The Value of Support: STEM Intervention Programs Impact Student Persistence and Belonging

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ABSTRACT
In response to unwaveringly high attrition from STEM pathways, STEM Intervention Programs (SIPs) support STEM students in effort to increase retention. Using mixed methods (survey and focus groups), we studied students at one university who were either supported or unsupported by SIPs to understand how students may differ in experiences believed to contribute to STEM persistence. We evaluated: sense of belonging, scientific self-efficacy, scientific community values, scientific identity, and STEM involvement. The enrollment status of students two and a half years postsurvey was also tracked. SIP students reported significantly higher science identity and sense of belonging and were more involved in STEM-related activities than counterparts unsupported by SIPs. Differences in these measures were correlated with race/ethnicity, college generation status, and age. Notably, SIP students had higher odds of persisting in STEM than students not supported by SIPs. Focus group data provide additional meaning to the measured survey constructs and revealed nuanced qualitative differences between SIP and non-SIP student experiences. Overall, being involved in a SIP at our institution trends positively with theoretical models that explain STEM student persistence. SIPs have the potential to provide and/or facilitate meaningful and critical support, and students without those intentional supports may be left behind.

INTRODUCTION
Of the hundreds of thousands of undergraduates who enter college intending to major in a Science, Technology, Engineering, or Mathematics (STEM) field, approximately 40% end up earning a STEM degree (Olson and Riordan, 2012). The reasons that students may leave a STEM degree program are abundant and span from students losing interest and motivation, to poor teaching, to the competitive and unsupportive culture of STEM fields (see Seymour and Hunter, 2019 for comprehensive discussion). These barriers can be more pronounced for students from groups that have been historically marginalized by STEM fields (Feder and Malcom, 2016) including women, students from nonwhite races and/or ethnicities, first-generation college students, and/or older students (>23 years of age; Rhine *et al.*, 2000, Ishitani, 2006, Olson and Riordan, 2012, D'Amico *et al.*, 2014, Allen *et al.*, 2015, Riegle-Crumb *et al.*, 2019). Thus, unsurprisingly, national data reveal that nontraditional and minoritized college students earn fewer STEM degrees than their represented counterparts (National Academy of Sciences, 2011, Olson and Riordan, 2012, Chang *et al.*, 2014, D'Amico *et al.*, 2014, Feder and Malcom 2016, Riegle-Crumb *et al.*, 2019).

Although the barriers to retention in STEM are well-documented and abundant, the literature also offers numerous evidence-supported factors that may positively influence student persistence at an academic institution or within a field of study. Though an incomplete list, some of the key themes that repeatedly arise in the persistence research base include: academic and social integration, student contextual factors, institutional and organizational factors and culture, student engagement, and

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sense of belonging (Braxton *et al.*, 1997; Hurtado and Carter, 1997; Milem and Berger, 1997; Tinto, 1997, 2006; Berger and Braxton, 1998; Hurtado *et al.*, 1998; Hoffman *et al.*, 2002; Hausmann *et al.*, 2007; Deil-Amen, 2011; Estrada *et al.*, 2011; Strayhorn, 2018, ; Murphy and Zirkel, 2015).

Persistence at the University

Within the aforementioned body of literature, some researchers uphold that students having "a sense of belonging" may be foundational to other persistence factors such as academic integration or well-being in a field or academic institution (O'Keeffe, 2013; Strayhorn, 2018; Murphy *et al.*, 2020). This is logical considering the premise that once one's safety and psychological needs are met, only then may they securely explore creativity and higher cognitive achievements (Maslow's Hierarchy of Needs, Maslow, 1954; McLeod, 2007). Belonging scholar T. Strayhorn frames sense of belonging in college in this holistic way: *Sense of belonging refers to students perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community or others on campus such as faculty, staff, and peers* (Strayhorn, 2018, p. 4). We use this definition to guide our thinking about STEM student belonging at our university.

Many circumstances or experiences may impede or bolster a student's sense of belonging at a university, some of which can be highly subjective and contextual (Hurtado and Carter, 1997; Strayhorn, 2018). Experiences hindering belonging can be nuanced and multifold, related to various internal (e.g., impostor syndrome) or external factors (e.g., poor instructional practices), and/or identity-related factors such as race and/or ethnicity, gender, socioeconomics, transfer student status, and first-generation status (Hausmann *et al.*, 2007; Marra *et al.*, 2009; Johnson, 2012; Good *et al.*, 2012; Strayhorn, 2018; Murphy *et al.*, 2020). Contextual and personal characteristics can compound and intersect in a variety of ways, with the result that certain students may face more challenges pursuing a STEM degree when compared with others (Feder and Malcom, 2016; Mahoney *et al.*, 2019; Strayhorn, 2018). Thus, it may be of critical importance for some students to engage in subcommunities within the larger university landscape to gain adequate and authentic social support from peers with shared identities to foster belonging (Hurtado and Carter, 1997; Ovink and Veazey, 2011; Burt *et al.*, 2020). Research has shown that engaging in subcommunities can provide spaces to challenge deficit-oriented narratives (Ong *et al.*, 2018), and some institutions have made efforts to build programs or spaces designed to create such subcommunities for students (Museus *et al.*, 2017; Jessup-Anger *et al.*, 2022). By working to measure sense of belonging at both the institutional and the subcommunity levels, we can begin to gain a more nuanced and perhaps accurate understanding of how students experience belonging than we would by attempting to measure belonging as one construct (Hurtado and Carter, 1997). Here, we build on previous researchers' insights on belonging by studying STEM student sense of belonging to a university, to subcommunities within the university, and consider how student characteristics (such as age and race/ethnicity) may interact with belonging as we aim to better understand persistence at the university.

Persistence in Science

M. Estrada and colleagues (2011, 2016, 2018b, 2021, 2022) set out to understand persistence of students in STEM fields, with a particular focus on predicting persistence of African American, Hispanic, Latiné, and Native (Native American, Alaskan Native, and Native Hawaiian) students. They developed an instrument rooted in the literature on social influence (*tripartite integration model of social influence* [TIMSI]) to understand whether and how individuals see themselves as a member of the scientific community, operationalized through students' scientific self-efficacy, identity as a scientist, and value for scientific research. These measures can be indicators of students persisting in STEM degree pathways and in STEM careers beyond graduation (e.g., Estrada *et al.*, 2011, 2018b, 2021; Hernandez *et al.*, 2018). This research is complimentary to the way that other researchers frame psychosocial factors that may contribute to students holistically developing a sense of belonging to a field. For example, belonging might come from students being engaged in doing the things that scientists do, like undergraduate research (e.g., Linn *et al.*, 2015) or being involved in STEM-related activities such as attending departmental seminars (Knekta *et al.*, 2020). However, students enter university with varying amounts of "science capital", and consequently for many students, even knowing that potentially impactful opportunities exist or how to obtain them can be an oppressive barrier (Allen *et al.*, 2015, Cooper *et al.*, 2019, Ceglie, 2021). Thus, in addition to measuring student belonging at the university and subcommunities within the university, we also study factors theorized to impact persistence in science more broadly including: science identity, scientific self-efficacy, scientific community values, and involvement in STEM-related activities.

STEM Intervention Programs (SIPs)

To strengthen STEM training, broaden representation in who enters the US STEM workforce, and to democratize access to key resources, federal, and nongovernmental agencies have been investing in the future of STEM by funding SIPs. SIPs are primarily designed to offer supports for undergraduate students (George *et al.*, 2018), and often with a specific intention of recruiting students underrepresented in STEM fields (Schultz *et al.*, 2011). Although SIPs vary widely, three prominent themes drive the development of SIPs: broadening participation in STEM, improving student experiences, and facilitating responses to external influences such as meeting regional mandates and national benchmarks (George *et al.*, 2019). SIPs are typically discrete programs, able to offer resources and support to a finite number of students. SIPs are funded from a variety of sources including corporations, internally from the institution, or externally from a granting agency (Rincon and George-Jackson, 2014). Thus, unless sustained institutionally, the programming may only last during the period of funding. Even if deemed successful, institutions may be unable or unwilling to fiscally uphold SIP programming (Rincon and George-Jackson, 2014), and if they are able to sustain aspects of the program, they must decide which programmatic elements to support and which to let go. Understanding the scope of the value added by SIPs within and across universities may help catalyze sustainability decisions.

