Increasing 1st and 2nd Year Retention of STEM Students Through Multifaceted Mentoring, Early STEM Community Integration, and Strengthening of Intersecting STEM Identities

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Abstract

Allegheny College has launched a comprehensive program using multi-faceted advising, rich academic and social programming, early STEM community integration, and numerous resources already available to increase both college and STEM retention and strengthen intersecting STEM identities among high financial need STEM students. Formal assessment in the form of a mixed-methods controlled study was used to compare the experience of the program cohort to a non-intervention comparison peer group in their first two years at Allegheny. We hypothesized that the comprehensive STEM program would lead to increased retention of students in STEM majors and strengthen intersecting STEM identities as compared to the control group. The results of this study support our hypothesis. Additionally, STEM program students' confidence and academic resilience increased over time.

Introduction

The past two decades have resulted in a 20% increase in Science, Technology, Engineering, and Mathematics (STEM) professions, which are projected to comprise the fastest-growing job market over the next decade (Chen et al., 2021; Rozek et al., 2019). Pennsylvania alone will have 590,000 new STEM jobs by 2026 and has nine nationally recognized STEM initiatives. However, merely increasing the number of STEM-interested students who are socioeconomically and ethnically diverse has failed to yield the needed workforce (Cannady et al., 2014). Thus, it is crucial to understand that STEM retention is influenced by social, cultural, economic, and situational barriers and that scholarships alone will not bridge the achievement gap (Babineau, 2018; Bettinger & Baker, 2014; Cline et al., 2023; Enriquez et al., 2014; Eschenbach et al., 2011; Martin et al., 2019; Wilson et al., 2012). This research examines the impact of a new STEM scholarship and mentoring program at Allegheny College, aimed to increase retention both at the college and in STEM fields specifically, and address achievement gaps among marginalized students.

Students from marginalized groups demonstrate the same level of interest in STEM as their peers, yet leave STEM pathways at higher rates (Harris et al., 2020). The extremely alarming attrition rate stems from achievement gaps and barriers created by various socioeconomic factors (Betancur et al., 2018; Harackiewicz et al., 2016; Harris et al., 2020; Rozek et al., 2019; White et al., 2021; Freeman et al., 2007). Thus, this vulnerable population is less prepared than their peers for the expectations of college STEM majors and possesses higher rejection sensitivity (Harris et al., 2020; Rozek et al., 2019; Toven-Lindsey et al., 2015). As STEM identity declines, marginalized students are more likely to abandon STEM fields (Harackiewicz et al., 2014; White et al., 2021). For students who remain in STEM, belonging uncertainty and stereotype threat impede further improvements, ultimately increasing achievement gaps and reinforcing inequality (Chen et al., 2021; Cohen & Garcia, 2008).

Thus, Allegheny College launched a comprehensive STEM cohort program, funded by a grant from the National Science Foundation, Division of Undergraduate Education (Scholarship-in STEM; S-STEM). The program aims to foster stronger STEM identities for academically talented, low-income students, leading to higher institutional and STEM persistence. NSF funding was pursued since it has a long and well-documented history of success in supporting academically talented STEM students with high financial need (Cline et al., 2023; Enriquez et al., 2014; Kalevitch et al., 2012; Martin et al., 2019; Wilson et al., 2012; Wright et al., 2021). The literature confirms that scholarship awards, while crucial, must be combined with academic-enhancing and community-building activities (Enriquez et al., 2014; Martin et al., 2019; Wilson et al., 2012). These interventions focus on study skills, time management, and STEM career preparation (Cline et al., 2023; Eschenbach et al., 2011; K. J. Graham et al., 2017; Jones et al., 2014; Kalevitch et al., 2012; Olson et al., 2016; Wright et al., 2021). These studies collectively stress the need for enhanced scholarship programs to holistically address students' needs, paving the way for higher persistence and success rates (Estrada et al., 2016; Freeman et al., 2007; Meixi et al., 2015; Nealy & Orgill, 2019; Snyder et al., 2016; Toven-Lindsey et al., 2015).

