEM

Students in this study faced challenges in STEM learning spaces and highlighted how pedagogical practices and narrow ways of knowing in STEM disciplines frequently marginalize underrepresented minority and first-generation college students. Students from both groups shared widespread experiences in STEM courses and contexts of stressful learning environments, unreasonable expectations, and challenges with academic performance. Students recognized that individual backgrounds and experiences shaped their level of knowledge on how to navigate these unique learning spaces, such as Alice (Completer, Inbound STEM Non-Research) who shared:

> It's important to acknowledge that some students don't have a solid background. Someone who has gone through foster care or some underrepresented minority that has to work 40 hours a week and their parents are immigrants versus someone whose dad is a doctor and mom's a lawyer, they're going to have two totally different [academic products].

Students felt their courses were fast-paced and unreasonably demanding. Amy (Completer, Inbound STEM Research) reflected on the intensity of their STEM courses:

> It was just super fast-paced for me…I'm smacked in the face with like ten weeks of courses that I have to like push through and power through, and just you're left alone there with how to figure out how to get through these classes on your own.

Students also shared discontinuity in the pedagogical approaches of their past learning environments and their present STEM learning contexts. Amy shared, "In our

community college, or just like [where I am from], everything is done as a community, as a group. Like we move forward as a group, it's not individualized, like how it is when I moved to [this university].” Derek (Completer, Inbound STEM with Unclear Research Trajectory) shared that a more individualistic approach in the large, university STEM setting replaced the collectivist approach of their past:

> I used to do really well back home, but then now I feel like I'm so dumb….Back in my community college, if a student in a class doesn't get it, we won't move forward until everyone gets it… I was failing some of my exams because I didn't know how to study. And just not having that one-on-one with the teacher, just being super supportive…was super stressful.

There were a few distinct experiences of students who left the program regarding pedagogical norms in STEM. Students who left the program-wide agreed that their workloads were too heavy, stated they had experienced burnout from classes or faced struggles to succeed in their classes and lab environments. Students felt that pedagogical norms and practices within their disciplines created a stressful environment. Jamie (Leaver, Inbound STEM Non-Research) noted, "the amount of homework that I had in those classes was outrageous. It was ridiculous. I was spending like four hours a night just doing homework." For some students who left the program, the overwhelming demands for academic performance impacted their ability to engage in the research training community of practice. Kayla (Leaver, Inbound STEM Non-Research) shared,

“it made it a little bit difficult because not getting enough sleep and having to finish multiple projects from different things, work stuff and then school stuff and then the EXITO stuff, I felt like everything was not organized.” Students understood that the classroom offered few options for performance. Liza (Leaver, Inbound STEM Non-Research) shared:

> I've never really been a fan of exams and how grades are usually based on how well you do on your two or three exams that you have for a course. Just 'cause for me, I'm a very hands-on learner and having to sit in a lecture for three hours doesn't really help me learn anything.

Students who left the program also reported challenges getting support from faculty in the classroom such as for Damien (Leaver, Inbound STEM Non-Research) who struggled in a class they took with a program-affiliated faculty:

> [The] faculty knew that I was in the program, but they weren't helpful… I guess I joined EXITO to fulfill the mission, right? If I'm a faculty and I see a student, and they're from [another country], and I know that whole gist, the whole purpose of that program, I would see them, and I would pull them aside and say, "Hey, you know, you know, what can I do to help you," you know?

This student had assumed that because they were taking a course from a program faculty, they may find additional support and guidance, but this was not the case.

Only six of the eleven students who left the program entered a research placement. Some of these students did not feel the research environment allowed them to learn scientific practices in their lab. Damien, again, shared, "They wouldn't teach me…I'm a curious person, and I'll ask things, and I felt that, that my PI was irritated because I asked questions." Kayla (Leaver, Inbound STEM Non-Research) shared about how the environment in the lab didn't support their learning:

> "Just knowing how to do things was the one that was difficult for me, having that training or having the ability to learn things super-fast, because they're super quick-paced. And doing the [scientific tasks in my lab] and stuff. It might have been also be a loss in communication if PI didn't know what the last things or the last step was that other those people taught me how to do.

Sometimes, the pedagogical norms in STEM, which students felt included rigid structure with little flexibility and consequences for failure to perform, were perpetuated by the practices of the program. They prompted fear of disciplinary action within the community of practice for not meeting the program's GPA threshold or maintaining full-time status. Students ran into barriers when they attempted to withdraw from classes, such as Jamie (Leaver, Inbound STEM Non-Research):

> I'm gonna fail the class if I stay in it. And [program staff] told me just to try my best and to stay in the class and all that. And I waited two weeks, and I failed

> another test in the class…so I was like, "Yeah, I'm gonna withdraw from the class because I can't risk my GPA by failing yet another class.

Jamie continued:

> There just seems to be no flexibility in the program for human beings living human lives outside of just being a scientist. And I understand it's a rigorous thing and it's to prepare you for grad school and it's to help you meet the demands of being a scientist. We are not scientists yet.

After withdrawing from this class, Jamie fell below the full-time requirement for program participation and was no longer eligible to participate in the program.

In sum, students who left the program shared about challenging learning environments in STEM courses and struggles to succeed in research placements. With narrow pedagogical practices used to teach science and limited options for successful performance in science, many students struggled to be successful. Students pointed to unreasonable course demands and a lack of support in their classes and hands-on learning environments that caused high levels of stress, led them to question their abilities, and in some cases led to their departure from the program.

Microaggressions, Discrimination, Bias, and the Culture of Power in Science

Students who left the program had persistent negative encounters with peers, faculty, program staff, and mentors. These experiences took place inside the research training community of practice and in other STEM-related contexts. While students in

both program groups described instances of discrimination, bias, and microaggressions, including in their classes, with staff and advisors, and within their research placements, six students who left the program were acutely aware that the culture of power in STEM was shaping their experiences in context. These students referenced norms and practices in science that created environments not designed for their success. Jamie (Leaver, Inbound STEM Non-Research) shared:

> Every single professor [in my major] that I encountered was a man. They were all these straight men, very dudebro, type of people. The classes are designed for people that go to school full-time and do nothing else because their parents take care of them which I have found is true in most STEM fields. Half the people in my class, their parents, were [well-educated professionals].

Three leavers shared instances where faculty, advisors, or mentors doubted their abilities or condescendingly spoke to them about what was possible for their future. Although marginalized identities were not explicitly mentioned in these interactions, students seemed to internalize these interactions as identity-related. Deidre (Leaver, Inbound STEM with Unclear Research Trajectory) shared about an experience with a program staff member that contributed to her decision to leave the program:

> She was talking to me differently…In front of the class she was professional, but she when she came to me…I didn't like when she was talking to me. Like I'm ignorant, like from a village ignorant…like a village girl.

Students who completed the program also received messages of doubt about their abilities but, unlike those who left the program, completers shared examples of faculty and staff who countered those messages with encouragement and support. For instance, Alice (Completer, Inbound STEM Non-Research) shared about an advisor who questioned their ability to get a fellowship to pursue their pathway when they asked for a letter of recommendation:

> It really irritates me every time I talk about it. They were just like, 'You need to be more realistic. This isn't for you. Yeah, it was rough. I don't know why you would be a mentor for somebody and then say, "No, you need to be more realistic. You're not gonna get it."

After this encounter, Alice went to two other mentors who wrote letters for her and encouraged her in the application process. Sofia (Completer, Inbound STEM Research) shared:

> A negative person was my faculty mentor...he was scaring me about [my pathway] and how hard it was going to be. Do I really have what it takes to be in it? And then I went to ask him a question, and then he never said anything to me ever again. And so that wasn't fun. That was a little traumatic.

However, Sofia had a very supportive research mentor who hired her on to work in the lab in addition to her program participation, "I remember he was like, 'Well, you are a researcher in here. I have the funding. I will hire you.' I would say probably the biggest

time I was ever considered a researcher." Maria (Completer, Inbound STEM Research) had a similar encounter in an interaction with an advisor, "It felt like they didn't really believe I could do what I wanted to do, …like if I would mention the class, they would be like, 'Oh well, that course is really difficult, so I don't know about that.'"
Like the other completers, Maria received support and encouragement from staff that countered these messages, "I became really close with [a program staff and a program faculty] and that was probably the most positive experience that I had was developing those relationships and having those mentors that you knew really cared about you." These combined experiences suggest that although students from both groups felt that faculty or staff doubted their abilities, those who completed may have been buffered from the negative impact of these interactions by positive relationships and interactions with program mentors and staff.

Students who left the program had negative experiences related to their marginalized identities with program staff and faculty. Deidre (Leaver, Inbound STEM with Unclear Research Trajectory) shared a negative interaction when staff set up a conversation between her and a guest speaker from her underrepresented group, "I just didn't like it…I wasn't comfortable. Because sometimes just because you're [a member of a specific minority racial or ethnic group], it doesn't mean you'll feel comfortable with all [people from your racial or ethnic group]." This student said they left the program

because of their interactions with this staff member. Jamie (Leaver, Inbound STEM Non-Research) also shared a negative staff encounter:

> We were writing on the board barriers to success and I wrote on the board [an identity-related barrier I experience]. And [a staff] took it as an opportunity to try and correct me and make it seem like that wasn't actually a barrier. I was like, "You're making me uncomfortable. I'm gonna walk away." [They] kept getting in my bubble and kept coming at me about how, what I was writing was wrong when [they] hadn't done that to anyone else that wrote anything else.

Students who completed also had these types of encounters such as David (Completer, Inbound STEM Non-Research) who shared an instance of interacting with program staff:

> [They told] this weird story to me, in reference to a situation where [they had a conflict with someone from my gender/sexual minority group]…it just made me feel uncomfortable, and I didn't really know how to respond to that. I didn't know what they were really wanting. And then, about a year later, again, when someone said something [about being from a different gender/sexual minority group], they told that exact same story, except the person in the story was [changed to the marginalized identity that student had mentioned].

This student's interaction with staff had a lasting, negative impact and they did not feel safe in this relationship. However, David spoke of his decision to not leave the program

and how he found subtle ways to exercise his agency and resist, “I think I kind of rebelled a little bit without ever actually saying anything was…I'd turn things in late. All my time cards were late. All of my little progress report things would be late. I would wait until the absolute last moment to do things.”

These experiences and encounters took an emotional toll on many students, impacted their participation, and shaped students' classroom engagement. Some students who left the program felt a burden to demonstrate competence on behalf of their entire group. Jamie (Leaver, Inbound STEM Non-Research) identifies as non-binary femme and shared of their experience in their discipline:

> It seemed to me that all of the men understood what was going on. And so I didn't want to be the one person who didn't understand what was going on…I just didn't wanna give them any more reason to be misogynistic. You know what I mean? Like if the men understand, then I understand. If the men are confused, then I am confused.

Some students who completed the program and faced discrimination sometimes used their program participation status to bolster their sense of worthiness. For example, Maria (Completer, Inbound STEM research) used their EXITO status to gain recognition as a strong student:

> There was a few times where [my advisor] wasn't being super encouraging or was kind of being dismissive, and then I would bring up I'm an EXITO scholar and [in

> other programs], and she would be like, "Oh." And put that on her notes, and then she would be a little more encouraging.

After Sofia (Completer, Inbound STEM Research) was told she would not do well in a class, she said, "I put my final on his desk, and I was like, 'You may not know this, but not only am I a [social science major] student but I'm also in BUILD EXITO,' and I just walked away. So that felt really good." None of the students who left the program shared instances of using EXITO to boost their status after facing bias or discrimination. These student responses suggest that discrimination in STEM spaces may trigger different responses from different students and some may be more likely to use their program status as leverage in these situations.

In sum, students who left the program had regular experiences with discrimination, bias, and microaggressions while in their STEM disciplines and research placements. These students highlighted how the culture of power in STEM permeates into their experiences in STEM classrooms and research training programs and impacts interactions, shaping their participation in these spaces.

Mental Health, Well-being, and Competing Demands and Pressures

Participants in this study shared widespread mental health challenges and struggled to maintain their well-being which negatively shaped their program and STEM discipline participation. Students' mental health and well-being were impacted by high stress levels and negative emotional experiences in STEM contexts in higher education.

Students shared the prevalence of mental health challenges, how excessive demands negatively impacted their mental health and well-being, and their mental health impacted participation in the research training community of practice and STEM courses. The topic of mental health came up in 17 cases, in interviews with eight students who left and nine who completed the program.

Many students who left the program felt depressed, anxious, overwhelmed, and burnt out. In many cases, students pointed to excessive demands in their work, academic, and personal lives contributing to high levels of anxiety and depression. This was true for Sara (Leaver, Outbound STEM):

> I think it was more just the whole picture cuz it was all affecting each other. Like everything else was making getting all my classes harder and when I tried to focus on doing class stuff, everything else suffered. It all just fed into each other.

Students felt that they had to perform at high levels across numerous domains with competing pressures and demands to be successful. Jamie (Leaver, Inbound STEM Non-Research) recounted:

> So I would get off work, and I would go home, and I'd stay up till four or five AM doing homework, and then I'd go to sleep for five hours, and then I'd wake up and go to class and to EXITO. And the coursework was intense for [my major].

Students' mental health and well-being challenges negatively impacted their ability to engage in the research training community of practice and often resulted in the

physical, emotional, or psychological withdrawal or feelings of anxiety and panic. Liza (Leaver, Inbound STEM Non-Research) said, “I kinda just wanted a break from school because of all the pressure from my family was just negatively affecting my mental health." Holly (Leaver, Inbound STEM with Unclear Research Trajectory) struggled with their mental health, “I was under extreme amounts of stress at the time and I wasn't even able to get to the enrichment sessions on time…It was hard focusing 'cause I wasn't sleeping. It's hard participating 'cause I didn't feel good.”

Those who completed the program expressed similar sentiments. Maria (Completer, Inbound STEM Research) noted, “I think there are definitely times where I was feeling really burnt out and pretty unmotivated and just unsure about my next step.” Dominick (Completer, Inbound STEM Non-Research) said, “Sometime in the first year I was a little depressed, and that was making it a little difficult for me to join the sessions.” However, students who left the program felt support was lacking to adequately deal with their mental health and well-being and recounted challenges accessing resources such as Amir (Leaver, Outbound STEM):

> I was brutally honest with [my program mentor] and I gave him permission to tell everyone else. Then a [staff from my college] reached out to me and that really didn't go anywhere. She didn't understand. She didn't [know about the challenge I was dealing with]. So, it didn't go anywhere.