SIPs typically intend to increase retention to graduation and to assist student persistence by providing some combination of academic, financial, professional, and/or social support and advocacy (Scott, 2013; Dyer-Barr, 2014; Rincon and George-Jackson, 2014; George *et al.*, 2018). SIPs provide these supports in part by scaffolding "high impact practices" such as providing research training and research experiences, learning communities, and cohort-based courses (Kuh, 2009, Scott, 2013). Although efforts to adequately assess the outcomes of SIPs have been inconsistent (and/or is unpublished data), some researchers have indeed demonstrated that students who participate in SIPs are likely to be retained in STEM fields (e.g., Wilson *et al.*, 2012, Scott, 2013, Ikuma *et al.*, 2019, Burt *et al.*, 2020, Estrada *et al.*, 2021). Studies often focus on the outcomes of a singular SIP at one institution (e.g., Estrada *et al.*, 2021), and the experiences of students participating in that SIP, and less on the overall impact of having multiple SIPs across a university's landscape. Here, we build on the SIP and STEM persistence literature bases by not only testing the relationship between SIP involvement and realized persistence in the major, but also the relationship between SIP involvement (or no SIP involvement) and key factors believed to influence persistence at the university (e.g., sense of belonging) and in the field of science (e.g., scientific identity).

How Might SIPs Contribute to Persistence?

The support offered across SIPs can vary (Scott, 2013, Rincon and George-Jackson, 2014), and therefore SIPs may differentially impact student experiences and persistence, both at the university and in science generally. There are countless ways in which SIPs may dramatically impact a student's life. High financial needs students for example may be prohibited from participating in various activities, as they must prioritize employment over participation in extracurricular scientific and community-building activities (Soria *et al.*, 2014). Some SIPs provide significant financial support, allowing students to spend less time working at a job, and more time focusing on their academics and perhaps other activities (Gray *et al.*, 2022). Similarly, nontraditionally aged students, who are 23 y or older (Chen, 2013), may feel out-of-place amongst younger students or have more family responsibilities, while first-generation students may not enter college knowing to seek out significant opportunities (Ishitani, 2006). SIP programs with built-in cohorts or structured group activities may aim to facilitate peer interactions which can build students' social support network and thus contribute to a sense of belonging among subcommunities within an institution (Hurtado and Carter, 1997; Ovink and Veazey, 2011; Estrada *et al.*, 2018b; Gray *et al.*, 2022).

Involving students in faculty-mentored research has been widely framed as a tool to directly introduce and integrate students into the scientific community (Brewer and Smith, 2011), and research experiences are often pillars of SIPs. Mentorship from faculty and peer researchers may influence or reinforce student sense of belonging–both at the university and within a community of scientists (Thiry *et al.*, 2011; Estrada *et al.*, 2022; Gray *et al.*, 2022). Intentional academic advising and faculty mentorship programs can provide students with additional social, emotional, and professional support, which may contribute to a student's sense of integration into the academic and scientific communities and ultimately influence their retention in STEM (Estrada *et al.*, 2018b; Hernandez *et al.*, 2018; Ikuma *et al.*, 2019; Riegle-Crumb *et al.*, 2020; Estrada *et al.*, 2022). Additionally and related, being involved and participating in various activities that are endemic to a discipline or institution (e.g., undergraduate research, attending departmental seminars) can contribute to sense of belonging and membership to a group or field (Astin, 1984; Lave and Wenger, 2001; Strayhorn, 2018; Knekta *et al.*, 2020).

While students who are not in SIP programs can theoretically participate in many if not all the opportunities described above, SIP programs typically increase both awareness of and access to activities and high-impact practices, if not require them (Rincon and George-Jackson 2014). Given the purposeful access to varied resources that many SIPs provide, SIPs may have the capacity to mitigate inequities in which students gain institutional capital (Cooper *et al.*, 2019).

Current Study

An intention of this work is to broadly appraise the potential influence of having multiple SIPs at one urban university serving largely nontraditional students. Towards this goal, our mixed methods study endeavors to understand how SIP participation and student characteristics relate to factors believed to predict persistence. We use the word "factors" to indicate two sets of student experiences: those related to persistence at the university (e.g., sense of belonging to the university and among subcommunities within the university) and those related to persistence in science (e.g., scientific identity, self-efficacy, values, and STEM involvement). Our three integrated research questions (RQs) are:

1. What is the relationship between student participation in a SIP and factors believed to predict persistence (A) at the university and (B) in science?
2. What is the relationship between student characteristics and factors believed to predict persistence (A) at the university and (B) in science?
3. What is the relationship between participation in a SIP and student persistence in STEM majors?

We used a convergent mixed-methods design (Creswell and Clark, 2007) to address our first two RQs. An overview of our RQs and related methodology is outlined in Figure 1. We administered a survey to STEM students to collect perceptions of their belonging to and within the university, and to gauge their connection to and involvement in the scientific community. Given the intention of SIPs, we expected that students who were involved in one or more of the ongoing SIPs at our institution (hereafter referred to as SIP students) would score higher on quantitative measures of factors related to persistence both at their university and in science and show increased persistence in STEM majors compared with students who are not involved in a SIP (non-SIP students). Immediately following the survey, we conducted focus groups with a subset of survey participants to develop a more nuanced understanding of the themes measured in the survey. To address our third research question, we collected graduation and enrollment status data two and a half years postsurvey to identify their persistence in a STEM major.

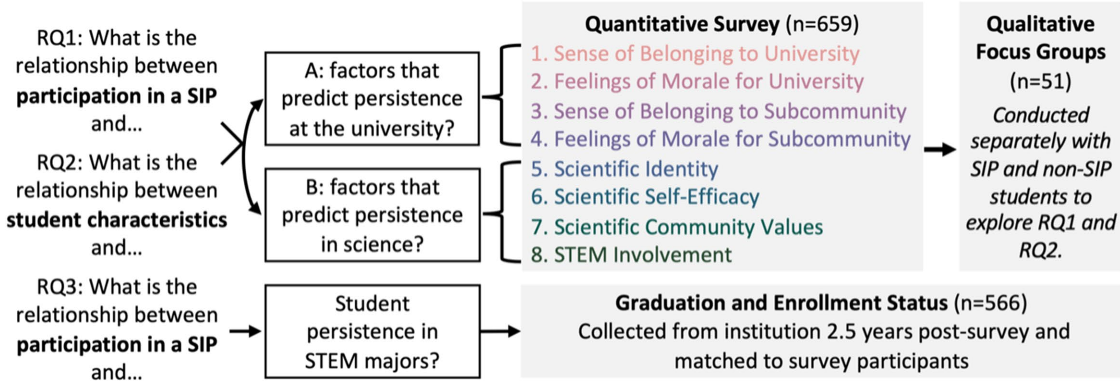

FIGURE 1. Overview of Data Collection for RQs.

MATERIALS AND METHODS

Institutional Context

We conducted this study at a large, public, urban, PhD-granting university, with "high" research activity (R2) and deemed a "medium full-time, inclusive, higher transfer-in" population (Carnegie Classification of Institutions of Higher Education). Among the STEM student population at the time of survey, approximately: 60% of students transferred from community college, 70% qualified for need-based financial aid, 50% were nontraditionally aged (over 23 y), and 90% lived off campus. As with the faculty, staff, and graduate student populations, the undergraduate student population was predominantly white (51%; Office of Institutional Research and Planning, PSU Fact Book). The university has been awarded several grants that fund SIPs (see Supplemental Materials, Appendix A), which in total, support approximately 10% of our undergraduate STEM majors. Compared to the overall student population at our institution, students in SIPs are disproportionately PEERs (persons excluded because of their ethnicity or race; Asai, 2020), otherwise SIP students are generally representative of the STEM student population. SIPs frequently recruit or are specifically designed to support PEER students due to underrepresentation and historic exclusion from higher education and STEM fields (Rincon and George-Jackson 2014). All research was approved by IRB # 174450 for human subjects.