Allegheny College S-STEM Program Overview: Liberal arts institutions similar to Allegheny College are well-poised to address STEM identity and belonging. Increasing STEM retention can be achieved by leveraging existing student support infrastructures, which include smaller class sizes, strong connections among myriad departments and offices across campus, one-on-one advising, and robust undergraduate research programs. Specifically, Allegheny can provide personalized attention and support to each student to create an environment that nurtures science discovery and education. Allegheny consists of 35% STEM majors while only 10% of its population identifies as marginalized STEM students (~24 students total per class). A comparative analysis of Allegheny's retention in STEM gateway courses revealed lower retention rates for marginalized students, as determined by a 40% higher DFWX percentage (the percent of students who earned a D, F, or withdrew from a course), especially during the first year. However, the retention trend among all demographic groups clearly indicates that once a student declares a major at Allegheny, they persist through graduation (≥88%), consistent with national trends (Asai & Bauerle, 2016; Dagley et al., 2016; Estrada et al., 2016; Tsui, 2007; Wilson et al., 2012). Thus, the Allegheny College NSF S-STEM program aims to increase STEM retention prior to declaring a major by providing activities and opportunities that strengthen STEM identity. Additionally, the program allows

students to explore a wide range of majors in contrast to other STEM programs (Enriquez et al., 2014; Eschenbach et al., 2011; K. J. Graham et al., 2017; Jones et al., 2014; Olson et al., 2016; Wright et al., 2021).

Recruitment and College Readiness: Promotional materials describing the S-STEM program and eligibility criteria were provided to Allegheny's admissions department to distribute. The program was also advertised during campus visitation events. All eligible prospective students (Pell-eligible students with a high school GPA of 3.0 or above) were personally invited (i.e., told they qualified for the program and would be immediately accepted) to the S-STEM program rather than requiring an application process and inadvertently creating additional institutional barriers. This process simply removed the application step and applied to all participants, thereby ensuring that no students were lost due to that additional step. Prior to the first semester, two comprehensive summer initiatives were offered to sustain students' excitement for the program and the college. The first was the Summer Enrichment Program (SEP), a virtual preparatory experience consisting of interactive modules. The SEP was designed to help participants improve STEM foundational knowledge, study skills, and time management. The second was an in-person STEM Orientation program that expanded on the SEP. For example, the program provided a space to discuss the hidden challenges of college life for marginalized students.

First-year seminar and STEM cohort courses: All Allegheny students are required to take a series of seminar courses that share a focus on communication. Students take the first one in their first semester, and instructors serve as academic advisors until they declare a major. The S-STEM program leveraged this existing structure and created a unique section for S-STEM scholars, incorporating general STEM topics and connecting to the SEP to further prepare students for college-level research. Additionally, the program advisors ensured that at least two scholars were enrolled in each gateway STEM course to provide a ready opportunity for study groups, moral support, and accountability.

Mentoring and Scholar Seminar: The scholar program incorporates a multi-faceted approach to advising involving the S-STEM PIs, academic advisor (if not one of the PIs), Class Dean, peer mentors, and the Office of Inclusive Excellence. Other opportunities, such as the biweekly Scholar Seminar and one-on-one check-ins, foster community-building and both academic and professional development. Speakers invited to the Seminar included directors from the Counseling Center, the Student Diversity and Inclusion Center, the Undergraduate Research Office, and Career Education. Faculty members from different STEM disciplines also introduced their research to the scholars. In addition, there were sessions to discuss exam preparation and time-management strategies. In the sophomore year, the seminars focused on networking with alumni and helping scholars secure a STEM-related internship or experience for the summer.

Early Integration and Long-Term Participation in Research: Access to research opportunities is one of the most frequently cited activities for increasing retention of marginalized students in STEM fields (Carpi et al., 2017; Dagley et al., 2016; Estrada et al., 2016; M. J. Graham et al., 2013; Hughes, 2018; Tsui, 2007; Wilson et al., 2012). Research positively impacts students' academics and overall knowledge (Aschbacher et al., 2010; Carlone & Johnson, 2007; Chemers et al., 2011; Lopatto & Tobias, 2009; McCormick et al., 2011). Most Scholars engage in research experiences beginning in the spring of the first year or fall of the sophomore year by participating in an Introduction to Research course that facilitates shadowing experiences in various STEM research groups.

Academic requirements and interventions: S-STEM Scholars are expected to maintain a GPA of at least 3.0. The program's multifaceted advising also provides multiple points of contact and opportunities to discuss academic challenges. In consultation with the student, advising teams articulate steps to help scholars succeed. The S-STEM advisors also routinely congratulate scholars for academic and professional successes. At the beginning of each semester, the team meets with each student with a semester GPA below 3.0 to set goals and a plan of action to improve academic performance. Finally, for students with two consecutive semester GPAs below 3.0, a written contract is added to the beginning of the semester meeting that outlines specific expectations and actions to hold students accountable for improvement.