Jamie (Leaver, Inbound STEM Non-Research) was impacted by a personal event and spoke of needing to take time away for counseling and recovery. They shared:

> It came time for me to get back into classes and get back with EXITO and things like that. And it was just really hard to get back into it. And there didn't seem to [sic] a lot of leniency. I guess I would say in the sense that it was very much viewed like, "Okay, you took your time now it's time to get back."

Students also faced pressures from family and family expectations about their academic and program participation. This experience put extra stress on students and negatively impacted their program participation. Liza (Leaver, Inbound STEM Non-Research) shared family challenges:

> I wasn't really going to school for myself 'cause my family just always expected me to go to school and get an education and just have a solid future for myself. And I get that, they were coming from good intentions, but it was just very stressful for me in the term mentally 'cause I was still going to school, but then I wasn't really doing it for myself. It was just to appease my family members so that they would get off my back…the biggest part of that really negatively affected whether or not I wanted to be in school but also whether or not I wanted to just participate in EXITO.

Liza described challenges with their mental health throughout the program and spoke to the complicated nature of their parent's involvement in their decisions about program and

academic participation, suggesting that students' mental health and well-being are impacted by many social partners in their lives.

In sum, students in this study shared challenges to maintain well-being and struggles with their mental health fueled by competing demands and pressures from their STEM courses, research training program, family, and other domains. For those who left the program, the stress and demands of their STEM disciplines and their research training environment, along with their personal lives, may have left them feeling stretched and stressed in ways that were detrimental to their progress. These experiences suggest that although programs may be creating rigorous and high-pressure environments to prepare students for future biomedical careers, these norms often fail to support their progress and have negative emotional and psychological effects.

A Sense of Community and Cultural Scientific Norms and Practices

Many students who participated in the research training community practice struggled to find a sense of community and belongingness in STEM both inside and outside of the research training community of practice. A sense of community came up in over half of the cases, and students shared various challenges and triumphs of understanding their place in science. However, students who completed the program shared more examples of how the research training community of practice buffered against feelings of not belonging in other science-related contexts. Ten of the students who completed the program talked about the importance of their community with peers,

while only four of the students who left had a strong sense of community with peers in the program.

Students from both groups reported experiences in class contexts that made them question whether or not they belonged in science, such as Derek (Completer, Inbound STEM with Unclear Research Trajectory):

> Just being in a class with over 200 students was like, well, what am I getting myself into? I'm failing some of my exams. Like, am I cut out for this? So, I feel like they, I wasn't super prepared when I transferred out into a university because just the teaching styles were different and the communities were different.

These experiences impacted students in various ways, including fueling self-doubt and raising questions around competence and future success. Kelly (Leaver, Inbound STEM Non-Research) shared feelings of not belonging and how that impacted their participation, "If you don't feel like you belong, then you're gonna, participate in that negative self-talk and talk yourself out of going." Students who completed the program felt out of place but also shared meaningful examples of intentional inclusion in spaces they felt they did not belong Maria (Completer, Inbound STEM Research) shared:

> I saw that [in this research environment], people are more polished I guess…maybe those little cues like that…I don't know how to explain it,[this research lab] kind of always felt like a competition…the people that I was around,

> I heard about where they came from and how they got to be where they were, and they all seemed very, I don't know if privileged is the right word, but very different than my background.

But, this student switched to a new lab and found a better fit and sense of community:

> I feel like my meetings with my [new] PI were really positive and then also my meeting with the grad student was always positive, and it was definitely kind of a relaxed environment. And when I would go in there, it was always positive.

Amy (Completer, Inbound STEM Research) reflected on how even though they experienced cultural discontinuity in social interactions, they were also explicitly included by their peers:

> [In my ethnic group/culture] people won't really [sic] their opinions or whatever… it's like a shared experience, or it's a shared opinion. But [in the program], everyone was so vocal about their opinions…I feel like we're always in a group [in the classroom], and we would just be like, wow, everyone is participating. We'd just be there [sic] the quiet ones. So they would come up to us and approach us and that was a really nice gesture to know that we're included in a group, even though that we don't feel as we are just because maybe we're too shy or we just don't know how to communicate as well, because we have different communication skills.

Amy highlights that although she was inclined to be with members of her ethnic/cultural group in learning spaces, she appreciated outgroup peers' efforts to include them in group activities and conversations.

Notably, for some students who completed the program, the research training community of practice buffered against feelings of not belonging in other science-related contexts. This did not come up in interviews with students who left the program. Although their STEM classrooms and disciplines often felt unsupportive and competitive, the research training program gave students the sense of community they were missing in other STEM spaces. Amy shared about the value of this community:

> Just being surrounded by a group full of undergrad researchers was really inspiring with how they're going through their program. And then I can also tell them about my experience and just be open about it. I could push forward with what I'm experiencing, and just having that community was very vital to my experience as a researcher.

Other students who completed shared similar sentiments of how the community of students in the program from diverse backgrounds was helpful in their efforts to find a place in STEM. Naomi (Completer, Inbound STEM Non-Research) experienced this sense of community:

> I would say that it helped me stay more positive about science and STEM and being in [my major] because I had a community at the end of the day that was advocating for me, supporting me, and just there for me when things were hard.

The struggles of underrepresented minority and first-generation students on their quest to find a sense of community in STEM are well-documented in the literature. Students in this study from both groups questioned their belongingness in STEM. Several leavers struggled to find a sense of community within the research training community of practice and their disciplines. However, students who completed the program shared explicit examples of inclusion and community and felt the program cultivated a sense of community, which supported their STEM participation and persistence.

Conclusions about Contextual Factors Shaping STEM Participation

The participants in the study who left the program pointed to numerous factors at the structural and person-in-context levels that shaped their participation in STEM disciplines and their research training community of practice. Students reflected on their struggles to pay for college and navigate financial systems in higher education, illuminating how the lack of affordable pathways to degree completion may impact students' participation. Students also highlighted how narrow pedagogical norms and ways of knowing in STEM often create environments in STEM spaces that do not support their learning and academic success. Furthermore, these students experienced

widespread microaggressions, discrimination, and biases related to race, ethnicity, gender, age, and class. Additionally, the pressures in students' lives, including academic, family, programmatic, and work domains, often impacted their mental health and challenged their sense of well-being. Lastly, the norms and practices in the sciences left some students feeling unwelcome in STEM and without a sense of community. However, the research training community of practice offered many students respite from the missing sense of community in their disciplines.

When taken together, these themes highlight how contextual factors, including both person-in-context and structural factors, play a prominent role in students' ongoing participation in STEM and shape their decisions regarding participation in these spaces. Furthermore, students' person-in-context experiences reflected structural and systemic realities such as college affordability, pedagogical norms in science, a culture of power in science, and specific cultural and scientific norms that marginalize students from underrepresented and first-generation backgrounds and shape their social interactions, participation, and experiences as they pursue undergraduate STEM degrees.

Science Identity Construction Within Research Training Communities of Practice

The second research question of this study examined the key processes and experiences within a research training community of practice that shaped students' science identity construction. Science identity was conceptualized using Carlone and Johnson's (2007) grounded science identity framework, which considers dimensions of

competence, performance, recognition by self and others as the core components of science identity construction. These three dimensions are understood to overlap. The descriptions of science identity construction by students who participated aligned with this theoretical conceptualization. The following section discusses the themes that emerged regarding students' identity construction within the community of practice, including the motivational climate of the program, opportunities for meaningful participation in scientific practice, and critical processes and experiences that contribute to scientific self-recognition.

Motivational Climate and Identity Construction

Students understood the motivational climate of their research placements and the program as impacting their engagement, participation, decisions, and self-perceptions about abilities. In interviews with students who left the program, six students discussed the motivational climate of the program, and two of six placed students discussed their research placement environment. Notable themes regarding these motivational climates for students included reflections regarding program requirements for sustained participation, program structure, autonomy support, and ongoing interactions with program faculty and staff. Many students who left the program struggled to meet the program requirements and participation thresholds needed to avoid probation or dismissal. In particular, four leavers shared they were afraid of punitive action from the program or recounted instances they were reprimanded for failing to meet program

requirements. Avoiding dismissal or probation was a driving force in students' decisions to attend events, caused stress about course grades, and impacted decisions about courses.

Although the program communicated to students that being on probation would not have lasting negative consequences, this was difficult for students to believe, such as for Sofia (Completer, Inbound STEM Research):

> EXITO never did anything to be like, "Oh, if you're ever on probation, we're not going to give you the recommendations that you need." And I knew that, but internally I was like, "Okay, but what if one day someone can see that I was on probation and because of that, then I wouldn't be accepted into my master's program or accepted into my Ph.D. program?

These policies were a significant cause of fear, stress, and in some cases, anger for students such as for Jamie (Leaver, Inbound STEM Non-Research) who shared their response to punitive program action:

> [To face punitive action] because I did what was best for my GPA, just felt very much like, all right, you don't actually recognize the fact that we are human beings. You want robots who can check boxes and do all the things instead of bringing their entire self into the program.

Although completers also faced punitive action, several found ways to assert themselves, such as Hope (Completer, Inbound STEM research), who shared:

> I just felt myself dragging my feet. I'm like, I don't really have a choice. I think I got some sort of warning one time. It was a warning about my GPA…I was so, so, so, so sad and upset. EXITO, they sent me this GPA warning, even though that one term, my term GPA had actually gone up a lot higher than my previous terms….Just because you guys are helping me financially doesn't mean that I should hate going to these classes and not really learn and just do something because I don't really have a choice.

Hope recounted that she went in and met with staff to get her name cleared from the warning and was taken off probation.

Some students wanted more structure in the program and felt chaos in the program negatively impacted their participation. For instance, Kelly (Leaver, Inbound STEM Non-Research) needed more support to be successful and spoke of confusion about requirements for participation from a faculty:

> [I] would be unsure if [I had to be somewhere specific on a certain day]…or what time, and then [they would] email that morning, "Okay, we are gonna meet today at X time," giving [me] absolutely no notice…You weren't given a lot of direction…Like in the beginning, it was like, "Here's all, here's all [you need to do]. Go for it." But [they] didn't ever go through and review [what to do].

Students who completed also experienced this chaos. Ariana (Completer, Inbound STEM Research) wanted more clarity on program requirements, financial aid, and access

to resources, "EXITO was a mess…And, nobody had answers, and, then...when [a key support faculty/staff person] left, it was…the biggest blow." The impact of these experiences on participation, however, varied. Kelly (Leaver, Inbound STEM Non-Research) left the program primarily due to the lack of direction. Ariana (Completer, Inbound STEM Research) took a different path, "I knew that if I left, I might not ever have a chance like this again. No, I knew I would never have a chance like this again."

Several who left the program students wanted more autonomy support and flexibility for engaging with the curriculum and completing program requirements. The absence of autonomy support was more prevalent for students who had left the program than those who completed and played a significant role in program departure for four students. For instance, Damien (Leaver, Inbound STEM Non-Research) needed more flexibility to participate in their research placement:

> I got this job offer. I was like, "Okay. Yeah, it's a good opportunity. I'll take it." And then, it interfered with [my research placement]…and I don't remember what they asked me to do or explain at the time. But in a nutshell, they basically said that because I didn't meet the requirements or the hours or there was an interruption due to my work that I couldn't continue.

Liza (Leaver, Inbound STEM Non-Research) shared another example of not having support in their research placement:

> One negative thing was just an interaction with the PI I was assigned to at the time. I was trying to figure out a schedule that would work for me in terms of the hours that we were supposed to spend doing research that summer, but I had a lot of things going on so I wanted to see if I could adjust the schedule. But there wasn't really a lot of communication from the [research mentor].

Kelly (Leaver, Inbound STEM Non-Research) engaged in program-related work preparing for their research placement and felt a lack of communication throughout and then unreasonable demands for a quick turnaround of assigned work at the end of the year:

> It wasn't 'til the very end that [my work was] finally reviewed. And there were so many changes that needed to be made because the expectations were so unclear that it was overwhelming….There was no way I was going to be able to finish all the assignments.

Kelly shared that not being able to complete the revisions in the time allotted was the main reason she left the program:

> I have a really strong drive to finish things out. And it was a really difficult decision for me to leave the EXITO program because I felt I was failing myself and the program and everyone. But there were certain things that happened that just made it impossible as a single [parent] to continue.

In contrast, several students who completed the program highlighted the value of autonomy support and many options to complete program requirements. These students recounted experiences working in a research learning environment that was flexible and supportive. Importantly, they were able to work on projects that interested them at times that worked with their schedule. Students in this group had agency over their schedule and could change it as needed when personal or academic demands peaked throughout the term. David (Completer, Inbound STEM Non-Research) noted:

> There was just that feeling of having my own authority…That was really important because I don't think I was getting that in any of my classes, and I don't think there's a lot of places where undergraduates are...I think there are a lot of places where undergraduates are kind of the butt of a joke, and I didn't have that in my lab.

David recognized that undergraduate students are often overlooked, and their contribution in STEM contexts is minimized. He saw his research placement and countering these common STEM norms and instead valuing him enough to provide autonomy while seeing him as a contributing member of the lab. Naomi (Completer, Inbound STEM Non-Research) recounted their lab experience, "it was a really laid-back environment so…our PI would let us work on anything we were interested in." Amy (Completer, Inbound STEM Research) said, "They gave me that freedom to choose my own research project within whatever data collections that we were doing." Hope

expanded on the impact of being in a lab environment that provided these types of supports:

> [They] respected what you had to say, and they were open to new ideas. So, for example, in my RLC, just because my PI had an interest...that didn't mean that I had to be interested in her special interests…we would make a unique project just for me to work on. So, then you don't feel like you're doing this because I don't really have a choice…it's a requirement to go to your RLC, but I think her goal was always to have the student be passionate for further research work. To own your own project, I think helps with independence and also kind of helped me be confident about asking for help.

These positive experiences by many completers contrast to the experiences of many leavers and highlight the significance of students feeling autonomy support in their research placements.

Social interactions with faculty, staff, and mentors in the program came up in every interview. Students who completed the program reported fewer negative interactions with faculty or staff and more positive interactions. Students who left the program reported more adverse interactions with faculty in their research placements. Out of the six leavers who were placed in research learning communities, four shared negative interactions with faculty in their research placement compared to four out of the twelve completers in research learning communities who shared of similar experiences.

