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Adopting a Multi-Systems Approach: Examining the Academic Belongingness of First-Generation College Students With Multiple Stigmatized Identities in STEM

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Abstract

First-generation college students often experience greater social alienation and marginalization due to a mismatch of their cultural values compared to those of their university and often report lower academic satisfaction and sense of belonging . The effects on sense of belonging and satisfaction are intensified when first-generation college students have identities that intersect with other stigmatized social and cultural identities, like low socioeconomic status, Black or Latinx racial identities or religious identities, specifically for STEM majors. Students' holistic health and well-being, including their sense of belonging, is highly correlated to their academic achievement, persistence, and overall student success, especially for underrepresented minority groups. However, there has been limited consideration for the nuanced experiences of first-generation college students with multiple stigmatized identities, and for how the academic STEM environment shapes student's perceptions of inclusivity in light of their social identities. To address these concerns, this study used the Bioecological Systems theory to contextualize drivers of sense of belonging for students with stigmatized social and cultural identities by allowing space to explicitly consider institutional, departmental, classroom and societal-level phenomena that may operate to erode or fortify belonging for some individuals over others. Findings were organized contextually first revealing how broader societal and familial values that shaped their perceptions of their first-generation identity. Next, we reported how various forms of engagement and interactions with institutional agents impacted their perceptions of support at the institutional level. We then documented behavioral patterns within STEM departments that culminated to reveal how first-generation college students' sense of belonging was impacted by perceived departmental culture. Last, we revealed interactions within STEM classrooms that signaled inclusivity through humanizing and intentional pedagogical practices. Infused throughout all findings are instances where student experiences were mediated through their multiple identities and were shaped by dual global pandemics of 2020, that being COVID-19 and the racial unrest resurfaced by the murder of George Floyd. Implications for this work has the potential to restructure how institutions provide support for first-generation college students given the salience of their intersecting stigmatized identities in shaping their institutional, disciplinary, and classroom belonging.

1 Introduction

First-generation college students (FGCSs), students whose parents did not attend or graduate college, make up over one-third of the undergraduate student population in the United States (RTI International, 2019; Dika, & D'Amico, 2016). However, only 19.5% of science, technology, engineering, and mathematics (STEM) students identify as FGCS, indicating a disparity in accessibility and support for FGCSs in STEM (Eagan et al., 2014; Peña et al., 2022). FGCSs are less likely to enter college, and once enrolled are less likely to persist and earn a degree relative to continuing-generation students (Chang et al., 2011; Horowitz, 2019; Harackiewicz et al., 2014; McCallen, & Johnson, 2020). Additionally, FGCSs are more likely to have overlap with social and demographic factors that limit college success relative to continuing generation peers, such as working full-time, delaying enrollment in postsecondary education, attending college part time, commuting to college, as well as being financially independent from their family or supporting dependents (Lohfink & Paulson 2005; Engle 2007; Greene et al., 2008; McCallen & Johnson, 2020). FGCSs often experience greater social alienation and marginalization due to a mismatch of their cultural values compared to those of their university (Carrigan et al., 2019; Stephens et al., 2012) and often report lower academic satisfaction and sense of belonging (McCallen, & Johnson, 2020). The effects on sense of belonging and satisfaction are intensified when FGCSs have identities that intersect with other stigmatized social and cultural identities, like low socioeconomic status (Engle & Tinto 2008; Redford & Hoyer 2017), Black or Latinx racial identities (Adelman 2005; Johnson et al 2007; McCallen, & Johnson, 2020) or religious identities, specifically for STEM majors (Avraamidou, 2020; Barnes et al., 2017, 2020).

Investigations on FGCSs have focused upon preparation and demographics (Choy 2001; Bui 2002; Atherton 2014), transitions to college (Ricks & Warren 2021), and attainment and persistence (Garrison & Gardner 2012; Forrest Cataldi et al., 2018), however, much of these conclusions have centered around addressing the 'deficiencies' of FGCSs to fit into systems that are predominantly normed by white, Christian, heterosexual, cisgender, middle-upper class, men (Johnson 2022). While often viewed through the deficit lens, Garrison and Gardner (2012) identified several internal strengths of FGCSs that relate to their ability to learn and persist, including their motivation, resourcefulness, and ability to identify and repeatedly seek support from key institutional agents and their ability to overcome obstacles (Thrasher 2016; Whitley et al. 2018; Ricks & Warren 2021). Campus environments and departmental culture can reinforce these strengths facilitating FGCSs experiences and academic performance (Jehangir et al. 2012; Museus et al. 2017; Museus & Chang 2021) or can work to erode their academic performance and belonging (Stephens et al. 2012a, 2012b). Addressing the need to shift FGCS scholarship away from deficit-based perspectives, this study draws attention to factors within the STEM learning environment that shape FGCSs' sense of academic belonging, rather than what FGCSs lack that hinder them from *fitting* into academic STEM.

We choose to focus on factors that impact FGCSs sense of belonging given the volume of empirical evidence that demonstrate students' holistic health and well-being, including their sense of belonging, is highly correlated to their academic achievement, persistence, and overall student success, especially for underrepresented minority groups (Alavi Tabrizi, 2020; Gopalan & Brady, 2020; Johnson 2020; Strayhorn, 2012, 2022; Tinto 1997). Studies have documented that belonging varies across institutional context and student identities, however, our nuanced understanding of how belonging is contextualized within the university setting is limited (Gopalan & Brady, 2020). We know that belonging is not experienced equitably across all students' social and cultural identities

(Johnson 2022). For example, students with stigmatized social and cultural identities experience higher rates of belonging uncertainty (Walton & Cohen 2007) and feeling unsure about their ability to 'fit-in' academic communities, impacting persistence (Smith et al. 2013; Thorman et al. 2014). Additionally, the fear of confirming negative stereotypes of a group the student belongs to and external cues, such as low representation may further shape belonging for students with stigmatized identities (Murphy et al. 2007; Rainey et al. 2018). While classrooms may serve as the central environment for students' social and academic identities to meet (Tinto 1997), multiple contexts, such as disciplinary departments, institutional environments, and the broader society play an important role in shaping students' sense of belonging and persistence (Karp 2011; Strayhorn 2012) and must be considered.

A socio-ecological perspective, such as Bronfenbrenner's Bioecological Systems Theory (1979; 1989), provides a broader lens to contextualize drivers of sense of belonging for students with stigmatized social and cultural identities by allowing space to explicitly consider organization, institutional, and societal-level phenomena that may operate to erode or fortify belonging for some individuals over others (Allen & Bowles 2012; Johnson 2022; Zaatari & Maalouf 2022). Within this study, we use the bioecological systems theory to rethink policies, procedures, and practices at institutional, departmental, and classroom levels that shape student perceptions of inclusion and belonging. This is a critical paradigm shift that may improve equity and inclusion efforts for students with stigmatized identities, like FGCSs.

Adding an additional challenge for FGCSs transition to college and sense of belonging over the last several years has been the ongoing COVID-19 global pandemic. Students across the globe reported higher deterioration of mental health and reduced sense of belonging as college courses transitioned to virtual formats, campus organizations and clubs were forced to postpone in-person meetings, and students navigated college from home (Son et al. 2020; Ramlo 2021; Lederer et al. 2020). Overlapping with the COVID-19 global pandemic was the cultural trauma associated with the murder of George Floyd and escalation of discussion on systemic racism, social justice, and power dynamics within social institutions (Stack 2021). The impact of these events has undoubtedly shaped college student perceptions of in-class experiences, departmental interactions, and institutional culture. Our investigation interviewed students primarily during the Spring and Fall of 2021, so it is important to contextualize our research findings through the lens of this dueling pandemic chronosystem.

2 Theoretical and Empirical Underpinnings

In this study, we used three theoretical constructs to guide our research on FGCS in STEM; sense of academic belonging, the intersection of multiple stigmatized identities, and Bronfenbrenner's bioecological systems theory. We layered characteristics from each construct to provide a unique perspective to provide some contextualization to the complexity involved in shaping belongingness for FGCS in STEM. We first took into consideration the salience of multiple stigmatized identities in shaping FGCSs sense of belonging in academic STEM. We then contextualize the experiences of FGCSs by considering how their sense of belonging is impacted by interactions within and between five socio-ecological environments or systems. Below we provide brief discussions of how each theoretical perspective supports the rationale and aims of this study as well as a synthesis of related literature.

2.1 *Sense of Institutional and Disciplinary Belonging of FGCS in STEM*-

The concept of sense of belonging has been described as a fundamental human motivation or a basic human need (Baumeister and Leary 1995; Maslow 1943; Pickett, Gardner, & Knowles, 2004; Twenge, Baumeister, Tice, & Stucke, 2001) and commonly defined as the extent to which students feel connected to their academic institution and the people within those institutions (Gillen-O'Neel, 2019; Strayhorn, 2018). The *need* or *motivation* to belong naturally leads to discussions about the context in which an individual desires to belong. Within an academic domain, a sense of belonging consists of feeling that one fits in, belongs to, or is a member of an academic community, in which they feel valued and accepted by fellow members (Good et al., 2012). Institutional and disciplinary communities within academia ascribe to a common set of practices, norms and values that characterize the communities' culture to outside individuals and membership often requires alignment of one's behaviors and values within the culture of the community. However, recent scholarship questions the ability for American universities and academic STEM to provide equitable opportunities to all deserving students, upholding cultural norms rooted in ideologies of historically white and masculine perspectives such as individualism, meritocracy and competition (Martinez, 2020; McGee, 2016; Stephens, et al., 2012A; Stephens, et al., 2012B; Verdin & Godwin, 2015). The STEM culture that students aspire to belong in exchange for social mobility, arguably recreates inequalities amongst groups based on access and equity that may limit the participation of marginalized groups (Stephens et al., 2012; Verdin & Godwin, 2015). Therefore, examining a sense of belonging primarily from the perspective of how a student *fits* into the current culture of academic STEM is problematic without critical inquiry into the characteristics of the learning environment.