Experimental Design: The Allegheny S-STEM Program assessment is organized as a controlled experimental study, and includes quantitative and qualitative analyses that offer an in-depth examination of how the program impacts participants by focusing on their experiences, challenges, persistence, and growth over their first two academic years, in comparison to a group of STEM students not participating in the program intervention. The primary psychosocial constructs measured are self-reported STEM identity development, sense of belonging, and mentorship effectiveness. Persistence in this study is demonstrated by: good academic standing as defined by GPA; STEM major declaration, and graduating with a STEM major. The study has three hypotheses: (1) the enriched support provided by the S-STEM program will yield a greater sense of College and STEM belonging; (2) students in the S-STEM group will report a stronger College and STEM identity; and (3) the S-STEM group will show greater institutional and STEM persistence.

The intervention was also framed through Social Cognitive Career Theory (SCCT; Lent et al., 1994), which models academic and career persistence as the joint product of self-efficacy, outcome expectations, and goals operating within a field of person inputs (e.g., socioeconomic status, first-generation status) and contextual supports and barriers. SCCT predicts that without compensating supports, contextual barriers blunt the learning experiences from which self-efficacy develops, weakening STEM-related goals and persistence (Chemers et al., 2011). Each component of the Allegheny program targets a specific mechanism: cohorting and the Summer Enrichment Program generate early mastery and vicarious learning experiences; multifaceted advising and the Scholar Seminar function as contextual supports; and early research integration supplies the authentic performance accomplishments through which STEM identity and career goals are built.

Methods

Participants: 21 first-semester, first-year students who planned to major in STEM were recruited from the Fall 2022 Allegheny College applicant pool for the study (Table 1). The S-STEM group comprised 12 students and the Control group comprised nine non-S-STEM students. The entire S-STEM group identified as members of underrepresented groups, including racial, ethnic, gender, and/or economic identities. The control group mirrors the general Allegheny College student population; therefore, the data set can foster discussions regarding the achievement gaps of marginalized STEM students compared to the overall campus STEM populations.

Study Design for Quantitative Measures: A multipronged study was necessary to evaluate all elements of the program fully, while also ensuring that the assessment tools possess similar aspects to well-vetted instruments for a comparison analysis. The statements used in the quantitative analysis were drawn from two different instruments: McDonald et al (2019) 1-item STEM professional identity overlap and Leibowitz, et al.'s (2020) subscales: campus sense of belonging, academic major sense of belonging, and residential community sense of belonging. Participants self-reported their sense of belonging at Allegheny College, in STEM, as an Allegheny student, and as a

STEM professional. They also completed open-ended questions that examine the degree to which students perceive they are being effectively mentored throughout their undergraduate career. Instruments available upon request.

Participant Demographic Information

	Fall 22		Spring 23		Spring 24	
Identity	STEMFA22 N = 12 [7]	CONTROLFA22 N = 9 [7]	STEMSP23 N = 12 [7]	CONTROLSP23 N = 9 [7]	STEMSP24 N = 11 [7]	CONTROLSP24 N = 7 [7]
Race						
Asian	1 (8.3%)	0 (0%)	1 (8.3%)	0 (0%)	0 (0%)	0 (0%)
Black	5 (42%)	0 (0%)	5 (42%)	0 (0%)	5 (45%)	0 (0%)
Multiracial	1 (8.3%)	1 (11%)	1 (8.3%)	1 (11%)	1 (9.1%)	1 (14%)
White	5 (42%)	8 (89%)	5 (42%)	8 (89%)	5 (45%)	6 (86%)
Latinx	1 (8.3%)	0 (0%)	1 (8.3%)	0 (0%)	1 (9.1%)	0 (0%)
Gender						
Cis Man	4 (33%)	2 (22%)	4 (33%)	1 (11%)	3 (27%)	1 (14%)
Cis Woman	5 (42%)	7 (78%)	6 (50%)	7 (78%)	6 (55%)	5 (71%)
Gender-Fluid	1 (8.3%)	0 (0%)	1 (8.3%)	1 (11%)	1 (9.1%)	1 (14%)
Not Listed	1 (8.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Transgender Man	1 (8.3%)	0 (0%)	1 (8.3%)	0 (0%)	1 (9.1%)	0 (0%)
Pell	12 (100%)	3 (33%)	12 (100%)	3 (33%)	11 (100%)	3 (43%)
FirstGen	9 (75%)	0 (0%)	9 (75%)	0 (0%)	8 (73%)	0 (0%)

[7] n (%)

Table 1. Demographic Information for Fall 2022, Spring 2023, and Spring 2024 semesters.