In program activities outside of the research placement, students who left the program had many positive connections with staff but also recounted negative encounters and experiences with staff and mentors. Lily (Leaver, Inbound STEM Non-Research):

> We had a specific [faculty or staff], and it was really clear that [they] played favorites…[they] would only ever call on two students…but at least I wasn't on the receiving end of the wrath, apparently from a lot of the peers in my group, if [they] didn't like you, [they] didn't like you.

Jamie (Leaver, Inbound STEM Non-Research) shared a negative relationship with a staff:

> I showed up, saw [this faculty] was there and I packed myself and I left. Because I just literally didn't want to hear anything [they] had to say. Anytime [they were talking] I just would zone out and be like, "I have nothing. I don't wanna hear what anything you're saying."

The positive connections with staff and faculty reported by those who completed the program occurred more frequently and were instrumentally supportive to students. Tina (Completer, Inbound STEM Research) shared:

> I knew if I were to walk into the office, I could talk to anyone about what I was going through or if I was in the study room or if I truly needed help and guidance to be like, "Hey, this is really bothering me. What's my next steps." Or "How can I change this?" I knew that I could always go in to find that support.

Notably, nearly every student who completed the program had at least one staff member or faculty mentor who served as a go-to resource, advocate, guide while in the program, and an ongoing encouraging, supportive presence for students. These go-to support staff and faculty provided emotional support, connection to services needed for personal health, and assistance dealing with toxic research environments. Ariana (Completer, Inbound STEM Research) shared:

> [Particular staff member] was also a good thing in EXITO…You know, I think of these good things as things that were mechanisms of success, and success in this instance means completion of the program and eventual completion of my bachelor's degree. And, so [my mentor] was one of those mechanisms and [a particular staff member] was one of those mechanisms.

They went on to share the specifics of the instrumental support they received:

> [This staff member was] available for everybody... and, just did such an amazing job. [They] sat with me through many phone calls. [They] gave me everything that I needed to be successful, in terms of just the basic first steps…you know, safety, security, housing, Maslow's needs kind of thing.

Naomi (Completer, Inbound STEM Non-Research) spoke of the importance of a relationship with an integral staff person:

> If I had an issue with someone that I didn't know how to resolve, I would ask her about tips on professional communication and tell her about the situation and

> figure out how to deal with it in an appropriate manner that wouldn't escalate things.

Alice (Completer, Inbound STEM Non-Research) spoke to how they utilized the support:

> I think a lot of it was knowing that people believed in me made me feel comfortable enough to seek help when I needed it. And then I got that help from... typically it was [a particular staff member]…I was just walking to the office and be like, "Can you guys help me with this or do you know what's going on with this?"

These relationships directly impacted students' participation in program components such as for Dominick (Completer, Inbound STEM Non-Research) shared, “I was like, "Oh my God, well [two key staff people] are going to be there, and you know what, I totally don't want to not go there, if they're going to be there. So, I'm going to go." Dominick highlights how these positive relationships impact participation by fostering a sense of accountability and increasing student attendance or engagement.

Notably, this was not the case for several of the students who left the program. As Damien (Leaver, Inbound STEM Non-Research) highlighted, “I felt like I was on my own really. Yeah. I didn't have anybody to say, ‘Hey,’ you know? You know, help me out, really.” Students who left the program also shared missing that supportive connection in their research placement. Damien (Leaver, Inbound STEM Non-Research) shared:

> When I started the lab, and I started new in the work… her body language just pretty much told it all, that [sic] she was frustrated. You know I made mistakes, right? I mean, who doesn't? And she was a little bit ticked off about that…I need someone who, like I stated before, that's gonna be an advocate for me and, and someone who wants to get to know me better and who wants to help me succeed. Which I didn't feel that I was helped in that way, the right way.

This student shared they did not have a go-to staff person or a supportive lab environment, contrasting with many of the experiences of those who completed the program. Notably, the students who described similar interactions (e.g., unsupportive research lab mates, unapproachable research mentors) from the completer group are not currently on an inbound trajectory into research careers.

In conclusion, students' experiences with the program's motivational climate impacted their participation and identity construction. Students who left the program feared punitive action by the program and had challenges meeting program requirements. Students also desired better communication about program expectations and more autonomy support to meet program requirements. Additionally, those who left the program articulated a need for more individualized approaches and support to complete program requirements. Students also discussed the importance of their relationships with program staff and faculty. Notably, students who completed the program were more likely to report positive faculty and staff interactions and have a "go-to" person who

provided instrumental support, mentorship, encouragement, and guidance. Students who left the program were less likely to identify these people and had higher instances of negative interactions with staff and faculty.

Meaningful Engagement in Scientific Practice: Opportunities, Training, and Support

Students in this study were asked about their participation in reviewing scientific literature, research design, data collection, data analysis, collaboration with other scientists, and disseminating research. Ongoing opportunities for meaningful engagement in scientific practices were a critical component of students' science identity construction. Students who completed the program gave more examples of opportunities to perform scientific tasks, demonstrate competence in their disciplines, be recognized by others as scientists, and recognize themselves as scientists. Interestingly but not surprisingly, students with positive and supportive lab environments felt more included in lab activities and had more training and research involvement.

Several of the students who left the program did not feel they were a valuable member of their lab such as Lily (Leaver, Inbound STEM Non-Research):

> I never felt like a scientist amongst my peers. I never even did that senior year presentation that everyone does. When people ask me what my research was, I would explain to them what the project was. And then when they would ask me what I was doing in it, I'd be like, "I just do phone calls."…I didn't feel like a

> scientist, my peers and us, whenever we talked and hearing what they were doing and then thinking about what I was doing, I really didn't feel like a scientist.

On the other hand, completers highlighted the importance of being treated as contributing members of their research team and looked for cues from others to understand their value in the research environment. David (Completer, Inbound STEM Research) reflected:

> [There was] the real understanding of different positions in labs and that it doesn't have to be this weird, power, control, I'm better than you, caste system kind of thing. That there is a place for all of these things, and we're all here to learn from each other. We'd have journal clubs, and it was absolutely expected that I would contribute articles to journal clubs.

David recounted an interaction in their research placement when a graduate student noticed they had been taking lab meeting notes for several weeks and initiated a conversation to find a new notetaker:

> I was like, "Oh, guys, I really don't mind. I just wanna be helpful." And he was like, "No. No, no, no, no, no. That's not how this works. You're a part of our team. We all take meeting notes. That's not one person's job, and you've got more things to do than just take meeting notes.

This made David feel they were a valuable member of the research team:

> I think that kinda represents a lot of the culture of the lab…they really valued me, and they didn't treat me as the undergraduate or, the little, go get us coffee type

> person. And I can't say that all EXITO students had that relationship with their labs. I did hear really negative stuff about grad students not liking them or not working with them or kind of treating them as secretaries.

Although scientific practices often involve seemingly menial and repetitive tasks, Lily did not feel like a scientist when completing phone calls. In contrast, David expressed feeling valued as a contributing lab member even when taking lab meeting notes.

Students felt varying levels of inclusion and exclusion in their lab environments. Several students who left did not feel their contributions were recognized in the lab. Damien (Leaver, Inbound STEM Non-Research) felt their research mentor was not supportive or knowledgeable about how to interact with them in the lab:

> I asked [my research mentor], " I think they want us to be able to know how to pose a question design an experiment, you know, things like that." And then, she was like, "Oh, I don't think that they know what they're doing with you guys."

Many completers, however, felt a sense of inclusion in their labs such as Maria (Completer, Inbound STEM Research) who shared:

> Definitely one of the biggest moments where I feel like the way I looked at myself changed was, so [my research mentor] had mentioned wanting me to go these conferences... and [my research mentor] decided to pay for me to go through [their] lab funds. And I think that moment really felt you know like they were] paying for me to go and trusted me to present on work from [the lab].

Students highlighted the need for explicit inclusion in scientific practice and ongoing, instrumental support in learning the ways of scientific research. Many students who left the program noted a gap in the lab training and support, which made it difficult for them to participate confidently in research activities. When asked if they were given guidance and support to conduct a literature review on pertinent lab topics, Jamie (Leaver, Inbound STEM Non-Research) shared, “No, not really. They basically just said, ‘Read these articles and understand these articles.’" When asked if they got support for more complex scientific tasks, Jamie said, "It was a little awkward because I need very much step-by-step instruction for things. And one of the grad students was more just, ‘Here's broad instructions. I need you to figure it out.’”

Students felt excluded from meaningful work in their labs because they did not have the tools and information they needed to participate in scientific practices successfully. Lily (Leaver, Inbound STEM Non-Research) spoke to feeling lost:

> My PI was not supportive. On the first day, it was like, "Here's everything you need to do." And then [they] just disappeared. There was no one to ask questions if I was doing it right or not. Cause I came in on the weekends and I, yeah, there was just no guidance, and I really needed that guidance.

Several other students who left the program recounted feeling they were not given the tools they needed to succeed such as Damien (Leaver, Inbound STEM Non-Research):

> [It is hard having a mentor] that's not gonna go to bat for you, right? That's not giving you the tools that you need in order to succeed really. In the lab I went to, I was really interested in it. I am. I'm still am. But there were things that I didn't know how to do, and when I first interviewed for that position through EXITO, you know what? I laid out, you know, "I haven't taken these courses, but I can learn them. I can learn the material, the sciences," and what have you. I'm a hard worker. You know I can, get the job done basically. So, my PI knew that, and then, when I started the lab, and I started new in the work, I don't know, her body language just pretty much told it all that because she was frustrated. You know I made mistakes, right? I mean, who doesn't? She was a little bit ticked off about that.

Liza (Leaver, Inbound STEM Non-Research) was confused about what they were supposed to do in the lab. She recounted a misunderstanding with their research mentor about when to come back and complete an experiment:

> There are just timeframes or time limits to when we need to go back in the next day or whatever...but then I came in, and he was really upset at me because he was like, "We can't wait for you to do these experiments," or whatever. And I didn't really say anything back at the time because I was just shocked. I was like, Okay, I understand that I just inadvertently wasted your materials and stuff and

> resources, but that's very conflicting with what you told me the day before, and it was that I could still arrive at the same time and things would be okay.

Some students felt they were either supposed to know how to do a particular scientific task without additional instruction or were left without enough information to perform the assigned tasks. Kayla (Leaver, Inbound STEM Non-Research):

> I felt like I was also trying to ask too much from my PI. I'm always like, "hey, so how do you do this again? Or what do I do now?" Because I really had zero idea of what I was doing. And even though they were giving me resources or books on how to code, I couldn't understand them or I didn't know how to because on the book, it's the basic steps but the data that I have are a billion pages.

Students who completed the program shared many instances of structured training in their lab and support to learn scientific practices. Amy (Completer, Inbound STEM Research) provided another perspective on how a scaffolded approach to research training is vital for students at the beginning of their research pathway:

> Her guiding me throughout, from the bottom of what research is, what research really is, what aspects were [sic] are most confusing and then she would explain it with me one-on-one because I would just be super lost….[I thought] I wasn't good enough because I don't have much experience. I don't even know what research is. But just having that positive relationship with the people around me and just

> knowing that this is where I'm at and just them pushing forward, okay, this is what you need to know...them guiding me one-on-one with what I have to do.

Naomi (Completer, Inbound STEM Non-Research) captured how the training in their lab tied to their sense of competence in science:

> It definitely made me feel very dumb at first when I couldn't read a single sentence and understand what it was talking about. But that was part of learning how to do, or learning about research. The more articles I read, the more it made sense. And after a while not only could I read it and understand it, but I could learn. I was beginning to be able to use the language when I was talking.

Additionally, completers felt they could approach their mentors and lab mates when they had questions or were confused. Sofia said, "If I ever had any questions about the field at the time, I always knew I could go to a grad student, or I could go to my PI and just ask general questions." Dominick had a similar connection with their research mentor, "the very strongest anchor and support I had was my PI. I mean, from the beginning, he put time with me, he worked with me." Naomi had a similar perspective on having approachable research mentors and being able to ask for help:

> I would just spend, three hours trying to figure it out by myself, and then I'd be like, "I've spent so long trying to do this, and I have no idea." And my research mentor would be like, "If you've spent 30 minutes on this and you're getting

> nowhere, and it should be taking you two minutes, come and tell me about it. Don't just keep going at it for three hours."

Hope (Completer, Inbound STEM Research) described the process of getting acquainted with the literature and learning to read and understand scientific articles with step-by-step coaching and feedback from their research mentor:

> She'd bring an example paper and would have me write the summary and then she'll go through and then she would in Word, you could do the corrections, and it shows you the corrections and whatever, and shows me how she changed it, and why she changed it and the way it had to be written. So instead of us stressing over it, [she would say] this is how you should do it and the reason we do this because of this and that. So, she would show me how to do it, walk through it, and on every, every piece of feedback she had rationale for us.

These hands-on and directive support examples suggest that completing a research training program and constructing a sense of science identity requires intentional and supportive environments where students can learn how to do science.

When considered together, students' opportunities to engage with meaningful research, inclusion in the lab community, support and training needed to engage in scientific practices were critically important for those who completed the program and missing for many of the students who left the program. These opportunities and this support played a crucial role in their experiences within the research training community

of practice and their science identity construction. Students who completed the program and are on inbound research pathways experienced higher instances of support and training in learning science techniques. In contrast, students who left the program were more likely to share instances of exclusion from meaningful scientific work in their research placement and lack intentional support and training in research environments regarding how to do scientific practices.

Key Processes and Experiences that Contribute to Scientific Self-Recognition

Students' ability to recognize themselves as scientists was an essential part of their participation and ongoing identity construction. Each of the twelve students from the group who completed the program recognized themselves as scientists while in the research training community of practice while only six of the eleven students who left this program shared this experience of self-recognition. The key processes that surfaced as most critical in the self-recognition process included combatting imposter syndrome by recognizing it as a shared experience, participating in disseminating research, and being recognized by others as scientists. The following sections unpack these themes and provide distinctions in experiences between those who left and those who completed the program.

The first essential process in self-recognition was overcoming imposter syndrome. Imposter syndrome came up in 17 of the 23 interviews. Nine of these were leavers and eight were completers. Students who left the program frequently felt that they did not

belong or that everyone else knew more than they did about science, which impacted their participation. Students sharing feeling "dumb," "stupid," "intimidated," "like an idiot," and "lagging behind." These students questioned whether or not they were a scientist such as Sarah, (Leaver, Outbound STEM), "I was getting information from people who were engaging in research and they were asking for my take, which imposter syndrome, I didn't really feel like I was qualified to talk about any of it." Kayla (Leaver, Inbound STEM Non-Research) shared, "I felt a lot of that imposter syndrome that we're always talking about, because when I was working on projects for my RLC, I really like had no idea how to do them."