Data Collection: Survey Design and Distribution

The STEM student survey was based on selected instruments from the education research literature that measure factors deemed to contribute to persistence in STEM (see Supplemental Materials, Appendix B for full list of survey items). We measured sense of belonging to and within the university by using the extensively established Perceived Cohesion Scale (PCS), which measures two three-item constructs: sense of belonging to a place or community and feelings of morale for that place or community (Bollen and Hoyle, 1990). PCS items are adapted to reflect the institution's name, for example, a sense of belonging item reads: *I feel that I am a member of the [University] community* (1 = strongly disagree, to 5 = strongly agree). Guided by literature, we hypothesized that many students may feel a greater sense of cohesion to subcommunities within their university, thus we additionally used the two scales of the PCS to measure student sense of belonging and feelings of morale to a subcommunity within the university. For the PCS questions referring to a subcommunity within the university, students were asked to select the student group with which they most closely identified from a drop-down menu and respond as it related to that group. The drop-down menu was developed based on an inductive analysis of open-ended responses provided by hundreds of STEM students in a pilot version of the survey administered in a previous term. Student group options included: social, cultural, or academic/professional clubs and centers, disciplinary departments, SIPs, study groups, etc. (see Supplemental Materials, Appendix B2 for full list of options). Students were given the option to write in a response for groups that were not captured in the drop-down menu, as well as to select "I don't belong to a group".

To measure student psychosocial perceptions of their relation to the scientific community, we used the Tripartite Integration Model of Social Influence (TIMSI) instrument (Estrada *et al.*, 2011, 2018b, 2021). The TIMSI includes six items to measure scientific self-efficacy, five items to measure scientific identity, and four items to measure scientific community values. An example item in the scientific community values scale reads: *I am a person who thinks scientists discussing new theories and ideas with other scientists is important* (1 = not like me at all, to 5 = very much like me); all survey items and scales can be found in Supplemental Materials, Appendix B.

To measure student involvement in various STEM-related activities within the university's scientific community (*STEM involvement)* we included items such as: *How frequently did you attend a seminar hosted by a STEM department (1 = never, to 5 = weekly)?* We modified the items based on an instrument that was in the process of being developed to understand involvement in a biology department and has since shown to produce valid data in a different undergraduate student population (Knekta *et al.*, 2020).

Finally, the survey also included a series of demographic and informational questions. One of the questions asked students if they were involved in any of the SIP programs on campus (Supplemental Materials, Appendix B). If a student selected any one or more of the SIPs listed, we counted them as a SIP student. This measure did not account for the level of engagement with the SIP, nor did we independently verify their choices.

Before dissemination, the full survey underwent response process validity to assess how study participants interpret and

TABLE 1. Student characteristics: survey and focus groups

Participants	Number	Age 23+	Women*	PEER	First Gen	CC Transfer
Survey – all	659	41%	52%	24%	34%	42%
Survey – SIP	104	40%	69%	51%	54%	54%
Survey – non-SIP	555	41%	52%	19%	30%	39%
Focus group – SIP	20	63%	35%	55%	45%	90%
Focus group – non-SIP	31	60%	50%	19%	33%	52%

*Nonbinary, agender, and participants who chose not to report their gender comprised 5% of the total survey participants, 6% of the SIP group, and 5% of the non-SIP group.

respond to survey items (Rickards *et al.*, 2012). Think-aloud cognitive interviewing was conducted with both experts and novices: interviewees took the survey and described the thought processes that they used to arrive at a response to each item, and a researcher noted this process to confirm that the respondents are interpreting the items as intended (Willis, 2004). Researchers conducted these interviews with three experts and six novices representing the intended population. This process resulted in slight wording changes of a limited number of items until all items were interpreted as intended.

The survey was deployed at the end of the Spring 2019 academic term and was sent to all declared STEM (as currently defined by the National Science Foundation and provided by institutional data from the Fall term) and prehealth majors at the university (in total, 5700 students). Participants were invited to participate in the survey via email, with the option to enter in a drawing to win one of multiple gift cards. At the end of the survey, participants were asked to provide their name and email if they were willing to be contacted for participation in a follow-up focus group.

Data Collection: Focus Groups

All survey participants who indicated that they were willing to be contacted were emailed by a researcher to confirm interest and availability to participate in a focus group. Using demographic information collected with the survey (SIP and community college transfer status), we recruited students to participate in focus groups from the pool of volunteers. In total, we conducted eight semistructured focus groups at the end of the academic year.

Focus groups were designed to better understand and provide further validation evidence for the survey (student perceptions of belonging at the university, scientific communities; science identity, etc.,), identify how student perceptions may differ based on SIP-status, and learn what kinds of supports or barriers students perceive influence their experiences. Three researchers iteratively developed focus group questions predicated on the constructs measured in the survey. Example questions included: *Do you think of yourself as a scientist? Is there a community or group at this university that you feel particularly connected to?* (For focus group questions and additional focus group context, see Supplemental Materials, Appendix C). Focus groups took place on campus with the same primary facilitator and a secondary facilitator who followed the established semistructured interview schedule. Each focus group was 1-h long. Focus groups were conducted within a 2-wk timeframe at the end of the academic year, and were audio and video recorded. Participants were compensated with a gift card for their time.

Participant Characteristics

We initially received 1216 survey responses, a 21% response rate from our total target population. Data cleaning to remove responses that did not meet our study criteria resulted in 659 usable responses. Student participants in the study were largely declared majors in Biology, Computer Science, Engineering, Environmental Sciences, Math, Physics, and Pre-Health pathways within STEM majors. With assistance from the office of institutional research and programs, we were able to obtain an incoming GPA for 80% of students in the sample population. By conducting t tests, we found no significant differences in incoming GPA between SIP and non-SIP students for either continuing students (high school GPA) or community college transfer students (transfer GPA), (continuing students: $t(63.4) = -1.27$, $p = 0.209$; transfer students: $t(76.87) = 0.11$, $p = 0.909$; Supplemental Materials Appendix D), indicating that these students did not vary in "incoming academic ability" as may be indicated by GPA.

Of the eight focus groups, four were held with SIP students and four with non-SIP students. The number of participants in each focus group ranged from two to 10, with a total of 51 participants. The undergraduate population at the time of data collection was predominately white (51%); however, PEER students were relatively overrepresented (55%) in the SIP focus groups. Similarly, due to targeted SIP recruitment, SIP students in our sample are more frequently first generation and transfer than non-SIP participants. We recognize that these discrepancies may lead to limitations of the generalizability of our results. Participant demographics and SIP status for both survey and focus group participants are summarized in Table 1.

Data Analysis – Quantitative

Incomplete surveys, and/or students who: took less than 5 min to complete, chose not to consent to the study, did not pass the "check" question, or chose the same response to all Likert-type questions, were removed from the dataset. We additionally removed responses from postbaccalaureate students and students who were enrolled in less than five credits. We report students who selected that they were of the following race/ethnicities as "PEER": Black/African American, Latiné/Hispanic, Middle Eastern, Mixed/Multiple Races, Native Alaskan, Native American, Pacific Islander, or any write-in "other" that was a nonwhite or Asian identity in STEM. Students who only identified as white and/or Asian were not included in the "PEER" category, as these races are not underrepresented in science fields in the United States nor at our university. We acknowledge that "Asian" as an omnibus label can misrepresent various groups who are not indeed underrepresented in STEM, but our survey did not further delineate among these groups.

Evidence to assess the capacity of our survey instrument to produce valid data was collected both before survey dissemination (i.e., response process validity and content validity checks) and after data collection (i.e., factor analyses to assess underlying latent factor validity) per Rickards (2012). Descriptive statistics for each survey item, a full description of the survey validation process, and correlation coefficients for variables used in regression models are included in Supplemental Materials (Appendices E, F, and G).

To assess how participation in a SIP impacted the latent constructs measured in our survey, we conducted eight linear models with weighted factor scores (see Appendix F) for each construct as the output and SIP status as a predictor. We also conducted a logistic regression model to assess how SIP participation relates to long-term graduation and enrollment. To achieve this, we obtained the institutional status of survey participants two and a half years after the survey was administered and categorized each student's status into two groups: 1) persisting in STEM and 2) left STEM. At 2.5 y postsurvey, "persisting" students had completed a STEM degree at the same institution or were currently enrolled as STEM majors at the same institution, and "left STEM" students had either switched to a non-STEM major or had not graduated and were not currently enrolled in classes at the same institution.