Note: S-STEM Scholars were recruited during the admission process. Control students were recruited by advertising during STEM Courses, announcements on web-based bulletins, and email correspondence to mirror the overall college demographics

Sense of belonging and identity were measured using a 15-item measure that asks students to indicate their agreement with statements using a 7-point Likert scale that ranges from Strongly Disagree (1) to Strongly Agree (7). Perceived identification as an Allegheny College student or a STEM professional was examined using a single-item identity overlap survey developed by McDonald et al (2019). Students were presented with seven images of overlapping circles to measure perceived identification. The degree of overlap ranges from 1 (no perceived overlap or 0%) to 7 (approximately 90% overlap) between the self and an Allegheny College student. The relationship between the self and a STEM professional is measured through an identical item with "a STEM professional" replacing "an Allegheny College student." Finally, given the centrality of mentoring within the S-STEM program, the developed assessment instruments also gauged the degree to which students perceive they are being effectively mentored, with measure parameters similar to Brady et al. (2020).

Procedure for Quantitative Measures: Data collection is implemented four times throughout the students' time at Allegheny: twice during the first year (beginning and end of the academic year), at the end of the second year, and at the end of the final year. For the present study, data collection was completed in person at Allegheny College for Fall 2022, Spring 2023, and Spring 2024 (i.e. the first cohort of students' first two years). The procedure remained the same for all assessment periods. After arriving in the specific group's testing room, participants were provided with a QR code to the consent form and survey instruments via Qualtrics. Non-S-STEM students received a small incentive ($25 gift card) for each assessment interval (i.e. one survey session and one Focus Group). In addition, a meal was provided to all participants. This paper summarizes the findings from the first three assessment intervals for the first cohort of scholar and control group students (90% or higher participation rate in each interval and group).

Data Analysis for Quantitative Measures: A total sense of belonging score was calculated for each participant by averaging the responses to the 15-item instruments for STEM and College belonging. Similarly, the scores for identification with an Allegheny College student and with a STEM professional were averaged across all participants. For all the quantitative measures described above, the mean and standard deviation were calculated separately for the S-STEM and Control groups. Inferential statistics were not conducted since they are likely to yield unreliable results due to the small sample size for each group. Thus, quantitative data analysis provides comparisons of means and standard deviations across groups.

Data analysis for persistence (GPA): To evaluate persistence, each participant's overall Grade Point Averages (GPAs) were averaged and examined separately for the S-STEM and Control Groups for Fall 2022, Spring 2023, Fall 2024, and Spring 2024. Similarly, to examine academic performance and resilience in STEM courses, the GPAs for all STEM courses were averaged and examined for the S-STEM and Control Groups separately for Fall 2022, Spring 2023, Fall 2024, and Spring 2024.

Materials for Qualitative Measures: The Focus Groups explore the same topics as the surveys, although in a discussion format designed to elicit more detailed student responses and gauge the extent to which the program meets student expectations. The discussions are based on 21 questions covering (1) the rationale for attending Allegheny College and choosing a major, (2) the perceived general impact of being a student at Allegheny and being a STEM or Non-STEM student, (3) the nature of the student experiences, and (4) the student's perception of potential long-term effects of their student experiences. Additionally, a final open-ended question (22nd question) is provided to students as an opportunity to discuss any other topic the students deem important or relevant.

Procedure for Qualitative Measures: Focus Groups are conducted four times during students' time at Allegheny, in conjunction with the survey schedule detailed above. The procedure remained the same for all assessment periods. All participants were scheduled to attend an in-person Focus Group session with their respective groups.

The Focus Groups are facilitated solely by the external Evaluator, previously unknown to the students. The audio recordings for the three sessions conducted for this paper were converted into anonymized transcripts. The transcripts were supplemented by the Evaluator's notes taken during the session. A coding system was applied to categorize the responses from the transcripts (see below). The coding system was based on six themes and their specific operational definitions for this study. The same procedures were used for each group. The analysis examines changes over time within each group and differences between the S-STEM and Control groups after the program intervention. With the use of a single evaluator, intracoder reliability was applied in the coding process for qualitative results to ensure that data were evaluated dependably and that interpretations didn't drift due to confounding factors.

Coding Categories

1. *Expectations and Perceptions*: Initial expectations about the STEM program and whether these expectations were met.
2. *Engagement in STEM*: Level of engagement in STEM activities and classes.
3. *Perceived Support*: Feelings of support from faculty and peers within the STEM fields.
4. *Career Aspirations*: Changes/developments in career aspirations within the STEM fields.
5. *Community Involvement*: Involvement and sense of belonging in the Allegheny College community, and specifically within STEM areas.

