Early Outcomes of Layered Supports for First-Year CS Majors

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Abstract

This evidence-based practice study examines the implementation and early outcomes of a support model developed through a National Science Foundation Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program for Pell-eligible first-year computer science (CS) majors at a large public research university. The program—the S-STEM Scholars Program (SOSP)—aims to address inequities in early academic progress and sense of belonging by providing coordinated supports, including orientation and bridge programming, faculty mentoring, peer tutoring, and industry-related forums. The study examined: (1) program implementation and constraints; (2) processes for identifying eligible students, enrollment, and participation; (3) early academic outcomes compared with similarly eligible nonparticipants; and (4) students' reported structural barriers and support needs influencing participation and help-seeking. Using a convergent mixed-methods design, participation records and institutional data were analyzed alongside scholar surveys, interviews, and stakeholder focus groups. Quantitative and qualitative analyses were conducted separately and then combined during interpretation to examine implementation conditions, levels of student participation, and early outcomes.
Most scholars participated in required program components (welcome orientation: 11 of 12), whereas participation in optional activities was limited (Summer Bridge: 2; financial education forum: 1; CS industry forum: 0; program-specific tutoring: 0). Faculty mentoring contact varied across students (none: 2; once: 8; five or more contacts: 2). Delays in FAFSA data availability shortened recruitment timelines and constrained opportunities for early engagement. In a Fall 2024 comparison between SOSP scholars ($n = 12$) and SOSP-eligible nonparticipants ($n = 12$), the proportion of students on track for credit accumulation (≥ 32 credits) was identical in both groups (83%), and mean cumulative GPA was similar (3.09 vs. 3.16). Overall, findings suggest that multi-component support programs benefit from clearly structured, time-anchored requirements—particularly for mentoring and career-related activities—and closer alignment with existing academic schedules to reduce participation barriers for students who commute or work substantial hours

Introduction

Improving persistence in engineering and computing programs is an ongoing challenge, particularly for students with financial constraints and limited access to professional networks [1], [2]. Although institutions have expanded curricular reforms and student support services, equity gaps remain evident in early stages of students' academic trajectories. These gaps often appear not only in academic progress but also in psychosocial factors associated with persistence, including students' sense of belonging, experiences of validation, and development of professional identity [3]–[6].

Early academic momentum—commonly reflected in credit accumulation, on-time progression through required coursework, and recovery from academic setbacks—has been shown to predict persistence in STEM fields [1], [5]. At the same time, computing education is shaped by sociocultural norms that influence how students come to see themselves as legitimate members of the field [7], [8]. Students from underrepresented backgrounds may encounter messages, often indirect, that signal misalignment between their identities and computing, underscoring the importance of ongoing opportunities for belonging and validation [3], [4], [9].

To address these challenges, National Science Foundation S-STEM programs have adopted scholarship-plus-support models that combine financial assistance with structured academic, social, and career-related activities [10]–[16]. While these programs are designed to reduce financial stress and promote engagement, participation in non-mandatory supports is often uneven. Students with work obligations or family responsibilities may be less able to take advantage of optional activities, limiting the reach of program resources [14], [17].

The S-STEM Scholars Program (SOSP) is an NSF S-STEM-supported initiative at a large public research university serving Pell-eligible first-year computer science (CS) majors. SOSP combines scholarships with a set of academic and career supports intended to promote academic progress and strengthen students' sense of belonging and validation within the discipline. As summarized earlier and shown in Table 1 below, program components include targeted recruitment, orientation activities, mentoring, tutoring, and career-focused forums.

To examine how these supports operate in practice, this study draws on a multi-level institutional support framework and Social Cognitive Career Theory (SCCT) [18]. The institutional perspective attends to how support structures are shaped by interactions among students, peer tutors, faculty mentors, program staff, administrators, and external partners. SCCT provides a lens for understanding how self-efficacy, outcome expectations, and goal development influence students' engagement with academic and career-related opportunities.

Prior research has examined financial aid, mentoring, and related interventions in STEM education, but less is known about how comprehensive, multi-component programs function during early implementation or which features are most closely associated with short-term academic outcomes. This study addresses these issues by analyzing the implementation of SOSP and its association with early academic indicators.

Accordingly, the study addresses the following research questions:
1. To what extent was SOSP implemented as intended, and what factors supported or constrained implementation fidelity?
2. How were eligible students identified and enrolled, and how did participation change over time?
3. How do early academic outcomes for SOSP participants compare with those of similarly eligible nonparticipants, particularly with respect to credit accumulation and GPA?
4. What structural constraints and support needs do scholars report, and how do these conditions shape participation and help-seeking behavior?

This study focuses on early academic outcomes rather than longer-term indicators such as retention or degree completion, which require extended follow-up. The remainder of the paper is organized as follows. The Methods section describes the program context, data sources, measures, and analytic strategy. The Results section presents findings corresponding to each research question. The Discussion and Conclusion situate the findings within the existing literature and consider implications for the design of scholarship-plus-support programs. The Limitations section concludes with constraints on interpretation and generalizability.