However, for many students who completed, the community of practice provided opportunities to overcome their imposter syndrome through recognizing how common feelings of inadequacy were for those at all stages of the research pathway. Naomi (Completer, Inbound STEM Non-Research) articulated how overcoming imposter syndrome shaped their belongingness:

> My research mentors were really supportive and I got over the idea in my head that they all thought that I was an idiot because I wasn't an expert at something that I was just starting to learn. They were always really supportive, really helpful, and really made me feel like I belonged.

Hope (Completer, Inbound STEM Research) also felt this support:

> I just felt like, wow, oh my gosh. I can do it. Before, it was just another world. But just people told me, you can. I can do it too. Like, I don't have to prove anybody. My work is showing it for me. Like it's showing it to people that I can do it.

As previously discussed, students in this study were asked how their engagement with each scientific practice changed their self-perceptions and contributed to their identity construction. Students who completed the program had more opportunities to present their research findings in a scientific environment, such as a symposium, poster session, or conference. Of the twelve students who completed, all had one or more opportunities to present their research, while just four of the eleven students who did not complete the program presented their research. Lily (Leaver, Inbound STEM Non-Research) reflected on the impact of not having the opportunity:

> I didn't even do a presentation on it. I never went to a conference for it. Maybe going to a conference would have changed it…I never really felt like a scientist, and now I don't know if I am one or not, but I kind of want to be one.

Completers who had these opportunities spoke of their presentations as pivotal moments on their pathway. Maria (Completer, Inbound STEM research) said, "It wasn't until I really presented on my data and was able to like have conversation with other people in the field about my analysis that I really felt like I was contributing." Amy (Completer, Inbound STEM Research) felt similarly:

> Honestly feeling recognized for myself, inside myself was when I did the presentation of my own….the research symposium made me feel like I was an actual researcher, just surrounded by my peers and [several principal investigators]. It made me feel like I can be a researcher…seeing how interested people were just, the crowd asking questions, and me fully knowing what purpose I had behind the research.

Derek (Completer, Inbound STEM with Unclear Research Trajectory) also called out the importance of their symposium presentation, "I guess if I had to pick a moment, it definitely would be during the symposium. The symposium was a really good experience where I presented and then people came over…I feel like it was received really well." Students also received support from faculty and peers in this process, deepening their connection to the scientific community. Amy (Completer, Inbound STEM Research) shared:

> That was kind of a turning point for me…not wanting to push on with the [research presentation] to actually knowing that I can do it. Through the guidance from them, through their support, and through their belief that I can do it, that was what really pushed me to know that I can be a researcher…I feel like this is what really forms a really great researcher is if you do it on your own and have experiences on your own and just having that support.

The more opportunities students had to disseminate their research, the stronger their sense of science identity became. Of the four leavers who did present, only one was at the program's symposium and only one shared having more than one opportunity to share their research. Students who had multiple opportunities to present in the completer group grew in their confidence with each presentation. Rachel (Completer, Inbound STEM Non-Research) reflected on this experience:

> I think the amount of them definitely helped…I don't think I killed at my very first presentation ever about my research. I think over time, I just found new ways to word it. And as I was learning things, finding new ways that it would click for me and sort of working that into my presentations.

A third key process in supporting students on their pathway to positive science identity construction through self-recognition was recognition by others. Recognition by others came up in only eight instances for the leavers compared to twenty-nine instances in the completer group. Not surprisingly, being recognized as scientists by others signaled to students to recognize themselves as scientists. For some students, being recognizing by peers was most significant, while for others, it was their research team members or members of the broader scientific community that mattered the most. Recognition by others often occurred after an oral or poster presentation where faculty and peers asked students questions or gave them positive feedback, further highlighting the importance of these dissemination opportunities for science identity construction.

Tina (Completer, Inbound STEM Research) shared the importance of being recognized as a scientist by people outside of the community of practice:

> I think EXITO always called us scientists, and we all were just like, "You guys are lying to us. You have to tell us that so we feel cool." But I think once I started going to conferences, that's when I [sic] really like, "Wow, I am a scientist." I am doing this stuff because it was random people telling it to you. And I don't know why that's more validating when a stranger gives you a compliment.

For others who completed the program, recognition was most important within their research placement when they were treated as an expert or invited to join a meaningful conversation. Some students recounted times when their mentors asked for feedback on a project or asked their opinion on future research directions. Others shared how important it was to talk with other researchers, such as Maria (Completer, Inbound STEM Research, who shared, “There’s a few times where I would sit in on conversations that [my research mentor] was having with other big names in the field, and that was really exciting.”

A fourth and final essential process in self-recognition for students was teaching or training others in scientific practices. None of the leavers shared any instances of opportunities to teach or train others. This came up in three of the interviews of those who completed and was a significant experience for students in their science identity construction. In their view, being asked to teach or train others meant they were

competent in scientific practice and revealed to them that they understood the topic deeply. Rachel (Completer, Inbound STEM Non-Research) shared:

> Actually, one of my favorite things about doing science is science communication. I found that out. I realized that when I started teaching…that was one of my favorite parts was talking about science. So yeah, I to answer, I felt like an expert.

In sum, this study surfaced several vital processes and experiences that supported students on their pathway to see themselves as scientists, an essential part of the science identity construction process. Both students who completed and those who left shared their own experiences of imposter syndrome but students who completed the program shared how their sense of community in EXITO and the opportunity to work closely with faculty in their field helped them overcome their self-doubt. Disseminating their research findings was key to self-recognition and being recognized by others inside and outside of the research training community of practice as a scientist. However, students who left the program had fewer opportunities to present research to others. A final critical process that bolstered students' sense of science identity, experienced only by those who completed, was the opportunity to teach or train others in scientific practices.

Conclusions about Science Identity Construction in Communities of Practice

Students in this study shared many insights into how their participation in a research training community practice contributed to their science identity construction.

Students discussed how the motivational climate of the program, including program policies regarding required participation, clear communication regarding program details, provision of autonomy support, and having supportive relationships with faculty and staff, contributed to their engagement in the program. There were challenges with the motivational climate for students who left the program, a lack of clarity on program structure and autonomy support, and fewer supportive staff and faculty relationships.

Students within the community of practice sought inclusion in meaningful scientific practices in their disciplines. They recounted ways they were included or excluded from scientific practice and the impact of support and training on their participation. Students who completed the program and described a strong sense of science identity provided more in-depth descriptions of how scaffolded training in their research placement supported their ability to participate confidently. Finally, students provided detailed information about experiences that were most central to their ability to recognize themselves as scientists. These processes included overcoming imposter syndrome, having multiple opportunities to disseminate research, being recognized by others as scientists, and teaching or training others in scientific practices. Those who left the program had limited descriptions of these experiences and opportunities.

Science Identity Trajectories: Pathways Into and Out of Research Careers

The program intends to train and prepare students from underrepresented backgrounds for biomedical research careers. Therefore, consideration of the unique

experiences of students currently inbound in STEM and research-related careers is valuable. The following section examines the various trajectories of students in this study. It provides a detailed explanation of the role of research training communities of practice in shaping these science and research trajectories. Themes include students' processes of science identity construction, the plentiful opportunities for science identity construction given to inbound students, how programs shape students' understanding of the relevance and culture of the research field, and student needs for practical guidance regarding pathways into biomedical research careers.

Summary of Trajectories

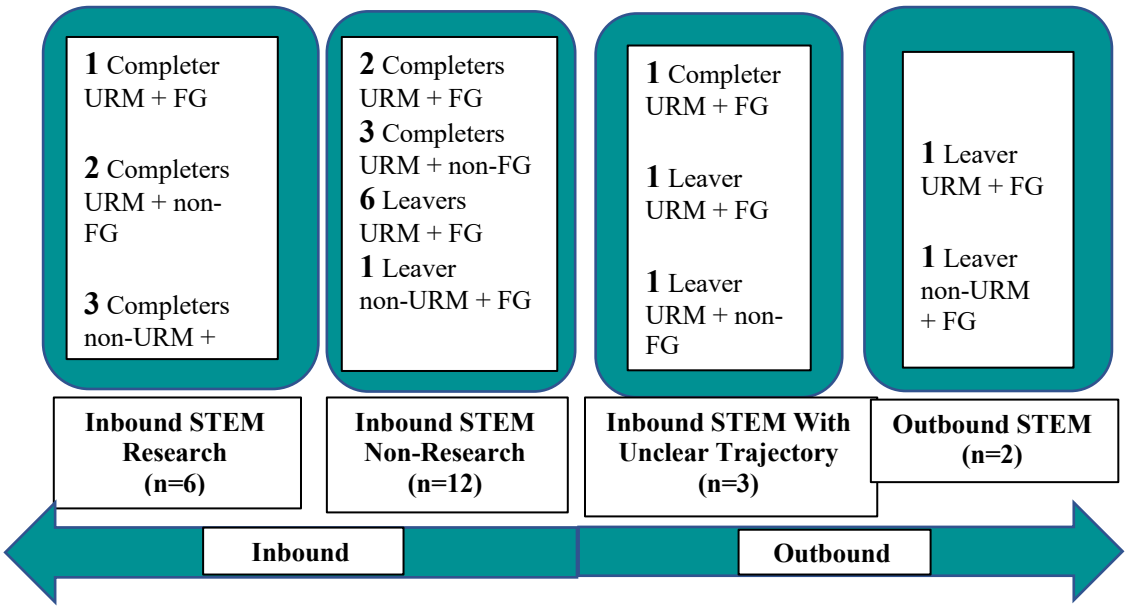
Students in this study were on four distinct trajectories related to their science identity construction and future educational and career. Not surprisingly, each of the 23 students in this study had a qualitatively unique trajectory, with several still uncertain about the future. Based on students' active engagement in STEM, research, and non-STEM pathways, and their intent regarding education and career pursuits, students were placed into four trajectory categories, which will be conceptualized in detail in the following sections.

A summary of the frequency of underrepresented racial and ethnic minority (URM) and first-generation (FG) students in each trajectory group by program completion status appears in Figure 3. The inbound STEM research trajectory group was made up of six students, all who completed the program. Half of these students identified

as White. Two of the six students in this group were continuing education students and only one was both an underrepresented racial and ethnic minority and first-generation student. The inbound STEM non-research trajectory group included seven leavers and five completers. In contrast to the inbound STEM research group, ten of the eleven students who were inbound STEM non-research identified as underrepresented racial and ethnic minority students and nine of the twelve students were first-generation students. The inbound STEM with unclear research trajectory group included one completer and one leaver who were underrepresented racial and ethnic minority and first-generation students and another leaver who identified as a minority student but was continuing student. The outbound STEM group included two leavers, both first-generation students.

Figure 3

Trajectory Summary by Underrepresented Minority and First-Generation Status



Inbound STEM research. Six students, all program completers, were actively on an inbound trajectory to a scientific research career. One student is currently finishing their undergraduate degree and applying to graduate school next year, another student graduated with their bachelor's degree and is applying to a research-focused graduate program for fall, two students are in full-time graduate school in a biomedical research-focused program, one student is working full time as a researcher and attending graduate school part-time, and the remaining student is in a full-time paid research position. Notably, each of these students shared their participation in the research training community of practice was necessary for the exposure to research it provided and the instrumental support they received at each step of their pathway. Maria (Completer, Inbound STEM Research) summed it up well, "I don't know if I could describe my relationship with science without EXITO."

The students in this group would not have known about the research pathways available to them without the program, and their love for research grew because of their program participation. Amy (Completer, Inbound STEM Research), shared:

> It changed my mindset big time on what science really is. I thought science research was just about, you know, just do your physics, just do your chemistry, just do all of those things. But with BUILD EXITO, it has really opened up my mind to what research really is and the opportunities within research as a minority.

A few students in this group were initially pursuing clinical pathways. They questioned the relevance of the program curriculum while participating, feeling that the clinical-focused pathways were not represented. However, these students changed their trajectories due to their research training participation. This was the case for Sofia (Completer, Inbound STEM Research), who shared, "I started out wanting to be pre-med, and then I realized I want to help people but not on the medical side, more on the research side. And so then I ended up switching to [a different major]." Hope (Completer, Inbound STEM Research) shared similar sentiments, "In the end, they did actually persuade me to follow the Ph.D. path, but I still plan on doing the M.D./Ph.D. versus just the Ph.D. by itself. I got interested in research. They kind of opened my eyes."

Four out of the six students in this group were offered continuing opportunities to work in their research placement after the program ended. This changed the trajectories of some students and gave them a practical next step on their pathway to pursue a research career. This also bolstered their science identity and provided needed financial support after the program support ended.

In sum, students on trajectories inbound in STEM and research pointed to the importance of the program's exposure regarding their research pathways. These students were given tangible and instrumental support, including opportunities for continuing research work in their labs. Students inbound also understood the relevance of research

work, the importance of research for their communities, and how their unique experiences and background could contribute to the future research workforce.

Inbound STEM Non-Research. The largest trajectory category included students pursuing careers in science that do not include biomedical research. This group included seven students who left the program and five who completed the program. Six students on this trajectory are pursuing pathways to clinical and direct patient care. Two of the students in this group attend graduate school programs in Non-Research disciplines, and another two were dismissed from the program for failing to meet program requirements.

Students who left the program and were on clinically-focused pathways saw the value of research but did not plan to pursue it in their careers. Kelly (Leaver, Inbound STEM Non-Research) shared:

> Before I even thought about applying, I never thought about research. And honestly…my research classes are my favorite classes that I've had so far at [college]. I'm really excited. I got into the advanced standing program [in my clinical field]. And so I'm going [to graduate school in a clinical field].

Damien (Leaver, Inbound STEM Non-Research) provided a good description of their current trajectory:

> I should be able to graduate soon, but then I also got another job offer, so I don't know…I already took [the MCAT], and I'm just getting ready to apply this season

> [to medical school] and just seeing what happens after that. But that's the goal. I've been just taking a few courses here and there, just because of having to work so that everything has to be done part-time. I'm a [technical, clinical position], they're wanting people, people are getting burned out.

Students in this group who were not on clinical pathways were pursuing STEM-related positions that did not require advanced degrees or were planning to pursue a career-focused in teaching. For these students, their choice to not pursue a research career was not necessarily intentional, while for others, it was intentional and explicit. Rachel (Completer, Inbound STEM Non-Research) shared:

> I'm applying to the [Non-Research focused pathway program] because I really miss science. I miss being in the lab, but [past experiences in research] left a super bad taste in my mouth. And so I just wanted a chance to do science without dealing with all the extra stuff. And so that's why I'm going towards a [Non-Research focused pathway] right now.

