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An Exploration of the Factors that Contribute to STEM Career Attainment in Former STEM Intervention Program Participants

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Abstract

Individuals from low-income, first-generation, and historically underrepresented backgrounds remain disproportionately excluded from Science, Technology, Engineering, and Mathematics (STEM) fields. STEM Intervention Programs (SIPs) aim to close these gaps by offering targeted academic, financial, and psychosocial supports. This mixed-methods study, guided by Social Cognitive Career Theory (SCCT), investigates the long-term STEM career trajectories and science identity development of participants in an NSF-funded S-STEM SIP supporting high-achieving, low-income STEM undergraduates at a private, Predominantly White Institution (PWI) in the northeastern United States. In-depth interviews with eight alumni, conducted three to five years post-graduation, explored factors shaping their STEM career outcomes. Three overarching themes emerged: (1) Structural and Contextual Influences, (2) Exploration and Emerging Interests, and (3) The Evolving Self. To complement the interviews, science identity was measured at three points between program entry and the time of the interviews. Findings illustrate how participants' pathways were shaped by financial and social barriers, mentorship and institutional supports, evolving interests, and the development of science identity, self-efficacy, and resilience. The study underscores the critical role of sustained, wraparound supports in fostering not only STEM persistence, but also personal agency, adaptability, and identity formation. These results contribute a rare longitudinal perspective to the SIP literature and emphasize the need to expand definitions of success beyond STEM degree completion to include meaningful, self-directed career outcomes.

Keywords: STEM intervention programs, Social Cognitive Career Theory, science identity, low-income students, first-generation college students, STEM career outcomes, S-STEM, mixed methods

An Exploration of the Factors that Contribute to STEM Career Attainment in Former STEM Intervention Program Participants

Introduction

Despite national efforts to increase representation in science, technology, engineering, and mathematics (STEM), students from low-income, first-generation, and racial minority backgrounds remain significantly underrepresented in STEM careers (Chen & Soldner, 2013; Lewis, 2003; Lichtenberger & George-Jackson, 2013; National Science Board, 2024). While many of these students begin college with strong interests in STEM and the motivation to pursue these fields, far fewer ultimately transition into STEM careers. Structural disparities such as unequal access to high-quality secondary education, limited exposure to STEM professionals, and fewer institutional resources create barriers that extend beyond college enrollment. These disparities affect not only who persists in STEM majors, but also who ultimately enters and thrives in the STEM workforce (Garriott, 2020; Turner et al., 2019).

In response, STEM Intervention Programs (SIPs) have emerged as targeted efforts to support students from low-income and underrepresented backgrounds (Dyer-Barr, 2014; George et al., 2019). These programs provide academic, financial, and psychosocial supports during college, with the goal of improving retention and preparing students for graduate education or employment in STEM (DePass & Chubin, 2008; Rincon & George-Jackson, 2016; Tsui, 2007). However, relatively few studies follow SIP participants beyond graduation to examine how such interventions influence long-term career outcomes (Pearson et al., 2022). This study purposefully addresses that gap by examining former participants of the Strategic Undergraduate STEM Talent Acceleration Initiative (SUSTAIN) Scholars Program, a SIP designed to support low-income STEM students at a private, Predominantly White Institution (PWI) in the northeastern

United States (Ceyhan, Thompson, Sloane, Tillotson, & Wiles, 2019; Ceyhan, Thompson, Sloane, Wiles, & Tillotson, 2019; Surman et al., 2025). Specifically, this study investigates how participants' identity as scientists evolved post-college and explores which factors shaped their eventual career trajectories.

Guided by Social Cognitive Career Theory (SCCT; Lent et al., 1994), this mixed-methods research explores how individual goals, contextual influences, and personal learning experiences shaped STEM career outcomes for SUSTAIN participants. The study is guided by two research questions:

1. Have former SUSTAIN participants' Identity as a Scientist beliefs changed since college?
2. What factors have influenced the SUSTAIN participants' STEM career outcomes?

By examining these questions three to five years after college graduation, this study provides a rare longitudinal perspective examining the pathways of students who were once considered at risk for attrition. In doing so, it contributes to a growing literature on the role of targeted supports and personal agency in advancing equity in STEM career attainment.

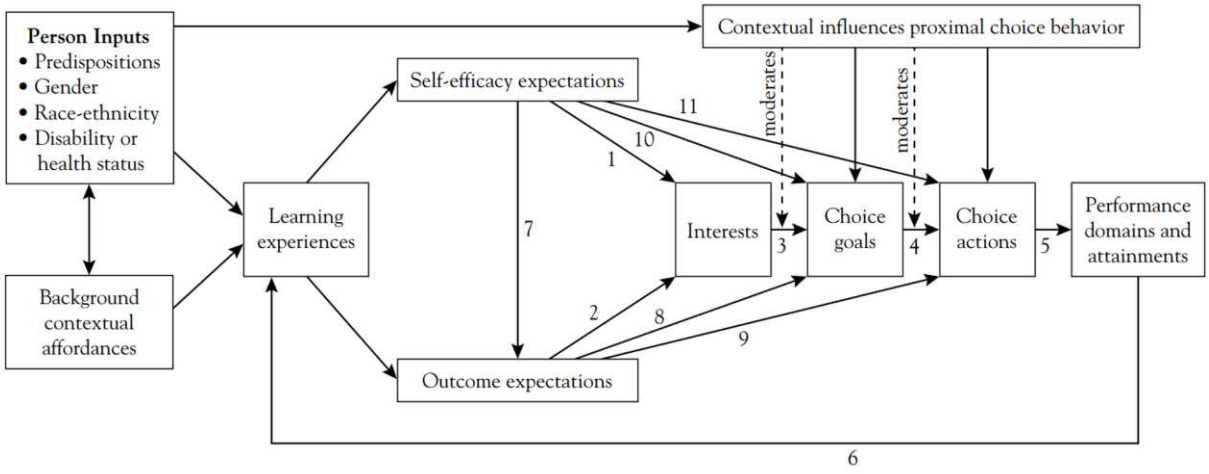
Background

Low-income students face a complex interplay of structural, contextual, and personal barriers that shape their access to and persistence within STEM careers. These barriers begin well before college: students from economically marginalized backgrounds are more likely to attend under-resourced grade schools, lack access to advanced STEM coursework, and have limited exposure to professionals in scientific fields (Davis & Wilson-Kennedy, 2023; Garriott, 2020; Lewis, 2003; Marasco & Dreyfuss, 2022). These early disadvantages can reduce both perceived and actual access to STEM opportunities, even when students exhibit strong academic potential and interest.

Social Cognitive Career Theory (SCCT) offers a conceptual model to explain how students' career development unfolds over time and across contexts (Figure 1). SCCT emphasizes the interaction between personal cognitive variables (e.g., goals, interests), learning experiences, and environmental affordances and constraints (Lent et al., 1994). In this model, career attainment is influenced not only by internal beliefs and choices, but also by social and structural conditions that either support or limit opportunities. For students from low-income backgrounds, SCCT highlights how contextual barriers such as financial strain, limited professional networks, or lack of institutional support can impede career progress even when motivation and ability are present (Garriott et al., 2013; Lindley, 2005; Turner et al., 2019).

Figure 1

Model of Person, Contextual, and Experiential Factors Affecting Career-Related Choice Behavior



Note. Reproduced with permission from "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance" by R.W. Lent, S. D. Brown, and G. Hackett, 1994, *Journal of Vocational Behavior, 45*, p. 93 (http://doi.org/10.1006/jvbe.1994.1027).

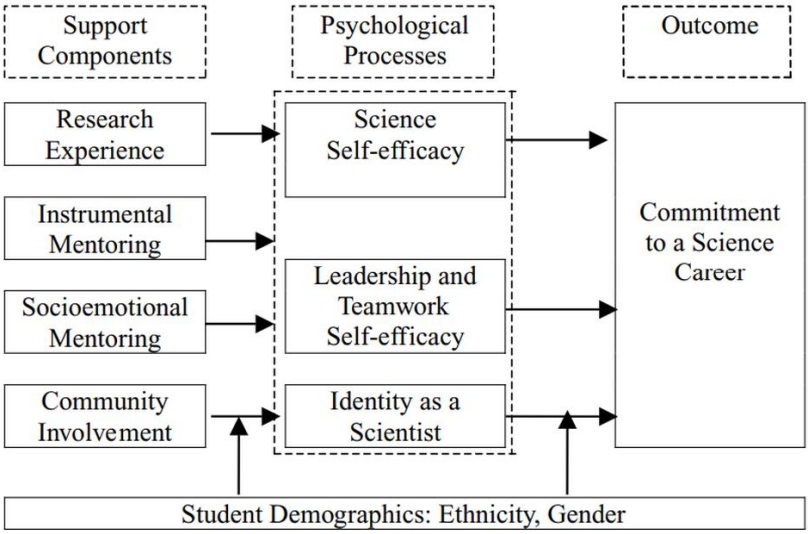
Research shows that environmental supports and barriers are especially consequential for students navigating STEM pathways. These include access to undergraduate research, quality

academic advising, opportunities for early professional exposure, and the flexibility to explore multiple career interests (Estrada et al., 2011; Turner et al., 2019). For example, students who are able to engage in meaningful research or internship experiences during college are more likely to identify and pursue STEM careers that align with their skills and interests (Chemers et al., 2011; Estrada et al., 2018). However, low-income students may be unable to participate in such opportunities due to financial pressures or a lack of institutional guidance, thereby missing critical learning experiences that shape long-term career direction.

In addition to these structural and contextual influences, psychosocial processes like science identity, play a critical mediating role in STEM persistence. Chemers et al. (2011) demonstrated that identity as a scientist, which measures aspects of science identity, significantly predicts commitment to science careers among underrepresented students. Their mediation model (Figure 2) illustrates how psychological processes can bridge the effects of supportive experiences (e.g., mentoring, research engagement) on STEM career outcomes. This is especially relevant for intervention programs like SUSTAIN, which aim not only to reduce financial barriers, but also to cultivate internal belief systems that support long-term success.

Figure 2

Mediation Model of the Effects of Science Support Experiences



Note. Reproduced with permission from "The Role of Efficacy and Identity in Science Career Commitment Among Underrepresented Minority Students," by M.M. Chemers et al., 2011, Journal of Social Issues, 67(3), p. 471.

Additional studies have affirmed the importance of science identity in predicting academic and career outcomes in STEM, particularly for underrepresented groups (Estrada et al., 2011; Hernandez et al., 2013; Robinson et al., 2018). These findings suggest that a strong science identity can reinforce persistence by shaping how students see themselves in relation to the scientific community and by motivating continued participation in STEM. Furthermore, Merolla and Serpe (2013) found that the salience of science identity (i.e. how central it is to one's self-concept) can mediate the effects of enrichment experiences on graduate school matriculation. In this way, science identity operates in tandem with other key SCCT constructs such as outcome expectations and personal goals to influence how students engage with and navigate their STEM trajectories. These internal beliefs are shaped not in isolation but within the broader context of students' lived realities.

Moreover, students' goal setting and career decision-making processes, key components of SCCT, are deeply shaped by their socioeconomic environment. Low-income students may prioritize financial stability, family expectations, or job security when choosing careers, which can constrain their choices or push them toward more "practical" STEM fields, even when other interests exist (Garriott, 2020; Lindley, 2005). The cost of graduate education, the uncertainty of research careers, and a lack of familiarity with non-traditional STEM career opportunities can all act as deterrents (George-Jackson et al., 2012, Plasman et al., 2020; Valentino et al., 2016). Consequently, career paths among these students may reflect not only their evolving interests and abilities, but also the constraints of their social context and the resources they are able to access over time.

Despite these challenges, SIPs can help mitigate contextual barriers by offering layered supports that align with SCCT's emphasis on environmental scaffolding. Programs like SUSTAIN that provide financial aid, research access, community support, and mentoring can enhance students' exposure to STEM pathways, facilitate skill development, and validate long-term career goals (Atkins et al., 2020; Ceyhan & Tillotson, 2020b). These supports may not only increase retention in STEM majors but also improve alignment between students' strengths and career pursuits after graduation.

This study utilizes the SCCT framework in examining how former SUSTAIN participants navigated the transition from college to the workforce or graduate school. By focusing on the post-college phase, it offers deeper insight into the structural, interpersonal, and experiential factors that either enable or inhibit STEM career attainment for students from low-income backgrounds. In doing so, it illustrates how long-term career development unfolds in real-world contexts where support structures and personal goals are continually negotiated.

Methods

Research Design & Study Context

This study investigated the long-term Identity as a Scientist and STEM career outcomes of participants from SUSTAIN, a STEM Intervention Program (SIP) established at a large, private, PWI in the northeastern United States in 2017. SUSTAIN was funded by an NSF S-STEM grant servicing a selected group of high-ability, low-income STEM students in the institution's College of Arts & Sciences. "High ability" was defined as a minimum 3.0 high school GPA and "low-income" was defined as being eligible for the federal Pell Grant. Additionally, only incoming students who were intended or declared majors in biology, chemistry, biochemistry, neuroscience, or forensic science were eligible.