We propose that a broader lens be used to examine FGCSs' sense of belonging in academic STEM, given that sense of belonging acts as both a trait that varies from person to person and a state that varies from day to day depending on environmental context (Gillen-O'Neel, 2019; Park et al. 2012). Measures of sense of belonging have been compared across multiple levels within academic STEM, yet few studies take into account how belonging may fluctuate among different student groups, like FGCSs. For example, Wilson and colleagues (2015) examined the relationship across the STEM classroom, STEM major and university setting and found that class-level belonging was consistently linked to behavioral and emotional engagement across institution and major.. However, Wilson et al. (2015), along with other studies, admitted limitations in failing to account for student social identities, such as race/ethnicity, when contextualizing sense of belonging (reviewed in Nguyen & Nguyen, 2018). FGCSs enact multiple aspects of their personal, cultural, and social identities as they navigate postsecondary environments (Orbe, 2004, 2008; Ellis et al. 2019; Garriot et al. 2021), however, studies that provide valuable insight into intersectional experiences of FGCS in STEM often focus specifically on classroom belonging (Freeman et al. 2007; Booker 2016; Henning et al. 2020) or U.S. academic institutions at large (Ellis et al. 2019; Garriot et al. 2021). Therefore, expanding the vantage point to consider how student identity negotiations fluctuate between and among multiple academic systems serves to fill a gap in our empirical understanding of FGCS experiences in academic STEM.

2.2 *A Multi-systems Approach to Sense of Belonging in STEM*

To contextualize the experiences of FGCSs with multiple social identities, we used the Bioecological Systems theory (Bronfenbrenner 1979) to frame how FGCSs academic belonging shapes and is shaped by a series of complex multi-level interactions. Bronfenbrenner's Bioecological Systems Theory (1979; 1989) posits that interactions among an individual (self) within nested social microsystems, mesosystems, exosystems, and macrosystems shape human development through

time. The microsystem is often described as "a pattern of activities, roles, and interpersonal relations experienced by the developing person in a setting with particular physical, social, and symbolic features that invite, permit, or inhibit engagement" (Bronfenbrenner, 1994, p. 39) and in the case of our investigation, a STEM classroom. The mesosystem includes connections among two or more interacting microsystems where an individual can play an active role, like a STEM department or academic unit. The exosystem often includes connections among different social settings including familial social networks, in which experiences of the individual have indirect influences on perceptions of the microsystem (Bronfenbrenner 1979). Our exosystem includes the multitude of social environments occurring at an academic institution (academic courses, research laboratories, extracurricular activities, greek life, athletic events, etc.). The macrosystem includes cultural, subculture, and societal norms that influence and define all subsequent systems. Finally, culture and societal norms evolve through time, so it is critical to contextualize interactions within the time period they have occurred, represented as the chronosystem. We provide a visual representation of how we conceptualized the interactions among FGCSs within STEM classrooms (microsystem), within STEM departments (mesosystem), across the institution (exosystem), embedded within societal norms, values, and ideologies (macrosystem) and that have occurred within the dual pandemics of 2020 and 2021 (chronosystem) in Figure 1.

2.3 *Intersecting Stigmatized Identities of FGCSs*

There is a myriad of other intersecting identities associated with FGCSs that adds additional dimensions to how they navigate postsecondary STEM environments as well as how institutions provide support for these students (Whitley et al., 2018). FGCSs may come from low-income backgrounds, historically-excluded populations, rural communities or may be older than their peers. It is estimated that 21% of the FGCS population identifies as low-income or Pell grant eligible , 27% of Latinx/Hispanic students are FGCSs, 14% of all FGCSs are Black or African American, and 20% are English as second language learners (Whitley et al., 2018). Institutional initiatives aimed at supporting the needs of FGCSs often focus on resource awareness and student engagement, factors historically identified as helpful in the promotion of student success. However, few initiatives take into consideration the salient experiences of FGCSs multiple identities that are considered stigmatized in STEM and how these experiences and interactions shape academic progression. In this light, our work examined the unique experiences of FGCSs holding multiple social identities that are historically underrepresented in STEM (i.e., race/ethnicity, gender, religious, lower social class) and how their experiences shaped their sense of institutional and disciplinary belongingness, STEM identity, and perceptions of institutional inclusivity.

3 Research Questions

RQ1: How do social, cultural, and familial backgrounds shape perceptions and motivations of FGCSs navigating STEM academic spaces?

RQ2: How do STEM FGCSs experiences shape their perceptions of institutional support and belonging?

RQ3: How do FGCSs experiences in STEM shape their perceptions of departmental culture?

RQ4: How do the experiences in STEM classrooms shape FGCSs perceptions of inclusivity?

4 Materials and Methods

4.1 Participation Recruitment and Context

Our initial participant sample included 586 undergraduate students enrolled across STEM majors at the University of South Alabama, a public, R2 research institution in Mobile, Alabama. We follow the definition of STEM majors following National Science Foundation (2022) guidelines which includes traditional life sciences, mathematics, engineering, agricultural, biomedical, and nursing fields as well as social sciences like psychology and sociology. During the Spring and Fall of 2021, we invited students to participate in our research via direct emails to all STEM majors sent through our Office of Student Success as well as emailing administrative assistants in each department to forward our survey recruitment email to all their majors. We hand curated our data to isolate any students that participated in the survey across multiple semesters and in those instances, we always chose to include data from the student's initial survey submission. Student participation in the study was completely voluntary and no monetary or class incentives were provided. The survey was emailed to 10,685 students in Spring 2021 and 10,506 students in Fall 2021 for a response rate of ~2.8% and took the average student 18.7 minutes to complete. Survey items and methodology were granted an exemption from full review by the University of South Alabama IRB, # 1544421-1 to J.A.H.

The student body of the University of South Alabama consists of 63% White, 20.6% African American/Black, 4.1% Latinx/Hispanic, and 3.7% Asian/Asian American students (Table 1); and consists of 67% female students, 32% male, and ~1% gender expressive students (University of South Alabama Institutional Research, 2021). Our pool of STEM students included a large number of Biology (229 students), Biomedical Sciences (90 students), Engineering (79 students), Computer Sciences (44 students), Nursing (36 students), Psychology (26 students), Health and Kinesiology (21 students), Earth Sciences (10 students), Chemistry (9 students), Mathematics & Statistics (9 students), with only a few students representing other STEM majors. Additionally, our student population reflected a broad array of student experiences at the university including 99 Freshman, 125 Sophomores, 203 Juniors, and 159 Seniors.

4.2 Data Collection

4.2.1 Quantitative Study Design and Questionnaire Development

Students enrolled in STEM majors were emailed a link to the Qualtrics survey as part of a larger data collection to measure student perceptions of their learning environments and how those perceptions were shaped by their visible and hidden social and cultural identities. The full survey consisted of questions to understand which majors students were enrolled in, questions to understand how their hidden and visible identities shaped their in-class experiences (Henning et al. 2020), academic belongingness (Good, Rattan & Dweck 2012), science process confidence (Robnett et al. 2015), intrinsic motivation (Pintrich 1993), perceived stereotype threat (Pincho & Brown 2011), science career commitment (Chemers et al. 2011), science interest (Pintrich 1993), science identity (McDonald et al. 2019), Deep/Surface Learning Strategies (Chiou, Liang, & Tsai 2012), as well as demographic information. Additionally, the final question provided a space for students to voluntarily include an email address if they were interested in a follow-up interview to expand on their experiences in STEM, in which students would receive a $50 USD gift card. The full survey can be found in Appendix 1.

We chose to focus on the experiences of FGCSs at the University of South Alabama for several reasons. First, the University of South Alabama has a proportion of FGCS that is similar to the national average of ~33% (RTI International, 2019), ~30% (171 of 586) of students self-reported

as FGCSs. Additionally, from this preliminary analysis of quantitative assessment of undergraduate experiences, we found the FGCSs reported stronger feelings of importance of their STEM majors ($F_{1,584}$ = 9.704, p = 0.002), which includes questions like: Doing well in STEM matters to me, STEM is important to me, Being good at STEM will be useful to me, My STEM abilities are important to my academic success, I value STEM, and Doing well in STEM is critical to my future success which were modified from Pincho and Brown (2011). To gain a deeper understanding of the experiences of FGCSs, we invited all the students that identified as FGCSs to conduct a zoom interview and ended with 28 participants in total. Participants represented a variety of classifications, and STEM majors, with the majority of the participants being Juniors (n=14) and/or biology majors (n = 12). Selected demographic variables are depicted in Table 1. Pseudonyms were used to protect the identity of the students.

4.2.2 Interview

We conducted semi-structured interviews with 28 participants to elicit their undergraduate STEM experiences and how these experiences have shaped their perceptions of institutional and disciplinary inclusivity. Prior to the interviews, participants were asked to respond to eight pre-interview reflection questions, collected via a secure survey administration software. Pre-interview questions were provided at least a week in advance to ensure students had adequate time to reflect on their experiences. Participants were asked to reflect on their classroom comfort levels considering their multiple identities and various STEM courses. Participants were also asked to provide an example of *when they felt particularly comfortable and/or uncomfortable in one of their STEM major classes*?, *to indicate which identities they were most aware of during their major STEM classes* (Table 1), and *to describe an experience in which they were made most aware of their selected identities*, if applicable. Reflection responses were used to individualize each interview and referenced throughout the interview. Pre-interview reflection questions and semi-structured interview script can be found in Appendix 2.