Many students inbound STEM non-research were focused on completing school and entering the workforce as soon as possible. For instance, Lily (Leaver, Inbound STEM Non-Research) shared, "I'm actually in the [Non-Research STEM degree] program. So now I'm in this program for another two years, and I will graduate with my [Non-Research STEM] degree." Others needed immediate employment or were offered a seemingly more practical next step, such as Kayla (Leaver, Inbound STEM Non-

Research), "I mostly been focusing on [family STEM-related] business and trying to like expand it and having my mom passed it on to me, I guess. So that's where I'm at right now."

For these students, non-research STEM fields may have been more accessible or seemed more attainable to students, such as for Damien (Leaver, Inbound STEM Non-Research), who shared how easily they had been able to get employment in their clinical field before graduating with their bachelor's because "they're wanting people" in this field even without a degree. For some of these students, a certificate program or clinically-focused graduate degree may have seemed like a more straightforward path to a stable career they could rely on.

Students in this group spoke in general terms about their science identity. Many leavers, who were outbound in research careers felt they meaningfully engaging in research related work while in the program but did not share distinct experiences of constructing their sense of identity as scientific researchers, such as Derek (Completer, Inbound STEM with Unclear Research Trajectory):

> [The program] made me [sic] realized I loved science. I always did in school, but then, I never really thought of going into healthcare or into the STEM field. And it was only because I got into a program like EXITO and there was a hyper-focus on looking into these certain things.

In sum, over half of the students in this study were inbound in STEM but had no plans to include research in their future careers. Many of these students were pursuing a clinical track in medicine, counseling, or a related field. Others were given employment opportunities, decided to pursue a career that required less graduate education, or recognized they did not want to pursue a career in research.

Inbound STEM with Unclear Research Trajectories. Three students in this sample took time off before deciding on their next steps in education and career. These students may end up in STEM research fields but also may choose another direction. One of these students, who left the program, took some time off from school and just re-enrolled at a community college. The other student in this group Derek (Completer, Inbound STEM with Unclear Research Trajectory), felt that the program did not give them enough time to explore their pathways options adequately and needed employment to pay for living expenses:

> Instead of looking at retention, I think it's interesting to ask them…did you experience financial struggles? Did you have to take a loan, and also, did you, did you feel like BUILD EXITO helped you get a job within a workplace setting that you want? Because I think some people have gotten pretty good jobs, but then that's through connections outside of EXITO.

Although this group is small, their perspectives suggest that for some students, the support provided, the structure of the program, or the length of time in the program were not adequate to help them discern their next steps and choose a pathway.

Outbound STEM. A small number of students in this sample, only two, left STEM altogether. Although these students left the program and STEM, both students spoke to the positive aspects of their program participation. One student recognized they wanted to pursue another path, while the other had personal issues that kept them from completing the program. Sarah (Leaver, Outbound STEM) realized during the EXITO participation that they were not interested in a science pathway:

> I guess good intentions don't get degrees. I realized that I am not really interested as much in the actual application of [my social science major] and going into it as a career path. Then I ended up switching majors…I think that EXITO was a big part of me coming to that realization that going into STEM probably isn't for me. But not because of any bad experiences.

The other student, Amir (Leaver, Outbound STEM), dealt with significant personal challenges that led to their program departure, "I wasn't able to go to school or to be in the EXITO program and [deal with my personal situation]." After leaving the program, this student followed a non-STEM pathway. Although this subgroup is small, these outbound trajectories are vital because they shed light on how and why students may end up leaving STEM disciplines and pathways to pursue other majors and careers.

The Role of Research Training Communities of Practice in Science Identity Trajectories

This study examined the role of experiences and social processes within research training communities of practice in shaping students' science identity construction and trajectories. The study surfaced several themes on this topic, including how students' identity construction connects to science and research trajectories, the prevalence of opportunities for performance, recognition, and competence for inbound trajectories, and students' understanding of clear pathways into research careers.

Science Identity Construction Processes and Research Trajectories. Students across trajectories shared significant moments of science identity construction. Science identity construction was a complex process that unfolded over time alongside opportunities for meaningful engagement in research activities with scaffolded support to learn the practices of their scientific discipline. Participants highlighted the dynamic and complex connections between performing scientific practices, feeling a sense of competence, and being recognized as scientists by themselves and others. Notably, many students not currently pursuing a research pathway also had ample opportunities for science identity construction and felt recognized as scientists during their time in the program. These experiences and this ongoing process of identity construction shaped their trajectories. A distinct research-focused identity trajectory surfaced and shaped students' inbound pathways to research careers.

As previously mentioned, only six of the eleven students who left the program were matched in research placements. This is significant as the most profound identity construction occurred within research placements for students who completed the program. Furthermore, the students who left the program did not participate in the research symposium, an important space for students to share their research work and progress with the community.

Students shared processes involving their identity construction and trajectories, highlighting potentially distinguishable pathways between science and scientific research. As previously discussed, more than half of the students were on an inbound STEM trajectory but outbound research trajectory.

Those who completed the program shared a more developed articulation about their identity as scientists and researchers. In these cases, there was often explicit references to a researcher focused identity, such as for Amy (Completer, Inbound STEM Research):

> BUILD EXITO made me believe that I was made to be in research and just how research is better strengthened with under [sic] minorities sharing the ideas within BUILD EXITO. So, I liked how BUILD EXITO focused on the minorities and then putting them into research and then seeing how they can be developed as future researchers from that program.

Alice (Completer, Inbound STEM Non-Research) shared a similar experience:

> I think [my relationship with science] definitely changed. When I went in, I was like, okay, I'm interested in this. I just don't know how I feel, like just testing the waters. And then I left knowing that I could do work that I was really passionate about…and that there was a lot of really interesting research going on around me…so I left feeling more passionate, and I'm more solidified in the fact that I was interested in research.

Students inbound in STEM research careers shared the highest performance, competence, and recognition instances. These opportunities formed a "science identity trifecta," occurring and reoccurring throughout their supported and sustained work in their research placement as a series of regular opportunities to practice science increasing in scope and complexity. Hope (Completer, Inbound STEM Research) is currently working in the research field and attending graduate school. They shared how they constructed their identity over time through growth in competence, ongoing opportunities for performance, and regular instances of being recognized as a scientist and seeing themselves as scientists and researchers. This student perspective helps illuminate how this "trifecta" unfolds in context. Hope shared, "In the beginning, I felt like, Oh my gosh, this does not make sense. What am I doing here?" Hope was in a lab environment they felt was supportive and where their feedback was welcome:

> I never felt like I was beneath anybody. So even though I was working with these highly qualified people...but when they talk to you, they didn't talk to you like you're just a student, like a nobody. They talked to you like a colleague.

Hope reflected on their growth in their competence:

> I started to think about the limitations. Why hasn't this way been done yet? How could I possibly answer this question? So now I can think do that versus just reading and not understanding. [I am] trying to make a connection based on what I know that I've learned and what I've seen.

Over time, this student was given ongoing opportunities for performance which led to being recognized by meaningful others as a scientist tying back to their sense of competence and self-recognition, "I was trained on how to do an experiment in a short period of time and it turned out perfect. And I got so many compliments by even people that were surprised that I was just an undergrad student."

These ongoing opportunities, including successful performance and recognition by others, led to increased competence for Hope. On an inbound STEM research trajectory, Hope has a strong science identity:

> I do feel like I listen, and I now think like a scientist, not just feel like it, but I think like a scientist because when I find something, I feel like I've become smarter too. I can think of a different level and try to solve something.

Hope's experiences provide an in-depth examination of the science identity construction process and the overlapping nature of performance, competence, and recognition, which significantly shaped the inbound trajectory of this student. Other inbound students, all who completed the program, shared unique processes of science identity construction, which were similarly impactful on their trajectory. Students who left the program had fewer opportunities to perform scientific tasks with scaffolded support and training, limited instances to demonstrate competence well aligned with their knowledge and skills, and few instances when they recognized themselves or were recognized by others as a scientist. This highlights the importance of this inclusion and support in research experiences for science identity construction.

In this study, the students on the most inbound STEM research trajectories were given many opportunities for performing scientific tasks, chances to demonstrate competence in their disciplines, and shared several instances of self-recognition and recognition by others. When considering the experiences of those on the most inbound trajectories, this "science identity trifecta" was central to their research training community of practice experience and trajectory.

Clear and Compelling Pathways to Research Careers. The research training community of practice provided students with in-depth exposure to research careers and provided ample opportunities for hands-on research experiences in their disciplines. Yet, more than half the students in this study were not planning to pursue biomedical research

careers. Seven of the eleven students who left the program were inbound in STEM but not pursuing a research pathway. Students in this group shared several reasons for not pursuing a research pathway, including a shortage of role models in research careers and a lack of certainty about if research careers were viable and sustainable. Deidre (Leaver, Inbound STEM with Unclear Research Trajectory) shared that their relationship with a mentor deterred them from a research pathway:

> I liked [my mentor], but I didn't feel like I wanted to do a Ph.D. or grad school….she didn't have any kids. You know, she was very career-oriented. I just didn't feel motivated. I thought she has a Ph.D., so if I have a Ph.D. I'll be like her. So I was like, No, I'm not going to do that. Yeah. I won't be like her.

Additionally, students who left feared the research pathway might not provide the kind of stability they wanted. To them, research careers appeared unstable and included a constant need to apply for funding combined and a never-ending workload that did not appeal to them. Liza (Leaver, Inbound STEM Non-Research) shared:

> [Research] relied on a lot of funding, and at the time, I just really sat down, and I thought about it, and I was like, even if I really like doing this, is it something that I should go into if I want stability later on? I think it was just that fear of not having enough stability just put me in a position where I wasn't sure if I wanted to continue to go into research.

For some completers, on the other hand, the exposure to research they encountered in the program compelled them to remain on a research trajectory. This was true for Amy (Completer, Inbound STEM Research), who shared:

> Just opening my mind up to what science really is and what research really means for the whole advancement of the human society made me realize, I do wanna have a part in becoming that change and becoming more representation for people like me. It's a really great feeling to have that you're doing this for yourself, but you're also doing this for your community and just making people more aware of science and STEM in general and just research and how it can really shape the lives of human society.

For students who left the program, the community of practice did not adequately set them on a clear path to move towards a research career. Kayla (Leaver, Inbound STEM Non-Research) shared, "I feel more... other students were more motivated than me or knew their path more. Because for me, I feel like I was still figuring things out and nothing seemed to be working." Jamie (Leaver, Inbound STEM Non-Research) doubted a research career was in their future given the loss of access to crucial support and letters of recommendation, "All of the resources and connections and things to break into the scientific world are in [these programs], and since I'm not in those clubs anymore, I don't have the same access."

Notably, program completers who were inbound STEM research had instrumental support from their mentors, were given step-by-step guidance in their process, and had ongoing support when offered research-related employment opportunities. Hope (Completer, Inbound STEM Research) shared, "After I was done with EXITO, they actually had a position for a research assistant. And so I didn't have to look anywhere else. I could just stay right here and keep doing more work." This suggests that students may need practical opportunities and instrumental support after the program to support their transition to their future pathway.

In sum, many students who left the program may have needed more support in determining an individualized plan for their future and more clarity on the next steps to pursue research careers. They also worried about the viability of a research career or did not feel compelled to follow that path.

Conclusions about Student Trajectories

Students in this study represented diverse science identity trajectories and levels of current and anticipated future participation in the STEM and research workforce. Students fell into four science identity trajectory categories. Some were inbound STEM and research, others were inbound in STEM but outbound in research, a small group was outbound in STEM and research, and a final group of students were inbound in STEM but had unclear trajectories.

Students' opportunities for performance, competence, and internal and external recognition, played a role in their science identity construction. These processes were overlapping and ongoing for students throughout their program participation. For students inbound in research and STEM careers, there was often a science identity "trifecta." These students were given many opportunities to perform scientific tasks, feel competent in their research skills, and experience recognition as scientists. Some students were not exposed to research career pathways that seemed compelling or viable. Other students, who were outbound in research careers or had unclear trajectories, lacked information regarding clear and accessible pathways into research careers.

Summary of Findings

As discussed in detail in the literature review, numerous factors shape underrepresented and first-generation students' participation in STEM disciplines and research training programs. This includes various systemic and structural realities, students' experiences in their personal lives and on college campuses, and their interactions with family members, peers, faculty, staff, and mentors. These experiences and interactions play a crucial role in shaping their ongoing participation, pathways, and trajectories. Students in this study from both program completion groups shared complex issues impacting their participation, including interactions and experiences in STEM contexts, and systemic and structural factors that filtered into their proximal contexts.

Students who left the program described several different core experiences that added challenges to program and degree completion. First, these students struggled to pay for college and meet their basic needs, highlighting that college affordability is an ongoing struggle even with tuition support and paid research placements. Students who left also shared fewer instances of support navigating the financial systems in higher education. Second, students from both groups shared difficulties in courses and disciplines stemming from narrow pedagogical norms in classrooms. Students who left the program were challenged by the limited ways of generating knowledge and demonstrating competence, and they struggled to perform well academically and succeed. Third, students in this sample provided many examples of discrimination and bias in their classes, research environments, or other STEM spaces. Microaggressions were commonplace for students who left the program, highlighting how the culture of power in science excludes particular groups based on their race, ethnicity, class, and gender. Although both groups received messages of doubt from others about their abilities, students who completed shared connections with other staff and mentors countered these messages with positive encouragement and support. Fourth, students who left the program shared widespread challenges with their mental health, which they attributed to unreasonable and competing demands in their academic, personal, family, peer, or research program domains. They revealed how the fast-paced courses and narrow pedagogical teaching practices in science make it difficult for students to maintain a

sense of well-being and successfully participate in scientific work. Additionally, students who left did not receive support inside or outside the program to deal with mental health challenges. Fifth and finally, students discussed challenges in finding a sense of community in science and shared experiences where they were excluded from scientific practices or received messages of doubt about their fit in the scientific community. This experience happened more frequently for students who left the program than those who completed it.