6. *Challenges and Disappointments*: Any difficulties or unmet needs expressed by students.

Results

Quantitative Results: Perceptions of Belonging. Differences between the S-STEM and Control groups' average belonging scores were examined separately for Fall 2022, Spring 2023, and Spring 2024 (Figure 1). The S-STEM group consistently indicated greater perceptions of belonging at Allegheny College; however, belonging decreased for both the S-STEM and Control groups in Spring 2024. While the S-STEM group consistently reported greater perceptions of belonging in STEM than the Control group, both groups showed decreased belonging in the Spring 2024 semester.

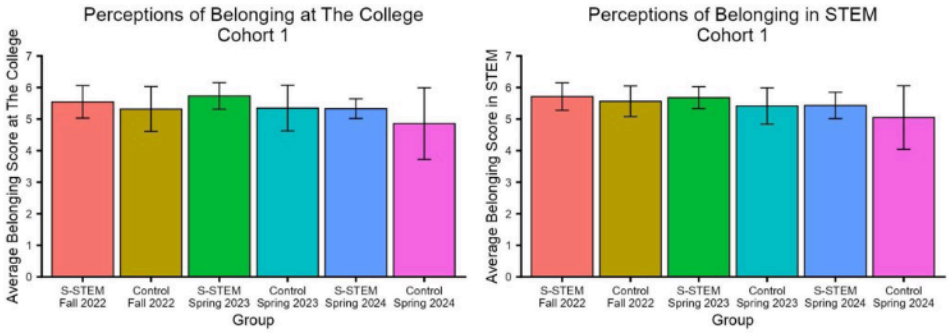

Figure 1. Perceptions of belonging at College and in STEM with 95% confidence intervals.

Quantitative Results: Perceived Self-Identification. Overall, the S-STEM group consistently perceived a greater overlap between themselves and an Allegheny College student (Figure 2). Additionally, the S-STEM group's identification with an Allegheny College student increased each semester, while the Control group's identification decreased for Spring 2024. The S-STEM group initially perceived a lower overlap between themselves and a STEM professional (Figure 2), but by Spring 2023, the S-STEM group perceived a greater overlap. Further, the Control group's identification with a STEM professional decreased, with the most significant drop occurring from Spring 2023 to Spring 2024.

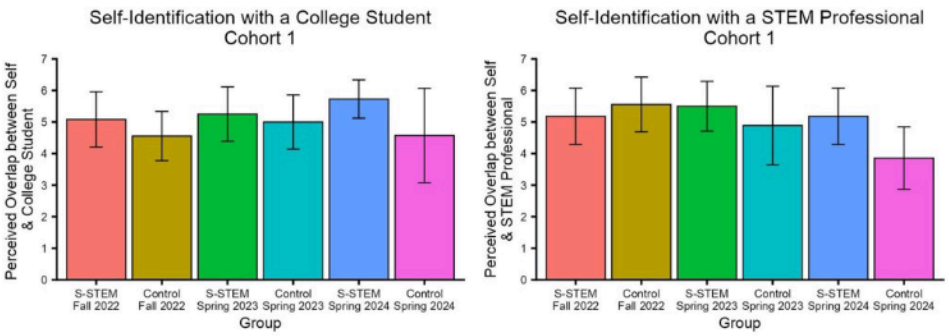

Figure 2. Identification between the self and a college student or STEM professional with 95% confidence intervals.

Quantitative Results: Academic Performance. Although the S-STEM group had a lower overall GPA than the Control group for each semester, the average GPA for the S-STEM group increased, while the average GPA for the Control group decreased across all semesters (Table 2). The S-STEM group also had a lower STEM GPA, but the gap between the two groups diminished each semester (Table 2). It is worth noting that Pell-eligible students at Allegheny College have lower overall GPAs at the end of their 1st year (GPA 2.9) when compared to the S-STEM scholars.

GPA Summary by Semester

Group	Fall 22[†]	Spring 23	Fall 23	Spring 24
Overall GPA				
S-STEM	3.14 (0.69)	3.17 (0.45)	2.95 (0.74)	3.24 (0.38)
CONTROL	3.8 (0.31)	3.82 (0.22)	3.6 (0.47)	3.39 (0.79)
STEM GPA				
S-STEM	3.11 (0.82)	2.75 (0.69)	2.57 (0.93)	2.87 (0.56)
CONTROL	3.74 (0.49)	3.77 (0.28)	3.29 (0.86)	3.14 (1.09)

[†] Values shown as Mean (Standard Deviation)

Table 2. Grade Point Average (GPA) for all classes (top) and STEM classes (bottom).