Each interview was conducted via a video conferencing software and lasted, on average, an hour. This virtual platform allowed students the option of turning off their cameras to increase comfort in discussing sensitive topics. We developed interview questions from an ecological systems perspective for how students' sense of belonging was impacted at an institutional, departmental, and classroom level (Bronfenbrenner 1979). For example, at the institutional level students were asked to describe experiences that either made them feel like a valued (or not valued) member of the community. At the departmental level, students were asked such questions as, *can you describe how it feels to be a part of your major department?* At the classroom level, students were asked questions about their comfort level similar to the pre-interview questions. In addition, to gain a deeper understanding of how various interactions between systems impacted students' sense of belonging considering their multiple identities, we included questions such as, *have any of your college STEM instructors ever said or done something that made them seem like they are purposely inclusive of (student's self described identity) or students from diverse backgrounds*? Lastly, we arranged questions to explore how student's unique intersecting identities and backgrounds shaped their perceptions of inclusivity by asking such questions as, *how, if at all, has being a first-generation college student influenced your experiences in the STEM community*? Students had an opportunity to express how each of their identities (e.g. race/ethnicity, gender, religious, social class, political, etc..) shaped their experience within the STEM community, by expanding on their pre-interview reflection responses. All interviews were audio-recorded and conducted by a single researcher (A.N.G.) to ensure consistency across interviews.

4.3 Data Analysis

4.3.1 Interview Analysis

We used inductive content analysis to find themes among interview responses (Cho & Lee, 2014; Krippendorff, 2018). For RQ1, we first used an *in vivo* coding approach to prioritize and honor the participant's voice by using terms and concepts drawn from the words of the participants themselves (Saldaña, 2021; Stringer, 2014). This coding method is often used when describing the nature of participants' realities particularly when desiring to illuminate experiences of vulnerable populations, such as those often stigmatized in STEM (e.g., first-generation college students, students of color, women, and religious students). We extracted short quotes from participants' transcripts that captured FGCS's perceptions and motivations as they navigated STEM academic spaces given their unique social, cultural and familial backgrounds. Next, we used the *inVivo* codes to develop themes.

For RQ2-4, we organized our analysis according to the ecological systems theory, inductively identifying factors that impacted FGCSs' sense of belonging within the context of their institution(exosystem), STEM department (mesosystem), and STEM classroom (microsystem). The construct of sense of belonging was conceptualized as comfort levels, perceptions of inclusivity, and overall student support. Therefore, emergent codes capturing FGCSs' experiences when they felt most comfortable/uncomfortable, included/excluded, or supported/unsupported within their STEM environment were arranged first by system (e.g., micro-, meso-, exo-) and next into clusters of codes accordingly. Emergent codes were condensed to form overarching themes that cultivate or hinder FGCSs' sense of belonging in academic STEM environments (Table 2).

Each interview was transcribed immediately after completion by a team of undergraduate researchers (G. S. and Z. M). To answer RQ1, one researcher (A.N.G.) conducted an *inVivo* analysis on relevant sections of each transcript. *InVivo* codes were then shared with another researcher (J.A.H.) and discussed in support of further analyses. Both researchers (A.N.G. and J.A.H.) met regularly to discuss patterns that derived from *inVivo* codes and until both researchers agreed on emergent themes. To answer RQ2-4, each transcript was reviewed independently by four researchers for preliminary themes (A.N.G., G. S., Z. M. and J.A.H.). Each researcher read and took detailed notes independently for three transcripts and then all four researchers met to compare the themes each researcher identified. Constant comparison methods were used to categorize quotes into each theme and ensure that each quote matched the theme description (Glaser & Strauss, 1967; Glesne & Peshkin, 1992). Themes were combined when similar and new themes were created if quotes were too dissimilar. Descriptions of the themes were discussed and revised among the four researchers and arranged with preliminary themes into a preliminary coding rubric. The first four interviews were coded with the rubric by all four researchers independently. All four researchers met to compare codes and to document agreement on if the codes were present or absent within each participant interview. Modifications were made to preliminary coding rubric based on discussion from this meeting. For the remaining interviews, at least two out of the four researchers used the newly modified coding rubric to code the transcripts independently. The two or more researchers met to compare codes and to determine agreement. If there was disagreement, a third researcher from the team would settle the disagreement by independently reviewing the quotes in question. The final coding rubric can be found in the Supplementary Materials. Finally, we calculated the frequency of each theme across the transcripts to determine prevalence of each theme and only included themes in our final coding rubric that were reported by at least five students (Table 2). Additionally, we disaggregated our coding frequencies across dimensions of race and gender (Table 3). Quotes have been lightly edited for clarity and to protect any potentially identifying information about the students

or their instructors. All specific department and course names were omitted and replaced with either *STEM department* or *STEM course* for anonymity purposes. All interview questions can be found in the Supplementary Materials.

5 Trustworthiness

Trustworthiness was established through triangulation of multiple data sources (e.g., survey, pre-interview questionnaire, and interview), peer debriefing, and negative case analysis (Carpecken, 1996; Lincoln & Guba, 1986; Marshall & Rossman, 2011; Merriam, 2009). We triangulated the data by conducting multiple levels of analysis. For example, survey responses measuring students' sense of belonging and STEM identity formation were used to support participant selection and interview responses. To minimize bias during the analysis process, we had multiple researchers code independently, which was thoroughly discussed and negotiated to agreement, what Lincoln & Guba (1985) refer to as peer debriefing. Last, we conducted additional analysis of the discrepant data (negative case analysis), to verify that excluded data did not fit with emergent themes. Although generalizability was not the goal of this study, we provided rich descriptions of the participants' experiences and study context to allow for individual comparisons and potential transfer of findings.

6 Researcher's Positionality

Statements of positionality are critical to uncovering how the researcher situates *self* in relation to the phenomenon under study and require acknowledgment of known presuppositions, biases, and identities they may carry with them into the research process (Espino, 2014; Moustakas, 1994; Van Manen, 1990). With this understanding, we recognize that our team of four researchers consisting of two faculty members and two undergraduate researchers, hold unique intersecting identities of race/ethnicity, gender, and first-generation status. All four authors were involved in the data analysis process, and the first author conducted all interviews.

The first author identifies as an African American female whose scholarship focuses on the experiences of students with identities traditionally stigmatized in STEM education, specifically students of color. Both of her parents obtained college degrees and fully supported her academic journey in biology education. She often reflected on personal racialized and gendered experiences throughout her formal science education that mirrored that of some participants, both positive and negative. With the full understanding that no two individuals' experiences are identical, she remained attentive to the lived experiences of the participants during data analysis and ensured that multiple researchers agreed on the interpretation of students' narratives.

The second author identifies as a Black woman, first generation immigrant, first generation student, and an undergraduate student in STEM at the time of the data analysis. It was important to reflect on and acknowledge her own experiences at the University prior to getting started with data analysis so she wouldn't allow bias, good and bad, to get in the way of other's stories whether they were similar or not similar to her own lived experience. Also, as an involved student who interacted with other undergraduates, she often heard students speak of their level of connection to their university and major and thus had to keep others' lived experiences separate from those participating in this study.

The third author identifies as a gay, Latino man who has previously held other marginalized identities, such as those of his religion and low socioeconomic status. As an undergraduate student in STEM, he feels that these identities led him to feel a low sense of belonging in the classroom, campus, and community level during his freshman year. As his education and involvement increased,

he slowly gained a sense of community. These identities and experiences may have potentially influenced his analysis of data through emotions and/or biases. He had to consciously minimize subjectivity so that negative experiences with white peers or faculty did not impact his analyses of data involving white students, or students holding non marginalized identities.

The fourth author identifies as a white male whose scholarship focuses on student perceptions of STEM learning environments and advocating for evidence-based teaching practices that support cultural shifts in the traditional STEM space. He identifies as a FGCS and it was critical for him to reflect on his own experiences as a student, instructor, and mentor, during the data analysis phase to separate his past experiences from participant narratives to not bias data interpretation. However, he focused on allowing participants' narratives to shape the story in hopes this manuscript helps drive change of STEM spaces at this university and beyond.

7 Results

Across multiple contexts, FGCSs shared experiences that shaped their overall sense of belonging in academic STEM spaces. Their experiences were organized contextually first revealing how broader societal and familial values within the macrosystem shaped their perceptions of their first-generation identity. Next, we reported how various forms of engagement and interactions with institutional agents impacted their perceptions of support at the institutional level. We then documented behavioral patterns within STEM departments that culminated to reveal how FGCSs' sense of belonging was impacted by perceived departmental culture. Last, we revealed interactions within STEM classrooms that signaled inclusivity through humanizing and intentional pedagogical practices. Infused throughout all findings are instances where student experiences were mediated through their multiple identities and were shaped by the chronosystem. Figure 2 is a visual representation of how each system within the ecological landscape of academic STEM interacts to shape and is shaped by the experiences of FGCSs, that is marked by twelve emergent themes for reference. All reported themes and frequencies can be found in Tables 2 & 3.

7.1 RQ1: How do social, cultural, and familial backgrounds shape perceptions and motivations of FGCS navigating STEM academic spaces?

7.1.1 "*it's not a handicap to me, it's a personal drive*"- (Jada, a FGCS in STEM)- Students work to shift social stigmas associated with first-generation identity.