All regression models additionally included other predictors (student characteristics) known to impact persistence at the university and in science, including college generation status, PEER status, and nontraditional student status, and controlled for the length of time the student had been at the university. There were more than sufficient survey responses from students who identified as SIP participants, nontraditional age students, PEER students and first-generation students to warrant including these variables as predictors in our regression models (Jenkins and Quintana-Ascencio, 2020). All regression models used the below formula:

$$\left[\text{Outcome}\right] \sim \text{SIP} + \text{Nontraditional Student Status} \\ + \text{PEER Status} + \text{Generation Status} \\ + \text{Time at University}$$

To interpret logistic regression findings, we calculated odds ratios (the natural exponential of the estimated coefficient) for each predictor variable. All quantitative analyses were conducted in R using the *base*, *pwr*, and *car* packages (Champely *et al.*, 2018; Fox and Weisberg, 2018; R Studio Team, 2019).

Data Analysis – Focus Groups

Recordings of the focus groups were transcribed verbatim (Rev.com). Multiple researchers read each focus group transcript to identify overarching themes and scaffold a codebook. Researchers then iteratively developed the codebook using deductive content analysis to test for evidence of existing ideas within our study design. We reviewed transcripts and identified themes and codes related to factors of persistence in the university and scientific communities. We additionally used inductive content analysis to identify emergent themes and codes from the focus groups that were not necessarily expected (Patton, 1990; Saldaña, 2015). We then used qualitative research software (MAXQDA 2020) to aid in the final coding organization and analyses.

Codes were organized into unifying categories such as "evidence of scientific identity". Three researchers used a finalized codebook to code two of the eight transcripts to consensus and one researcher then coded the remaining six transcripts and conferred with other researchers regarding any questions or issues where there was a lack of clarity. While focus groups are limited in that not every participant will answer every question (Parker and Tritter, 2006) they can produce group-level data and give participants the opportunity to produce a collective understanding of an experience (Wilkinson, 1998; Hydén and Bülow, 2003; Onwuegbuzie *et al.*, 2009). Because not every participant will answer each question, we do not quantify each category of response. Rather, we present an overview of the experiences discussed by the participants and their group-level understanding of these experiences, specifically aiming to better understand the constructs measured by the survey scales. To illustrate how students perceive and experience belonging and involvement in the scientific and university communities, we provide sample quotes in tables that exemplify the deductively identified themes. Some quotes were lightly edited for grammar and clarity.

RESULTS

Research Question 1: What is the relationship between participation in a SIP and factors believed to predict persistence (A) at the university and (B) in science?

SIP Participation is Positively Correlated with Sense of Belonging and Feelings of Morale at the University.

Linear regressions were conducted to investigate the unique impact of SIP participation on student sense of belonging and feelings of morale, while controlling for generation status, PEER status, nontraditional student status, and time (in years) spent as a student at the university. Compared to non-SIP students, SIP students report statistically significant higher sense of belonging at the institution ($b = 0.273$, $p = 0.013$), as well as higher belonging ($b = 0.736$ $p < 0.001$) and morale ($b = 0.874$, $p < 0.001$) for a smaller group (subcommunity) within the institution (Figure 2). SIP students did not report significantly different feelings of morale for the institution compared with non-SIP students ($b = 0.062$ $p = 0.578$; Figure 2). The full results of the regression analyses are included in the Supplemental Materials, Appendix H.

In focus groups, students shed light on what it meant to them to belong to the university or to a subcommunity within the university. Student quotes in Table 2 illustrate and contextualize what it means to have (or lack) a sense of belonging at or within the university.

Patterns that were distinct between SIP and non-SIP students emerged in the focus groups. For example, compared with SIP students, non-SIP students generally expressed feeling less like a part of the university community. Students across the focus groups felt that the demographics of the university were diverse and "nontraditional", and thus were representative of how they see themselves. Non-SIP students expressed that they were simply going to the university because it is relatively convenient or inexpensive, and that they were essentially

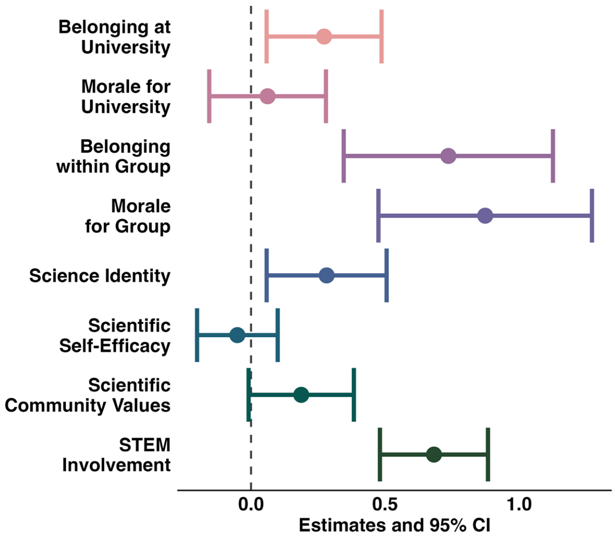

FIGURE 2. Impact of SIP student status on factors related to persistence at the university and in science. Circles represent the estimates (*b*) from linear regressions exploring the correlation between SIP participation on student survey scores for each outcome, while controlling for years at the university, generation status, PEER status, and nontraditional student status. Estimates above zero (to the right of the dotted line) represent a positive correlation between SIP participation and the outcome, while estimates below zero represent a negative correlation. Bars represent the 95% confidence interval for the estimate. Bars that overlap with the dotted line indicate the correlation of SIP participation and the student the outcome was nonsignificant. Number of observations used in each model ranges from 564–570, as observations in linear regressions are removed if data is missing. Full regression results and are included in Supplemental Materials, Appendix H.

"getting by" because the university was the easiest choice (see. Gray *et al.*, 2022 for more); whereas SIP students more often expressed that the university was a good school for them. Both groups of students discussed subcommunities within the university with which they had connected. One advantage of focus groups is that researchers can assess the tone or emotionality within the group responses (Onwuegbuzie *et al.*, 2009), and we identified that the tone in which non-SIP students discussed belonging was less emotional and more pragmatic or even negative compared with the sentiments voiced in the SIP student focus groups.

SIP Participation is Positively Correlated with Students' Science Identity, Science Community Values, and involvement in STEM

While controlling for other demographic characteristics, linear regressions indicated that SIP students experience higher science identity ($b = 0.282$, $p = 0.014$), but do not experience significantly higher science self-efficacy ($b = -0.051$, $p = 0.507$) or scientific community values ($b = 0.187$, $p = 0.062$; Figure 2). Additionally, SIP students reported participating in significantly more STEM-related activities (STEM Involvement; $b = 0.683$, $p < 0.001$; Figure 2). Many SIP programs facilitate involvement in STEM-related activities, such as participating in undergraduate research, or offer structured faculty mentorship for SIP students, so it is expected that SIP students participate in these activities at a higher rate than non-SIP students. Quotes to illustrate SIP and non-SIP student experiences related to factors believed to impact persistence in science can be found in Table 3.

The focus groups helped us to understand how both SIP and non-SIP participants experienced varying levels of self-efficacy towards their "success" in STEM. Some participants revealed evidence of self-efficacy, while others a lack thereof. Being self-efficacious was often revealed by students discussing that they were sure of their STEM-related goals, they had evidence of persisting in STEM in the past, and described tangible outcomes and experiences that reinforced their abilities. Factors contributing to a lack of self-efficacy included low motivation, being unsure of one's goals, lacking time to work towards one's goals, or lacking support from a community.

Similarly, students varied in their development of a science identity. Some participants showed evidence of having a strong science identity; others discussed that they felt they were getting there, but not fully comfortable calling themselves a scientist yet; others did not identify as a scientist. Factors supporting science identity included participating in scientific activities, having a strong interest in STEM, and being able to share scientific knowledge. Barriers to having a science identity included feeling as if one was still novice or learning, that they were not contributing to new discoveries, or did not have tangible evidence of their contributions to science. We noticed that SIP students often reported that they believed a scientist to be someone who pursues knowledge or has curiosity, and non-SIP participants more often described a scientist as someone who has made a discovery and contributed to their field, suggesting that their perception of scientists and what they do may influence science identity.