Qualitative Results: Perceptions of Belonging at Allegheny College. The Focus Group discussions indicated that S-STEM participants developed a powerful sense of belonging at Allegheny College, largely due to the community and support structures provided by the program. One student reflected, "I was really nervous about fitting in here. But having a group of people who were going through the same thing made it easier. The S-STEM program gave me a community where I felt understood and supported." The S-STEM program's structured support helped students navigate academic and social challenges. This support was crucial in helping students transition into college life and integrate into the broader campus community. Another student noted, "The S-STEM program was like a family. It was a place where I knew I could go if I was struggling, and there would be someone there who understood what I was going through." These qualitative insights align with Strayhorn's (2018) findings that a strong sense of belonging can significantly enhance student motivation, academic engagement, and persistence in marginalized groups

Qualitative Results: Perceptions of Belonging in STEM. The program positively influenced students' perceptions of their place within STEM, helping them to see themselves as future scientists and engineers. One student shared, "Before the program, I was worried I wouldn't measure up in STEM. But the S-STEM program gave me confidence. The research opportunities and the support from my mentors made me feel like I could really do this." This was echoed by others who described how the program helped them overcome imposter syndrome and build a strong STEM identity. The program's emphasis on research and mentorship was effective. One student reflected, "The S-STEM program was the first time I really felt like a scientist. The research projects and the support from my mentors made me realize that this is something I can do." Okochi et al. (2023) explored this type of outcome, highlighting the importance of early research experiences and mentorship for marginalized groups to develop a strong STEM identity, which is critical to student retention and success.

Qualitative Results: Self-identification as a College Student and STEM Professional. The S-STEM program also played a significant role in helping students internalize professional STEM identities. One student remarked, "When I first got here, I didn't really see myself as part of this place

or as a future STEM professional. But the S-STEM program changed that. Now, I feel like I belong here and that I have what it takes to succeed in STEM." This shift in self-identification was significant for students. Another student noted, "I didn't think I would ever really fit in STEM. But as I got more involved with the program, I started to feel like I really belonged, and that I could actually have a career in STEM." These findings are similar to Eccles' (2009) work which emphasizes the importance of self-identification in developing a strong sense of identity as a member of an academic community and as a professional.

Qualitative Results: Academic Performance. Academic performance is a critical outcome measure for the S-STEM program and serves as a proxy for long-term retention at Allegheny and in STEM fields. While the quantitative data indicated that the S-STEM group had lower overall GPAs and STEM GPAs, the qualitative findings suggest that the support provided by the S-STEM program played a crucial role in helping students persevere through academic challenges. A student reflected, "The classes were tough, especially in the beginning. But having the S-STEM community to fall back on made a big difference. We could study together, share resources, and lean on each other when things got hard." This sense of solidarity and mutual support was a recurring theme, with many students crediting the program for helping them persist despite academic difficulties. Another student shared, "I struggled a lot with my classes at first, but the S-STEM program taught me how to study effectively and manage my time better. That made a big difference in my grades." This observation is consistent with Tinto's (2017) research, which argues that learning communities provide the social and academic integration necessary for students to succeed in challenging academic environments.

Qualitative Results: Impact of Mentorship and Support. Across the board, students highlighted the critical role of faculty mentors and peer support in their academic and personal development. One student shared, "My mentor was incredible... I don't think I would have made it through my first year without her." The importance of mentorship was also reflected in students' descriptions. Another student noted, "The friendships I've made through the S-STEM program have been so important. We support each other, study together, and help each other out when things get tough." Mentorship is a key factor in student STEM retention and success, providing students with the resources, guidance, and support they need to navigate the challenges of college life and succeed in their academic pursuits (Packard, 2016).

Qualitative Results: Professional Clarity and Readiness. Many students described how the program helped them gain career clarity and the skills and experiences needed for their chosen career. One student commented, "Before joining the program, I wasn't sure what I wanted to do with my STEM degree. But through the research opportunities and the career workshops, I now have a clear idea of what I want to do and how to get there." The program's emphasis on research and practical experience was also a key factor in professional readiness and goals. For example, all scholars completed a research shadowing course, and 75% of S-STEM Scholars participated in summer research internships. A student noted, "The research opportunities I had through the S-STEM program were invaluable. They gave me real-world experience and helped me build the skills I need to succeed in my career." Research has shown that providing students with these opportunities can significantly enhance their career readiness and likelihood of persisting in STEM (Lopatto, 2010).