SUSTAIN provided the participants with academic, professional, social, and financial support for their first two years of college. This included a series of seminars and workshops to help with college acclimation, financial success, and career exploration. Additionally, participants were involved in early-immersion undergraduate research and received faculty mentoring. For social support, students engaged in field trips, holiday parties, and an overnight camping trip to build a strong sense of community among the participants. Lastly, the participants received a $10,000 scholarship for each of their first two years, totaling $20,000 on top of existing financial aid packages the students received from the university.

This study employed a mixed methods design that drew on Social Cognitive Career Theory (SCCT; Lent et al., 1994). The research integrated longitudinal quantitative survey data with in-depth qualitative interviews to explore how constructs like science identity, interests, and self-efficacy developed over time and how these constructs influenced participants' career trajectories. A convergent design was used, in which qualitative and quantitative data were

collected and analyzed separately, then integrated during interpretation to provide a comprehensive understanding of career outcomes among former SUSTAIN participants (Creswell & Creswell, 2017).

Participants and Data Sources

The study sample consisted of 25 SUSTAIN alumni who began their undergraduate education in STEM fields in 2017. Quantitative data were collected at three time points: during participants' first semester in college (Fall 2017), after two years in the program (Spring 2019), and in a follow-up survey administered in Fall 2024. Overall, 24 (96%) participants completed the fall 2017 survey, 22 (88%) participants completed the spring 2019 survey, and 13 participants (52%) completed the fall 2024 survey. At the end of the fall 2024 survey, participants were invited to participate in follow-up interviews; eight accepted and completed one-on-one interviews.

Quantitative Data Collection and Analysis

Identity as a Scientist was measured using a modified version of Chemers et al.'s (2011) instrument at all three time points (Additional file 1: Figure A1). In fall 2024, participants completed a Qualtrics survey including this instrument as well as questions about career graduate education status (Additional file 1: Figure A2). Normalized change scores were calculated to examine shifts in identity as a scientist between 2017, 2019 and 2024, using values from –1 to +1 to reflect the direction and magnitude of change. Further statistical analysis could not be carried out due to the low sample size and lack of normally distributed data.

Qualitative Data Collection and Analysis

A qualitative approach was used to explore the final research question: What factors have influenced participants' STEM career outcomes? Semi-structured interviews were used to allow

participants to narrate their academic trajectories, reflect on personal decision-making, and describe the contextual supports and barriers they encountered (Lewis-Beck et al., 2004). The interview questions were informed by the results of the survey from fall 2024, which asked participants about their current career status as well as any former jobs or graduate school attendance (Additional file 1: Figure A2). The interviews were semi-structured to provide scaffolding for a cohesive framework, while also allowing for flexibility for relevant questions and subsequently responses from participants (Smith et al., 2021). This was especially important to appropriately address the variety of paths that individuals took after graduation leading to graduate school or entry into their careers. The interview questions were guided by Social Cognitive Career Theory's three models: 1) interest development, 2) choice, and 3) performance (Additional file 1: Figure A3). Eight alumni completed ~60-minute interviews, which were audio-recorded, transcribed using Otter.ai, and manually reviewed for accuracy. Identifying details were redacted and pseudonyms assigned.

The interviews were coded following an iterative and inductive process (Locke et al., 2022; Neale, 2016). Specifically, the constant comparative method, informed by Social Cognitive Career Theory, was utilized to code and re-code the data (Glaser, 1965; Marco-Bujosa et al., 2024b). Open coding was first applied line-by-line to identify key phrases and ideas related to participants' experiences in and beyond college. Axial coding was then used to organize codes into categories based on similarity, frequency, and salience. This allowed for themes to emerge from the data rather than utilizing deductive coding, therefore allowing novel findings to develop (Chandra & Shang, 2019). Emergent themes such as identity formation, mentoring relationships, and structural barriers were then mapped onto SCCT constructs, allowing for both theoretical and grounded interpretation.

A second trained qualitative researcher independently coded a subset of transcripts using the established codebook. Cohen's Kappa was calculated to assess inter-coder reliability, yielding a value of .76—considered moderate agreement (McHugh, 2012). Discrepancies were resolved through collaborative discussion, and the coding framework was refined accordingly. Analytic memos were written throughout the process to track interpretive insights and ensure consistency in theme development.

Data Integration Strategy

The quantitative and qualitative findings were integrated during interpretation to provide a holistic understanding of how identity as a scientist and contextual factors contributed to STEM career outcomes. Quantitative data identified trends, while qualitative interviews illuminated the mechanisms and lived experiences underlying these trends. This integrated approach allowed the study to capture the nuanced, personal, and systemic factors influencing STEM career attainment among these SUSTAIN SIP participants.

Ethics Approval and Consent to Participate

This study was reviewed and approved by the Institutional Review Board of [institution name blinded for review]; no. 24-232. All participants provided informed consent prior to completing the survey and interview, and pseudonyms are used throughout to protect participant confidentiality.

Findings

This chapter presents the key findings from eight former SUSTAIN participants, highlighting how their experiences influenced their academic pathways and career development (Table 1). Each participant engaged in one semi-structured interview ranging from 60 to 90 minutes. A semi-structured interview provided scaffolding for a cohesive framework, while also

Table 1
Participants' Degrees and Career Status

Participant	Degree(s) Held	Career Status
Dana	Biology & Neuroscience	Paramedic & Cast Technician
Jackie	Biotechnology & Marketing Management	Brand Manager for Consumer Healthcare Company
Lucas	Biotechnology, M.S. in Computer Sci	Software Engineer
Maya	Biochemistry	MD/PhD Program
Selena	Biotechnology & Spanish	Patent Lawyer
Veronica	Biology	Senior Clinical Lab Technician
Winston	Biochemistry & Neuroscience	Pharmacy School & Research Assistant
Zari	Chemistry & Forensic Science, M.S. Forensic Science	Pharmacy School & Chemistry Professor

allowing for flexibility for relevant questions and participants' subsequent responses. Questions focused on undergraduate and SUSTAIN-specific experiences, continuing education, and career status. Following an iterative and indicative analysis, three overarching themes emerged related to "What factors have led to the SUSTAIN participants' STEM career outcomes?": (1) Structural

& Contextual Influences, (2) Exploration & Emerging Interests, and (3) The Evolving Self (Table 2).

Table 2

Themes and Subthemes

Themes	Subthemes
Structural & Contextual Influences	First Generation & Low-Income Backgrounds
	Institutional Barriers & Support Programs
	Mentorship & Support Systems
Exploration & Emerging Interests	Entering College with Set Goals
	Discovery Through Research & Coursework
	Changing Majors & Adding Fields
	Openness to Alternatives
The Evolving Self	Identity Formation
	Sense of Belonging
	Self-Efficacy & Resilience

The theme of Structural & Contextual Influences describes the impact of students' demographics and personal circumstances on their college experience. This theme then discusses various supports and barriers that the students face in the institutional environment. Within this theme, a number of sub themes also emerged. Participants consistently cited the impacts of their low-income and first-generation backgrounds, institutional barriers and support programming, and highlighted the importance of mentorship and support systems.

The Exploration & Emerging Interests theme can best be described by its comprehensive subthemes, which illustrate the commonalities of participants' progression as they entered

college with set goals and then discovered opportunities through research and coursework, which in turn led to changing majors or the addition of goals, demonstrating the participants' openness to alternative paths.

Lastly, the theme of the Evolving Self demonstrates how the participants' developing identities and understanding of themselves has shaped their unique paths. As part of The Evolving Self, participants' narratives illustrate the process of Identity Formation, their Sense of Belonging in STEM, and the development of Self-Efficacy & Resilience. These psychosocial factors are interwoven throughout the preceding themes and serve as the backbone for the participants' ultimate STEM career trajectories.

Structural & Contextual Influences

Participants' career trajectories were profoundly shaped by structural and contextual factors in their lives, including both the resources and barriers they encountered. Their demographics and personal contexts that they inherently brought to campus often acted as a barrier in the relatively affluent college environment at their institution. Many were first-generation college students in addition to being from low-income households, contexts which did not provide much social or cultural capital. They spoke about navigating college "pretty blind (Winston)," without parental know-how to serve as a guiding force. Institutional structures were often the source of both supportive settings and challenging barriers. The structure provided by support programs helped participants persist while the structure of rigid course requirements and limited research access hindered opportunities for other participants. Together, these intersecting structural and contextual dynamics played a critical role in shaping participants' access to opportunities, sense of belonging, and ultimate career outcomes in STEM.

First-Generation and Low-Income Backgrounds

All participants were from low-income backgrounds, and many were also first-generation college students or from families with little collegiate experience. These contexts often leave students with less social and cultural capital than their more affluent peers (Estrada et al., 2016; Garriott, 2020). They often lacked "anyone around" who knew how to guide a STEM career, which initially left them on their own to figure out college and career choices. *"Both of my parents are not college educated, and so… we weren't really sure about the formal education process. I was going into it pretty blind, kind of me figuring things out as I went along*[1]*,"* explained Winston, who immigrated with his family and had long aimed to become a medical doctor. For Selena, being first-gen meant she "*didn't have a lot of that influence around*" from family or role models in professional careers. For Jackie, she explained that she initially didn't have her parents' full support:

> I'm a first-generation college student. I didn't know – my parents didn't really even want me to be a dentist, because they were, like, 'Jackie, do you realize how much money that's going to be…and how much time? And then you're gonna get sued being a dentist.' It was this whole thing.

Jackie's experience illustrates a common first-generation barrier of parental hesitation or discouragement, often stemming from unfamiliarity with the demands and risks of professional careers. Without informed guidance or encouragement, many participants had to navigate these choices independently, which made the perceived stability of STEM careers especially appealing. These participants gravitated toward STEM in part because it seemed a secure path to upward mobility (Beattie, 2002). *"I really wanted to have a career that was stable and secure…*

[1]Italics are used to distinguish participants' quoted speech from the surrounding analytic text, enhancing readability and emphasizing the experiential nature of their narratives. This practice aligns with qualitative research conventions that stress the importance of clearly representing participant voice (Saldaña & Omasta, 2016).

my parents didn't go to college… I saw science and I was like, that's secure… a STEM degree will get me a job, and I'll be set," Selena recalled of her decision to pursue biochemistry. This thought process was common – given the financial instability or lack of safety nets at home, they viewed STEM fields as promising routes to a *"high achieving job"* with a good income. Some research has shown that students from low-income backgrounds are more likely to be interested in STEM careers than higher-income students (Lichtenberger & George-Jackson, 2013).

Financial pressures were a constant structural influence. Many participants strategically leveraged AP credits, scholarships, and program support to manage college costs. Maya, for example, entered college with a plan to graduate in three years to save money. *"From a financial standpoint, the SUSTAIN scholarship was only for two years… that gave me a full ride for the two years,"* she noted, so she loaded up on credits and switched from Biology to Biochemistry to streamline requirements. She even took 21 credits in some semesters, determined to finish early and avoid a fourth year of tuition: *"Me paying for another year or two of school was just not in the cards,"* she said. Zari likewise entered with 60 transfer credits and chose a double major (Chemistry and Forensics) both out of interest and to make the most of her advanced standing. She explained that she *"definitely wanted to finish a year early to save money,"* since her scholarship could *"make it work for three years"* but a full four years *"would have been a stretch"* financially. Graduating in three years was feasible, she said, but *"two [years] would be too fast… I didn't want to graduate in like two years – that would be crazy*." By finishing early and utilizing the SUSTAIN scholarship, Zari avoided undergraduate debt entirely. This freedom allowed her to pursue graduate studies without hesitation: *"I got two undergrad degrees and a master's without having to take out loans... If I had undergrad loans, I probably wouldn't be*

[going for my doctorate]." Her comment illustrates how reducing financial barriers opened doors to further graduate STEM education which in her case, was a PharmD program.

While some participants minimized costs through accelerated graduation, others managed financial needs by working throughout college, often at the expense of time, energy, and academic focus. The need to work throughout college created a burden on some participants – a burden that was not equally shared by their higher-income undergraduate peers, a contrast that has also been noted in prior research (Bozick, 2007; Walpole, 2003). For Dana, balancing employment and coursework was a constant necessity. She described working multiple part-time jobs during the academic year and full-time during every break:

> I grew up working on a farm, probably from 11 to 20, and I waitressed at home as well. So, whenever I went home for break, I worked six days a week, from 6am to midnight with Mondays off… it was awful. Don't recommend, but you gotta do what you gotta do… then I worked at Tractor Supply so I could transfer between back and forth from the location near campus and home. During the semester, I would work maybe two to three times a week… working like 6am to 2pm doing like truck work or working nights after class. Stuff like that, which not a lot of my peers were doing.