Students shared multiple instances of science identity construction with the theoretical conceptualization of science identity from Carlone and Johnson (2007), including competence, performance, and recognition, and the overlapping experiences of these elements. Not surprisingly, those who completed the program shared more examples of opportunities to perform scientific tasks, demonstrate competence in their disciplines, were recognized by others as scientists and recognized themselves as scientists. Students pointed to the importance of support and inclusion in their research placements and meaningful participation in these contexts when recounting their performance, competence, and recognition experiences. Notably, only six of the eleven students who did not complete the program were placed in a research community, and only four had any opportunities to share or disseminate research.

Students shared in-depth experiences about their science identity construction within research training communities of practice. The motivational climate of programs

was critical for students. Many students who left the program struggled to meet program requirements, were afraid of punitive action from the program, and desired clear program communication and more autonomy to complete program requirements. Students highlighted the centrality of relationships with program staff and faculty. Many completers shared the importance of having a go-to staff or faculty to support them throughout the program. Identity construction and meaningful engagement in scientific practices included opportunities for participation in scientific practice in research placements and the presence or absence of the necessary training and support to engage in meaningful scientific work. Key processes and experiences that contributed to scientific self-recognition included overcoming imposter syndrome, disseminating research findings, being recognized as a scientist by others, and having opportunities to train others in scientific practices.

Finally, themes regarding students' science identity trajectories and in-depth consideration of their pathways into and out of research careers were explored. Participation in research training communities played a key role in shaping students' science identity trajectories. Student trajectories included inbound in STEM and research, inbound in STEM and outbound in research, outbound in both STEM and research, and those with unclear research trajectories. Students on the most inbound pathways, all completers, experienced a "science identity trifecta" with multiple, meaningful opportunities to perform scientific practices successfully, a developing sense

of competence, and recognition by self and others of their value in the scientific community. Many students who left the program lacked compelling information regarding why research is worthwhile, the viability of a stable career, and clarity about the next steps to a career in STEM research.

Chapter 7 : Discussion

This study examined the experiences of underrepresented racial and ethnic minority and first-generation college students in STEM by exploring their participation in an undergraduate research training community of practice. The study aimed to provide a deeper understanding of how contextual factors impact underrepresented racial and ethnic minority and first-generation students' decisions regarding ongoing participation in STEM programming and pathways. It also looked at the critical experiences within research training communities of practice and STEM disciplines that shape students' science identity construction. Additionally, the study examined the connection between students' science identity and their decisions regarding research training community of practice and STEM career participation. The present study findings highlight the importance of participation in a community of practice for STEM identity and the role of contextual features of research training communities of practice in shaping students' construction of their science identity trajectories. The following sections include a discussion of the results and interpretations of the themes that emerged in this study, the strengths and limitations of this study, implications for theory and research, implications for practice, and future research directions.

Broader Contextual Factors Impacting Student Participation in Research Training Communities of Practice

The first two research questions of the study sought to examine contextual factors impacting student participation and identify key experiences shaping students' science identity construction. Student identities are constructed through practice in context and are not isolated from structural contexts. Therefore, the following section will integrate themes regarding factors impacting participation and key experiences in science identity construction.

Each study participant was asked about the impact of their mental and physical health, finances, extended or immediate family, commitments outside the program, academic coursework and preparation, relationships, and institutional features on their participation. Students who left the program discussed financial hardship, academic challenges, experiences with bias and discrimination, personal and family challenges, struggles with mental health and well-being and lacking a sense of community in STEM. These findings align with previous work suggesting that underrepresented and first-generation persistence in STEM majors is impacted by academic preparation, financial challenges, competitive school environments, science identity, a sense of belonging, cultural continuity in academic courses, racialized dynamics in STEM, stereotype threat, and interpersonal relationships (Beasley & Fischer, 2012; M. J. Chang et al., 2014; Hurtado et al., 2011; Seymour & Hewitt, 1997). The current study extends what is known about STEM inequities by explicitly examining reasons for leaving research

training communities of practice. Results surfaced that students' rationale for departure included a lack of flexibility to complete program requirements, dismissal, no longer feeling the program was relevant, negative encounters with faculty, and encountering significant personal challenges that made participation difficult.

This study conceptualized research training programs as communities of practice wherein members can learn and construct their identity through opportunities to participate in scientific activities. Study results lend credence to situated learning research, which recognizes that learning is a social process and science identity construction is shaped through social interactions mediated by contextual values, norms, and cultures (Lave & Wenger, 1991; Wenger, 2008). A significant takeaway from this study was the central importance of meaningful participation in communities of practice and the need for regular and increasingly complex performance opportunities (Hurtado et al., 2009; Seymour et al., 2004). This aligns with past work on communities of practice wherein members need to move freely across multiple levels of participation as needs and interests evolve (Wenger, 2008). The findings extend the concept of legitimate peripheral participation, which focuses on how students come into learning contexts on the periphery and are supported by core members as they increase knowledge and grow in their expertise (Lave & Wenger, 1991). The current study results showcase that through legitimate peripheral participation, students developed their skills and moved

from outsiders to experts. It also highlighted the importance of being intentionally mentored from peripheral to core participants.

The motivational climate of the program played a significant role in participation for students. In particular, students who left the program highlighted how rigid program practices and punitive program actions negatively shaped their participation and impacted their trajectories. Research to date has highlighted how many norms and practices in STEM learning contexts do not support learning for underrepresented minority and first-generation students (Hurtado et al., 2011; Hurtado & Ruiz Alvarado, 2015). This study extends this work to highlight how practices within research training programs may be unknowingly perpetuating STEM inequities by upholding STEM norms that focus on rigid structures and limited options for performing successfully.

Students' descriptions of constructing their science identity align with Carlone and Johnson's (2007) grounded model of science identity, including dimensions of performance, competence, and recognition. Previous research has considered the importance of mentored research experience and emphasized that students need opportunities to work in research settings with faculty supporting and supervising their work (Linn et al., 2015; Shanahan et al., 2015; Thiry et al., 2012). However, little work has considered the *quality* of social processes and relationships within these environments. Study results suggest that scaffolded and supportive training is needed for underrepresented racial and ethnic minority students and that relational apprenticeship

experiences must accompany opportunities for hands-on research with mentors. One notable finding was that most inbound students described instances in their research placements or mentoring relationships where the culture of power in STEM was explicitly acknowledged, and there were active efforts to combat power differentials. These results suggest that meaningful participation in communities of practice is central in the science identity construction process (Hurtado et al., 2009; Seymour et al., 2004) and highlight the importance of explicitly integrating conversations around power dynamics to strengthen the framework for use in disciplinary learning contexts (Agarwal & Sengupta-Irving, 2019).

Each student pathway included detailed descriptions of the unique sociohistorical realities in which their proximal contexts are embedded. Students provided several examples of how structural forces shaped their moment-to-moment interactions. Previous work has illuminated how STEM learning contexts are socially constructed (Vakil & Ayers, 2019) and rejected the idea that isolated individuals are a sufficient unit of analysis that can be detached from their contexts (Vygotsky, 1978). Burke and Mattis (2007) suggested that underrepresentation in STEM persists because of realities at numerous levels, including personal (e.g., mental health), family (e.g., financial support), educational system (e.g., classroom climate), workplace (e.g., compensation), and society at large (e.g., policy). This study examined how deeply rooted systemic realities shape STEM contexts and highlighted the importance of foregrounding structural inequities'

role in STEM identity development. Study results clarify contributions of structural factors to individuals' experiences in STEM research training programs and highlight the fundamental role of structural forces in shaping students' proximal contexts, suggesting that student participation must be examined with systemic and structural factors in the foreground.

In this study, student perceptions and sources of knowledge regarding research careers highlighted research career attainment as a fundamentally social process, rather than primarily an individual-level one. The result lends credence to work, suggesting that science career attainment is a social process and that an individual intends to pursue these careers is only one element (Lewis, 2003). Results suggest that a novice student in a community of practice is highly reliant on the efforts of the most expert community members to lead them through each phase of the learning and career process. In other words, those in positions of authority and power in these spaces serve as facilitators or gatekeepers for underrepresented minority and first-generation students in STEM.

In sum, students in this study provided a rich and detailed description of complex, evolving, and overlapping processes shaping students' decisions regarding research training program participation. Many students who completed highlighted how their mentoring relationships and research placements worked against exclusionary norms in STEM and provided ample training and support for their personal growth and movement from peripheral to central in their lab environments. The results also highlight the

importance of the motivational climate within these programs and the need for scaffolded apprenticeship to learn scientific practices within program contexts.

Relationship Between Science Identity and Departure Decisions

The final research question of this study considered how identity construction links to student choices to stay in or leave research training communities of practice and/or STEM pathways. Results surfaced distinct trajectories between students inbound into STEM research and those inbound into STEM non-research. Research to date has focused chiefly on pathways into and out of STEM careers and this study extends this work by suggesting unique trajectories specific to those entering the biomedical research workforce. Study results also illuminated potential differences in patterns between these distinct trajectories based on underrepresented racial and ethnic minority status. One striking finding from this study was that underrepresented racial and ethnic minority students were overrepresented in outbound trajectories and underrepresented in inbound trajectory categories. Three out of the five total students in the study who were not underrepresented racial and ethnic minority students were on inbound STEM research trajectories. In contrast, ten of the eleven students on inbound STEM non-research trajectories identified as underrepresented racial and ethnic minority students. First-generation students were evenly spread across the trajectory categories. Sufficient information is not available for in-depth interpretation, given that students were not directly asked how their racial minority and first-generation status impacted their

participation. However, this raises important questions about how the combination of racial minority and first-generation status may create challenging situations for students on STEM pathways.

Students encountered race and class-based discrimination in STEM learning contexts and within the research training community of practice program in this study. For instance, students in this study shared widespread experiences with microaggressions, racism, and bias related to their marginalized identities highlighting the racialized hierarchy in STEM learning contexts. This aligns with previous work on the racialized STEM hierarchy, which attributes STEM inequities to structural racism and posits that systemic racism informs and is reinforced by practices, beliefs, values, and resource distribution with STEM higher education contexts that discriminate against underrepresented minority groups (McGee, 2020; Vakil & Ayers, 2019). It also highlights that students' marginalized identities and social positions are highly relevant in understanding and explaining their trajectories (Brown et al., 2017; McGee, 2020). Results added to what is known about supporting students by highlighting the potential importance of positive connections with faculty and staff to buffer these negative experiences. These connections bolstered student's science identity and gave them direct access to information and necessary support. These supportive relationships may have mitigated the harmful effects of the structural realities impacting students' experiences as

staff explicitly stated the systemic nature of students' struggles and then offered tangible support for addressing the issue.

Students on inbound STEM research trajectories in this study described a "science identity trifecta" with meaningful performance, growth in competence, and numerous recognition experiences. This aligns with previous work that takes an interactional approach to science identity development and emphasizes both the individual and the scientific context in science identity development (Kim & Sinatra, 2018). The study contributed to what is known about scientific practice and science identity construction by providing a notable contrast between those who left the program and those who completed as the leavers shared significantly fewer opportunities for science identity construction and described research environments that were not supportive or inclusive. These findings suggest that these environments may not have allowed students to engage in these spaces meaningfully. Students may have left after deciding there was no place for them within the scientific research workforce. Study results indicate that students need regular, ongoing, and increasingly complex opportunities for performance, frequent instances to demonstrate competence, and explicit recognition by others in supportive research environments.

In sum, science identity surfaced as a critical component of success for students who follow STEM research pathways. The present study revealed a complex picture of how science identity forms within changing trajectories situated in communities of

practice. In particular, results highlighted the importance of ongoing interactions, inclusion in meaningful participation, and explicit opportunities for growth and advancement in identity construction and trajectories. Various features of the community of practice, including continuing opportunities for performance, competence, and recognition, supported students' science identity construction.

Study Strengths and Limitations

Strengths

This study had several strengths related to its design and approach to studying complex social processes within a research training community of practice. First, the study took a qualitative approach to gain new insight into the complex factors contributing to student success in STEM. Previous studies examining STEM inequities often isolate a single systemic force or person-in-context experience but fail to explore aspects at both levels and the dynamic relationship between the two. The current study's theoretical model proposed that factors at the systemic *and* individual level interact to shape environments that support or hinder identity construction for students and impact their decisions to stay in or leave these programs and majors.

Second, the study had built-in contrast groups. It considered the experiences of students who completed a research training community of practice *and* students who departed. In doing so, the study examined an understudied group, the "leavers," to

consider unique experiences that contributed to their departure, their science identity construction, and their trajectories. The study's qualitative approach moved beyond positivist-leaning perspectives, which prioritize quantification of phenomena over understanding meanings as constructed by the participants involved (Guba & Lincoln, 2005). The current study did not seek to identify a "normative" path for success but focused on understanding students' perspectives as yielding crucial information needed to build more equitable STEM educational contexts in the future.

Third, the current study provided insight into the complex, socially negotiated nature of science identity construction. The in-depth interviews allowed for exploring social processes as students provided detailed descriptions of their interactions with mentors and peers, engagement in scientific practices through performance, opportunities for demonstrating their competence, and instances where they were recognized as a scientist by themselves and others.

A final strength of this study is the richness of the data which allows for generalization to theory. This study contributes meaningful information to existing theories on science identity construction and produced rich, thick descriptions of the student experience, enabling case-to-case transferability and significant implications for theory and practice (Firestone, 1993).

Limitations

Although this study can offer higher education administrators and practitioners insight into how to best support underrepresented and first-generation STEM students and provide the rationale for future studies on this topic, it has several limitations. The following section details limitations of the study's design, data collection, and generalizability.

The first limitation is that the study participants may not represent the broader student narratives around program participation, completion, and departure decisions. The study used purposive sampling to select from a pool of students who responded to a request to participate, and there may be several perspectives not represented in the sample. For instance, students who left the program in good standing may have been more willing to talk about their experiences. Students who had a negative experience in the program may not have wanted to discuss their experiences or reasons for leaving. Additionally, particular subsets of the EXITO student population are hard to reach. Specifically, students who live in the U.S. territories, such as Northern Marianas and American Samoa, often report slow (or no) internet and limited access to the technology needed for remote communication. These students were not represented in the group of students who left the program. Although the study attempted to capture a diverse subset of the EXITO Scholar community, critical perspectives may be absent, limiting our understanding of the many factors contributing to students' decisions regarding participation and their experiences in STEM disciplines.