FGCSs often absorbed narratives from the border society that stigmatized their first-generation identity as lacking the social, navigational, and family capital commonly associated with academic success, which put into question if they belonged in academic STEM. However, societal stigmas were often transformed into personal motivation when coupled with familial and individual aspirations of social mobility. Family played perhaps the most important role in shaping students' first-generation identity and their motivation to persist in academic STEM. Students viewed their enrollment in college as an opportunity that their parents did not have, rather than an obligation. For example, Kelly "*had immigrant parents that did not get the opportunity to go to college"* and Vanessa was "*grateful to have the opportunities*" to go to college yet did not receive any pressure from her parents to attend college. Students like Ryan recognized that his parents, who also moved to the U.S., did "*back breaking work*" to afford him the opportunity to *"do something that [he] enjoys for the rest of our life*". This perspective of gratitude towards being the first in their family to attend college, fueled students' drive to succeed in college. Academic success was associated with social mobility and financial independence. Narratives from their family and society at large, linked college

success with life success, in that students expected to obtain financial stability through an interesting career path. For example, Kelly, a Vietnamese-American most aware of her racial/ethnic and social class identities in academic STEM, spoke of how her parents and cultural community expected life successes from those who obtained a college degree.

> *"They [her parents] think if you have a degree that you're more respected in the community. Especially like in the Middle Eastern community. A lot of people expect you to go to college and do something and be successful."* (Kelly, FGCS undergraduate student)

Kelly, like other FGCS, carried the expectations of her family in her persistence to succeed in college. Parental expectations not only impacted FGCSs' decision to obtain a college degree, but it also influenced their perceptions of STEM-related careers. At the intersection of their ethnic culture and FGCS identity, students were encouraged to pursue a STEM degree to ensure financial independence. For example, Faith, an American student born in Africa, revealed the career hierarchy African parents stereotypically pass down to their children pursuing college degrees. Faith expressed that *"there's a stereotype within the African community where typically your child has like two options, either a doctor or a lawyer".* Fortunately, Faith's passions for becoming a doctor aligned with her parents' expectations. In contrast, June, an Asian American, expressed that her parents "*push [her and her siblings]to go into the medical field, more than anything else". June* admitted that "*it can be stressful because I'm choosing a career that's not really [my] dream, but I'm willing to do so to help my future.* Kelly knew that going to medical school was not her dream, but parental influence shaped her perceptions that a STEM degree will help her more in the future. Overall, students revealed that their personal drive to attend and persist in academic STEM is often shaped by familial expectations and societal values of higher education. However, students' perceptions of their familial and cultural background also worked to shift how others viewed their persistence in STEM.

FGCSs' like Jada (a very religious, Black woman), viewed their first-generation identity as a *personal drive* and not a *handicap*, signaling that their background equipped them with unique tools to navigate the space of academic STEM. Students' backgrounds often required them to operate with independence, as they were primarily responsible for their financial support, locating resources, and for some, supporting a family. For example, Faith reported that she has "*the responsibility of paying for school"* herself because her "*parents are not able to financially support"* her through college. She also highlighted that this responsibility drove her to create "*a little excel sheet trying to figure that [financial] stuff out",* and to search university *websites* for funding opportunities. Likewise, Faith knew that as a FGCS from a low economic background, she would have to take on additional responsibilities that perhaps her continuing-generation counterparts did not have to face. Thus, her personal drive to succeed manifested in her independently seeking out the resources to meet her needs. Students often held the mentality that they "*don't have time to fail"* (Jada), given their first-generation identity and thus personally took on the responsibility of ensuring their academic success, despite financial, family, or personal obligations.

7.1.2 **"*It is all (being a FGCS) overshadowed because I am a black male*"-(David)- Recognizing the salience of other stigmatized identities for FGCS in academic STEM.**

In the consideration of students' multiple stigmatized identities, we found that students' first-generation identity was not always most salient within their academic STEM space. In fact, only 36% of FGCS students reported that they were most aware of their first-generation identity within their STEM community. When interacting with peers and faculty in STEM 61% of FGCS revealed that they are most aware of their race/ethnic identities followed by social class (46%), non-traditional

status (32%), gender (29%) and religious affiliations (29%). See Table 1 for detailed results. These interactions took place in multiple settings such as STEM classrooms, instructors' office hours, departmental gatherings. Students described that their heightened awareness of these identities resulted from moments of stigmatization, discomfort, isolation, disagreement, and or heighten visibility. Students often spoke of their first-generation identity as a concealable stigmatized identity that sometimes held internal significance. For example, when asked how their first-generation identity impacts their academic STEM experiences, some students reported that "*it [first-generation status] doesn't really come up"* (Vanessa) and Mary added that "*the only time that I'm reminded of first-generation status is if I'm applying for a scholarship".* However, when asked if any of their other identities impacted their experiences in academic STEM, students spoke of racialized, gendered, class and non-traditional experiences that accompanied their internal awareness of their first-generation status. For example, David expressed that, *"it is all (being a FGCS) overshadowed because I am a black male***",** as he recalled his experiences navigating academic STEM. David is a non-traditional student who supports his spouse and children while pursuing his degree. It took David over 8 years to complete his undergraduate STEM degree and he attributed most of his struggles to biases on the part of advisors and faculty towards his identity as a Black male. David's journey in academic STEM is unpacked more in sections to follow. Similarly, Amala reported that at the intersection of her nationality, race/ethnicity, and religious identity she feels like "*I'm not welcome in my own country, sometimes*". Amala identifies as a biracial, American Muslim that wears a hijab. Societal bias towards Middle Eastern Muslims in America coupled with societal pressure to fit into one socially acceptable race category, either Black or White, pushed Amala to fade into the background of her classes when political, religious, or racial topics were referenced. In class Amala said she felt "*extremely self-conscious"* and the "*majority of the time stayed out of [the conversation]".* Amala, like other FGCSs, were hyper aware of multiple identities that have been stigmatized in society and/or the STEM community, and this awareness impacted their comfort and engagement levels in STEM academic spaces, and ultimately their sense of belonging.

7.2 RQ2: How do STEM FGCSs' experiences shape their perceptions of institutional support and belonging?

7.2.1 Students' institutional belonging is greatly impacted by intentional, passive and/or selective engagement

At the institutional level, campus engagement whether it be intentional (direct emails about events), passive (genuine community friendliness), or selective (only certain information made transparent by administration) greatly shaped how FGCS perceived themselves as a member of their university community. Students representing a diverse array of identities interpreted intentional efforts by their institution (71.43%) to engage the general student population as an indicator that they belonged and were welcomed members of the community. For example, Claire, a White, female student from an upper-class economic background, recalled being invited to social, academic and student wellness events that made her feel welcomed. Likewise, Jade, a very religious, Black female student, "*got an email and a text"* about an academic coach program her freshman year that planted a seed for when she later needed academic help. Robert, a student Veteran, who commutes to campus had this to say when asked if anything made him feel like a valued member of the university community.

> *"The emails that go out are very inclusive and want you to come out and participate in things that are going on at [the university]. It makes me feel included and makes me feel part of the culture, even when I'm not really present."* (Robert, FGCS undergraduate student)

Robert, like many non-traditional students lived off-campus and depended on intentional university communication to stay connected and feel like they belonged. Students also described their university as a genuinely friendly environment that made a medium-sized institution feel like a small, connected community. Students described faculty, staff and peers "*speaking and waving whenever on campus" (Aubree) and* emphasized that *"You never see a stranger on campus most of the time walking around" (Bethany).* Even in the aftermath of strict social isolation due to the COVID-19 pandemic, students like Jade's felt cared for when random members of the university community engaged in conversation with her or showed genuine concern for her well-being.

Despite the board sense of community, 18% FGCSs with multiple stigmatized identities felt devalued, unwelcomed, or silenced when campus administration limited communications surrounding the termination of academic programs (Bethany), additional financial obligations (Jasmine), or racially charged events (Kimberly, Rose, and Kelly). For example, after two years working towards a specific health program, Bethany was told in an email that the program was shutting down, therefore she needed to choose another major pathway. Below, Bethany described her frustrations with what she referred to as unprofessional university-level communications.

> *"We were basically sent an email after I spent all this time working to apply for this, saying, 'hey sorry we don't have this anymore, transfer'. And so, I just felt like at that point, like my entire world came crumbling down because, this is my plan, this is what I was going to do. I just thought that was handled very unprofessionally."* (Bethany, FGCS undergraduate student)

Bethany eventually found another STEM path that suited her passions however, in the process Bethany expressed that she was "*mentally not in a great place"* and experienced a *panic attack* as a result. Likewise, Rose vividly recalled two racialized experiences that occurred on campus geared towards African Americans. As an African American student, Rose felt that the university was slow to respond to what Troug et al., (2016) defined as observed racism or instances where individuals experienced indirect racism by hearing stories or seeing racism directly, which invoke negative emotions and psychological reactions from that individual. [Note that the description of these racialized events will be general to maintain anonymity of participants and other university members involved]. Rose described one event from years prior meant to threaten and invoke negative emotions among the African American student population. After several reports made by students, it was never made completely clear to the students how these incidents were handled. Rose stated that, *"the campus just never straight up says, 'we don't tolerate this'".* Rose also recalled a more recent event that led to student protest in the wake of the George Floyd murder and racial unrest across the globe. Rose expressed that she along with other African American students felt unsupported by their institution. She commented that *"they still are dragging that case out so a lot of us are disappointed, but I wouldn't say surprised".* Overall, students associated a heightened sense of belonging with intentional campus engagement and genuine community friendliness, yet reported shifts in their belongingness when they felt devalued or unsupported by selective institutional communication.