This demanding schedule significantly shaped her college experience, not only consuming time and energy but also highlighting an inequity she recognized among her peers. She reflected that many classmates had the privilege to reduce their work hours or opt out of employment altogether to prioritize school or extracurricular enrichment:

> I feel like if I didn't have to worry about that so much, I could have taken a lot more time to do literally anything. I probably could have focused on school a lot more… Even now,

> a lot of my classmates just cut their hours back for this paramedic program. And that's not something I can do.

Dana's experience exemplifies how financial strain can restrict academic flexibility and access to enrichment opportunities. These structural barriers are often invisible to students from more affluent backgrounds.

Institutional Barriers and Program Supports

While family finances and education level presented external context, participants also encountered institutional structures that could either impede or support their progress. On the supportive end, participants benefited from programs like SUSTAIN that provided scholarships, cohort-based support, and early immersion research opportunities (Ceyhan, Thompson, Sloane, Wiles, & Tillotson, 2019). *"SUSTAIN was a godsend… they were like, 'Oh, here you go,' and I was like, thank you so much,"* Lucas said of receiving the scholarship. Multiple participants noted that without the SUSTAIN scholarship, they might not have afforded a private university. *"It actually made [the university] cheaper for me to go to than other schools,"* Veronica pointed out, adding *"I wasn't sure if I was going to be able to afford college at all"* before the program. Prior research affirms that institutional grant aid significantly influences both college attendance and college choice, particularly for low-income students (Angrist, 2017; Hurwitz, 2012).

Beyond financial access through scholarship, SUSTAIN also offered discipline-specific support that helped students persist in STEM. Several participants credited the program with keeping them on a science track during the critical early period of college when most STEM attrition occurs (Chen et al., 2018). Jackie, who was a dual Biology–Business major, reflected that *"the scholarship really kept me focused… I had to keep the STEM major. By the time [the two years] were up, I'd already come so far." Sh*e admitted that without this tie, *"maybe there would have been a thought to drop the dual major and just focus on business… my college life*

would be easier," but with SUSTAIN's support, she persisted and ultimately *"it all was worth it."* In this way, program structures functioned as *"*safety nets*"* that caught students who otherwise might have left STEM under the weight of difficulty or doubt. Selena similarly stated that if not for Dr. T (SUSTAIN director) and the SUSTAIN cohort, *"I probably wouldn't have pursued my STEM degree… I would have changed majors."* Having *"support from the SUSTAIN Scholar Program, and kind of seeing the different opportunities that could come from my degree,"* convinced her to *"see through what I had started"* in STEM despite early struggles.

These cases underscore the importance of targeted, front-loaded support in mitigating early attrition and reinforcing students' commitment to STEM. By combining financial aid with intentional academic and psychosocial support scaffolding, SUSTAIN helped participants persist through the most vulnerable phase of their STEM journey.

However, institutional support was not always consistent or sufficient. Even with program-level support, the participants still had to contend with institutional structures that were less flexible and, at times, impeded their ability to fully explore or shift within STEM pathways. These hurdles were often bureaucratic and required strategic navigation. For instance, Lucas discovered an interest in computer science in his sophomore year but faced rigid curricular rules that prevented an official switch. *"I tried to get a minor in [the Information Studies] School… they rejected it, saying it was too late,"* he recalled. These classes had prerequisite chains he had not started in freshman year, effectively blocking him from joining that track. Rather than abandoning his interest altogether, he *"infiltrated that school"* by unofficial means: *"I used all my free electives to take [information studies] courses… I ended up taking website building [and] other stuff… basically doing a soft switch, not on paper."* Lucas's workaround highlights both his own resilience and a structural barrier that nearly derailed his true passion.

Another inconsistent structural barrier was described in the difficulty of finding a suitable research lab through SUSTAIN. Selena noted, "*It was kind of a clunky experience… not feeling like I was in the right fit,*" which initially soured her opinion of lab work. Dana similarly noted:

> It was kind of hard getting started up in the research [in college], because [the PI] had so many other students there. And I was given a responsibility, but not as much as the other people. And then she had a major lab change, and I couldn't work in the lab anymore because a couple of her grad students were leaving, and it was, like, a whole thing. So, it was just kind of like a mismatch. I think it was cool, but I don't think it was necessarily for me.

Even when research is built into intervention programs like SUSTAIN, the quality and fit of those experiences matter. A mismatch such as poor mentorship, limited intellectual engagement, or lack of inclusion in lab culture can undermine the intended benefits and discourage continued participation (Thiry et al., 2011). In Dana's case, rather than reinforcing her interest in STEM, the initial lab experience introduced new doubts about whether she belonged in that space. Her story underscores that research access alone is not sufficient; the structure, support, and inclusivity of those experiences must also be thoughtfully designed and orchestrated.

These examples reveal that even well-intentioned structures like prerequisite sequences and research placements can present friction if inflexible. What enabled participants to overcome such barriers was often the presence of supportive mentors and networks who helped them stay motivated and adapt their plans.

Mentorship & Support Systems

Across all interviews, participants emphasized that mentors like faculty and advisors, as well as peer support networks were pivotal in shaping their paths. Effective mentorship provided not only academic guidance but also emotional encouragement, professional opportunities, and

role modeling. Participants who had strong mentors credited them with building their confidence and opening doors; those without such guidance initially felt the void. In addition to various forms of mentors, the participants found support in their SUSTAIN community. The cohort had shared courses, living arrangements, and study sessions which allowed a community of support to develop. Collectively, these formal and informal support systems fostered participants' persistence, identity development, and navigation of STEM pathways in ways that extended beyond traditional academic advising.

Faculty and Advisors

Several participants formed close relationships with faculty in their departments or research labs. Dana, for example, had two professors who served as her neuroscience advisors. She enthusiastically described their influence: *"They were super, super supportive and really great if you just wanted to go and talk about whatever was going on. They were awesome,"* she said. Simply knowing that *"they had gone through higher education to the PhD"* and were willing to share advice made it *"easier to keep my career goals*." When Dana felt stressed and questioned if she should continue on her track, her mentors reassured her: *"They were like, 'You're doing fine. Why don't you stay?'… They definitely made me want to stay because I liked learning from them."* This kind of encouragement was critical in strengthening her self-confidence and persistence.

Likewise, Winston credited a faculty mentor – in his case, his undergraduate research supervisor – with having a profound influence on both his personal development and career trajectory. *"My research mentor had a huge impact, and he doesn't even know how much of an impact he had on my life,"* Winston remarked. This mentor pushed Winston into new experiences, such as applying for a highly competitive international research internship. *"One of*

the things that set my application [to pharmacy school] apart… is the fact that I did an internship in Austria. And he pushed me to apply for that," Winston said, recalling how the mentor expressed confidence in him: *"He was like, 'Oh, I think you have a good shot. I think you got it.' …Sure enough, I got the call saying I got it."* That opportunity broadened Winston's horizons considerably. Maya similarly emphasized that the quality of mentorship in research labs made the difference between a mediocre experience and one that inspired her. *"It's really important who you're working with and who your PI [principal investigator] is, because they're serving as your mentor… you want to get good experiences out of it,"* she explained. Fortunately, across multiple lab stints, Maya found that *"no matter who my PI was, they were all amazing and provided me guidance,"* and unlike some peers' *"nightmare stories,"* her mentors were supportive. Reflecting on why the relationship mattered, she noted that even brief interactions with a caring mentor were impactful: *"Even if it's like 10 minutes, it just really makes an impact on your life,"* she said about conversations with PIs. These faculty mentors not only taught technical skills but also took personal interest in students' goals, sometimes even guiding major life decisions.

Mentorship often extended beyond academics into psychosocial support. In Zari's case, her research advisor and lab team became like a family to her on campus. She recalled being the *"only undergrad in my lab, and the only girl,"* which could have been intimidating, but *"the people in my lab were awesome. I had the best grad student [mentor] ever,"* and her principal investigator was *"very intense, but in a tough love kind of way."* This combination, she said, *"really made me into the scientist I am."*

Still, the learning curve was steep, and Zari often felt out of her depth as she adapted to the lab environment:

> When your high school didn't prepare you for any wet lab stuff… I didn't have the background to understand the work I was doing… [my lab mates] were really patient with me and really helpful…the next thing I knew, I was cooking in the lab.

This mentorship not only taught her practical skills but also gave her a sense of belonging as she transformed from *"the only girl"* outsider into a valued member of the lab "family." By senior year, Zari spent *"all of my time in college in the lab"* and had three go-to mentors (her PI, a Chemistry professor, and the SUSTAIN director, Dr. T) for any issue that arose.

Her story underscores how effective mentorship provides both technical guidance and personal encouragement, fostering growth in ability and confidence. Zari's experience illustrates how meaningful mentorship can bridge academic gaps while nurturing a deep sense of belonging, ultimately shaping not just skills but identity. Her trajectory exemplifies the transformative potential of support that is both rigorous and relational.

Peer Support and Community

In addition to faculty and advisors, participants drew support from peers – often fellow SUSTAIN scholars who shared classes, study sessions, and the journey through STEM being from an under resourced background. The SUSTAIN cohort model intentionally created a *"community as well,"* as Jackie noted. *"A lot of the people were all in the same classes together, we all know each other,"* she said, describing how they would plan schedules together and form study groups. These peer connections eased the academic pressure. Dana recalled participating in peer-led team learning workshops in introductory biology, where *"older mentors were really nice… they could give us better advice for where we wanted to go with our classes next."* Equally important, it helped her *"definitely make more friends in [her] major through that,"* friends she would *"sit with in classes"* and even coordinate future classes with. In turn, having

that network *"made it easier for me to stick with [the major] because I understood it more…making classes easier made it easier for me to stay on the line I wanted to be on."* These organic peer networks offered both academic and emotional reinforcement, especially for students who might otherwise have felt isolated in STEM spaces. For students like Dana, this sense of mutual support helped normalize struggle and fostered a shared commitment to success. This illustrates how peer study groups and friendships strengthened Dana's academic integration and persistence.

Beyond academics, the emotional support and sense of community among SUSTAIN students played a critical role in their overall well-being. Veronica became close friends with another scholar, rooming together sophomore year and even joining the same sorority. They and others in the cohort would candidly discuss their challenges in the SUSTAIN first-year forum: *"we'd help each other with adjusting to college life and how to take advantage of campus,"* sharing tips on everything from scheduling classes to navigating dorm life as first-gen students. Knowing that *"many of the people in the program were also first-gen… and also didn't really know what to expect"* made Veronica feel less alone in her struggles. Several participants pointed to the program's social outings (camping trips, holiday parties, etc.) as key moments where this peer support solidified. *"It felt like home almost,"* Dana said of a SUSTAIN trip where they cooked together and went on a hayride: *"we had a nice break from all the stress… we could just be kids again."* These relaxed bonding experiences created *"a positive impact"* on her college experience, giving her a sense that *"if all else is failing, at least I have these people"* to lean on. Zari echoed that sentiment – the structured social events hosted by Dr. T allowed her to *"hang out with my friends in a way I didn't feel bad about."* Normally she felt guilty taking time away from studying, but because these gatherings were part of her *"scholarship program,"* she could

relax and enjoy *"guilt free."* They *"forced me to have a little break and chill out for a bit,"* she said, noting that Dr. T *"would always feed us, which was lovely."* SUSTAIN's support system of caring mentors and peers mitigated the isolation and pressure that underrepresented STEM students might otherwise experience, enabling participants to thrive in an environment that could have easily overwhelmed them. By intentionally building both academic scaffolding and social connection, the program created a holistic support structure that helped participants persist, belong, and ultimately succeed.

Exploration & Emerging Interests

The undergraduate years proved to be a time of discovery and re-evaluation for the SUSTAIN participants. Although many entered university with a predetermined STEM career goal, often medical or health-related, all underwent some form of career pivot or course correction as they encountered new experiences or information. Under the theme of Exploration & Emerging Interests, participants shared how research opportunities, internships, and even elective courses broadened their perspectives on what they could do with a STEM background. In some cases, early experiences confirmed that their initial path was the right one; in many others, participants "pivoted" to an alternate career track that better fit their skills and passions. The subthemes capture these moments when participants questioned their trajectory and made consequential changes. Crucially, these pivots were not failures, but the results of intentional exploration – participants actively tried new things, often facilitated by SUSTAIN or their university, and learned more about themselves in the process.

Entering College with Set Goals

At matriculation, most participants believed they had a clear and defined career goal. The majority began their undergraduate studies in biology or biochemistry, identifying as "pre-med" or aspiring to adjacent professions such as pharmacy, dentistry, or forensic science. Veronica, for

example, entered as a Biology major with the intention of becoming a medical examiner: *"When I went into college, my ultimate goal was to be a medical examiner… so that requires med school, and all of that was my intention going in,"* she explained. Jackie had similar plans, as she planned to be a dentist and chose a dual degree in Biology and Business to prepare for the possibility of running her own dental practice someday: *"I wanted to be a dentist... I noticed [the university] had an option to do a dual degree in a STEM major and a business major… I thought if I do become a dentist, I should know some business to have my own practice."*

Others, like Winston, arrived with similar goals but less personal conviction, following a well-worn path based on external validation. He declared Biochemistry as a stepping stone to medical school simply because, as he put it, *"I was told… if you're good at school, [become] the typical doctor or lawyer. And I was good at this, so I thought becoming a doctor is what I should do."* His cultural background growing up in the Caribbean reinforced that prestigious expectation. Even participants without direct family role models in higher education had internalized the message that STEM degrees were synonymous with success.