Discussion

Allegheny College's S-STEM program aims to strengthen and refine students' sense of belonging through targeted academic and professional activities that recognize their intersecting and evolving identities. This study hypothesizes that fostering stronger STEM identities and networks will strengthen persistence in, and resilience for, STEM majors among S-STEM scholars. The results confirmed that many S-STEM students expressed uncertainty regarding their place at Allegheny College and in STEM. The S-STEM program's structured support helped students navigate academic and social challenges, fostering a sense of inclusion and belonging that was crucial for transitioning into college life and integrating into the broader campus community. In sum, S-STEM Scholars consistently reported greater perceptions of belonging at Allegheny and in STEM, greater overlap with an Allegheny College student identity, and a sense of community. Qualitative data also revealed that the S-STEM program helped students develop essential study skills and greater academic resilience. Specifically, the analysis of their first two years reveals a compelling narrative of growth, resilience, and identity development. In the reviewed key measures, the qualitative findings highlight the profound impact that the program has had on students' experiences.

Our results demonstrating a greater sense of belonging in the S-STEM group are well supported by the literature as being important for greater persistence and success in college and in STEM fields (Babineau, 2018). A sense of belonging at the academic, social and/or campus level is important in creating a bond between a student and a college or university, which increases the student's likelihood of continuing at the institution through graduation (Ovink et al., 2024). This bond is especially important in predicting persistence in STEM fields, which are particularly alienating environments, resulting in many students (and especially those from minoritized groups) feeling unwelcome (Hansen et al., 2024). Given that the majority of the S-STEM scholars represent one or more minoritized identities, they are particularly vulnerable to stereotype threat (Cohen & Garcia, 2008). Timely institutional interventions, such as the S-STEM program, contribute to enhancing students' feelings of identity as scientists, and lead to greater feelings of belonging (Cohen & Garcia, 2008; Hansen et al., 2024; Rainey et al., 2018).

The importance of the S-STEM program is also evident from the differences in the average sense of belonging at Allegheny between the comparison groups. While perceptions of belonging in STEM fields decreased for both the S-STEM and Control groups at the end of the second year, possibly due to increased academic expectations, the S-STEM group consistently reported greater belonging. The observed gap in the sense of belonging at Allegheny illustrates that the benefits of the program are more evident as students progress through their academic careers. These results also suggest that the impact of such academic and moral support programs is positive and gradual, supporting longitudinal assessments in establishing clear patterns.

The results for self-identification with an Allegheny College student showed that the S-STEM group consistently identified more with an Allegheny student than the Control group, and this difference increased over time in the face of greater academic expectations. Conversely, this self-identification for the control group diminished during this time. Regarding self-identification with a STEM professional, the S-STEM group initially indicated lower identification scores. However, this gap was reversed by the spring of their first year. Although this measure decreased, the S-STEM group continues to demonstrate higher identification with a STEM professional. By participating in the S-STEM program, these students identified more with an Allegheny student and a STEM professional, which is notable, especially considering that the majority of Scholars are first-generation (75%) and high-financial need students (100%). Thus, a program that successfully develops STEM professionals necessitates coherence in integrating multiple identities across time and contexts (Chemers et al., 2011). A strong cooperative relationship must exist among the three constructs of science identity, sense of belonging, and motivation/

persistence (Cohen & Garcia, 2008; Rainey et al., 2018). Research indicates that incorporating academic, social, and emotional support within a program contributes positively to students' developing identities as scientists along with their other intersecting identities. Additionally, programs such as the one presented in this study lead to enhanced persistence in STEM as measured by GPAs or other metrics of achievement (Chemers et al., 2011; Cohen & Garcia, 2008; Ovink et al., 2024).

Initial GPA analysis also supports the program's hypotheses. While the Control group started with higher GPAs, the gap diminished over time. We interpret the GPA data to indicate that marginalized students benefited from the S-STEM program structure. The S-STEM group comprises a higher proportion of Pell-eligible and first-generation students than the control group (Table 1). Each of those groups separately demonstrates more challenges in college/university settings (Babineau, 2018), thus reinforcing the need for programs like S-STEM. The data also suggest that the program played a critical role in helping students develop the skills and resilience needed to improve their academic performance. Further, these results highlight the importance of providing targeted academic support to students, particularly those from minoritized backgrounds. The increase in GPAs overall is a testament to the program and the resilience and determination of the scholars themselves.