7.2.2 Institutional agents shaped both positive and negative perceptions of institutional support.

Institutional agents (i.e., Faculty mentors, Academic Advisors, Program directors) are defined as people who have "status, authority, and control of resources in a hierarchical system" (McCallen, & Johnson, 2020), and thus have the capacity to build or erode FGCSs' sense of institutional belonging. In response to how their institution makes them feel like a valued or devalued member of the community, FGCSs (17.86%) described both positive and negative interactions with institutional agents that shaped their sense of belonging. Students like Faith and Sarah spoke of positive experiences with formal and informal advisors that helped them navigate college success as well as made them feel more connected to the university. Faith, expressed that her program director informally took on the role as her mentor and actively expanded her network of related professionals on campus and within the surrounding community. Sarah transferred to the targeted university in the midst of the COVID-19 pandemic, and credited her transfer recruiter with providing the encouragement, support and guidance needed for academic success, even while primarily interacting through virtual platforms. In contrast, other students felt devalued by key agents that they initially trusted for institutional support. For example, Nathan, a non-traditional student taking care of his spouse and child, had this to say when asked if he felt like a valued member of the university.

> ***"****The colleges are set up perfectly for people that come straight out of high school into college, and that's all they do is college, but for, and I know there's a lot of us out there that we're trying to come back to college to be better. I'm trying to do better for my son, it's not set up for us at all. Just the amount of workload and everything like that".* (Nathan, FGCS undergraduate student)

Nathan, like many non-traditional students with families, had to balance his academic workload with family obligations and felt devalued when he perceived that the institution did not take his concerns into consideration. He noted key instructors and advisors that he believed did not care about his non-academic responsibilities, thus he perceived the entire institution as a system designed to advantage young, single, non-working individuals.

7.2.3 Students' sense of belonging increased when their multiple/ intersecting identities were acknowledged and valued.

At the institutional level, students linked their sense of belonging to experiences that affirmed, acknowledged, and/ or valued their social identities. Although students mostly spoke of experiences connected to their racial/ ethnic identity, we acknowledge that other identities such as non-traditional, religious, class, and political identities were also salient and are discussed in other sections. As for their racial/ethnic identities, students felt connected to their institution when they visibly saw a diverse array of races and ethnicities across campus. Students like June, an Asian American woman, felt *very comfortable* with her university's diversity and ethnicity, and described the culture of the university to be *open minded,* when it came to speaking to and accepting racially diverse student populations. However, students consistently noted that their sense of value and connectedness to their institution increased over time and that their awareness of diversity related campus initiatives was heightened during periods of racial unrest in 2020 and 2021. For example, Gregory, a religious Black man, shared that he didn't really feel included until his senior year, which was the year he interviewed for this study. He felt that his university did make efforts towards

inclusivity, but he only recently became aware of these efforts. Likewise, Rose, an African American student, stated that she did not feel valued *until the past year* and stated:

> *"It's (the institutions' inclusion efforts) a bit reactionary, you know, how based on a lot of incidents that have happened on campus that administration has gone into this mode of diversity and inclusion. So, out of the woodworks are all these social justice scholarships and all these African American based scholarships, like the visibility and everything is now all of a sudden, but I would say during my first half of college, not so much".* (Rose, FGCS undergraduate student)

Rose did express feeling valued within her college community but admitted that the institutional efforts felt disingenuous and reactionary at times. Jasmine, a Hispanic student, also experienced a delay in feelings of value and connectedness toward her institution, given her diverse racial/ ethnic identity. Jasmine noticed the underrepresentation of the Hispanic community on campus and made it her mission to seek out opportunities to integrate her ethnicity. Later on in her academic journey, Jasmine was hired as a bilingual campus tour guide for incoming freshmen and she expressed that "*I was the person who complained about not having a person to speak Spanish during my tours on [campus] day and [now] I get to be that person to help others*". Jasmine found that once she sought ways to embrace her ethnicity on campus, she was supported by the university with identity-affirming opportunities.

7.3 RQ3: How do FGCSs experiences in STEM shape their perceptions of departmental culture?

We asked participants what it felt like to be a part of their STEM department and what experiences made them feel valued and/or not valued in that space. As we aim to authentically capture the voices and experiences of FGCSs'with multiple stigmatized identities, we acknowledge that student perceptions may only be shaped by one or two encounters with STEM faculty within their STEM department. However, it is worthy to note the significant impact one institutional agent (e.g., a professor, advisor, department head) can have on the trajectory of a students' academic journey and sense of belonging [see finding 7.2.2]. Therefore, we frame each instance through a critical lens to reveal behaviors and attitudes, such as *hidden expectation*s*, faculty concern, and explicit recognition,* that shaped their perceptions of their STEM department and ultimately impacted their sense of belonging in academic STEM.

7.3.1 Hidden expectations of what students should know creates elitist departmental culture

46% (13 of 28) of FGCSs spoke of hidden expectations within STEM departments that shaped their perceptions of what students *should know* at the undergraduate level or how they *should act* as a STEM student. These hidden expectations were established through experiences of dismissive and devaluing help seeking efforts (14 of 28) or explicit attitudes and behaviors such as displays of favoritism and intimidation from STEM faculty and peers (14 of 28). For example, Olivia, a politically liberal, member of the LGBT community, expressed how instructors' devaluing behavior towards student questions in-class and during office hours shaped feelings of intimidation and cultivated an exclusionary learning environment. Such devaluing behavior signaled that STEM students shouldn't ask questions or make mistakes, and therefore only the students who automatically understood the course material are worthy of being a STEM major. Below Olivia reflected on an intimidating experience in her STEM lab.

> "*In my [STEM] labs, I had a couple of professors that were very intimidating. I went in feeling like I knew what I was going to be doing, but then I feel like one of them in particular kind of overreacted whenever I almost made a simple mistake. I had asked him to double check how I was supposed to do it, because I hadn't made the mistake yet. It was kind of rude, he was like, "oh no, no, no, oh well I don't know why you would make that sort of mistake like this is very basic [STEM subject]," and I don't know it just it made me feel very uncomfortable at the moment".* (Olivia, FGCS undergraduate student)

Olivia goes on to describe how conflicted she was after her intimidating lab experience. She no longer felt comfortable asking questions in her STEM lab, which built a fear of being perceived as unintelligent. Like others, Olivia also witnessed her professor dismiss a female student question during a STEM lecture class. Olivia is currently a sophomore, however, all of these experiences happened during her freshman year, when students began to solidify their perceptions of their learning environment and begin to develop their professional STEM identity. Similarly, Tiffany, a non-traditional student in age, felt silenced after she attempted to answer a question in her STEM class and was belittled in front of her peers. Like Olivia, Tiffany came into the academic space open to learning, but after the instructor publicly reprimanded her for getting a question wrong, she formed the perception that wrong answers are not acceptable and that she should just say nothing. She described her experience in the following quote.

> *"The teachers asked in essence a rhetorical question. I didn't know that. [specific question was omitted to maintain anonymity] So I answered, I said 'yeah you can do that, yeah that's fine', and boy she raked me over the coals in that zoom meeting. I felt so belittled, instead of just saying 'no, actually we can't', no, no, like she came at us about that, and I literally, for a month after that, I said nothing at any of the zoom meetings. I sat back, I was like 'I ain't saying nothing'".* (Tiffany, FGCS undergraduate student)

Tiffany, like other FGCSs, developed the perception that when you become a STEM major, "*all of a sudden you're meant to know everything"* and "*anytime you try to ask for a little bit more feedback, you don't really get it".* The experiences of Olivia, Tiffany, and other students highlight the role of instructors in shaping student sense of belonging and how that cascades to student perceptions of departmental culture and norms. In some cases, such as with Amala, devaluing encounters with STEM faculty sometimes lead students to switch majors. Amala, a mixed race, American muslim, started her studies as a natural science major with a pre-medical focus. After getting "*brushed off*" several times by STEM faculty and students when she asked for help or advice, she decided to change her major to nursing, still keeping a health science focus. Amala recalled faculty saying that she "*should just know this and be prepared next time*" and feeling that natural science "*majors have to be a little bit arrogant*" to feel like they belonged in academic STEM. She described her current nursing department as, "*much more compassionate and so much nicer*". Students like Amala developed a perception that students and faculty in natural science departments were arrogant, not willing to help struggling students, and expected students to independently work through academic concerns, which led to them switching majors. It is understood that students will switch majors to find what suits their academic interests, however when the attitudes and behaviors of key institutional agents go against departmental inclusivity efforts, it signals to some students that they do not belong in STEM and contribute to perceptions of departmental culture.

Other actions that supported perceptions of elitism in academic STEM, included STEM faculty displaying bias or favoritism towards students "*doing research with them"* (Claire), " *who speak up in class and are making the grades"* (Faith), and who are "*[natural science] majors or*

trying to be a doctor" (Gregory). Kelly, an Asian American from a lower socioeconomic background, added that she always felt "*intimidated during in person lectures to ask questions*" because she felt like other students may be "*smarter or more experienced*". Kelly linked the perceived intelligence of the other students in class to the reasons it was easier for certain professors and students to interact. She expressed that "*it's kind of hard to ask a question in class when you're not like the teacher's pet."* In addition, for several FGCSs these experiences of favoritism or bias perpetuated the stigmatization of their intersecting identities. For example, Gregory as a religious, Black male, intimidation was filtered through his racial/ethnic identity. He was constantly aware that his institution was "*predominantly White"*, and tried his "*best to not think about it too much".* However, he felt "*a bit intimidat[ed]" w*hen applying for STEM jobs*, or* raising his *hand in the classroom,* because he feels that preferences were given to students from the dominant culture. Likewise, David, a Black male, felt *"like the majority of the [STEM] department, doesn't have my best interests at heart, because I'm not a White male."* He felt like his STEM department "*favored White males and Asians"* and concluded that "*they think I don't belong there*". Additionally, Tiffany, a non-traditional student in age and family, and Rose, an African American female from a lower socioeconomic background, both concluded that many high achieving students were economically privileged. Tiffany listed the resources students in her program were required to purchase in order to be successful and commented that unless students are from an economically "*privileged"* background, it would be a struggle for them to pay for such resources. It is evident that FGCSs STEM students holding multiple stigmatized identities link their sense of belonging to experiences of bias and favoritism towards students who hold opposing identities or behaviors.