Dana, for instance, shared that in her hometown, *"not a lot of people [pursue] higher education – maybe 25% of my graduating class went to college"* yet she set her "end goal" to become an MD. Her interest was sparked by a love of neuroscience and early experiences shadowing surgeons in high school. For her and others, the perceived stability and societal prestige of professional careers were especially appealing. *"I wanted a high-achieving job… something people would think 'oh she has a good job,'"* Selena admitted, linking her ambitions to a desire for financial security.

Thus, at college entry, the cohort was largely homogenous in their goals. Most sought a narrow set of traditional STEM careers and viewed their STEM major as a necessary first step

towards those ambitions. These early career goals reflected a shared belief in linear, high-status STEM pathways as the clearest route to success and stability. Participants arrived with focused intentions shaped by cultural narratives, community expectations, and a desire for upward mobility.

Yet as the following subthemes reveal, these initial plans often evolved in meaningful ways. These evolutions were not due to failure or indecision, but a result of intentional exploration. Through new experiences and greater exposure to the breadth of opportunities within STEM, participants developed deeper self-understanding and discovered alternate career paths better aligned with their strengths and interests.

Discovery Through Research and Coursework

Once in college, these students encountered new fields and experiences that expanded and sometimes upended their career thinking. SUSTAIN's early research immersion was a significant catalyst for many. Some participants discovered a love for research that led them to pivot away from earlier plans. For example, Veronica credits her first-year lab experience in Dr. P's biochemistry lab with changing her mind about medical school: *"I dropped pre-med because of SUSTAIN – not in a bad way – because through SUSTAIN we got into the research labs… and I actually found research really interesting,"* she explained. Working at the bench showed her an alternative to the physician route: *"I decided I wanted to do a career more on the research side of things,"* Veronica said, *"and I also didn't want to do however many years of med school just to work with dead bodies,"* she added with a laugh. Once research captured her interest, she no longer felt the need to become an MD to have a fulfilling science career.

Winston's research experience confirmed he enjoyed science but also made him realize the clinical profession he'd planned wasn't the best fit. He described growing frustrated during the medical school application process and questioning if medicine was truly what he wanted: *"I*

had liked research, but I also did not know anything about research. So, I was hoping biochem would give me that exposure," he said. Sure enough, by senior year he was conducting ALS-related neuroscience research and loving it. As he applied to med schools, he felt *"constantly kind of frustrated with the system, the whole medical application system"* and began exploring other paths. Talking with a friend who had chosen pharmacy opened Winston's eyes to a career he *"had no idea"* about previously. *"I knew one person who had gone to pharmacy school… he shared what pharmacy was, what he liked, what he didn't… and I was like, actually, I think pharmacy might be for me,"* Winston recounted. In his case, the pivot to a PharmD happened *after* college graduation during a gap year, but it was his cumulative experiences in college – gaining confidence in science through research, and realizing he valued a *shorter, more predictable training path* – that led him there. *"I made a pivot, and here I am,"* he said simply of the decision. Notably, he remained within STEM but chose a different professional application of it that better suited his personality and goals.

Not every research experience led to a positive epiphany; for some, it clarified what they *didn't* want. Dana, for instance, participated in neuroscience lab research but found it *"wasn't necessarily for me."* She recalled it was *"kind of hard getting started… [the PI] had so many other students,"* and after some lab restructuring, *"I couldn't work in the lab anymore."* While she made friends and learned techniques, the experience *"solidified the fact that I probably didn't want to work in a lab"* long-term. Instead of pursuing a PhD or research career, Dana remained focused on healthcare – but even there she explored alternatives to medical school. *"I was thinking about other things within the medical field itself, like PA, EMS… also I could fall back on general science,"* she said, considering more direct or hands-on roles instead of the MD route. By senior year, Dana had expanded her view of potential careers: she even took a professional

cooking class and half-jokingly considered *"becoming a chef or opening a bakery"* as a backup plan. Though she ultimately stayed in STEM as a paramedic, these explorations into unrelated interests like culinary arts, psychology, and teaching indicate a mind actively reevaluating what would make her happy. *"I'm not opposed to hard work… I love working with kids, teaching possibly… that's always a great option,"* she mused, describing how a friend's unconventional high school biology teaching path made her realize there were many ways to apply a science degree.

These experiences illustrate how exposure to research and academic exploration played a critical role in reshaping participants' understanding of what a STEM career could look like. Whether through confirming a passion, redirecting an initial plan, or clarifying what paths to avoid, these moments of discovery helped participants align their goals with their evolving interests, values, and strengths. Importantly, even when their paths shifted, participants remained grounded in STEM. This commitment demonstrates how early access to hands-on learning and reflective exploration fostered not just persistence, but more personalized and informed career trajectories.

Changing Majors and Adding Fields

For some participants, career exploration not only shifted goals, but prompted formal academic changes. As students encountered new interests and reevaluated their original plans, several made significant adjustments to their majors or added new fields of study. These decisions were often difficult, as they required letting go of long-held identities and expectations, but they ultimately opened new and more fulfilling pathways.

Lucas, who entered as a Biology/pre-med student, experienced a "click moment" when he realized his *"true interest"* was in computers. *"I could sit there and code for hours… I actually enjoyed doing this,"* he realized, contrasting it with the plan he felt he was given by his

family. Midway through college, Lucas switched his major to Biotechnology to incorporate more applied tech and engineering content and simultaneously started taking every computer-related course he could, even without official permission. This eventually led him to pursue a master's in computer science immediately after undergrad. He described the internal struggle and ultimate liberation of changing course: *"It was really hard… once you have such a path forged in your brain. I was lucky – after big talks with my family… they just want me to be okay. It was more my mental block,"* Lucas said of letting go of the med school plan. Once he embraced his computing passion, he went *"full send"* toward it: *"I said, I'll finish my biotech degree… but I'm going to focus on applying for master's in computer science to get what I wanted,"* he explained. That decision clearly paid off – at the time of interview, he was a software engineer and delighted with his choice.

Selena provides another example of a significant pivot. Initially aiming for pharmacy, she chose Biochemistry as a major because *"I Googled and saw that biochemistry was the degree to get"* for a pharmacist. However, she found herself disliking her science courses in freshman year. *"I did not like my science classes very much. I was having a hard time in them, and also did not enjoy them,"* she admitted. This led her to consult the SUSTAIN director (Dr. T) with a radical thought: *"I [was] even being concerned about not pursuing a STEM degree at all,"* Selena said. [The project director] encouraged her to reflect on what *did* interest her, and she realized she was interested in learning about economics and business. [The university] happened to offer a Biotechnology major that *"allowed me to take economics and business classes in addition to the bio and chemistry,"* so Selena switched into that major, finding it more interdisciplinary and practical. She also picked up a second major in Spanish, an area she loved.

After this change, her career goals shifted: she no longer planned on pharmacy school but rather imagined a "business side of science" career, even if she wasn't sure what specific job that would be. *"I thought I was gonna go into business more so, like something… science-related but business,"* Selena said of her mindset sophomore year. This ambiguity was uncomfortable for her, "not having a path… was something I was super uncomfortable with," but exposure to guest speakers through SUSTAIN helped. *"We had multiple people come in and speak to us… about different careers you could pursue,"* she recalled, *"I remember there must have been a speaker that... showed me I could pursue a career in something I didn't even know existed at the time."* This reassurance that *"there was more to my STEM degree than just the courses"* kept Selena in the STEM pipeline even as she strayed from the pharmacist track. Indeed, after graduating, she eventually discovered the field of patent law and decided to become a patent attorney – a profession that perfectly blended her scientific background with her newfound interest in law and business. *"I found patent law and yeah, that's what I do now,"* Selena announced proudly. She noted that she might never have landed there had she not pivoted majors or had SUSTAIN's broadening influence to consider lesser-known careers in science.

These stories demonstrate how changing one's major or adding a new academic focus was not a sign of indecision, but rather an act of agency. By following their interests and expanding their view of what a STEM career could look like, participants built more authentic and sustainable paths. Support from mentors and flexible degree structures allowed them to evolve, blending old ambitions with new passions in ways that kept them both motivated and meaningfully engaged in STEM.

Openness to Alternatives

A key trait among participants who successfully navigated career pivots was a willingness to explore new opportunities and re-evaluate their original plans. Jackie's journey

exemplifies this kind of adaptability. She entered college laser-focused on becoming a dentist, but she had a change of heart: *"after my first year… I realized I didn't want to be a dentist."* Instead of panicking, she entered a phase of exploration: *"I started thinking, what am I going to do?"*

Through SUSTAIN, Jackie became involved in a biology research project, which gave her the idea to consider pursuing a PhD. At one point, she even considered law school, specifically patent law, because it offered a way to combine her scientific knowledge background with a professional degree. At the same time, her dual major in Biology and Business *"opened [her] eyes to the possibility of working for a pharmaceutical company"* in a business-related capacity.

By senior year, Jackie had seriously considered at least three career path. She continued "*with [research] until like senior year,"* when COVID disruptions limited further lab work. At that point, she shifted her focus on industry and began applying to pharmaceutical and consumer healthcare companies. This led to her first job in marketing in a consumer healthcare division, a role she found aligned well with both her scientific knowledge and business training.

Jackie's story highlights how academic flexibility, combined with exposure to multiple career paths through SUSTAIN, allowed her to adapt without losing momentum. Her openness to alternatives ultimately enabled her to find a career that was both unexpected and well suited to her strengths. As Jackie would say it's *"my dream job."*

The Exploration & Emerging Interests theme illustrates that STEM trajectories are rarely linear. Rather than following a single, unchanging path, participants' stories reflect a process of active discovery by testing interests, weighing practical considerations, and making intentional pivots when their original plans no longer aligned with their evolving goals. These shifts were

often catalyzed by new inputs such as research opportunities, industry exposure, elective courses, or conversations with mentors, many of which were made accessible through the SUSTAIN program.

Far from seeing these pivots as setbacks, participants generally described them as clarifying moments that helped them feel more confident in their eventual direction. Maya, one of the few who remained firmly committed to medical school, still experienced a moment of pause: *"There was a part of me that was like, maybe I should have a backup plan… but at the end of the day, there wasn't really anything else I could see myself doing."* Her early research experiences, rather than diverting her path, reinforced her original devotion to medicine with the added pursuit of being a physician-scientist.

For many others, exploration led to meaningful shifts in career goals. Veronica moved from pre-med to research, Winston and Zari transitioned from medicine to pharmacy, Jackie pivoted from dentistry to consumer healthcare marketing, Selena shifted from pharmacy to patent law, and Lucas transitioned from pre-med to software engineering. Each of these pivots followed a period of reflection and experimentation that illuminated alternative pathways.

Importantly, these transitions did not occur in isolation. They were frequently supported and encouraged by mentors or made possible through program structures that enabled exploration. In this way, the participants' emerging interests were not only validated but actively nurtured into new, concrete goals. Their stories exemplify adaptive career development in action, which was driven by curiosity, informed by experience, and supported by intentional scaffolding.

The Evolving Self

Across the interviews, it became clear that participants' college and early career experiences did more than just expand their academic and professional horizons; they catalyzed

profound internal development. The theme of “The Evolving Self” captures this process of personal transformation as students moved from uncertainty and external expectations toward a more self-defined sense of identity, purpose, and agency. This evolution was not immediate or uniform, but emerged over time as participants confronted challenges, took intellectual and emotional risks, and reflected on what success and fulfillment meant to them.

For many, entering college as first-generation, low-income students in rigorous STEM programs brought feelings of imposter syndrome and heightened pressure to follow "safe" or prestigious career tracks such as medicine. However, as they engaged with opportunities like research, mentorship, peer collaboration, and internships, they began to question, reshape, and sometimes completely redefine their aspirations. With these external experiences came deep internal shifts as they started to reimagine what they were capable of, what they wanted, and who they were becoming.

This theme explores how participants came to see themselves not only as scientists or professionals, but as empowered individuals with the ability to make authentic, informed decisions about their futures. It encompasses three interwoven subthemes: Identity Formation, which traces how participants’ science identities emerged, faltered, or were reimagined; Sense of Belonging, which highlights how community, mentorship, and representation influenced participants’ feeling of "fitting in" within STEM spaces; and Self-Efficacy & Resilience, which examines how students built confidence and perseverance through overcoming setbacks and succeeding in unfamiliar or challenging environments.

Each subtheme represents the cognitive, emotional, and social changes that contributed to the development of a stronger, more autonomous self. Together, these narratives reveal that personal growth in STEM is not simply about mastering content or securing degrees. It is about

755 becoming someone who sees themselves as capable, who belongs, and who is worthy of being in
756 STEM.