The focus groups did not ask the students explicitly about STEM involvement, but the types of actions and activities captured in the involvement items of the survey were mentioned throughout the focus groups. Examples include involvement in both STEM and non-STEM related clubs, activities, or campus resources such as tutoring centers or cultural centers. Others referred to their research labs and/or meeting with their research mentors, forming student study groups, various SIP activities, and one-on-one meetings with faculty or mentors.

Research Question 2: What is the relationship between student characteristics and factors that predict persistence (A) at their university and (B) in science?

Student Characteristics can Influence how Students Perceive Belonging at their University and their Relation to the Scientific Community

In our quantitative analyses, we did not detect significant impacts of generation status or PEER status on students' sense of belonging or feelings of morale for the university (full regression results available in Supplemental Materials Appendix H). Factors that were significant (with a characteristic showing either higher or lower than average impact) are shown by characteristic in Figure 3. Nontraditionally-aged students (23 y +) experienced significantly lower sense of belonging at their university ($b = -0.305$, $p < 0.001$), and feelings for morale for the university ($b = -0.178$, $p < 0.027$), belonging to a subcommunity within

TABLE 2. Themes of factors believed to predict persistence at the university

Code		Quote
Evidence of Belonging to the University	**SIP**	*I do feel at home at [the university]. The environment is really awesome for all types of people and I've had nothing but really wonderful conversations with people. I feel like if you want to get involved you can get involved and you'll be embraced with open arms, and if you want to do your own thing, there's lots of people doing their own thing too.*
	Non-SIP	*I live with my parents so I commute to campus. I think it places a toll on what clubs I can join or whatnot, but I do feel a part of the [university] community. I access a lot of the resources. I've had a pleasant experience with my interactions with Financial Aid or any department like that. I always think of the library as my home away from home because I spend so much time there.*
Evidence of Belonging and Feelings of Morale for a Subcommunity within the University	**SIP**	*I think back to summer bridge week, and I remember a lot of us just seemed to have that sense of 'man, we are just going to school, and we don't really feel like we can relate or belong to a group of people'. But that [SIP] bridge week it is like 'oh yeah', I really feel like these people relate to me. It is nice. In my classes I am talking to my classmates, and even though we are in the same major, it is different somehow. So having the [SIP] community feels good. And it is also nice because it kind of gets me out of just focusing on school.*
		Having a group of, I call them my tribe, my tribe of people who are like-minded that we can talk to outside of class and debrief. And they are just there for moral and emotional support, which is the most important part for me. I get so tied up in my inferiority complex, like I'm not good enough, I don't belong here, I should just quit. It is just nice to have that base level underneath it of people who are in the same boat as you, who can tell you, 'No, you are doing fine.'
	Non-SIP	*I started feeling more connected when I got hired to be a math tutor at the learning center. And so then I met all these … I was the only undergrad, also the only female, and there were four, I think there's four grad students who are math tutors there. it was really fun to get to know them, because then we would have classes together and be like, "Hey." And it's a tutoring center, so sometimes you have students to tutor, sometimes you don't have students to tutor, so it's like, just talk about math and all of the fun math things. Up until then, it was like, "Oh yeah, I only know a couple of people." But working there has made it feel a little bit more like I have a group that's like, my people.*
General Lack of Belonging	**SIP**	*I don't feel part of the community here much at all. I met a couple of friends in a couple classes that I'll see out and about and I know where they work and I'll run into them or whatever, but I don't really spend a lot of time on campus. I'm studying at home or at work. I don't, I don't know, I just don't come here. I've not been in any classes yet that require a lot of group work where I meet with people consistently.*
	Non-SIP	*I personally don't feel like a sense of community. I'm not a city person at all. And I don't live anywhere near [city]. I commute in and basically, I just come to school and I have to show up to school early just so I can get a [public transportation] parking spot. And then I just sit around by myself to do all my schoolwork, go to class and then as soon as I'm done, I just go straight home, because I'm not a city person. I don't want to do anything that involves being in the city.*

the university ($b = -0.520$, $p < 0.001$), and feelings of morale for a subcommunity within their university ($b = -0.460$, $p = 0.002$; Figure 3). Time (in years) at the university significantly negatively predicted feelings of morale for the university as a whole ($b = -0.092$, $p = 0.002$), but positively predicted sense of belonging for a subcommunity within the university ($b = 0.112$, $p = 0.031$).

Models revealed that some student characteristics significantly predicted factors related to persistence in science. Nontraditionally-aged students reported significantly higher science identity ($b = 0.182$, $p = 0.027$), scientific self-efficacy ($b = 0.143$, $p = 0.010$), scientific community values ($b = 0.339$, $p < 0.001$), and involvement in STEM activities ($b = 0.209$, $p = 0.005$) compared with younger, traditionally aged students (Figure 3). First-generation students reported higher Science Identity ($b = 0.212$, $p = 0.014$), but lower Scientific Self-Efficacy ($b = -0.132$, $p = 0.023$) compared with continuing-generation students (Figure 3). PEER students reported lower Scientific Community Values ($b = -0.288$, $p = 0.001$) and involvement in STEM activities ($b = -0.175$, $p = 0.045$) compared with non-PEER students (Figure 3). Time at the university positively predicted students' science identity ($b = 0.067$, $p = 0.024$), science self-efficacy ($b = 0.052$, $p = 0.009$), and involvement in STEM-related activities ($b = 0.090$, $p = 0.001$). The full results of the regression analyses are included in the Supplemental Materials, Appendix H.

Although we did not specifically ask focus group participants how their identity and personal characteristics may influence their experiences of belonging at the university and their perceptions of being a part of the scientific community, many participants organically offered those insights. Table 4 highlights examples of how students in focus groups volunteered information about the intersection of their identities and experiences.

Research Question 3: What is the relationship between participation in a SIP and student persistence in STEM majors?

SIP Participation is Correlated with Persistence in STEM Degrees

We conducted logistic regressions to understand how different student factors impacted persistence in STEM degrees. It is important to note that the "left STEM" category includes students who had transferred to a different university or had taken

TABLE 3. Themes of Factors Believed to Predict Persistence in Science

Code		Example quote
Evidence of Self-efficacy	**SIP**	*For me, I know I'm going to do it without a doubt. It is what I have set out to do. I have basically thrown everything in my life at going through, getting the degree, getting a job, in research, get the graduate degree, then go into academic research and then teach and do research for life. That's the plan. I'm just doing it single-mindedly. There is no doubt for me that I will do it through blood, sweat and tears.*
	Non-SIP	*I feel pretty confident just because when you want something, you're going to do what it takes to get there and I feel like I have the resources I need within myself and within my education. So, if I want it I'll get there.*
Lack of Self-efficacy	**SIP**	*Honestly speaking, I don't feel very confident in my ability. I'm premed, and trying to get into medical school. I'm the first person in my family to go to college. None of the women in my family, well none of the men either, but especially the women, ever went to school.*
	Non-SIP	*I'm just mostly worried about actually getting my degree and getting enough time to spend doing mathematics because it requires me a lot to just sit there and just play with it. I am a little worried about that.*
Science Identity	**SIP**	*When I first started school, I didn't see myself as a scientist. Because I kind of fell into the route of, 'Oh, I'm not smart enough. I'm not good enough, I'm not producing anything from my work', so that was what I thought a scientist was but now, actually, working in a lab and taking classes, and seeing the different aspects of science I do consider myself a scientist now, because even when I feel like I'm not doing work that is important, it is still important in some speck of what is happening overall.*
	Non-SIP	*I would say I'm a scientist as well because I always question how something is actually done and so I would go through the process of trying to figure it out and then just trying to go through the steps of allowing someone to understand exactly how something is done, just in normal ways of life, outside of just science areas as well.*
Emerging Scientist	**SIP**	*I definitely feel like school's helping me have all those building blocks that makes me feel like I'm getting to be a scientist, but I definitely don't feel there yet. Just because I am connecting ideas and understanding more and more, I just feel like I'm still building to that level where maybe I do get to define something because of my research, but I'm not at all anywhere close to that.*
	Non-SIP	*"I feel like a scientist in training or learning to become a scientist or think like a scientist and do things that a scientist would do but not necessarily that I am a scientist right now.*
Lack of Science Identity	**SIP**	*I on the contrary would consider myself more of a student. I haven't really done research. I don't know, outside of school I do a lot of clinical things and I'm taking a lot of prehealth classes, so not so much in the research field or doing much research outside of class, so I wouldn't feel comfortable calling myself a scientist, even though I have, I can understand literature and do labs, but I haven't really conducted my own lab and experiments outside of something that's set up for me.*
	Non-SIP	*I don't feel like a scientist personally because in all of the labs that we do, we're not really finding out new things or testing new things, we're just doing something that people have already done hundreds of times. So that can be a wrong opinion maybe, but I just don't feel like a scientist because I'm not doing anything new, I'm just learning.*
STEM Involvement	**SIP**	*The [SIP] community has been very, very helpful. That is how I was able to get into research. I went to [mentor] and talked to her about labs that I would be interested in.*
	Non-SIP	*I didn't get into a research lab until this year. And now I'm coauthor on two papers and working on my own right now.*