7.3.2 Faculty signal lack of concern for students through their tone, inflexibility, and by placing work above students' well-being

When FGCSs in STEM perceived their faculty genuinely cared about their academic progress (18 of 28) and/or were empathetic towards their holistic well-being (14 of 28), they reported feeling more like they belong in that academic community. In contrast, faculty that were inflexible with academic concerns and perceived to prioritize their research agendas over students' academic progress communicated a lack of care to their students which negatively impacted student's sense of academic belonging. For example, two of Emma's (a White, female student) STEM professors made her feel "*included or cared for"*, when they extended the deadline for an assignment due to COVID related issues and *"they would quickly respond"* to her emails. Likewise, Olivia, (a politically liberal, member of the LGBT community) expressed that "*anytime I reach out to someone in the department, they are very friendly".* Similarly, Faith, a black female, felt "*reassured"* in her STEM journey when one STEM faculty proceeded "*to explain [the content] another way"* "*picking up on the cues*" that her and other classmates did not understand. Faith reported that certain faculty cultivated a welcoming environment that built her confidence in her ability to succeed, despite early experiences of dismissive or devaluing help seeking efforts. Overall, students interpreted basic levels of faculty care and concern as an indicator that they were worthy of belonging in academic STEM.

7.3.3 Explicit recognition of merit or struggle supports inclusive norms

1. Lastly, students spoke highly of faculty that went out of their way to notice if they were struggling or if they were doing a great job in class. For example, Amala expressed tears of gratitude when more than one of her professors recognized that she was performing very well in class. These words of encouragement came at a tough time in Amala's personal life and confirmed her ability to persevere and succeed in STEM. Likewise, Kimberly's grades were slipping below average, and one of her STEM professors *"asked how she was doing and how he could help me"*

after noticing that she missed a few days of class. Kimberly was ready to take full responsibility for her absences even though they were because she needed to pick up extra shifts at work to cover financial obligations. However, when her professor reached out to her, Kimberly saw that her academic journey mattered to a member of the academic STEM community. Departmental recognition, such as scholarship nominations (Mateo), praise for good grades (Cecilia) or personalized academic support (Mary), made FGCSs students feel very much a part of their academic community.

7.4 RQ4: How do the experiences in STEM classrooms shape FGCSs perceptions of inclusivity?

Student perceptions of inclusivity were shaped by course structures that (1) humanized the learning experience, and (2) provided multiple means of representing the content (Figure 2). We operationalize the term humanize to describe experiences that address or portray someone in a way that emphasizes that person's humanity or individuality (Merriam-Webster, 2023).

7.4.1 Humanized STEM learning experiences increase classroom comfort

FGCSs students expressed that faculty cultivated humanized learning experiences when they explicitly integrated inclusive dialogue in class content (29%), genuinely got to know the student through course activities (32%), and acknowledged current events (46%), such as the dual pandemics of COVID-19 and racial unrest (Tables 2,3). Professors were said to communicate their acceptance of students from diverse backgrounds when they started their class asking about student's preferred pronouns (Emma) or in David's experience when they looked past stereotypic ideas of who can be successful in STEM. David shared that he struggled throughout his years in academic STEM as a Black male until one professor took the time to get to know him as a learner. David expressed his feeling that his academic STEM mentors thought he did not belong through the following statement when asked about his experiences.

> "*I'm constantly reminded that I'm not like them because I'm Black. I feel like I'm an endangered species walking through the department building*". (David, FGCS undergraduate student)

However, David encountered a humanizing learning experience when one of his STEM professors saw his academic struggle as an entry point to investigate the source of that struggle rather than a precursor to his failure.

> "*I took a [STEM course] and I was failing. [The professor] was like 'hey, your problem isn't that you're not learning the material', he said 'you're panicking on test for some reason' he's like 'I think you may have test anxiety'. He actually did the work and got me in touch with someone, a counselor that helped me with my test anxiety. In fact, that was the one of the biggest things holding me back more than anything. But some of the other teachers saw what I was doing [before] and told me basically you're not smart enough or I don't think you're qualified to be here."* (David, FGCS undergraduate student)

David described this as a pivotal moment in his academic career that opened his eyes to the fact that such academic resources were available. David frequently filtered his STEM experiences through the lens of a Black male; however, this experience highlighted the intersection among his racial/ethnic, gender and first-generation identity. David, like many other FGCSs, had limited awareness of available academic resources, and although he was confident in his ability to understand course

material, early instances of conscious and unconscious racial-focused bias prolonged his diagnosis of test anxiety.

Nearly ⅓ (32%) of FGCSs agreed that they felt most comfortable and included in courses where professors took the time to get to know their names and their backgrounds, even in large introductory lecture courses (Table 2). Nathan, a non-traditional student in age, felt noticed when his professor "*actually sat down at the beginning of class with every student to [learn] our background and where we're coming from".* Mateo, a student veteran, described how his professor got to know everyone in class by breaking everyone up into small groups and would try "*to get a feel for everyone"* by asking*, "hey how's your weekend and what are y'all doing next week or how's classes going"* to different small groups each time. Kimberly, a religious student from a lower economic background recalled feelings of inclusion after a professor from her 200 student lecture course remembered her name years later. Even in an emergency remote online learning environment, Jada, a very religious, Black female, felt more included in her STEM course after her professor provided several opportunities for students *to get to know each other*, through the chat or breakout rooms. This simple but powerful pedagogical strategy, of showing a genuine interest in students as humans as well as learners, signaled to students that they were allowed to connect their whole selves to their classroom experience. To push this concept a step further, FGCSs' sense of belonging was heavily impacted by instructors' willingness to acknowledge current social and political events of 2020 in the STEM classroom.

In the wake of dual global pandemics of health and racial unrest in 2020, nearly half (46%) of FGCSs noted their sense of belonging was positively impacted when their instructors acknowledged current events in relation to enlightenments in the STEM fields (e.g., public health inequalities, effective/ineffective science communication, technological advancements, economic conditions) (Table 3). For example, Gregory, a religious, Black male, recounted a whole class discussion that incorporated social justice topics into STEM course content. He walked away from this course intrigued and motivated by the fact that the professor provided a platform for all students in the course to discuss difficult yet empowering topics. Gregory noted that even in a virtual space, students were respectful of each other's opinions and cultivated an inclusive environment.

> *"He (the professor) got my attention when he mentioned how [environmental] racism is related to climate change action. He was coming from the point that we cannot really deal with climate change, until we deal with issues of society when it comes to racism and justice. Honestly, we've never had one debate in the class. We always listen to one another, and it was on zoom. That was the even more crazy part, we don't even know each other. We've never seen [each other] and we have this conversation of using inclusive language."* (Gregory, FGCS undergraduate student)

Gregory entered his STEM course not expecting open discussion and student input opportunities, however, this opportunity signaled that his perspective was welcomed in that space. Similarly, Rose, a Black female studying public health, felt "*seen"* and "*like [she] could share a little bit more"* about herself when her "*courses address[ed] social determinants of health issues* and *when people [could] talk about their personal experiences".* Mateo, a veteran, liked when his instructors would discuss "*what's going on in the world* in his technology class *because [it] helped everyone be aware that technology doesn't just stop when we're coming to school, like it just keeps going".*

7.4.2 Providing multiple means of representing content increases students' sense of belonging in STEM

Pedagogical strategies were noted among FGCSs to impact their sense of belonging in academic STEM. When instructors deviated from traditional didactic instruction and integrated multiple modalities within their STEM classrooms, many students like Emma, a female from a lower-income family, "*felt really comfortable"* and felt the instructor cared that she understood the material.

> *"I felt really comfortable in that class just because of the way that it was set up and his teaching style. It was a very active class; it wasn't just reading off a PowerPoint. He would offer PowerPoint slides that you could write down, we had a lot of personal discussions like with our classmates and then we also did like a clicker or Kahoot every now and again just to see if we're doing well with the information that we're given."* (Emma, FGCS undergraduate student)

Likewise, Cecilia, a politically conservative, religious female, found her STEM lab fun and helpful when she and her peers were allowed to discuss topics during class, unlike other STEM labs she took. Cecilia also credited her professors' "*allegorical way of presenting [course] material with stories"*, to her ability to "*really understand* and *recall [STEM] content much better".* Similarly, Londyn, a mixed-race female, felt like she belonged in her STEM course after her professor presented the content in a way that signaled they cared if she understood the material.

> "*I had struggled [in previous STEM courses], so I was nervous about having to take [STEM course] but I did fine because the Professor actually, like, cared that we understood the information and taught it in a way that made me comfortable with learning it and comfortable with being in the classroom. Not like I'm out of place or I don't belong there, like, I felt like that's where I was supposed to be."* (Londyn, FGCS undergraduate student)

Londyn described being engaged by *YouTube videos*, *various practice problems*, *quizzes*, and the ability to earn back lost points by speaking one-on-one with her professor. In conjunction with providing multiple means of representing content, ~40% students felt more comfortable in their STEM class when professors extended an open-door policy in which students could get scheduled one-on-one help (Table 2).