757 ***Identity Formation***

758 For underrepresented students in STEM, developing a science identity – seeing oneself as
759 a "STEM person" or future professional in the field – can be a gradual and sometimes fragile
760 process (Carlone & Johnson, 2007). Participants' narratives revealed identity shifts over time.
761 Initially, some felt like imposters or simply students going through the motions; by the end of
762 college, many had come to embrace an identity as a scientist, engineer, or other STEM
763 professional, even if they ultimately applied that identity in non-traditional ways. Key to identity
764 formation were experiences of competence (doing STEM work successfully) and recognition
765 (being seen and validated by others as a STEM talent) (Carlone & Johnson, 2007).

766 Several participants described a turning point when they began to internalize a STEM
767 identity. Zari's account is illustrative: she entered college confident in her analytical skills but
768 unprepared for lab work. Initially she felt out-of-place in the research lab, *"I was the only*
769 *undergrad… and only girl"* and doubted her abilities in that context. However, as her lab mates
770 trained her and her skills grew, she began to feel like a scientist. She cites her PI's tough-love
771 mentoring as pivotal: *"he really made me into the scientist that I am."* By senior year, Zari
772 wasn't just a student doing experiments; she self-identified as a capable member of the scientific
773 community, evidenced by spending all her time in lab and taking on responsibilities like a
774 graduate student.

775 I got to present my research a bunch of times, so help me with, like, public speaking. I
776 won a bunch of awards for research, had fellowships, stuff like that. So, [research] kind
777 of just gave me a stronger background. [Research] also kind of gave me confidence, like,

> as a person, a woman in STEM because I was, like, really bad at it at first, and then I got my footing, and [my lab mates] were really patient with me and really helpful. And then I was like, Oh my God. Like, I'm really good at this. So, then I was like, I'm a scientist – nobody can tell me I'm not. I'm so happy with the confidence aspect as well.

Zari's story highlights how identity transformation can be experiential and built gradually through moments of success, social validation, and self-recognition. Her shift from doubt to certainty was not instant, but the accumulation of experiences helped her fully claim the identity of a scientist.

Another student, Selena, spoke about leveraging her STEM credentials in non-STEM spaces. When applying to law school, she initially *"didn't associate a strong part of my identity with my STEM degree,"* she viewed it more as a qualification she could "play" to stand out. *"I leveraged it because I had it… I was proud of my degree… it gave me an edge,"* she said of touting her biotechnical background in law school. But she also admitted that earlier in college she *"pushed away [from science] for a while"* after not enjoying it and was *"not 100% sure [in law school] that I wanted to do anything with science anymore."* Over time, her perspective evolved: as she succeeded in patent law, she rediscovered value in her scientist identity. Now, she said, *"I love what I do"* and recognizes that *"bringing that [STEM] piece"* of herself was actually a source of strength in her career. Selena's identity as a "STEM person" thus went through phases: from externally motivated by choosing STEM for security, to disengaged when science classes didn't resonate, to re-integrated when embracing her unique dual identity as a scientist-lawyer.

For those who stayed in pure STEM pathways, identity formation often meant growing from student to professional. Maya, now a medical student, talked about how doing post-

baccalaureate research and working alongside scientists made her feel part of the scientific community. *"I was the only undergrad in my lab… but they treated me like a colleague,"* she said, noting that lab meetings, conferences, and mentor interactions helped her "see [her]self" as a budding scientist and physician. She learned what it meant to think and work like a professional in the field: *"certain things you'll see – whether or not the students can actually communicate with the PIs, or whether the PIs are communicating well – you start to notice what good science practice is,"* Maya explained, demonstrating an identity shift from novice to a more seasoned, perceptive scientist. By the time she was interviewing for M.D./Ph.D. programs, she was evaluating labs for "fit" just as they were evaluating her, which signals strong scientific self-understanding. She chose a bioinformatics lab for her Ph.D. rotation because it aligned with her identity and goals: *"I wanted to be in a lab where my skills could be applicable to any specialty… I actually completely switched gears [from wet lab] and I rotated in a bioinformatics lab, and that's where I ended up joining."* Maya's story reflects a confident assertion of identity as she knew what kind of researcher she was and where she belonged.

Not all participants, however, ultimately identified strongly as "scientists," and that , too, is an outcome of identity development. Veronica, for instance, realized during college that while she loved science, she didn't necessarily need to be a scientist in the traditional sense. She shared that had she discovered her love of writing or math earlier, she might have pursued journalism or teaching. Over time, her identity shifted toward prioritizing work-life balance and personal fulfillment over maintaining a professional science label. "*It's not as important to me now to stay in a science field*," she reflected, despite being a clinical laboratory scientist.

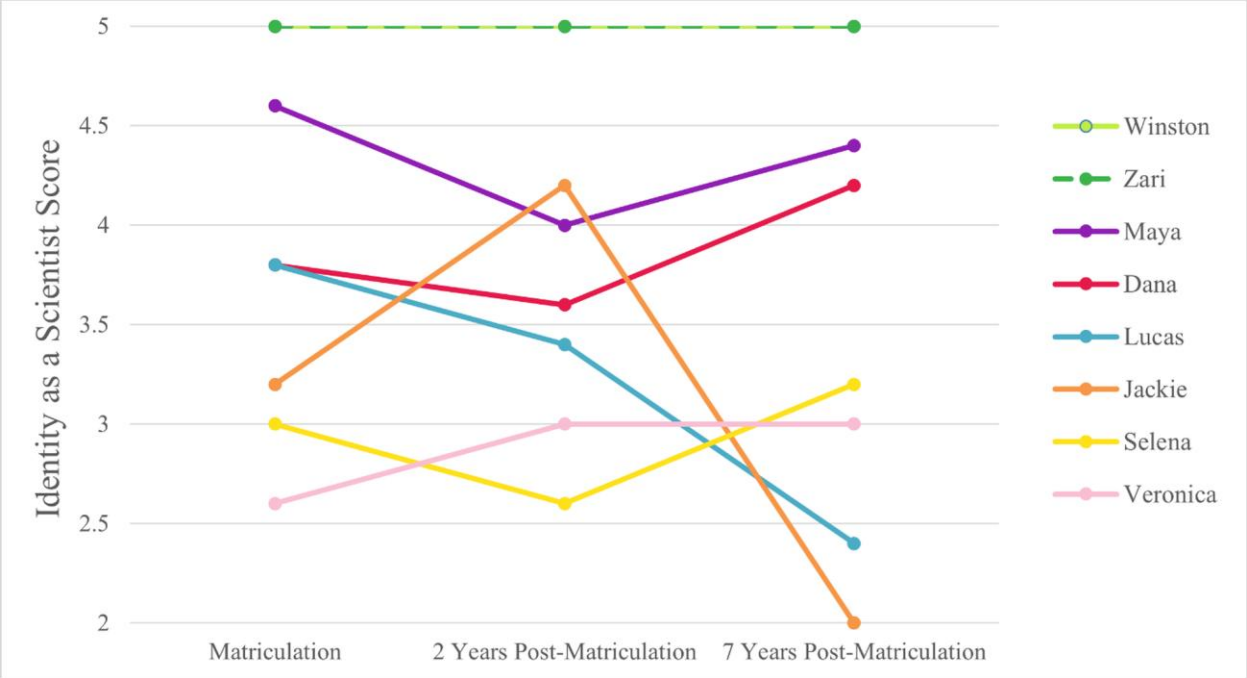
To further examine how participants' science identities developed, a longitudinal analysis was conducted using identity-as-a-scientist scores at three timepoints: matriculation, two years

post-matriculation, and seven years post-matriculation. As shown in Figure 3, these trajectories varied widely by individual, reflecting distinct experiences of growth that shaped identity development.

While Zari, Winston, and Maya maintained consistently high identity as scientist scores across all three time points, others like Lucas and Jackie showed declining or fluctuating identification as a scientist over time. Selena, for example, experienced a dip in her identity as scientist midway through college but showed renewed connection by the seven-year mark which mirrors her narrative of rediscovering value in her scientific background through patent law. Meanwhile, Jackie, who began with moderate confidence, peaked mid-college but later moved into industry roles less centered on science, which aligns with her sharply dropping score at the final timepoint. These trends reinforce the nuanced, nonlinear nature of identity development illustrated by the interview data.

Figure 3

Change in Identity as a Scientist Score from Matriculation to 2- and 7-Years Post-Matriculation.



Note. Winston and Zari had the same scores at each timepoint; therefore, their lines overlap.

Together, the figure and participants' stories underscore that identity formation in STEM is not fixed but evolves in response to experience, environment, and evolving self-concept. Whether participants embraced, revised, or distanced themselves from a scientist identity, their journeys were shaped by opportunities for competence, recognition, and authentic engagement which were often supported by mentoring and program structures like SUSTAIN. These dynamic trajectories demonstrate the complexity of career development for underrepresented students in STEM and highlight the importance of fostering flexible, affirming spaces where identities can be explored and redefined.

Sense of Belonging

Feeling like one "fits" in STEM – in the classroom, lab, or professional community – was frequently mentioned as both a challenge and, eventually, a triumph for these participants. Early on, several felt they did not belong, whether due to imposter syndrome, being one of the few women or minorities in their cohort, or simply the shock of transitioning to a rigorous university environment. Over time, various factors like peer support, mentorship, or successful experiences helped cultivate a stronger sense of belonging in STEM. This subtheme is closely tied to both the prior (identity) and next (self-efficacy) subthemes, as belonging often reinforced identity and strengthened confidence.

Participants often pinpointed SUSTAIN's community as instrumental in fostering belonging. Veronica recalled that in the first year SUSTAIN seminar, they discovered many shared struggles. *"It was good sharing those experiences,"* she said, *"a lot of us… didn't really know what to expect [in college] … we'd discuss our classes, how to help each other adjust."* Those discussions normalized their feelings and created a bond of *"we're in this together,"* which contrasted with how isolated they might have felt otherwise in large intro STEM courses. Veronica and her close friend Dana also built their own micro-community, supporting each other as roommates and joining a sorority, which gave them an additional layer of belonging at the university. Dana spoke of the SUSTAIN social events as moments she felt truly comfortable: decorating a Christmas tree at a professor's farm or carving pumpkins with her cohort made campus feel like *"home,"* as she described: *"It felt like home almost… we had a nice break from all the stress… I kind of felt like we could just be kids again."* These experiences strengthened her sense that she *belonged* at college and in STEM – she had a group of friends who understood her and faculty who treated the students with sincerity.

In the academic domain, belonging in the lab was crucial. Maya insightfully noted that the dynamics of a lab – how well the PI and students communicate, how welcoming the group is – determine if a young researcher feels they belong. *"If you don't click well with everybody else you're working with, you're just going to feel miserable,"* she observed. She felt fortunate that in one rotation *"the lab was nice and small… I mostly worked with a PhD student. He was really great."* That close-knit environment made her *look forward* to going in each day, a sure sign of belonging. In another instance, she experienced a lab that was less organized, and the fit was poorer – she mentioned *"lots of bumps along the way"* with experiments not getting off the ground – and she recognized she *didn't* belong there as much. By comparing these, Maya learned to seek environments where she felt included and valued. When she found the bioinformatics lab that clicked, she joined it and found her place. Zari's story similarly highlights the progression from non-belonging to belonging. Initially she was an outsider in her research lab, but over time she became "one of the team." She stated: *"The people in my lab were awesome… I had like the best grad student… we became friends. My lab manager was like an older sister figure."* With those relationships, the lab transformed from a scary, foreign place to her community, so much so that she spent more time there than anywhere else on campus by senior year. Feeling *"I fit in here"* boosted her comfort to ask questions, take on challenges, and flourish scientifically.

Belonging was not just about personal comfort; it had tangible effects on persistence. When participants felt they belonged, they were more likely to stick with difficult majors and pursue STEM careers. Jackie mentioned how being part of a cohort of STEM scholars made her more comfortable tackling hard courses. She didn't feel out of place in challenging classes because she always had peers by her side, studying together. That communal aspect meant a setback was easier to overcome – e.g., if she struggled on an exam, it helped to know *"we all*

found that tough, let's work on it together." Conversely, the feeling of *not* belonging could hasten a pivot out of a field. Selena's dislike of her initial science classes was coupled with feeling out of place among science majors. She felt more at home once she switched to a more interdisciplinary major, where she met other students who, like her, had broader interests.