time off from school but may return. Therefore, our "left STEM" group is likely an overrepresentation of the number of students who left a STEM field. While controlling for first generation status, PEER status, nontraditional student status, and time at the university, we found that students who participated in SIPs had 3.0 times higher odds of persisting in STEM majors (Figure 4). Students who had been at the university for longer at the time of taking the survey had higher odds of graduating or persisting in STEM majors, such that for every year they had been at the university they had 1.7 times higher odds of having graduated or persisted in a STEM major. PEER status, first-generation status, and nontraditional student status did not significantly impact the odds of persisting in STEM in our model. Full regression results can be found in Supplemental Materials Appendix I.

DISCUSSION

This work provides further evidence for a positive relationship between the structured supports and experiences offered by SIPs and positive academic and affective student outcomes (Rincon and George-Jackson, 2014). Here, we sought to identify if and how undergraduate STEM students supported by SIPs might differ from their peers in factors purported to lead to persistence within the university and in science more broadly. Notably, while controlling for key student characteristics and noting no differences in incoming GPA, students involved with SIPs scored higher quantitatively on, and qualitatively aligned more readily with factors believed to contribute to persistence, and ultimately, our SIP students persisted in STEM at higher rates than their non-SIP counterparts. This work reinforces evidence for many theorized factors (including psychosocial and

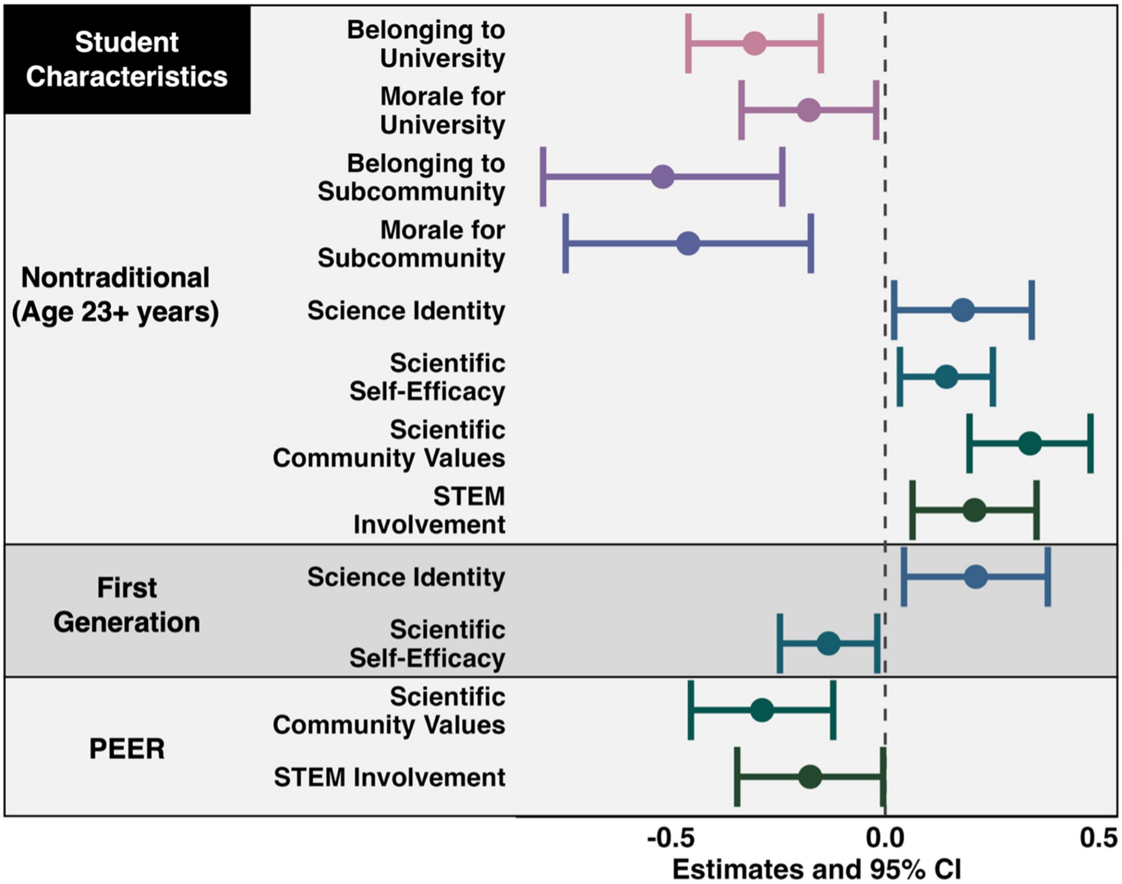

FIGURE 3. Impact of individual student characteristics on factors related to persistence. Circles represent the significant estimates from linear regressions exploring the unique impact of the specified student characteristic on the student score for each outcome, while controlling for time at university, SIP status, generation status, PEER status, and nontraditional student status. Estimates above zero (to the right of the dotted line) represent a positive correlation between the specified student characteristic and the outcome, while estimates below zero represent a negative correlation. Bars represent the 95% confidence interval for the estimate. Number of observations used in each model ranges from 564–570, as observations in linear regressions are removed if data is missing. Additional significant estimates for the impact of time at university are not shown in Figure but are included alongside full regression results in the Supplemental Materials, Appendix H.

affective, as well as experiential), that are purported to influence STEM persistence. Importantly, our study was conducted on a largely understudied student population with a large proportion of nontraditional-age students. Given our unique population, we offer novel evidence of validity for multiple survey scales designed to measure college persistence factors. Further, we were able to disaggregate how these individual persistence factors can be experienced differently across student characteristics, providing important information for more nuanced interventions and studies. Qualitatively, the focus groups help us unpack what it means for undergraduates to belong to a scientific community or to develop a science identity, bringing more nuance and meaning to theorized constructs that can be difficult to conceptualize or turn into action. By holistically examining the entire STEM landscape at one nontraditional university, and looking across SIPs rather than between them, we demonstrate that regardless of individualized programmatic factors, students in SIPs may be having a different, and possibly enhanced experience as they move through our STEM programs compared with non-SIP students – a finding likely of interest to a spectrum of stakeholders.

Factors Influencing Persistence Vary by SIP Status and Student Characteristics

Although it has been suggested that all three of the factors measured in the TIMSI interplay to facilitate persistence in science (Estrada *et al.*, 2011), we were particularly interested in the importance of students' *Scientific Identity*. Identity as a construct has been and continues to be evaluated and debated in the literature, and has thus been defined in several ways which we do not address here in detail; however, many of the theorized components of a science identity are interrelated with ideas such as belonging, socialization and integration (Gee, 2000; Carlone and Johnson, 2007; Vincent-Ruz and Schunn, 2018). A longitudinal study on the impacts of scientific self-efficacy, identity, and value found that scientific identity uniquely predicts persistence in STEM careers 4 y postgraduation (Estrada *et al.*, 2018b), indicating that supporting the development of students' science identity may be critical to achieving long-term persistence of students from historically excluded groups in STEM fields (their work did not test the instrument on students that are majority white or Asian).