8 Discussion

As a fundamental human motivation, FGCSs desired to fit within their academic STEM environment both as a college student and as a member of their STEM community (Gopalan & Brady, 2020). This study took a contextualized approach to examine how FGCSs multiple social identities fit into the academic hierarchies and how interactions within multiple academic systems impacted their state of fit or sense of academic belonging. Schmader and Sedikides (2018) helped to frame considerations for students' social identities when examining sense of academic belonging with the introduction of the model of *State Authenticity as Fit between* one's identity and the *Environment* (SAFE). Within this model Schmader and Sedikides considered how a given environment often signaled *fit* to some social identities more than to others, which led students to avoid or approach a particular environments based on fit between an individual's core characteristics and those of their environment (Schmader & Sedikides, 2018). In a broad sense, if a student perceived that they could be their authentic self within a context they were more likely to remain within and even thrive in that context. Likewise, we found FGCSs perceptions of belonging were mediated through their social identities,

and that their academic STEM environment signaled acceptance or exclusion of some social identities more than others. We use this space to discuss broadly three ways in which FGCSs identity -based experiences in academic STEM shaped their sense of institutional and disciplinary belonging.

8.1 **Reshaping Perspectives of the FGCS identity**

First, as students shared their experiences across multiple contexts, they worked to reposition their first-generation identities as assets to their persistence. Findings revealed that students perceived their first-generation identity as a personal motivation to persist in academic STEM, which counters narratives that position FGCSs as lacking the social, navigational, and family capital associated with academic success. FGCSs transformed societal stigmas associated with their parent's educational background into opportunities for social mobility. Students were grateful for the opportunity to go to college and for the sacrifices made by their parents which cultivated academic persistence. In addition, FGCS leveraged hard independence skills learned from survival-focused, self-reliant family values, when navigating unfamiliar college territory (Covarrubias et al., 2019). Recent discussions in FGCS literature have revealed class-based differences in students' socialization patterns at home and at school and showcased aspects of independence as an asset for academic success. For example, upper- and middle-class families tend to endorse soft, emotion-focused independence that encourage expressions of personal preference and individuality. This individualism also takes the form competitiveness in academic STEM environments where one's ability to outperform their peers and succeed on their own is valued and rewarded. Whereas, working-class families, often with a limited or non-existent safety net, groom tough, self-reliant individuals who respect hierarchy and follow rules (Covarrubias et al., 2019). Thus, FGCSs who also hold a working-class identity, often transform their value of hard independence into a mechanism to persist when faced with limited resources, support, or academic capital. Coupled with a non-traditional identity, FGCSs who have spouses and children transfer skills learned from managing their families to managing their academic responsibilities. In contrast to the competitive and individualistic nature of academic STEM, FGCS often work hard to accomplish communal success, where their success also means success for their family and community (Allen et al., 2015; Azmitia et al., 2018). This goes back to FGCSs viewing college as an opportunity for social mobility not only for themselves but for their family. In reshaping how society views the FGCS identity, one must consider first how the students themselves view their FGCS identity to then illuminate opportunities to leverage aspects of their unique identities when cultivating inclusivity in STEM environments. In keeping with the reciprocal characteristics of the macrosystem representing the belief systems or ideologies underlying FGCSs broader social community, students' perceptions and experiences are not only shaped by societal beliefs, but societal belief systems can be shaped by student experiences for those that are open to acknowledgment and change (Bronfenbrenner, 1979). Further, the behaviors and interactions within said community between students and key institutional agents, have the capacity to uphold or dismantle exclusionary ideologies embedded in academic STEM communities for students with multiple stigmatized identities.

8.2 Humanizing Student Learning and Disciplinary Culture

Next, we learned from FGCSs that simple acts of genuine care and concern for students' academic success and well-being most frequently signaled acceptance within their academic STEM environment and ultimately affirmed that their whole self belonged in that space. Further, when faculty, staff and even peers demonstrated care they cultivated inclusive and humanistic cultural norms for FGCS with multiple stigmatized identities. For FGCS care and support were shown through pedagogical activities that aimed to get to know the students, their backgrounds and their

academic (and sometimes social) needs. Additionally, when faculty took the time to present course materials in diverse modalities, such as group activities, recorded lectures, or class discussions, students felt that their instructors cared about their academic success. Prior literature has found an association between teaching practices and belongingness at the classroom level (Kirby & Thomas, 2021) and a link between caring and supportive instructor behaviors and increased sense of connectedness with larger academic communities (Gopalan & Brady 2020; Johnson et al., 2007; Means & Pyne, 2017; Museus et al., 2017). Given that classroom-level belonging facilitated by specific instructors may be even more impactful than campus-level belonging to student success (Blackwell-Starnes 2018; Wilson et al. 2015), faculty have the opportunity and responsibility to cultivate healthy communities and inclusive climates in the learning environments (Kirby & Thomas, 2021). Such healthy communities are often characterized by humanized education, where students feel like faculty and staff care for their well-being and holistic support, where students can ask questions, are connected to resources, and can problem-solve with a faculty or staff member. (Museus et al., 2017). Specifically, within the STEM learning environment, faculty and staff behaviors, both positive or negative, collectively establish the norms and values of the academic STEM community in which FGCSs seek to belong. While positive behaviors such as care and diverse pedagogical practices cultivated an inclusive culture, negative behaviors such as dismissive and devaluing help-seeking efforts cultivated an exclusionary culture. FGCSs were often silenced after they experienced or witnessed faculty belittling them for asking a content related question. This negative behavior supports historic perspectives that STEM students are innately intelligent and should be knowledgeable of the content at a level that minimizes the need to ask questions or make mistakes (Williams & King, 1980). However, a STEM academic culture centered around the mindset that ability and intelligence are malleable qualities that depend on one's dedication and commitment to learning in that domain, creates an opportunity for a diverse array of individuals to feel like they belong in STEM (Good et al., 2012). Taking a more humanistic approach to pedagogical practices and student-faculty interactions has the potential to establish and maintain a welcoming and inclusive culture in academic STEM.

8.3 For Such a Time as This- Grappling with Two Global Pandemics as a FGCS

Last, it is imperative to recognize that most FGCS experiences were contextualized by the two global pandemics of 2020, that being COVID-19 and the racial unrest resurfaced by the murder of George Floyd. Students illuminated the salience of their social identities in institutional and disciplinary inclusivity efforts, while navigating student protests, emergency remote learning, physical and mental health concerns, and increased family responsibilities. In our study, we interviewed students during the spring and fall of 2021, therefore factors that impacted their sense of belonging were marked by a before-, during-, or after the COVID-19 pandemic timeframe. With over ninety percent of US undergraduate students thrust into emergency remote learning in 2020 (Cameron et al., 2021), FGCSs described an immediate shift in their in-class, departmental and institutional engagement, which is directly linked to a sense of academic belonging (Wilson et al., 2015). Although remote learning and virtual social events were viewed as less engaging than in-person alternatives, students perceived instructor's flexibility in course deadlines and acknowledgment of current events as factors that increased their sense of belonging. In addition, students who identify as Black, Indigenous or as a person of color (BIPOC) reported experiencing hypervisibility and increased negative and positive attention because of the escalation of discussion on systemic racism, social justice, and power dynamics within social institutions (Stack 2021). Students felt less like a member of their university community when administrators or faculty failed to clearly communicate how racially charged incidents would be addressed in a timely manner. Across the U.S., BIPOC students were less likely than White students to live in places where they felt their identities were respected and where they

felt safe, resulting in increased emotional and physical abuse during the COVID-19 pandemic (Soria et al., 2020). Viewing FGCS experiences through a multi-systematic and multi-identity lens, allowed us to account for how socio-historical context and time influenced students' sense of academic belonging characterized by the chronosystem. Given that FGCS experiences were not monolithic during this historic time frame, it is critical to consider how students' sense of academic belonging differs based on social identities.

9 Limitation and Future Directions

While our investigation has highlighted the experiences of FGCSs holding multiple stigmatized identities through a multi-system lens, we must acknowledge that student perceptions and experiences during this time were undoubtedly influenced by the ongoing COVID-19 pandemic, civil unrest surrounding the murder of George Floyd, as well as racially-motivated events occurring on the institution's campus environment. That is evidenced by 61% of our FGCSs noting that their race and ethnicity was the most salient identity that shaped their in-class experiences. Within the interviews, students often mentioned civil unrest, how faculty chose (or did not) to address the murder of George Floyd and events occurring on campus. At the institutional scale, students voiced frustrations with university words versus actions during on-campus racial events which worked to erode a sense of belonging for our student population. Previous work has highlighted that sense of belonging is not static and is often influenced by day-to-day, week-to-week interactions (Gillen-O'Neel, 2019; Park et al. 2012). Thus, a longitudinal study of this student population would reveal long-term trends in the sense of belonging in FGCSs at this institution and how it has recovered following 2020-2021. The single snap-shot of sense of belonging, the chronosequence of our interviews, our location in the Deep South, and our middle-sized regional public R2 research institution may place challenges to transferability across all institutions and further work is needed to understand if these patterns hold across universities that differ in size, student demographics, geographic location, and social supports.