It's also worth noting that representation plays a role in belonging. Being "the only one" in a space – whether the only woman, only student of color, only first-gen student, etc. – can erode belonging. Participants did not always explicitly mention demographics, but a few clues emerged. Zari's note that she was *"the only girl"* in her lab at first indicates she noticed that aspect. Once she proved herself and earned respect, that gender minority status likely felt less salient – especially as her lab mates treated her as an equal. Winston, as an immigrant student of color, didn't mention race explicitly, but he did express immense gratitude for a mentor who saw his potential and pushed him upward – a form of *recognition* that is vital for belonging for underrepresented students. Jackie, who is also first gen, pointed out that her parents initially questioned her professional choices. They *"didn't really even want me to be a dentist"* due to cost and fear of potential lawsuits. However, as they saw her thriving in the program, *"their perspective shifted as well… they saw the importance of this major through this program,"* and they became more supportive. In essence, Jackie's family came to see her as a legitimate STEM professional in the making – an external recognition that likely reinforced her own sense of belonging in that world. By the time she was applying to jobs, Jackie no longer felt like a kid out of her depth; she felt like a young professional *with options*, which is a strong indicator of belonging in the professional STEM community.

Self-Efficacy & Resilience

Finally, participants' journeys reflect the development of self-efficacy (belief in one's ability to succeed in specific tasks) and resilience (the capacity to recover from difficulties and persist) (Bandura, 1982; Southwick et al., 2014). In the beginning of college, despite being high-achieving students, many grappled with self-doubt. The rigors of STEM courses, coupled with heavy workloads, and sometimes lack of immediate success, tested their confidence. Over time, through a mix of support and personal determination, participants built stronger self-efficacy – they learned *"I can do this"* – and resilience – the mindset that setbacks can be overcome. These traits were crucial in enabling them to reach their STEM career goals even as those goals evolved.

Several interviewees spoke about moments of low confidence and how they overcame them. Maya admitted that while she was dedicated on going to medical school, the COVID-19 pandemic dealt a blow to her confidence when it repeatedly disrupted her MCAT exam schedule. *"My MCAT got canceled a bunch of times… I was anticipating a higher score… I think that's when I got second thoughts. I was like, I don't really know if this is gonna work out,"* she recalled. This dip in self-efficacy could have derailed her, but she displayed resilience: *"Eventually, you know, everything got started, so I'll take it,"* she said – she kept studying, took the test as soon as possible, and gained admission to medical school. Maya's comment *"I have no idea how this all got managed"* belies the fact that she managed it through her own perseverance. The support of mentors also bolstered her self-efficacy; hearing from PIs that she was doing well and having successful research outcomes gave her confidence that carried over to her med school pursuit.

Dana provides an example of resilience in the face of extreme workload and financial stress. As a first-gen from a rural, working-class background, she not only took a full course load in a double major but also worked long hours to support herself. *"I worked off campus… whenever I went home for break, I worked six days a week, from 6am to midnight,"* she said matter-of-factly. During the semester she kept a part-time job at a farm supply store, working *"maybe two to three times a week… on the only off days I had."* This kind of schedule would break many people, yet Dana pushed through with remarkable grit – *"It was awful. Don't recommend, but you gotta do what you gotta do,"* she laughed. Her resilience was fueled partly by her long-term goal of applying to med school and partly by a personal ethos of hard work. It was also supported by understanding mentors: when academic stress mounted, her faculty advisors gave her flexibility and encouragement, helping prevent burnout. Over time, surviving this workload likely gave Dana a strong sense that she can handle whatever comes her way. Indeed, she emerged with the insight that she could continue to pursue her goals in a way that's best fit for her. At the time of interview, she held a grueling workload while in Paramedic school, all without dropping her goal of pursuing medical school.

Lucas's journey also highlights self-efficacy gained through overcoming obstacles. Initially set on an MD path largely due to family expectations, he found himself struggling in biology and craving a different intellectual challenge. The process of pivoting was not easy – he effectively had to self-teach and hustle to get opportunities in a new field. *"I used all my free credits to take [computer science] classes… everything in engineering had prereqs I didn't have, but I found a way,"* he said. He even took on roles like being a TA and joining a research lab in the [Computer Science College] to immerse himself. Each hurdle he cleared from convincing professors to let him into classes to getting accepted to a competitive CS master's, was a boost to

self-efficacy. By senior year, Lucas remarked, *"I was lucky… it was really hard [to change course],"* but his tone and outcome show tremendous confidence in his decision and abilities. He said applying to grad school was *"the most nerve-wracking time of my life… this could change the path of my life,"* and when he was admitted, *"I was very happy how everything turned out."* Achieving that goal cemented his belief in his own competence.

Mentors and programs explicitly worked to build students' self-efficacy. Jackie noted that SUSTAIN gave them incremental successes – research projects, presentations, scholarships – that cumulatively made them feel *"I can do science."* For instance, she obtained research grants through SUSTAIN that funded her summer lab work, which she said, *"pushed me to want to continue doing it."* Completing a summer of research and presenting her findings to peers gave Jackie tangible proof of her capabilities, boosting her confidence. Similarly, the cohort's practice of sharing struggles likely helped members realize that needing help doesn't mean you don't belong. Veronica mentioned that in SUSTAIN's forum, *"we talked about how to manage our schedules, pick classes… [Dr. T] had specific questions, but it turned into us discussing our classes"* and helping each other. Through collective problem-solving, they all became more self-sufficient and assured. Veronica emerged from college with the mindset that a biology degree was a *"safe bet"* precisely because she knew she could handle various professional paths in STEM. She had gained confidence that her training had equipped her with skills for many options, indicating high self-efficacy in her adaptability.

By the end of their undergraduate experience and in their early careers, each participant demonstrated remarkable resilience: they all attained a STEM degree and proceeded to meaningful next steps like graduate school, professional school, STEM employment, or STEM-related careers. They did so despite personal and structural challenges that often cause students to

leave STEM. They also exhibited self-efficacy in specific domains – for example, Maya feeling capable of succeeding in med school and research, Zari feeling capable in the lab and now in pharmacy school, Jackie feeling capable in bridging science and business, and Selena feeling confident enough in her STEM knowledge to use it in a legal career. These senses of efficacy were hard-won. Many participants noted that the beginning of college was the hardest, but by the end they had transformed. *"I think it all worked out the way it was supposed to,"* Jackie reflected, *"I'm glad I didn't have the thought freshman year to quit STEM… I felt supported through [SUSTAIN]… through such difficult courses, and through something so new to me."* This quote encapsulates how support fostered her resilience and, ultimately, her success.

In conclusion, the findings from the SUSTAIN participants illustrate a holistic picture of their STEM journeys. Structural factors like being first-generation or low-income provided both motivation and hurdles, but support systems like mentors, peers, and support programs greatly mitigated barriers. Through exploration, participants often recalibrated their career goals, demonstrating agency in finding paths that align with their evolving interests. And through those experiences, their sense of self as STEM professionals solidified – marked by growing confidence, a feeling of belonging, and the resilience to navigate challenges. Each theme interweaves with the others: for instance, mentorship enabled fruitful exploration, which in turn bolstered identity and confidence. Together, these findings address the research question by showing that it is not one single factor but a union of supportive influences, exploratory experiences, and personal growth that ultimately led to the participants' STEM career outcomes.

Discussion

This project investigated the factors that have led to the former SUSTAIN participants' career outcomes in STEM. In this discussion, the themes presented above are interpreted

primarily through the lens of Social Cognitive Career Theory (SCCT) and participants' experiences are situated within the broader literature on supporting underrepresented students in STEM (Figure 1). SCCT serves as a useful organizing framework, emphasizing how personal factors (such as self-efficacy and identity), contextual supports and barriers, and learning experiences jointly shape career interests, goals, and actions. The findings align strongly with SCCT – participants' trajectories were driven by enhanced self-efficacy and outcome expectations due to positive experiences (e.g., mentoring, research) and were navigated in the presence of certain barriers (financial, institutional) and supports (scholarships, community). In what follows, each major theme is connected to existing research, demonstrating how this study both reinforces prior work and offers new insights.

The Role of Contextual Supports and Barriers in STEM Persistence

These findings underscore that context matters greatly for STEM career outcomes, especially for first-generation and low-income students. Participants' stories vividly illustrate how contextual barriers like financial strain, lack of familial college knowledge, and certain institutional rigidities initially placed them at a disadvantage, and how contextual supports like scholarships, program community, and mentorship helped level the playing field. This aligns with a substantial body of literature documenting the extra obstacles faced by students from underrepresented or under-resourced backgrounds and the kinds of support that can facilitate their success (e.g., Surman et al., 2025).

Consistent with prior research, nearly all the participants entered college with significant financial need and limited social capital in academic settings. These conditions are well-documented among first-generation, low-income students in STEM. For example, Hurtado et al. (2009) note that underrepresented students in STEM often face unwelcoming campus climates,

limited mentoring, and financial stressors, all of which can undermine their academic persistence. In this study, participants like Dana and Zari felt this acutely. Dana juggled multiple jobs to support herself, noting *"not a lot of my peers were [working]… but you gotta do what you gotta do."* This reflects what Perna (2010) and Terenzini et al. (1994) describe as the reality for many low-income undergraduates who must balance employment and academics. This dynamic can limit their engagement with educational opportunities but may also cultivate time-management skills and resilience. Moreover, first-gen students often lack familial examples of navigating college or STEM careers (Hurtado et al., 2009; Perez et al., 2014). Indeed, the participants spoke of having no one in their immediate circles who could guide choices like selecting a major or prepping for med school. Jackie's comment – *"I didn't have anybody in my family I could call… I'm a first-generation college student"* – exemplifies this. This absence of inherited college knowledge meant that programs like SUSTAIN, which offered advising and cohort-based learning, were crucial compensatory supports.

The financial scholarships provided by SUSTAIN were particularly impactful, as they reduced the need for outside employment and enabled full participation in academic and research activities. Dana notes:

> My first year and a half I didn't work at all…I didn't have to bear the burden of the financial difficulty as immediately because of [the SUSTAIN scholarship], which was really nice, because the first few years I could pretty much just focus on my studies instead of focusing on everything else…which is the first time in a really long time that I could do that.

Dana's experience aligns with Carpi et al. (2017), who found that stipends and financial support allowed low-income students to engage meaningfully in undergraduate research, thereby

increasing their self-efficacy and long-term commitment to STEM fields. By providing funding during the first two years, SUSTAIN enabled participants to focus on academics rather than on burdensome work schedules or on taking out large loans. Several participants explicitly stated that the scholarship was a “game-changer” that made college feasible. This mirrors results from Atkins et al. (2020), who observed that targeted financial support in STEM intervention programs alleviates students’ stress and allows them to seize learning opportunities, like unpaid research, that they otherwise could not. Our findings go further to suggest that the scholarship’s influence was not only economic, but also psychological. Zari’s insight that graduating debt-free empowered her to enroll in a doctoral (PharmD) program without fear aligns with the concept of “cost perceptions” in expectancy-value theory (Eccles, 1983). She perceived the “cost” of further education to be manageable thanks to her scholarship, whereas had she carried undergraduate debt, the cumulative cost might have deterred her. This resonates with Perez et al. (2014), who found that URM students’ decisions to persist in STEM are influenced by weighing the financial and opportunity costs against the value they place on a STEM career. By mitigating financial cost, SUSTAIN shifted that decision in favor of persistence for our participants.

In terms of institutional climate and structure, the participants’ mixed experiences reflect broader patterns noted in the literature. A welcoming, inclusive academic climate can significantly improve URM student outcomes (Hernandez et al., 2013; Hurtado et al., 2009), whereas a chilly or inflexible environment can reinforce feelings of not belonging. Some of our participants encountered “weed out” course designs or rigid curricula that were not conducive to exploratory learning. Lucas’s frustration at being unable to minor in computer science due to a late declaration highlights the structural rigidity that can hinder students’ ability to pursue newly discovered interests. This reflects concerns raised by Wong et al. (2022), who found that

underrepresented STEM students often encounter inflexible academic pathways that limit exploration and make it difficult to shift directions, potentially discouraging those who come to their passions later in their academic careers. On the other hand, participants who found welcoming micro-environments – such as supportive lab groups or approachable professors – reported far better integration. This aligns with Estrada et al. (2018), who demonstrated that early research experiences and mentoring increase students' sense of belonging in STEM, particularly for those from underrepresented groups. This study adds qualitative depth to those findings. Veronica's case showed how a positive lab experience replaced a less welcoming pre-med atmosphere and ultimately kept her in STEM via a research route.

Most strikingly, these findings reaffirm the central importance of mentorship and multi-layered support systems in mitigating structural barriers, a point extensively supported by prior literature. The strong mentoring relationships described by participants align with the consensus in research that mentorship is a key factor in URM student success (Atkins et al., 2020; Chemers et al., 2011; Estrada et al., 2018). These studies argue that mentors provide not just academic guidance but also social cues and encouragement that help students visualize themselves as future STEM professionals. For example, Chemers et al. (2011) found that for underrepresented students, the combination of mentor support and increased self-efficacy significantly predicted commitment to STEM careers. In this data, we see exactly this combination: Dana's mentors convinced her she was capable of succeeding in her major when she doubted herself, which boosted her confidence and contributed to her remaining in STEM. Jackie's relationships with her advisors and the SUSTAIN director made her feel *"supported through such difficult courses…something so new to me,"* which she directly credits for her decision to stick with a STEM major rather than drop it for comfort. This reflects Estrada et al. (2018) findings that high-

quality mentorship within undergraduate research experiences significantly predicted students' scientific self-efficacy and science identity. Both were, in turn, positively associated with long-term persistence in STEM pathways.