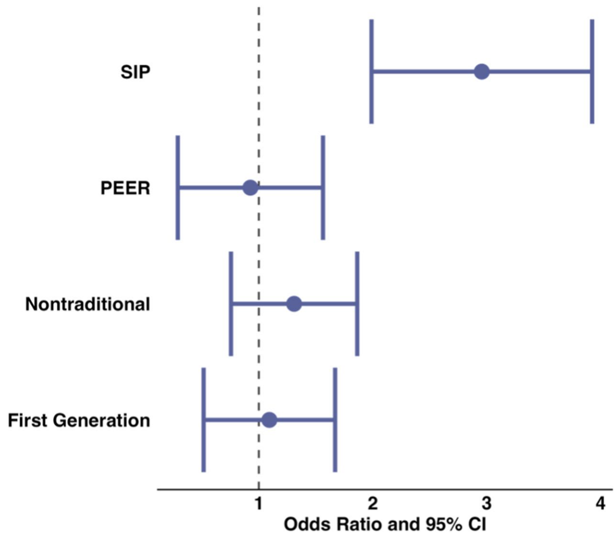

FIGURE 4. Impact of SIP participation and student characteristics on STEM persistence. Odds ratios and confidence intervals (natural exponential of beta ± 1.96 × SE) for students' persistence in STEM, as defined by having graduated with a STEM degree or continuing in STEM majors 2.5 y after the original survey deployment. Models controlled for time at university (full model data included in Supplemental Materials). Estimated confidence intervals that do *not* cross the dashed gray line at $x = 1$ are statistically significant. Full regression results are included in the Supplemental Materials, Appendix I. $N = 556$.

Our survey and qualitative analyses revealed that participants in SIPs have a stronger scientific identity compared with those who are not in STEM support programs (Figure 1; Table 3). We interpret this finding as a sign that these programs may contribute to increasing representation in STEM professions, as found in a study by Estrada *et al.* (2021) conducted on a cohort of underrepresented biology students who were part of a SIP. We explored the concept of a science identity further in the focus groups by asking students if they thought of themselves as scientists. As illustrated in Table 3, students expressed evolving perceptions of their science identity: some clearly identified as a scientist, while others expressed nascent perceptions of a science identity, or did not feel they were not a scientist at all because they were a student or just beginning to learn scientific norms. Previous literature has found that perceptions of gender stereotypes and racial stigmas within the sciences negatively influence students' science identity (Zhao *et al.*, 2005; Chang *et al.*, 2010; Williams and George-Jackson, 2014; Hazari *et al.*, 2013; Starr, 2018). Yet, in our work, SIP students identified as a scientist or emerging scientist more readily than non-SIP students (quantitatively and qualitatively), and PEER students make up over half of our SIP participants (Table 1), again suggesting that SIPs can benefit historically excluded students in ways that lead to persistence.

Like *Science Identity, Scientific Self-Efficacy* is a construct with an extensive literature base and several instruments designed to measure it. Again, we chose the TIMSI to measure these ideas as a proxy for likelihood of persistence in science, although the authors themselves (Estrada *et al.*, 2011) have identified that *Scientific Self-Efficacy* lags as a predictor of persistence when other factors are included in models, this could be due to the inherent fluctuation in self-efficacy as a student grows into a discipline. As students progress through STEM programs, they may recognize more realistically how much they must learn, as opposed to a tendency to express inflated beliefs about ability at the outset of their programs (Kruger and Dunning, 1999). We conducted this survey at the end of the school year, thus presumably students had experienced both successes and challenges in their journeys in science courses and experiences. This was reflected in the focus groups, where students expressed a range of scientific self-efficacy beliefs, from very low to having a clearly efficacious outlooks (Table 3).

Research using the TIMSI scales identified *Scientific Community Values* to be a longitudinal predictor of persistence in a STEM career for minoritized students (Estrada *et al.*, 2021). PEER students in our study, controlling for all other factors, reported significantly lower on this scale compared with the other tested student characteristics (Figure 3). While focus groups did not reveal insight into why this might be the case, it is possible that inherent biases in STEM disciplines are infused throughout many SIP programs as they typically conform to Western cultural norms of science. Our survey items may likewise reflect such cultural norms. Our finding is counter to those by a few researchers including Estrada and colleagues (2022) who found that response to the *Scientific Community Values* scale was strongly positively associated with Native STEM student persistence. That work focused on a SIP which included tailored mentoring for Native students. Importantly, those authors (Estrada *et al.*, 2022) presented a clear rationale for how thinking about "integration" into scientific community should not involve expecting assimilation, but instead true integration such that students can see how their contributions, beliefs, and identities are valued and included in a STEM community (akin to the definition of belonging by Strayhorn (2018)

TABLE 4. Student characteristics influence perceptions and experiences of STEM students

Example Quotes
My community college teacher referred to us as junior scientists, so I am probably a 41-y-old junior scientist. But I think at this point, especially now that I'm finishing up my undergraduate degree and I know I'm going to be pursuing a future in this direction, I started saying confidently that I'm at least in the science field and that I'm a scientist. (SIP Non-traditional age student)
I'm just a first in family college student, so literally everything that has to do with college has been kind of like, I guess, on the rough side. Because it's like, I didn't know what those terms meant as far as like, what is a major? What's the difference between a Bachelor's and a Master's degree? What is a minor? And I didn't know anything about college. (non-SIP first generation student)
In mathematics I've only seen maybe only two other brown people so it gets pretty difficult to have groups and really try to go outside the class and get together, because I feel like I'm not on the same level or culturally the same. I don't know how to explain it. (non-SIP, PEER student)

quoted in the introduction). Another study that looked at the outcomes of undergraduate research experiences demonstrated that when students identified faculty mentors as "inspirational" and as "relevant" role models and perhaps being more "like them", they developed a stronger response to the *Scientific Community Values* scale than other students (Hernandez *et al.*, 2018). SIPs at our university could benefit from a self-examination of how *Scientific Community Values* are represented and communicated to our students, with research studies designed to assess the construct more deeply. Additional think-aloud cognitive interviews with PEER students on the survey items would also help us to better understand our results.

Both the survey and focus groups revealed that SIP and non-SIP students differ in their reported involvement in STEM-related activities. This result is expected, in that many of the survey items asked about activities that are either promoted regularly by SIP programs (e.g., going to an instructor's office hours, talking to a faculty member about career goals, attending seminars), or are directly facilitated by SIPs as part of the programming–such as joining a faculty member's research lab and one-on-one faculty mentoring. Yet, PEER students, controlling for other factors (including SIP status) reported lower on the STEM Involvement scale than other tested characteristics. In the focus groups we heard instances of students of color saying that they felt they were one of few in a space or not the "same" as their peers (Table 4). With such experiences, it follows that students who are underrepresented could feel less inspired to engage. More intentional efforts by the institution to create counterspaces for students of color (Case and Hunter, 2012; Ong *et al.*, 2018) as well as generally making subcommunity spaces within the university more apparent and welcoming (Jessup-Anger *et al.*, 2022) may help mitigate the implications of this finding. We are aware of a physical counterspace established by at least one SIP on our campus currently. Here students in the SIP can visit, study, hang out, and socialize. At least a few focus group participants who utilized this space indicated that it was indeed important to them. Future work to understand these likely intersecting themes of identity, space, and perceived support and/or welcoming environments, will reveal more insight into this finding.

Differential Belonging

Researchers have suggested that for many students, developing a sense of belonging in a field of study can be crucial to persistence, and that this may be particularly important for PEER or otherwise underrepresented students (Estrada *et al.*, 2016; Strayhorn, 2018; Murphy *et al.*, 2020). Further, (Hurtado and Carter, 1997) found that having a specific subcommunity to which a student belongs may be the most impactful factor for underrepresented students in developing belonging. We therefore asked students about their belonging both to the university, and to a subcommunity within the university separately. While SIP students scored on average higher on both scales, perhaps unsurprisingly, we found that students supported by a SIP reported a particularly stronger sense of belonging and feelings of morale to a subcommunity than non-SIP students. SIP students sometimes chose a SIP as their "group" in the survey, but many others reported thinking of other options (e.g., a multicultural center, a research group, a disciplinary department). We believe that SIP students' strong subcommunity identity may reflect the focus of SIP programs in both supporting cohort-development within the SIPs themselves, and in supporting and encouraging students' involvement in other subcommunities and activities across the university (for example, securing positions for SIP students within research groups or internships).