A second limitation is that this study did not consider how particular marginalized identities and their intersections may lead to distinct experiences and perspectives. Past research has surfaced that intersectional identities play a critical role for unrepresented STEM college students (Johnson, 2011; Strayhorn, 2015) and how many identities beyond race and ethnicity are salient in these contexts. This sample included diverse students from different racial and ethnic backgrounds, gender identities, age groups, and disciplines. However, the study recruited students from only a few campuses, and to ensure students were not identifiable, students were placed into the broad categories of "underrepresented minority" and "first-generation." As a result, the study did not examine ability- or gender-based exclusion and discrimination systematically and may not have captured important themes regarding how specific identities and their intersectionality shape student trajectories. Furthermore, the study was unable to examine the unique contributions of the program context as it lacked students who were URM or first-gen in STEM but were not participating in a research training community of practice.

A third limitation is related to the trustworthiness of data provided by the students in the interviews. Students may have felt pressure to speak positively of the program or their mentors to protect themselves from potential retaliation or minimize damage to their reputation. Although I worked diligently to ensure they knew their identities would be kept anonymous, my role as staff may still have made them feel they could not be fully transparent about their experiences in the program. Furthermore, students were asked to

reconstruct their experiences while in the program retroactively. The data only captures students' understanding of why they left the program and descriptions of interactions they can recall or have come to interpret as meaningful. Missing from the study is the observational data needed to consider the impact of events that research has identified as relevant, such as an underrepresented minority student being excluded from meaningful research activities and given minimally challenging lab tasks. Thus, the results offer a limited window in the complex nature of social interactions in research training communities of practice.

A fourth significant limitation is that the study did not examine how the precise implementation of the program model may have impacted students' experience and did not account for changes in program structure over time. Students in the study spanned five cohorts, and the community of practice programming implemented for cohort one differed significantly from cohort five. Additionally, students started their EXITO participation at various pipeline colleges. Although the study asked about their experiences with their institution, the institutional differences and the transfer experience were not explored in depth.

A final and notable limitation is that extrapolating useful information from the study results to students participating in other similar programs may be difficult. The theoretical framework used in this study assumes a high level of contextuality, and so variation is expected given the unique contextual features of different programs. The

focus of this study was student departures from research training programs and/or STEM disciplines. The information uncovered regarding factors contributing to these decisions for students in this sample may not be helpful in the broader consideration of persistent STEM inequities, given they unfolded in a particular program context. The BUILD EXITO program is a three-year experience that includes several components related to mentoring, hands-on research, and professional development, along with a financial package including paid research placements and tuition remission. The unique program features may have played a role in student decisions to stay in or leave the program. Additionally, specific aspects of the complex and highly scaffolded program model are not separable from participant's identity construction and trajectories. Considerations of the utility of findings from this study in different contexts require further studies to examine the prevalence of patterns identified.

Implications for Theory and Research

In this study, a sociocultural approach was used to investigate identity construction, and student research training programs were examined through a community of practice lens (Wenger, 2008). The themes that emerged from this study impact our theoretical and conceptual understanding of underrepresented and first-generation STEM student success and persistence.

This study intentionally rejected approaches to explain student success through a deficit-based model that considers individual factors and behaviors key to explaining

student persistence (Valencia, 2012). The traditional theoretical models used to understand college student retention focus on individual participation, individual and family background factors, and student involvement (Astin, 1984; Tinto, 1975). These theoretical perspectives fail to consider the systemic forces and factors, such as economic and political realities, disproportionally impacting students from underrepresented minority and first-generation backgrounds. In contrast, this study provided a conceptual framework for underrepresented racial and ethnic minority and first-generation STEM students that recognizes the root causes of STEM inequities from an asset-based approach, rejecting approaches to supporting students that put the onus of solving these inequities on students or their families. Future research seeking to explain underrepresented minority student success and persistence in STEM must avoid deficit-based approaches, which suggest that individual-level factors are the target phenomena for understanding student success. Future theory-building and research on this topic should account for how systemic factors, such as pedagogical norms, impact student participation and how particular students may be differentially affected by systemic and structural forces that perpetuate race and class-based inequities.

Notably, students who left the program recounted how barriers they encountered impacted their physical, emotional, and psychological engagement. Past research on STEM inequities has used a metaphor of a STEM pipeline and posited that "leaky points," where underrepresented racial and ethnic minority students are leaving STEM

pathways, are the targets for interventions to increase underrepresented minority student STEM participation. However, the present study diverges from this conceptualization and highlights the problematic nature of suggesting that simply keeping students inside STEM programs and disciplines will erase current inequities and increase persistence in STEM graduate study (Cannady et al., 2014). Instead, results suggest it is not merely the *quantity* of students' participation that matters but the *quality* of their involvement.

The findings from this study align with conceptualizing identity construction as complex and dynamic, shifting between contexts and changing over time as students continually make sense of interactions and experiences (Thiry et al., 2012). Science identity in this study was conceptualized using Carlone and Johnson's (2007) grounded model of science identity adds credence to the model's emphasis on the social construction of science identity and the significant role of race, ethnicity, and gender in these social processes. Future theoretical considerations of science identity could more thoroughly explore how the nature and frequency of performance and demonstration of competency and students' social positions shape students' identity construction. Additionally, students articulated a need for recognition by others, but the source of recognition differed between students and changed over time. Future theoretical attempts to understand and explain identity construction may consider the various sources of recognition, why recognition by particular individuals matters more for some students than others, and how recognition needs may change throughout their pathways.

Finally, there were distinctions in identity trajectories between students in this study who were inbound STEM research and those inbound STEM non-research. Efforts to increase biomedical research workforce diversity would benefit from theoretically distinguishing the unique experiences of students inbound in STEM with strong science identities and those who construct identities as scientific researchers. In recent research on STEM identity, McDonald and colleagues stated, "we offer a new, single-item measure of STEM identity, the STEM-PIO-1, that can be easily administered to diverse populations. Future research should continue to test the merit of the measure so as to advance and unite research in this field (2019, p. 14). Study results do not support claims that we can deepen our understanding of STEM identity by moving away from qualitative approaches to validate a quantitative scale to be used for all students. Instead, they suggest that future work should delve even further into qualitative approaches and observe unfolding processes to unpack the complexity of these social processes and examine students' unique experiences entering STEM research fields.

In sum, this study provided insight into the specific experiences that connect to previous theoretical perspectives on science identity construction. Theoretical and conceptual frameworks must recognize the socially stratified contexts of STEM learning spaces and seek to explain student pathways within the sociohistorical realities in which they unfold. Future theory-building in this area may consider the frequency and complexity of opportunities for science practice, the support offered to students, and a

greater focus on recognition sources. Additionally, frameworks may seek a distinct scientific research identity trajectory.

Implications for Practice

In this study, key processes and interactions within a research training community of practice were explored along with their impact on students' science identity construction and trajectories. Results from this study raise several important implications for practitioners and administrators working to support diverse students on their campuses.

Students who left the research training community of practice struggled with the motivational climate of the program. They wanted more flexibility to complete program milestones, more autonomy support, and limited punitive program responses for failing to meet particular requirements. This suggests that a more relational approach might be helpful in this regard, and programs create flexible pathways to program completion, prepare for complex student challenges, and anticipate the need for flexibility based on evolving student needs.

Second, the current study provides insight into how programs can most effectively and holistically support underrepresented and first-generation students on research pathways. Students in the study provided detailed accounts of being overwhelmed, overworked, and declining mental health due, at least in part, to program demands and requirements. If research training programs want to support the diversification of the research workforce, practitioners must design programs that resist maintaining the status

quo in STEM, which idolizes productivity and constant work at the expense of individual well-being. Instead, they should care for students as whole people, including their well-being, and teach students that making time for self-care and personal pursuits will set them up for productive and prolific research careers.

A significant implication of this study is that opportunities for legitimate peripheral participation are core to the science identity construction process. Each student who completed the program shared positive and supportive mentoring relationships and instrumental support as they entered their research placement as a novice. In contrast, many students who left the program described distant and unapproachable mentors who did not provide needed support. These findings add credence to research that has indicated that underrepresented minority and first-generation STEM students need caring and supportive relationships with faculty and staff to succeed (Summers, 2006; Tsui, 2007). Results suggest that students need intentional and mentored opportunities for meaningful scientific practices and scaffolded training and support to engage. Program mentors and staff should be screened for their scientific expertise and ability to build strong and supportive relationships with students. To support science identity construction, mentors should explicitly communicate care and concern for students, actively listening to students to understand their perspectives, allow ample time to train and support students, and exercise patience as students learn scientific practices.

Finally, students who completed the program shared that opportunities for dissemination were "pivotal," "a turning point," and a moment of great significance in their science identity construction. These dissemination opportunities were program facilitated (e.g., summer symposium), research placement specific (e.g., lab meeting), and in the broader scientific community (e.g., conferences). Notably, students who left the program had minimal opportunities to participate in research dissemination. Programs should provide plentiful opportunities for dissemination, including program-specific events and support to present to the broader scientific community, accompanied by training and support so students can confidently participate.

In sum, this study suggested that those developing undergraduate research training programs must resist perpetuating STEM norms of workaholism and focus on student well-being. Practitioners should build a motivational climate that allows flexibility in milestone completion for students and avoid rigid structures that result in punitive action for students' failure to meet participation thresholds. Mentors and staff should continually and explicitly provide holistic student support and work to implement program components focused on student well-being. It also suggested that ongoing opportunities for meaningful participation in research placements are critical to students' science identity construction. Finally, opportunities for dissemination surfaced as significant for students in this study and should be built into program models to ensure student success.

Future Research

The findings of this study and the limitations provide several next steps for research on underrepresented and first-generation STEM students. This study highlighted the critical role of systemic and structural factors in shaping underrepresented minority and first-generation STEM student identity construction and trajectories. Future studies could extend explorations into how systemic realities filter into students' proximal contexts to impact their participation. For instance, past research has used classroom observations of interactions better to understand microaggressions (Suárez-Orozco et al., 2015). Future studies could consider microaggressions in unfolding social processes in research training programs through observations to get a clearer sense of how these experiences of discrimination and bias in STEM may be impacting students.

The current study suggests that research lab culture and explicit communication to students about the value of contributions may significantly impact students' identity construction. However, this study captured only student perceptions of these interactions. Future research could examine how lab activities and interactions in a complex and dynamic social system interact holistically to construct these experiences and shape these student perspectives. For instance, a future study could more closely examine the impact of social interactions by including mentor and staff interviews and research placement observations to get a more holistic picture of social processes in the lab environment.

This study gathered detailed reflections from students but involved a retrospective reconstruction of these experiences. Future research could follow students throughout their participation and seek information about their identity trajectories at multiple time points to better understand the nature of social interactions in research training communities of practice and their unfolding science identity construction.

The students in this study represented various disciplines, including non-traditional STEM majors such as social work, and found no substantial differences between student experiences in social sciences versus those in natural science. However, very little research has considered how student experiences within these majors may differ, and this study did not sufficiently collect information to examine potential differences in depth. Future research should consider how research training communities of practice may function differently across disciplines and how scientific norms may create unique learning environments within these disciplines.

Finally, this study considered students in a single research training program and did not examine ability-based exclusion or the unique experiences of sexual and gender minorities. Given past research on the unique challenges students with disabilities and transgender students encounter in STEM contexts (Hughes, 2018; Moon et al., 2012), more information is needed on these student perspectives. Future studies could look across multiple programs and institutions and intentionally recruit transgender students

and students with disabilities to consider contextual factors impacting their participation, identity construction, and trajectories.

Conclusion

This study sought to identify unique contextual factors that may affect students' participation in STEM and/or research training communities of practice, focusing on potential differences between students who completed the program and those who left the program. When taken together, study results reveal the importance of foregrounding the structural and systemic forces that significantly impact students in context. Results underscore the need to focus on systemic and structural factors filtering into contexts to create challenges for students including college affordability, motivational climates in programs, racialized and gendered dynamics in STEM, narrow pedagogical norms, and exclusionary practices in STEM disciplines and programming.

The community of practice lens used in this study viewed the program as an environment for aspiring researchers to learn by participating in scientific practices. The themes that emerged underscored students as active, agentic, and dynamic individuals whose science identities are constructed in these spaces. Study results highlighted the importance of legitimate peripheral participation, scaffolded and supportive mentoring, and explicit inclusion in hands-on research environments. Additionally, the study highlighted the importance of performance, competence, recognition, and the centrality of students' marginalized identities throughout the science identity construction process.

Taken with its limitations, this study provides critical insight into the underrepresented racial and ethnic minority and first-generation STEM student experience, the science identity construction process, and factors that contribute to choices to depart from STEM research training programs and/or STEM disciplines. Given the persistent inequities that plague STEM education, this study shed light on the student experience and uncovered themes in systemic and contextual realities contributing to these inequities. Furthermore, the study extended previous research on the importance of practice and science identity construction opportunities by examining student perceptions of these experiences and processes in a research training community of practice. The study also provided implications for practice and future research to extend knowledge on supporting underrepresented racial and ethnic minority and first-generation STEM students.

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Appendix A: Description of NIH Racial Categories

The following are descriptions for each racial category included in the racial categorizations designed and used by the National Institute of Health:

American Indian or Alaska Native: A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.

Asian: A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.

Black or African American: A person having origins in any of the Black racial groups of Africa. Terms such as Haitian can be used in addition to Black or African American.

Hispanic or Latino: A person of Cuban, Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race. The term Spanish origin can be used in addition to Hispanic or Latino.

Native Hawaiian or Other Pacific Islander: A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.

White: A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

Appendix B: NIH Underrepresented Populations in the U.S. Biomedical, Clinical, Behavioral and Social Sciences Research Enterprise

Individuals from disadvantaged backgrounds, defined as those who meet two or more of the following criteria:

1. Were or currently are homeless, as defined by the McKinney-Vento Homeless Assistance Act (Definition: https://nche.ed.gov/mckinney-vento/);
2. Were or currently are in the foster care system, as defined by the Administration for Children and Families (Definition: https://www.acf.hhs.gov/cb/focus-areas/foster-care);
3. Were eligible for the Federal Free and Reduced Lunch Program for two or more years Have/had no parents or legal guardians who completed a bachelor's degree (see https://nces.ed.gov/pubs2018/2018009.pdf):
4. Were or currently are eligible for Federal Pell grants (Definition: https://www2.ed.gov/programs/fpg/eligibility.html);
5. Received support from the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) as a parent or child (Definition: https://www.fns.usda.gov/wic/wic-eligibility-requirements).
6. Grew up in one of the following areas: a) a U.S. rural area, as designated by the Health Resources and Services Administration (HRSA) Rural Health Grants Eligibility Analyzer (https://data.hrsa.gov/tools/rural-health), *or* b) a a Centers for Medicare and Medicaid Services-designated Low-Income and Health Professional Shortage Areas (qualifying zip codes are included in the file). Only one of the two possibilities in #7 can be used as a criterion for the disadvantaged background definition.