10 Implications and Conclusion

Implications for this work has the potential to restructure how institutions provide support for FGCSs given the salience of their intersecting stigmatized identities in shaping their institutional, disciplinary and classroom belonging. First, student responses suggested the need for FGCS interventions to move beyond primarily targeting resource awareness and availability, to also address the obstacles they face due to their intersecting stigmatized identities. Interventions that aim to develop cultural competence (Barnes & Brownell, 2017; Betancourt et al., 2003) or ideological awareness (Beatty et al., 2021; Costello et al., 2023) have the potential to reshape how students, faculty and university staff view FGCSs experiences. In addition, faculty concern and empathy towards holistic student success most frequently shaped FGCSs' sense of academic belonging in STEM (see Table 3), suggesting that when faculty took the time to answer students questions, recognized student merit or struggle, or formally and informally mentored students through tough situations, students felt like their whole self was valued in that space. Traditionally in higher education, tenure track STEM faculty are rewarded for developing robust research programs with less attention paid to teaching and mentoring practices (Suchman, 2014). Perhaps if institutions and STEM communities incentivised humanizing student learning practices often derived from student centered teaching and mentoring, then more students from a diverse array of backgrounds would feel like they belonged in STEM.

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14 Tables

Table 1: Cultural and Social identities that 28 First Generation College Student interviewees were most salient in college STEM classrooms.

Pseudonym	Major	Year	Racial/ Ethnicity	Social status	Non-Trad	Gender	Religious Affiliation	Political Affiliation	Sexual Orientation	Commuter
June	Biology	Junior	■			■				
Gregory	Biology	Senior	■	■			■	■		
Emma	Biology	Soph	■	■		■				
Olivia	Biology	Soph		■				■	■	
Kimberly	Biology	Senior		■			■			■
Kelly	Biomed Sci	Junior	■	■			■			
Faith	Biomed Sci	Junior	■	■						
Claire	Biomed Sci	Junior	■	■		■				
Rose	Biomed Sci	Soph	■	■						■
Mary	Biomed Sci	Junior	■		■			■	■	
Londyn	Biomed Sci	Junior	■			■				
Robert	Chemical Eng	Soph		■	■			■		
Jada	Computer Sci	Fresh	■			■	■			
Vanessa	Computer Sci	Junior	■				■		■	
Ryan	Computer Sci	Junior	■				■			
Nathan	Engineering	Soph		■	■					■

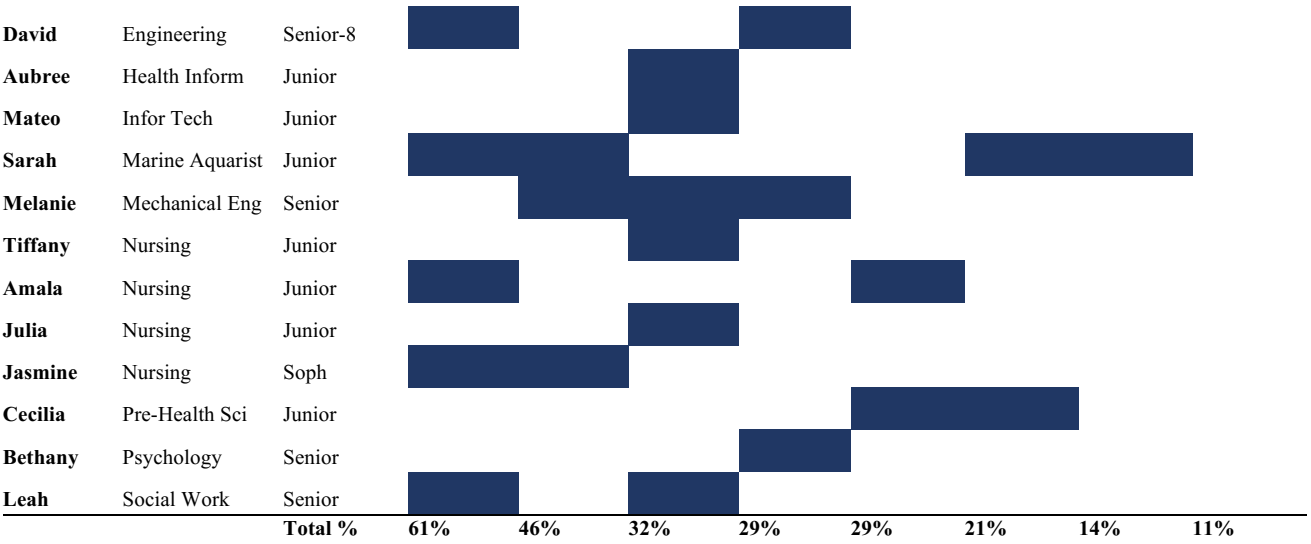

Table 2 (=U): Research question, themes, codes, and coding frequency of our first generation college students' perceptions of sense of belonging in STEM classrooms, STEM departments, and institutions.

Research Question	Themes	Codes	Code Frequency
RQ2: STEM Classroom	Humanized Learning Experience	Explicit Inclusive Dialogue	29%
		Genuine Efforts to Get to Know Students	32%
		Acknowledgment of Current Events	46%
	Multiple Content Modalities	Open-Door Policy	32%
		Encouragement of Peer Engagement	25%
		Multiple Means of Representing the Content	39%
RQ3: STEM Department	Hidden Expectations	Dismissive or Devaluing Help Seeking Efforts	50%
		Elitist Departmental Culture	50%
	Faculty Concern	Faculty Concern for Academic Success	64%
		Faculty Empathy Towards Students' Well-Being	50%
	Explicit Recognition	Being Noticed	22%
RQ4: Institution	Intentional, Passive, Selective Engagement	Intentional Engagement	71%
		Genuine Community Friendliness	29%
		Lack of Transparency	18%
	Institutional Agents	Limited Safeguards on Student Success	18%
	Valued Intersecting Identities	Visibility of Diversity	29%
		Passive Isolation	39%

Table 3: Emerging coding frequencies and percent responses of FGCS perceptions of sense of belonging at the institution, department, and in STEM classroom. Additionally, we decomposed coding frequencies by Persons Excluded because of their Ethnicity or Race (PEERs) or non-PEERs, as well as binary gender.

INSTITUTIONAL SENSE OF BELONGING	Total Percentage (All students)	PEER % (n=12)	non-PEER % (n=16)	Women (n=22)	Men (n=6)
Intentional, Passive, Selective Engagement					
Intentional Engagement	71.43% (20)	83.33%	62.50%	68.18%	83.33%
Genuine Community Friendliness	28.57% (8)	25.00%	31.25%	31.82%	16.67%
Lack of Transparency	17.86% (5)	16.67%	18.75%	22.73%	0.00%
Institutional Agents					
Limited Safeguards on Student Success	17.86% (5)	8.33%	25.00%	18.18%	16.67%
Valued Intersecting Identities					
Visibility of Diversity	28.57% (8)	58.33%	6.25%	27.27%	33.33%
Passive Isolation	39.29% (11)	41.67%	37.50%	36.36%	50.00%
DEPARTMENTAL SENSE OF BELONGING					
Hidden Expectations					
Dismissive or Devaluing Help Seeking Efforts	50.00% (14)	50.00%	50.00%	59.09%	16.67%
Elitist Departmental Culture	50.00% (14)	66.67%	37.50%	54.55%	33.33%
Faculty Concern					
Faculty Concern for Academic Success	64.29% (18)	58.33%	68.75%	68.18%	50.00%
Faculty Empathy Towards Students' Well-Being	50.00% (14)	33.33%	62.50%	54.55%	33.33%
Explicit Recognition					
Being Noticed	21.43% (6)	16.67%	25.00%	22.73%	16.67%
CLASSROOM COMFORT					
Humanized Learning Experience					
Explicit Inclusive Dialogue	28.57% (8)	16.67%	37.50%	27.27%	33.33%
Genuine Efforts to Get to Know Students	32.14% (9)	16.67%	43.75%	27.27%	50.00%

Acknowledgment of Current Events	46.43% (13)	33.33%	56.25%	45.45%	50.00%
Multiple Content Modalities					
Open-Door Policy	32.14% (9)	41.67%	25.00%	36.36%	16.67%
Encouragement of Peer Engagement	25.00% (7)	25.00%	25.00%	27.27%	16.67%
Multiple Means of Representing the Content	39.29% (11)	50.00%	31.25%	31.82%	66.67%

Table 4 (=Y): Emerging coding frequencies and percent responses of FGCS perceptions to improve institution, department, and in STEM classroom climate. Additionally, we decomposed coding frequencies by Persons Excluded because of their Ethnicity or Race (PEERs) or non-PEERs, as well as binary gender.

IMPROVING CLIMATE	Total Percentage (All students)	PEER % (n=12)	non-PEER % (n=16)	Women (n=22)	Men (n=6)
INSTITUTIONAL					
Increase Resource Awareness for Students	46.43% (13)	66.67%	50.00%	59.09%	9.85%
Intentional Care Demonstrated by Professor	28.57% (8)	25.00%	31.25%	36.36%	6.06%
More Comprehensive Advisement Efforts	17.86% (5)	25.00%	18.75%	22.73%	3.79%
Increase Non-Traditional Student Resources	17.86% (5)	8.33%	43.75%	22.73%	3.79%
DEPARTMENTAL					
Update Building Infrastructure	7.14% (2)	8.33%	6.25%	9.09%	1.52%
Increase Faculty Diversity	7.14% (2)	25.00%	6.25%	9.09%	1.52%
Relationship Building Opportunities	21.43% (6)	33.33%	18.75%	27.27%	4.55%
More relevant and timely course offering	17.86% (5)	25.00%	25.00%	22.73%	3.79%
Departmental Resources	17.86% (5)	33.33%	6.25%	22.73%	3.79%
CLASSROOM					
Diversify Pedagogical Practices	39.29% (11)	50.00%	50.00%	50.00%	8.33%
Smaller Class Sizes	17.86% (5)	25.00%	18.75%	22.73%	3.79%