Furthermore, these findings resonate with the concept of "recognition" in science identity formation (Carlone & Johnson, 2007). Many participants experienced a turning point when a mentor recognized their potential or achievements – Winston's mentor encouraging his internship, Zari's PI trusting her with independent work, Veronica's professor inviting her to continue in research. While Carlone and Johnson (2007) originally highlighted this mechanism in the context of women of color, the core insight that being recognized by meaningful others as a "science person" strengthens one's science identity was clearly applicable across this sample. The SIP's home institution has been highlighted in the research as having faculty members who "consider undergraduate researchers as scientists," which could have contributed to the participants' science identity growth (Schmid & Wiles, 2022).

For students from low-income and first-generation backgrounds, such recognition may be particularly consequential, given their limited prior exposure to STEM professionals and fewer family role models in scientific fields. External validation from mentors appeared to bolster participants' internal sense of belonging and capability in STEM. For instance, Winston's experience of receiving praise and high expectations from his research mentor not only opened concrete academic opportunities but also contributed to his evolving self-concept as someone who belonged in the scientific community. These moments of recognition helped to counter the imposter syndrome that is often experienced by first-generation and low-income students in elite academic spaces. Merolla and Serpe (2013) similarly found that the salience of science identity—feeling recognized and seeing oneself as a "science person"—is strongly associated

with students' decisions to persist in science and enroll in graduate STEM programs. This pattern was evident among participants like Maya, Zari, and Lucas, whose recognition-rich experiences contributed to their continued progression in STEM.

In summary, the participants' journeys through structural challenges and supports reinforce a key insight of SCCT: contextual factors can significantly hinder or facilitate career development. The findings here align with extensive research that calls for addressing financial barriers, creating mentoring programs, and fostering inclusive climates to improve the retention of first-gen, low-income, and URM students in STEM (Carpi et al., 2017; Estrada et al., 2018; Hansen et al., 2023; Maxwell et al., 2023; Sloane et al., 2021). The SUSTAIN program exemplified many recommended practices – providing scholarships, undergraduate research experiences, cohort-based belonging, and intensive mentoring (Ceyhan, Thompson, Sloane, Wiles, & Tillotson, 2019) – and this study demonstrates its synergistic impact. Without these supports, many of the participants might have left STEM; with them, they not only persisted but flourished to the point of supporting each other. Thus, this work validates and adds narrative detail to the importance of structural interventions in creating a more equitable STEM pipeline.

Navigating Career Exploration and Change: Pivot Points in Context

Another salient aspect of these findings is the prevalence of career pivots and exploration, which SCCT also helps explain. SCCT acknowledges that interests and goals are not fixed; they evolve as individuals gain new experiences and as their self-efficacy and outcome expectations change (Lent et al., 1994). In this study, participants often started with one goal but later shifted to a different trajectory. This adaptive re-routing is supported by the literature – rather than representing "failure," changing one's STEM goal can be a positive response to better self-knowledge and realistic judgments of fit (Garriott, 2020). The participants' pivots were typically

caused by two things: (1) learning experiences that revealed new possibilities or disproved old assumptions, and (2) ongoing support that gave them confidence to make a change rather than leave STEM entirely.

Learning practices in the form of undergraduate research, internships, and specialized coursework played a pivotal role in reshaping interests. The value of such experiences for URM students has been highlighted by numerous scholars (Estrada et al., 2018; Lopatto, 2007). These practices function as what SCCT terms "learning experiences" – they provide feedback on one's abilities and enjoyment, thereby influencing interests (Lent et al., 1994). For instance, Veronica's early research experience led her to discover an interest in scientific investigation she hadn't previously considered, effectively shifting her outcome expectation: she realized a research career could be just as, if not more, fulfilling to her as the MD path, without some aspects she found unappealing: *"didn't want to do all those years of med school to work with dead bodies."* This mirrors findings by Russell et al. (2007) that undergraduate research experiences can increase students' STEM career interests and expose them to alternative careers in STEM. Jackie's experience was a textbook case of exploration. By engaging in a research project established through SUSTAIN, she entertained the idea of a research career which furthered her self-efficacy in lab work, while simultaneously through business courses and networking she envisioned industry roles. Lent et al. (2002) describe how new mastery experiences and social persuasions can realign a person's goal hierarchy – Jackie initially ranked "dentist" highest, but positive experiences in marketing internships and feedback from mentors in biotech likely elevated "pharma marketing professional" as a goal and lowered "dentist." Notably, she did not abandon STEM, she simply found a niche that combined her strengths. This suggests an important nuance also noted by Rosenzweig et al. (2024): underrepresented students might

change majors or specific career targets, but with proper support they can remain in the STEM ecosystem, thus broadening definitions of success.

These findings also align with expectancy-value theory perspectives (Eccles, 1983) on how students evaluate career options based on their evolving interests (intrinsic value) and perceived utility (utility value). Selena's pivot from an interest in pharmacy, which she saw as practical, to patent law is a case in point. Early on, she prioritized utility and security as she chose STEM over art for stability. But after finding that she *"did not enjoy"* the day-to-day of science classes and lab work, her intrinsic value for that path dropped. Meanwhile, exposure to law and business through courses and speakers showed her a career that could satisfy both her intrinsic interests and her utility goals of financial and professional stability. Rosenzweig et al. (2024) observed similar patterns where STEM students who perceived misalignment between their majors and their interests or life goals were likely to reconsider their direction. Importantly, Selena's story ended with her staying in a STEM-related profession, which suggests that broad interventions that introduce students to diverse STEM careers can retain talent in STEM in a larger sense. This touches on the work of Marco-Bujosa et al. (2024a) who emphasize validating non-traditional career paths for STEM students as a way to sustain their participation in STEM fields. The participants who found hybrid careers (like Selena in law, or Jackie in marketing) benefited from mentors who valued those choices rather than dismissing them as "leaving STEM." For example, Dr. T's encouragement of Selena to consider what she truly enjoyed was pivotal for her to pursue an adjacent career that leveraged her STEM background and fulfilled her goals.

Another facet to discuss is that not all pivots were away from original goals – some participants reaffirmed their initial aspirations but with a more nuanced understanding of them.

Maya is a prime example: she started and ended with "medical doctor" as her goal, but through exploration, she refined it to "physician-scientist" (MD/PhD). Her exposure to research via SUSTAIN gave her a new dimension to add to her identity and career plans as she learned about the existence of physician-scientists during this experience. This reflects SCCT's idea that interests can expand even if the general field remains the same. SCCT would label Maya's case as one where contextual support (research opportunities) and mentoring led to incorporation of a new interest (research) alongside an existing one (medicine), ultimately strengthening her commitment by providing multiple satisfactions (Lent et al., 1994). Her case echoes Hernandez et al. (2013)'s findings, who reported that undergraduate research experiences can reinforce students' motivation for STEM careers by increasing their sense of scientific contribution and competence.

These findings also reinforce that support systems are crucial during pivot points to prevent students from completely detaching from STEM. When students considered changing majors or careers, having advisors and peers to discuss it with made a big difference. For instance, Lucas might have simply dropped out of STEM entirely when he felt disillusioned with pre-med, but instead he sought counsel and was *"lucky though, [my family] just want me to be okay… it was more my mental block."* That familial openness, combined with a mentor who helped him strategize his "soft switch," enabled him to remain in STEM through a different route. Atindama et al. (2025) suggests that when underrepresented students leave STEM majors, it's often not due to lack of ability, but lack of fit or guidance on alternative STEM majors – this study provides a success case where guidance was present, so the student stayed in STEM via a better-fitting major. Former reports on SUSTAIN noted that a number of participants did switch majors but still graduated in STEM fields, which were interpreted as positive outcomes of

students narrowing down their interests (Ceyhan, Thompson, Sloane, Wiles, & Tillotson, 2019). These data further support the interpretation that those switches were indeed positive adaptations, not failures.

In summary, the theme of "Exploration & Emerging Interests" in these findings is well-supported by SCCT and related career development models. Underrepresented students benefit from opportunities to explore because these opportunities provide feedback that refines their self-efficacy and outcome expectations (Estrada et al., 2011; Lent et al., 2002). Moreover, given the initial narrow career perceptions many had, being exposed to a wider variety of STEM careers through program interventions is critical. This aligns with calls in the literature for STEM programs to include career education and diverse role models, so students can find paths that resonate with them personally (Hansen et al., 2023). The participants who engaged with guest speakers, internships, or dual majors clearly benefited from that broader horizon. Finally, the fact that every participant remained in a STEM or STEM-adjacent career outcome, even if many changed course, suggests that a flexible, student-centered approach to STEM education – one that validates personal interest and multiple definitions of success – can keep more underrepresented students in the STEM talent pool, although sometimes in unexpected ways. This is a valuable insight for SIP's like SUSTAIN and is consistent with the evolving perspective in STEM education research that "success" should include things like transitioning to STEM-supportive roles (e.g., educators, policymakers, patent lawyers) and not only traditional scientist tracks (Estrada et al., 2016; Marco-Bujosa et al., 2024a).

Developing a STEM Identity and Resilience: Personal Growth Through Program Participation

The evolution of participants' science identities, sense of belonging, and self-efficacy – captured under *The Evolving Self* – is perhaps the most encouraging aspect of these findings. It speaks to the transformative power of supportive STEM experiences in shaping how students see themselves and their place in STEM. These psychosocial outcomes are heavily emphasized in the literature as key mediators for academic and career outcomes (Carlone & Johnson, 2007; Chemers et al., 2011; Stets et al., 2017). This study adds rich detail to how these constructs manifest in students' narratives. We observed participants move from tentative participation in STEM toward more confident involvement – effectively from outsiders to insiders in the STEM community of practice (Lave & Wenger, 1991).

Science Identity Formation

The concept of science identity involves seeing oneself as a science person and being recognized as such by others (Carlone & Johnson, 2007). Recognition from mentors, peers, and instructors is a critical mechanism for this development; how others see a student deeply influences how the student sees themselves, which in turn shapes their decisions (Hazari et al., 2010). Many of the participants began college with fragile or underdeveloped science identities. For instance, Zari was confident in her science abilities but didn't fully identify as a "scientist," she described feeling unprepared and inexperienced in lab settings. By the end of college, she described herself as *"a scientist 24/7,"* immersed in her research, presenting her work, and mentoring others. This identity shift was enabled by mastery experiences and recognition in her lab. It aligns with the findings of Chemers et al. (2011), who showed that research experience contributes to developing a sense of oneself as a scientist, which in turn predicts commitment to

a science career. Zari's case specifically resonates with Carlone & Johnson's (2007) findings on women of color in science that she initially lacked the performance, competence, and recognition. Through SUSTAIN, she gained all three: competence via research skills, performance via teaching and presenting her work, and recognition from her PI and peers as a talented researcher. Her resulting science identity became strong enough that she's now pursuing a STEM doctorate.

Jackie and Selena's identities, on the other hand, highlight a nuance: developing a STEM identity does not necessarily mean one will remain in a traditional STEM role, but it can provide a unique strength in cross-disciplinary careers. Jackie described that she didn't think being a STEM major was "essential" to reach her goals by the end of college, but she *"was happy to have that knowledge"* and identity to leverage. She mentioned that she was proud to be the "science person" on her marketing team, bringing a different perspective. This illustrates the idea of "science capital" proposed by Archer et al. (2015) which is a proposed form of "economic, social, and cultural capital that specifically relates to science." Students like Jackie might carry their gained science capital even as they move into adjacent fields, thereby broadening the impact of STEM education. Selena explicitly leveraged her STEM identity when entering law: she realized it gave her an *"edge"* and was *"excited to play it"* in law school. Over time she weaved that identity into her professional persona as a patent attorney, which is consistent with findings by Stets et al. (2017) that science identity can endure and be expressed outside of research labs per se, influencing career choices indirectly. Notably, both Jackie and Selena credited SUSTAIN for giving them confidence that even if they personally didn't continue in research or academia, they still "belonged" in STEM in a broader sense. This suggests that comprehensive programs can produce STEM ambassadors and innovators in diverse arenas, a

point echoed by Carpi et al. (2017) and others who advocate measuring long-term "STEM workforce" outcomes, not just immediate grad school matriculation.

Sense of Belonging

A strong sense of belonging is a critical predictor of persistence in STEM, particularly for students from underrepresented backgrounds (Hernandez et al., 2013; Walton & Cohen, 2007). For these students, belonging is not a given - it must often be intentionally cultivated in environments where they are likely to feel isolated or marginalized. Belonging involves more than simply being present; it means feeling seen, valued, and connected to a community that affirms one's place in a larger academic or professional context. When students feel like they "fit" within STEM, they are more likely to stay, thrive, and pursue long-term careers in the field.