It is important to note that the generally small differences in quantitative data between the S-STEM and control groups support our hypotheses that the S-STEM program is beneficial due to the demographic difference between the groups. Historically, significant gaps in belonging and other achievement metrics have been observed between students from minoritized groups and those from majority groups (Cohen & Garcia, 2008; Chen et al., 2021).

Developing and strengthening STEM resilience and determination in scholars is a significant step towards achieving the program's overall aim of increasing retention in STEM fields. Although the retention data are preliminary, retention rates up to the point of major declaration can be examined for the students discussed in this paper. Eleven out of the initial twelve S-STEM scholars, or 91.7%, are still at Allegheny pursuing STEM majors. Specifically, the first-to-second-year retention rate for scholars was 100%, while the second-to-third-year retention rate was 91.7%. In contrast, seven out of nine students in the initial control group, or 77.8%, remain at Allegheny, all as STEM majors. The program's control group experienced a decline of one student per academic year at the end of the first and second academic years. Although the sample sizes are very small, retention for the S-STEM scholars at Allegheny College as STEM majors is markedly higher than that of the control group at the same time point. Notably, the S-STEM retention rate is on track to potentially exceed the college's four-year retention rates: collegewide (86%), all STEM majors (88%), and marginalized/Pell-eligible students (76%).

The quantitative and qualitative results suggest that (1) the S-STEM program at Allegheny College is an effective model for supporting marginalized students, (2) the program helped students gain clarity regarding their career goals, and (3) similar programs should be considered by other institutions seeking to improve STEM retention and academic resilience. Viewed through the lens of SCCT (Lent et al., 1994), the pattern we observed (i.e. increased STEM identity, narrowing GPA gaps, and higher college and STEM retention) suggests that the intervention provided the contextual support and mastery experiences students needed to build self-efficacy and develop STEM-related goals despite substantial structural barriers.

The use of the above mixed-methods approaches highlights the importance of capturing both quantitative and qualitative data to thoroughly understand the impact of interventions. While earlier investigations only used quantitative assessments (Eschenbach et al., 2011; K. J. Graham et al., 2017; Jones et al., 2014; Olson et al., 2016), the merit of using a mixed-method approach is also supported by recent studies (Babineau, 2018; Wright et al., 2021). Ovink et al. (2024) demonstrated how qualitative assessment data allow researchers to uncover more specific details underlying quantitative survey results. While the mixed-methods approach shows great promise, the study has limitations: a small sample size, non-randomized group assignments due to the S-STEM eligibility requirements, and volunteer-based recruitment for the control group. This organization led to demographic differences between the control and S-STEM groups as described above. However, this design sought to tightly link qualitative and quantitative assessment results with each other and with college/STEM GPA and retention data. The tight connection among all the data also helps to compensate for relying on self-reported belonging and identity data.

Given the mixed-methods design of this study, we are confident that the specific comments and sentiments expressed in the focus groups were from the same subjects who completed our surveys on belonging and identity. Future research should explore the long-term impacts of the S-STEM program and similar mentoring support programs on students' academic and professional trajectories and identify the specific elements of the program that are most effective in fostering and maintaining student success. The research team aims to continue and finalize the proposed formative and summative study.

Mitigating the effects of the recent global COVID-19 pandemic was a priority at the start of the S-STEM program, since these students attended high school during the lockdown. The hardships students faced at all grade levels during the pandemic are well-documented (Reimers, 2021). Educators still cope with the downstream effects, often requiring supplemental instruction such as laboratory inquiry courses to enhance foundational experiences. Additionally, classroom etiquette and executive functioning skills decreased due to social isolation. Thus, the present S-STEM program strategically incorporates academic and student coaching to enhance skills affected by COVID-19 (Bettinger & Baker, 2014). Therefore, our study contributes to this important growing body of literature.

Finally, this S-STEM program is potentially applicable to other institutions, but it may be particularly relevant to small liberal arts colleges (SLACs) with strong mentoring and student research infrastructure, as shown by our single institution model. Although SLACs often have more difficulty recruiting and retaining students from minoritized backgrounds, they are also uniquely poised to support STEM scholars in an environment centered on individual attention, empowering them to actively shape their academic and career pathways.

Acknowledgments

The funding for this work was provided by the National Science Foundation (NSF) S-STEM program (DUE Award #2130097) to Allegheny College.

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