Appendix C: Pre-interview Questionnaire

1. What is your name?
2. Which year/term did you join EXITO?
3. Did you complete the EXITO Program?
4. If yes, which year and term? (drop down)
    1. If no, what was the final year/term of your participation? (drop down)
5. What is your current employment and student status?
    1. Full-time employed, part-time graduate student
    2. Full-time graduate student
    3. Full-time graduate student also full-time employed (outside of a research or teaching assistant role)
    4. Part-time employed, not a student
    5. Part-time employed, also part-time graduate student
    6. Unemployed
    7. Other
6. Please review the following list of activities you may have engaged in while in EXITO. Please answer for each
    1. **Engage with Existing Research (**i.e. conducted a literature review, read journal articles to obtain scientific information)
        1. Did you participate in any of these activities while in EXITO? (yes/no/don't know)
        2. If yes, how would you rate this experience? (positive/negative/neutral
    2. **Study Design (**i.e. generated research questions, developed a hypothesis, planned data collection strategies to answer a particular scientific question)
        1. Did you participate in any of these activities while in EXITO? (yes/no/don't know)
        2. If yes, how would you rate this experience? (positive/negative/neutral)
    3. **Data Collection (**i.e. collected quantitative data, conducted interviews or focus groups, transcribed qualitative interview data, entered data for quantitative analysis, entered data for qualitative analysis)
        1. Did you participate in any of these activities while in EXITO? (yes/no/don't know)
        2. If yes, how would you rate this experience? (positive/negative/neutral)
    4. **Data Analysis (**i.e. participated in the coding process for qualitative data, organized study results in graphs or charts, analyzed and interpret data to

determine patterns and relationships in quantitative data, analyzed and interpret data to determine patterns and relationships in qualitative data, participated in developing a coding scheme for qualitative data)
    1. Did you participate in any of these activities while in EXITO? (yes/no/don't know)
    2. If yes, how would you rate this experience? (positive/negative/neutral)
5. **Dissemination of Research Findings (**i.e. presented research findings to EXITO community at Summer Research Symposium, created a scientific poster, Presented a poster at a conference, submitted a manuscript for publication)
    1. Did you participate in any of these activities while in EXITO? (yes/no/don't know)
    2. If yes, how would you rate this experience? (positive/negative/neutral)
6. **Collaboration among Scientists (**i.e. participated in a STEM club or similar organization, co-authored a scientific paper, participated in journal club with peers)
    1. Did you participate in any of these activities while in EXITO? (yes/no/don't know)
    2. If yes, how would you rate this experience? (positive/negative/neutral)
7. **Other Scientific Activities** (i.e. attended a scientific conference, attended a scientific poster session, presented an elevator pitch at New Scholar Orientation, met with PI for RLC work, met regularly with Research Mentor (if different than PI), participated in RLC Fair, attended lab meetings)
    1. Did you participate in any of these activities while in EXITO? (yes/no/don't know)
    2. If yes, how would you rate this experience? (positive/negative/neutral)

Appendix D: Semi-structured Interview Protocol

Interviewer Instructions
Introduction/Opening Statement

Hello. My name is _____. [insert a couple of sentences about yourself, role, profession, or anything that may establish a connection at this early stage]. Thank you for your willingness to participate in this interview.

The purpose of this interview is to better understand the experiences of individuals from traditionally marginalized and underrepresented groups in college STEM majors who participated in underrepresented minority STEM programming. In particular, understanding why students choose to leave these programs is of particular interest.

In these interviews, we will be asking questions about student experiences in higher education, interactions with faculty and peers, and experiences in your research labs.

For all of your responses, there are no right or wrong answers and your comments will remain confidential. Please feel free to be open and honest about your experiences and perspectives. If there are any questions you do not want to answer, just let me know. And if you need clarification on any questions, please ask.

Again, your comments will not be shared with any identifying information attached. The responses from these interviews will be compiled in future work and pseudonyms will be used for any specific comments that end up in the final report for this study. If you say anything that might identify you or your previous research placement or mentors, details such as people's names and project topics will be changed to ensure your comments remain confidential.

Do you have any questions for me before we start? [Give time for questions, encourage participant to ask for clarification if anything was unclear]

I will be recording our conversation. This is so that I can capture all the details of what you say while being present to our conversation. Do you consent to this interview being recorded? [Get verbal consent for taping]

Interview Questions

1. How did you end up attending PSU?

2. When did you choose your major? How did you choose it? Have you changed majors to date?
3. What were the top three motivators that led you to join BUILD EXITO? If you have less than three, that is okay, too.
4. Did you feel like you had a sense of community while you were in EXITO?
5. What are the top three positive and top three negative experiences from your time in EXITO? (Encourage them to answer separately, but tell them to choose whichever is easiest to answer first) (RQ 1 and 2)
6. Now, we will discuss things that you feel affected your ability to participate in EXITO. For each topic, I would like you to think about whether it was a positive, negative, or mixed effect on your participation.
    a. Did personal health affect your participation in EXITO?
        i. If yes, explain.
    b. Did immediate or extended family affect your participation in EXITO?
        i. If yes, explain.
    c. Did finances or money affect your participation in EXITO?
        i. If yes, explain.
    d. Did commitments outside of EXITO/school (i.e. work, childcare) affect your participation in EXITO?
        i. If yes, explain.
    e. Did academic coursework including workload and/or course difficulty affect your participation in EXITO?
        i. If yes, explain.
    f. Did academic preparation or experiences before your time in EXITO affect your participation in EXITO?
        i. If yes, explain.
    g. Did relationships with people in EXITO affect your participation in EXITO? (This could be with career or research mentors, other Scholars, or anyone in the EXITO community)
        i. If yes, explain.
        ii. Note: ask about any parties they don't mention (e.g. if they talk about peers but say nothing about faculty/staff, ask a follow-up about faculty/staff)
    h. Did relationships outside of EXITO affect your participation in EXITO? (This could be at the university such as with peers or professors or outside of PSU such as with friends, family, or co-workers)
        i. If yes, explain.
        ii. Note: ask about family (immediate and extended), friends or other connections outside PSU if not discussed

    i. Did institutional features of PSU affect your participation in EXITO? (i.e. navigating financial aid or trouble navigating your degree requirements
        i. If yes, explain.
    j. Did anything else affect your participation that we have not discussed?
7. When you think about your experience in your research learning community, what key experiences and relationships come to mind? (RQ 2)
    a. Prompt if needed: How would you describe the culture in your RLC? (RQ 2) (omit if the student didn't make it to RLC phase)
    b. Prompt if needed: Can you describe what was your Research Learning Community like for you? (RQ 2) (omit if the student didn't make it to RLC phase)
8. The next set of questions dive into some of the activities that you engaged in while in EXITO [Using the pre-interview survey, review normative scientific practices in which students engaged. For each indication of "yes, I did this while in EXITO" ask the following questions] (RQ 2)
    a. First Activity
        i. You indicated that you engage in (fill in practice here). Can you tell me more about that?
            1. How did you know what was required of you for that task?
            2. How did it feel to complete that task?
            3. Did working on this task make you think differently about yourself? Why or why not?
    b. Do for each additional activity (as applicable)
            1. You indicated that you engage in (fill in practice here). Can you tell me more about that?
            2. How did you know what was required of you for that task?
            3. How did it feel to complete that task?
            4. Did working on this task make you think differently about yourself? Why or why not?
    c. Were there other opportunities for engaging with science and research that we have not talked about that you engaged in while in EXITO? (RQ 2)
9. Were there any ways where EXITO and your personal life or family life just didn't fit together? If so, explain. (note: ask for a story if they are having a hard time explaining)
10. (note: only ask if Q 6 does not provide information about student challenges) Think about the specific challenges you faced in EXITO. What comes to mind? These can be on- or off-campus, personal or related to institutional barriers. (RQ 1 and 3) (Save as a follow up to 6 in case people aren't answering it spontaneously).

11. How did EXITO influence how you thought about your relationship with the sciences? (RQ 2 and 3)
12. In what ways were you recognized as a scientist by others while in EXITO? (RQ 3) (only use if info isn't provided from 6 and 11)
13. Is there anything else you think is important for me to know before we finish this interview?

Thank you. This concludes the interview. I will now turn off the recorder. Do you have any questions for me at this time? (Respond to questions and tell participant they can return to the consent form if they have more questions later)

Appendix E: Case Memo Sample

Jamie (Leaver, Inbound STEM Non-Research)

Summary Overview of Student Trajectory:

Participant 4 is a self-described mixed race individual who is first-generation and began as a natural sciences student but graduated with a bachelors in the social sciences. The student joined EXITO to get support for graduate school applications, engage in internships and hands on research, and for the financial support.

The student had some significant negative interactions with the program and had some good experiences in their RLC. The student had to work, maintain full time status, and participate in EXITO activities. They shared feeling overwhelmed and that it was unreasonable and unmanageable. The student also discussed the how EXITO was only designed for certain types of students and hard to navigate for others (like them).

The student shared several instances of racialized and gendered dynamics in their STEM disciplines but were grateful to work with an RLC mentor who identified as BIPOC. Although they felt comfortable in their RLC, they also described not feeling that they could ask for clarification or help when needed in their lab because they didn't want to reinforce stereotypes about underrepresented people in STEM.

The student really wants a career in STEM, but is currently lost at how to move forward. They feel an acute loss of connections and resources, as they are no longer in EXITO.

Trajectory Patterns:

- Science: Inbound
- Research: Outbound
- Trajectory Summary: Student is currently hoping to go to graduate school but unsure of their next step and not clear in how research would fit into future education and career

Person-in-context Factors:

- Course difficulty and workload
- Program demands and lack of flexibility
- Sense of belonging in STEM

Systemic Factors:

- Finances and paying for college

- Racialized and gendered dynamics in STEM
- Ways of Knowing in STEM

Notable Quotes:

I wanted to be in the program because it seemed like a good gateway to getting like access to things for grad school. Um, and what I mean by that is just, there were like a bunch of internship opportunities and opportunities to speak in like conferences and to work in a lab and gain experience and things like that. That was probably my biggest motivation. Um, my second biggest motivation was the recommendation letters that I'd be able to get from people.

I would go to [my mentor] like, I really enjoyed... Sorry. I really enjoyed her mentor sessions. And we had a lot of like one-on-one conversations. Um, and those were really helpful. And she was really supportive of me as an [underrepresented person in STEM].

I've pretty much given up on the whole scientist dream. Um, because one of the things that I've learned in not just EXITO, but in higher education in general is that it's honestly not what you know, it's who you know. And all of the, the resources and connections and things to like break into the scientific world are in like [in programs] and things like that. And since I'm not in those clubs anymore, I don't have the same access to like internships and reference letters.

Appendix F: Emerging Themes by Construct Sample

Topic/Theme: Mental Health

Case Frequency of Topic:

- Left Program: 8/11 cases
- Completed Program: 9/12 cases

Distinctions between leavers and completers

- **Leaver Summary:** Students who left struggled significantly with mental health issues, ranging in severity. They expressed having high levels of depression and anxiety. Although these were often not named as direct reasons for leaving the program, in several instances they contributed to situations where students felt they had no choice but to leave EXITO including academic challenges, struggles to meet course or program requirements, and a sense that the fast pace of their lives was not sustainable. A few students in this group heavily relied on EXITO faculty for support and assistance with mental health challenges.
- **Completer Summary: S**tudents from the completer group also experienced significant depression and anxiety. These often played a big role in how they showed up for EXITO programming and research placement opportunities. Mental health impacted the quality of student participation. Students from this group sought support from program staff, faculty, and the institution. They received varying levels of effective support with their challenges but several called out staff and faculty by name who gave them instrumental support and resources.

My interpretations/thoughts of emerging ideas

- A majority of the students in this sample experienced challenges related to their mental health, students across the group who left and those who completed had similar reflections on the role of mental health in their program participation and shared that it made it difficult for them to show up to programming or engage meaningfully even if physically present.
- Students shared having anxiety, depression, panic attacks, and other general mental health challenges, several went to seek assistance with on campus counseling services, others shared their struggles with an EXITO faculty and staff.
- Several students shared feeling felt supported around these struggles and like they could talk about these challenges to program staff. Some others did not feel that the program or institution provided ample support, one student mentioned feeling

discriminated against when seeking on campus counseling and two others shared they didn't feel comfortable talk about their mental health with anyone so kept it to themselves.

- Several students spoke to factors influencing their mental health, although in many cases these challenges had been with them since childhood or adolescence, including family demands and other personal situations. However, in many of the cases, students were extremely overwhelmed by the demands of job, courses, extracurriculars, their program requirements and responsibilities.
- The leavers accessed less support around mental health and nearly ever case with mental health struggles also included high levels of stress regarding program and academic demands.

Exemplary Quotes:

- *I think personally I was also like, I don't know. I struggle a lot with anxiety and depression and I don't know, I just never directly dealt with it. Like I just kept denying it. I kept telling myself it wasn't that bad anyway. And I am just now actually getting help and like, 'cause I started having physical symptoms and I was like, "This is crazy. Like, I can't believe it's all because of that.* (Lily, Leaver, Inbound STEM Non-Research)
- *It was hard focusing 'cause I wasn't sleeping. Um, it's hard participating 'cause I don't feel good. Like, and there's a lot of interaction that goes into these enrichment sessions and I just did not, I didn't really feel like talking. Um, but I got, I got through it. Um, yeah, my mental health affected like my ability to pay attention, um, my ability to get there on time.* (Holly, Leaver, Inbound STEM with Unclear Research Trajectory)
- *Towards the end of that year um my mental health was kind of on a decline. And when I finally did make that decision, like I had basically had like this whole meltdown over like the weekend before if I made the final decision of whether or not I was going. To stay or leave. (*Jamie, Leaver, Inbound STEM Non-Research)
- *I was experiencing a lot of anxiety during that time. Um, and it was really hard to reach out about that because I didn't, it was so fresh at the time that I didn't know how to talk about it. And so it made it where a lot of times I, I couldn't share what I should have shared at the time, you know, like when I was having a difficult time or when I needed help*. (Sofia, Completer, Inbound STEM Research)
- *My mental health [impacted me] a few times, yeah. I think there are definitely times where I was feeling really burnt out, um, and pretty unmotivated and just like unsure about my* next step (Maria, Completer, Inbound STEM Research)