In this study, participants frequently described early college experiences marked by doubt, isolation, or feeling like an outsider, particularly in large lecture courses or competitive academic settings. However, many also recalled key turning points when they began to feel part of something meaningful. The SUSTAIN program played a foundational role in these shifts. Through its cohort structure, living-learning communities, and social events, SUSTAIN helped foster a peer environment where students could be themselves, connect with others who shared their background and aspirations, and gain a sense of comfort that the broader university environment sometimes lacked. This kind of targeted programming filled critical gaps that general campus culture often failed to address.

Consistent with Hernandez et al. (2013), who found that underrepresented minority students in STEM enrichment programs reported greater belonging, SUSTAIN provided a structured, affirming space that helped anchor participants within STEM. Dana's reflection on living in the SUSTAIN residence hall captures this well:

> I was living with people who were in similar situations as me…and you know, they understood where I was coming from, and that kind of stuff, and it made it easier for me to keep going… because it was a lot of people who also wanted to stay and pursue these kind of STEM majors. And you know, we were trying to take classes together and trying to stay within the same realm, and you know, they were doing the same things as me, so it was a lot easier to kind of stick with things.

This quote reveals how peer networks grounded in shared context and goals fostered not only social comfort but academic persistence. By surrounding herself with students who "were doing the same things," Dana felt less alone and more capable of navigating the rigors of STEM.

Moreover, once a strong foundation of belonging was formed within SUSTAIN, participants like Dana and Veronica felt confident branching out into other campus spaces without sacrificing their STEM identity. Their experience reinforces prior findings that peer communities can act as stabilizing anchors for students navigating predominantly White or competitive STEM environments (Ribera et al., 2017; Snyder et al., 2016). These community ties offered reassurance that, even when stepping into unfamiliar spaces, they had a home base to return to.

Belonging also emerged in research lab environments, particularly when mentors cultivated inclusive climates. Maya's emphasis on strong communication and relational dynamics in her lab underscores the importance of mentor-mediated belonging. As Hernandez et al. (2018) note, when mentors model inclusive values and recognize students' contributions, students are more likely to internalize their role within the scientific community and persist in STEM. Veronica's research experience reflects this dynamic: when her mentor and lab team

supported her learning and invited her into the lab culture, her sense of belonging and identity as a scientist deepened.

Similarly, Winston's story illustrates how a mentor's verbal affirmation *("I think you have a good shot*") was not just encouragement, but a cue that he belonged in elite STEM spaces. That recognition helped sustain his confidence through a career pivot to pharmacy, maintaining his presence within STEM even as the specifics of his path evolved. As Strayhorn (2018) emphasizes, recognition and affirmation are core mechanisms for cultivating belonging. When students are seen and validated as legitimate members of the community, their internal sense of fit strengthens, sometimes enough to carry them through institutional barriers or moments of doubt.

Self-Efficacy and Resilience

Participants frequently described a growing sense of confidence and capability during college, much of which can be understood through the lens of self-efficacy, a central construct in Social Cognitive Career Theory (SCCT). Many entered the program with significant uncertainty about their ability to succeed in college. As Winston shared, *"I had no idea what I was walking into,"* and Dana echoed *"I was a little stressed not knowing people going into it."* Despite these early doubts, participants' self-efficacy increased over time through repeated experiences of mastery, such as completing research projects, excelling in difficult courses, managing heavy workloads, and observing peers with similar backgrounds succeed.

This pattern aligns with prior research. Chemers et al. (2011) found that undergraduate research and mentoring can significantly boost science self-efficacy, which in turn predicts greater commitment to STEM careers among underrepresented students (see also Schmid et al., 2023). That dynamic is visible across participants' stories. Veronica's growing proficiency in lab

work contributed to her decision to pursue a career in a clinical laboratory setting. Dana's ability to juggle school and multiple jobs gave her a sense of resilience and competence that now sets her apart from her peers. Lucas's leap into computer science, based on self-taught skills and reinforced by academic success, reflects the kind of self-belief that sustains persistence through uncertainty.

These narratives reflect findings from Cromley et al. (2016), which show that self-efficacy and expectancy of success are powerful predictors of STEM persistence, sometimes even more so than academic preparation. By the end of college, many participants spoke about applying to graduate programs or jobs with a clear belief in their ability to succeed. This growing confidence reflected not just academic gains, but a deeper belief that they had something meaningful to offer and could succeed.

Resilience, while closely related to self-efficacy, emphasizes students' capacity to recover from setbacks and persevere through adversity (Annisa & Hariko, 2024). Participants consistently demonstrated this kind of academic and emotional resilience. A key factor was their access to communities that normalized struggle and provided support. In SUSTAIN forums, for instance, students shared challenges and encouraged one another, helping to mitigate the isolating effects of failure or self-doubt.

Mentorship also played a crucial role in cultivating resilience. Atkins et al. (2020) describe how mentors help underrepresented students develop a "sense of future," supporting them to envision success even in the face of difficulty. This was clearly evident in Dana's story: when she considered switching majors due to stress, her mentors reminded her of her goals and reinforced her capability, which kept her on track. Similarly, Maya's mentor guided her through research setbacks, which ultimately prepared her to face the demands of applying to M.D./Ph.D.

programs. These cases align with Estrada et al. (2018), who found that high-quality mentorship fosters not only technical skills but also coping strategies and a growth mindset, all of which are critical to long-term persistence.

Importantly, these findings underscore the interconnection between identity, belonging, and self-efficacy. As participants began to feel more at home in STEM spaces, they were more willing to take on challenges, which in turn reinforced their self-efficacy. As they gained confidence and competence, they began to see themselves as scientists, and their sense of belonging strengthened. This positive feedback loop is supported by SCCT and identity theory. For example, Stets et al. (2017) showed that a strong science identity predicts greater persistence in science careers.

In this study, that connection was clear. Participants like Zari, Maya, and Winston, who had the strongest science identities, persisted into graduate programs or professional STEM roles. Those who forged hybrid identities, such as Jackie and Selena, also remained in STEM-adjacent fields, applying their skills in interdisciplinary or professional contexts. Across the board, participants increased their self-efficacy and found a space within STEM where they felt they belonged, whether in a lab, a graduate program, or a career that allowed them to apply their STEM background in new and meaningful ways.

Extending the SUSTAIN Narrative

The current findings build directly upon and reinforce the body of research regarding the SUSTAIN program (Ceyhan, Thompson, Sloane, Tillotson, & Wiles, 2019; Ceyhan, Thompson, Sloane, Wiles, & Tillotson, 2019; Ceyhan & Tillotson, 2020a; Ceyhan & Tillotson, 2020b; Surman et al., 2025). In particular, the present findings echo the initial analysis of SUSTAIN program's wraparound supports, which emphasized how a set of interventions including financial

support, academic engagement, research opportunities, and community-building, fostered a sense of belonging and improved retention (Ceyhan, Thompson, Sloane, Wiles, & Tillotson, 2019). The current study expands on this by showing how such supports enabled not just retention, but also meaningful career exploration and even redirection. Students like Jackie and Selena described how SUSTAIN's holistic structure gave them both the stability and confidence to pivot to career paths better aligned with their strengths and interests. These outcomes suggest that SUSTAIN not only helped students persist in STEM but also supported the development of adaptive, self-aware professionals—findings that underscore the value of broadening success metrics beyond major retention alone.

This study also supports earlier conclusions about the importance of layered support structures for low-income STEM students. Ceyhan and Tillotson (2020b) documented that early-year undergraduates experienced multifaceted mentoring structures that were often in the form of mentoring triads involving faculty, graduate students, and undergraduates that provided both socioemotional and technical guidance. These mentoring systems were shown to promote students' engagement and integration into research environments. The current data supports and elaborates on that finding. Participants such as Zari and Winston not only reported receiving multiple forms of support from different mentors but also emphasized how specific interactions like being trusted with independent tasks or encouraged to present at conferences, helped shift their self-perceptions and future goals. This reinforces the conclusion that strategically structured mentorship—especially when it is relational, personalized, and sustained—can significantly impact science identity and career persistence for students from underrepresented backgrounds.

Finally, the participants' reflections align closely with earlier conclusions that socialization into STEM fields is an iterative process shaped by both structural access and

individual agency (Ceyhan & Tillotson, 2020a). Where the previously discussed study identified mentorship and lab immersion as key avenues for socialization, this study confirms those pathways while also highlighting the importance of recognition and self-efficacy as mediators of long-term commitment to STEM. The fact that many participants continued in STEM and STEM-adjacent fields, even when their original goals shifted, provides additional evidence that early research experiences foster not only technical skills but also flexible career resilience. In this way, the findings from this study deepen the longitudinal narrative established previously by illustrating how early interventions influence decision-making and identity development well beyond the program's duration.

Limitations

While this study offers valuable insights into the long-term STEM career outcomes of former SIP participants, several limitations must be acknowledged. First, the small sample size limits the generalizability of the findings. Of the original 25 program participants, only eight completed interviews and 13 completed the final survey, raising the possibility of selection bias. It is possible that those who chose to participate in the follow-up were those with particularly strong program experiences or positive career outcomes. As a result, the narratives may underrepresent alumni with more negative, neutral, or non-traditional trajectories.

Second, the study is situated within a single STEM Intervention Program (SUSTAIN) at a private, PWI in the northeastern United States. The institutional context, program structure, and student demographics may differ substantially from those at other institutions or programs, limiting the transferability of results to other settings. Moreover, all participants entered college in the same cohort year, which may have influenced group dynamics, exposure to specific

faculty, and external conditions such as the COVID-19 pandemic. These are all factors that may not replicate in other cohorts or institutions.

Third, although the study used a mixed-methods approach, the quantitative component was constrained by low survey response rates and small sample sizes at the final timepoint. This precluded the use of more robust statistical analyses and limited the ability to explore potential correlations between science identity scores and specific career outcomes. As such, the survey data primarily served as a longitudinal descriptive measure rather than a source of inferential analysis.

Fourth, all interviews were conducted by the primary researcher, who shares similar background characteristics with the participants and had previous post-program affiliation with SUSTAIN. While this positionality helped establish trust and rich dialogue, it also introduces the possibility of interpretive bias. Efforts were made to mitigate this risk through reflexivity, independent coding, and inter-coder reliability checks; however, some degree of researcher influence is inevitable in qualitative work.

Finally, although the SCCT framework provided a useful lens for analyzing career development and psychosocial growth, the retrospective nature of the interviews introduces recall bias. Participants were asked to reflect on experiences that occurred three to five years earlier, which may have led to idealization, omission, or reframing of events in light of current circumstances.

Taken together, these limitations suggest the need for caution in interpreting the findings. Future research should seek to replicate this work with larger, more diverse samples, across multiple institutions and programs, and with longitudinal tracking that includes more frequent data collection points. Nonetheless, the in-depth, narrative-driven approach employed here offers

a rich foundation for understanding how layered supports, identity development, and career exploration interact over time in the lives of students from historically underrepresented backgrounds in STEM.

Conclusion

In conclusion, SUSTAIN's influence on participants is multi-faceted and decidedly positive, echoing known factors in the literature that promote STEM persistence among underrepresented students. These include robust mentoring, authentic research and professional experiences, an affirming peer community, and attention to developing the whole person. The participants' narratives provide concrete examples of these findings in action. Notably, their experiences underscore that STEM career outcomes for underrepresented students are not predetermined by initial conditions; rather, with the right support and opportunities, students can adapt, grow, and find success along varied trajectories. This reinforces the imperative that institutions should invest in programs that provide such supportive ecosystems (Bradford et al., 2021; Palid et al., 2023; Shortlidge et al., 2024). By doing so, we not only help students overcome structural inequities, but we also enable them to become resilient scientists and professionals who contribute richly to STEM – sometimes in traditional roles and sometimes in innovative crossover careers that break the mold of what a STEM professional looks like. The SUSTAIN participants' journeys – from tentative beginners to confident, goal-oriented individuals – exemplify the power of combining financial, academic, and socio-emotional support to foster the next generation of STEM talent.

List of Abbreviations

ALS	Amyotrophic lateral sclerosis
COVID-19	Coronavirus disease 2019
EMS	Emergency medical services
GPA	Grade point average
MCAT	Medical College Admission Test
MD/PhD	Doctor of Medicine/Doctor of Philosophy
NSF	National Science Foundation
PA	Physician assistant
PharmD	Doctor of Pharmacy
PI	Principal investigator
PWI	Predominantly White Institution
SCCT	Social Cognitive Career Theory
SIP	STEM Intervention Program
S-STEM	NSF Scholarships in Science, Technology, Engineering, and Mathematics program
STEM	Science, technology, engineering, and mathematics
SUSTAIN	Strategic Undergraduate STEM Talent Acceleration Initiative
URM	Underrepresented minority

Supplementary Information

Additional file 1: Appendix. Science identity instrument (Figure A1), survey distributed to former SUSTAIN participants in fall 2024 (Figure A2), and interview protocol template (Figure A3).

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