Non-SIP students had lower feelings of belonging and morale than SIP students (Figure 2). Strikingly, quite a few non-SIP students reported that they did not identify with a group within the university at all, implying that a significant proportion of students without SIP support may struggle to integrate into subcommunities within the university, which could have a direct impact on their ability and desire to persist (Strayhorn 2018). While controlling for SIP status, nontraditional age (older) undergraduates tended to score higher than average on science identity, self-efficacy, community values as well as in STEM involvement scales, yet less than average on all belonging and morale scales (Figure 3). This is interesting as our campus has a large population of nontraditional age students (Table 1), and students who did express experiencing a sense of belonging often explained that it was because of the large presence of and support for a nontraditional student population (defined by Choy (2002) as older than 23 y of age, with children, do not live on campus, work at least part time, etc.). Our population creates an environment where nontraditional students are more likely to "fit in", as they are not necessarily in the minority on the campus. Such themes were threaded throughout the focus groups with our data demonstrating qualitatively (Table 4) and quantitatively (Figure 3) that students' identities and characteristics are salient to their experiences. A more concentrated study on the value of belonging and what it means to nontraditional students specifically could reveal important insights regarding that population. It is possible that there is a subpopulation of students for which belonging at an institution is not critical or perceived to be critical to their success, in particular if they have families, jobs, and various other outside priorities. Our previous work focused on the STEM transfer student experience hints that this may be true for some nontraditional students (Gray *et al.*, 2022), but the hypothesis would need to be tested explicitly. This current work and the in-depth scholarship of others (e.g., Strayhorn, 2018) has informed our evolving conviction that it is critical to move beyond quantitative measures identifying the degree to which a student feels they "belong" or does not –but also to probe the what, where, and how of belonging for individuals.

Social Support as Key to Belonging

Focus groups revealed that students in SIPs emphasized the importance of having a social network, while non-SIP students discussed a lack of belonging to the university. The supports that SIPs provide vary by program, but they are generally designed to promote high-impact practices such as facilitating a research experience or developing a community of scholars (Rincon and George-Jackson, 2014). Delineating which programmatic aspects of each SIP lead to specific outcomes was beyond the scope of this study; however, the focus groups provided vital insight into some of the reasons students felt that they were thriving, much of which was related to connections made and maintained. One of the SIPs for example required a year-long cohort-based course-based undergraduate research experience (CURE), on which students reflected:

> *The consistency of the [SIP CURE] is great. Just seeing the same people. I like the Friday class even though I'm here all day. Just that 4-h block, it's just nice to be in because it's not the same as how other classes are structured. – SIP Student*

> *When I was there every Friday, I was like hey [student name], you're alive! That's the one thing I miss the most, thinking of that community there. – SIP Student*

These data, similar to that of other's suggestions (e.g., Thomas, 2016), suggest that built-in time spent as a student cohort is impactful for buttressing social belonging. Increasingly, researchers are finding that supporting students with not only academic but also social and emotional support will affirm social inclusion, contribute to broader participation in the STEM fields and ultimately result in greater persistence. This affective support can be promoted by instructors demonstrating a growth mindset (Canning *et al.*, 2019), intentionally integrating belonging interventions (Murphy *et al.*, 2020), and sending students simple cues of kindness (Estrada *et al.*, 2018a).

Graduation Rates and Persistence in STEM Majors

Students supported by SIPs at our institution were more likely to either have graduated in STEM or still be making progress in their STEM degree pathways when compared with non-SIP students, who were more likely to have left STEM or the university (Figure 4). This is particularly notable given that SIPs often recruit students who face more barriers to persistence, including transfer students, first-generation students, or students from ethnic or racial groups historically excluded from STEM–demographics which are reflected by the SIP students who participated in our survey. Our study spans the COVID-19 pandemic, and studies have shown that COVID-19 had a disproportionately negative impact on students traditionally targeted by SIPs, with low-income students, PEERs, women and gender-nonconforming students taking leaves of absence or withdrawing entirely from institutions at notably higher rates (Cameron *et al.*, 2021). The fact that many of our SIP students did not show similar trends in leaving their degrees during the pandemic suggests that these programs may have provided critical support in helping these students persist in their education even given the significant barriers presented by the pandemic.

Limitations

These data are limited to one institution therefore are unlikely to be generalizable beyond contexts similar to ours. Further, we group SIPs across our institution recognizing that they are not all the same and that we do not have suitable data describing the activities or supports survey participants in any given SIP would have experienced. The intent here was to first survey STEM students, both involved and uninvolved in SIPs. Much federal funding as gone towards these programs and thus it is an important first step to take broad brush strokes across the STEM landscape to identify any discernable differences between groups of students and their experiences. Here, our data indeed suggest evidence of a positive influence of SIPs on the sample of students. We can now take a finer-grain approach to understanding the why and how.

We acknowledge that there is potential for self-selection bias in the students that choose to apply to and then end up engaging with SIP programs, thereby limiting the generalizability of the data. Further, SIP programs may differentially select for high-performing students, biasing the population towards those with an incoming advantage, which would clearly influence any conclusions that could be drawn from comparison results. A previous study at our institution found that STEM students' incoming GPAs can be a predictor their final course scores in introductory STEM courses, and that PEER students had lower incoming GPAs (Shortlidge *et al.*, 2019). The literature would suggest that this disparity is rooted in various structural, classist, and socioeconomic inequities in education and access to education (Crenshaw, 2017; Whitcomb and Singh, 2021). Yet, here we found no significant difference in incoming GPA between SIP and non-SIP students in our sample. While our regression models can offer quantitative insights into the connection between participation in a SIP and both affective and persistence outcomes, it is important to remember that these are models that simplify students' real-world experiences. For example, although we control for several variables, there are many unmeasured variables in students' backgrounds and experiences that our models cannot account for. Our models leave potentially salient interaction terms and therefore do not address intersectionality. A larger sample size of PEER and otherwise underrepresented students in STEM may have permitted us to disaggregate our data further to investigate potential differences among students in outcome variables and experiences. However, representation in focus groups was adequate, allowing us to draw conclusions confidently yet cautiously about our students' experiences.

There is potential for social desirability bias to occur in qualitative research methods such as in a focus group setting, and we acknowledge this could impact how willing students were to share and/or be honest in their responses (Bergen and Labonté, 2020). We designed focus groups to be comprised of SIP and non-SIP students only, and used equitable and encouraging practices in focus group facilitation in an effort to reduce the limitations of the methodology.

Lastly, here we do not quantify the frequency of responses across focus groups due to the nature of focus groups. Not all students will respond to every question, and much nuance is captured in gestures, tone, and nonverbal communication (Parker and Tritter, 2006; Onwuegbuzie *et al.*, 2009). Representative quotes illustrate how students conceptualize the measured constructs, underscoring what they may have been thinking as they responded to survey items. With the focus groups we strove to present a more holistic portrayal of our students' experiences beyond the aggregate quantitative results. In-depth interviews with a diverse group of both SIP and non-SIP students are underway to gain a more nuanced intersectional understanding the experiences of STEM students at our institution.

CONCLUSIONS

This work augments the literature on and provides additional support for theories that affective concepts such as sense of belonging influence STEM student persistence. We show that at a nontraditional, urban commuter institution, SIPs positively relate to multiple factors oft believed to contribute to persistence, as well as to actual persistence in STEM. If this finding holds across institutions, SIPs may represent consequential contributors to diverse student success and persistence in STEM. Yet, the existence of SIPs are often predicated on external funding being secured by faculty and staff. Future research and evaluation should critically consider which programmatic elements directly foster persistence-related attitudes and experiences. And, because no student group is a monolith, future work must also seek to understand which (if any) elements of SIPs effectively support all students, as well as if certain elements of programs differentially support students with marginalized identities more or less than their represented peers.

Given the positive influence that SIPs may have on students – in particular historically underserved and marginalized students – it would be a disservice to not invest in infrastructures developed by SIP leadership. Institutions who not only recognize the impact of efficacious STEM programs, but also provide internal supports for studying, extending, and building upon core aspects of them, may foster a university community designed to support diverse student success, thus moving towards STEM retention goals.

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