Background and Conceptual Framework

This study is guided by Social Cognitive Career Theory (SCCT) and a multi-level institutional support perspective. Together, these lenses specify how SOSP's layered supports are expected to influence first-year students' academic engagement and career development and provide a basis for interpreting implementation and early outcomes.

Social Cognitive Career Theory

SCCT explains educational and career-related behavior as a function of reciprocal relations among learning experiences, self-efficacy beliefs, outcome expectations, interests, and goals, operating within contextual supports and barriers that enable or constrain action [18]. In first-year computer science contexts, early learning experiences are frequently consequential because they shape students' perceived competence in foundational tasks (e.g., programming, problem decomposition), their interpretations of challenge and feedback, and their willingness to engage in help-seeking and persistence behaviors. SCCT therefore provides a mechanism-level account of why students with comparable preparation may diverge in engagement and trajectory depending on the feedback, supports, and constraints they encounter.

Within SCCT, self-efficacy refers to beliefs about one's capability to perform tasks necessary for success in a domain. Efficacy beliefs develop through mastery experiences, vicarious learning, social persuasion, and interpretation of physiological/affective states [18]. SOSP components that increase students' opportunities to complete demanding coursework successfully (or to recover from setbacks through guided problem solving) are expected to strengthen efficacy. Similarly, mentoring and peer interactions can support vicarious learning and social persuasion by providing models of successful navigation and reinforcing students' interpretations of difficulty as normative and manageable rather than diagnostic of low fit.

Outcome expectations refer to beliefs about the consequences of pursuing particular academic and career actions (e.g., whether continued investment in computing is likely to lead to valued opportunities). Career-oriented activities, exposure to pathways, and access to knowledgeable mentors can clarify the connection between near-term academic decisions and longer-term career options, thereby shaping students' perceived utility of persisting through early coursework demands [18]. Goals represent intentions and commitments that organize behavior over time; in early CS trajectories, relevant proximal goals include structured help-seeking (e.g., attending office hours), maintaining prerequisite sequencing, engaging with mentoring, and preparing for internships or co-ops. From an SCCT perspective, these goals are more likely to be formed and enacted when students hold stronger efficacy beliefs, clearer outcome expectations, and experience sufficient contextual support to sustain participation.

A central implication of SCCT for this study is that contextual constraints—particularly time scarcity associated with employment, commuting, and family responsibilities—are not peripheral considerations. SCCT treats supports and barriers as integral determinants of whether goals translate into sustained action [18]. Accordingly, scholarship support is conceptualized as a contextual support that may reduce barrier intensity (e.g., by lowering the need for extensive paid work), while coordinated academic and career supports are conceptualized as mechanisms that can strengthen efficacy, clarify expected returns to persistence, and support goal-directed behaviors.

Belonging and validation as mechanism-relevant contextual supports

SOSP also targets psychosocial conditions associated with persistence in computing, particularly sense of belonging and validation [3], [4]. Sense of belonging concerns students' perceived acceptance and fit within a disciplinary community, while validation emphasizes interactions that communicate that students are capable learners and legitimate members of the academic environment [3], [4]. These constructs are treated here as socially mediated contextual supports that condition SCCT processes. Specifically, belonging and validation influence how students interpret academic feedback, whether they attribute difficulty to a temporary learning challenge versus a lack of fit, and whether they view help-seeking and participation in academic communities as appropriate and worthwhile.

In SCCT terms, belonging- and validation-relevant experiences can shape both the development and use of self-efficacy. When students perceive themselves as legitimate participants in computing communities, they may be more likely to persist through uncertainty and to pursue learning opportunities that produce mastery experiences. Conversely, when students experience ambiguous or negative cues about fit, identical academic challenges may be interpreted as confirmatory of non-belonging, weakening the translation of effort into efficacy and reducing engagement in supports that could otherwise strengthen performance. For this reason, cohort formation, mentoring relationships, and community-oriented activities are not treated as ancillary program features; they are theorized as part of the social infrastructure through which students' interpretations of their experiences in CS are formed.

Multi-level institutional support and participation conditions

SCCT specifies individual-level mechanisms, but SOSP is implemented through a multi-level institutional system involving students, peer tutors, faculty mentors, program staff, administrators, and external partners. A multi-level institutional support perspective is therefore used to interpret implementation as an organizational accomplishment rather than a uniform "delivery" of services. From this perspective, participation depends not only on student interest but also on how program structures reduce or amplify participation costs, including scheduling demands, communication channels, overlap with existing course-based supports, and clarity of expectations.

Because many SOSP activities are voluntary, participation is expected to be sensitive to "participation conditions," including the extent to which activities are aligned to academic milestones, integrated into existing routines, and communicated with predictable timing. Institutional design features that reduce coordination burden (e.g., default scheduling, early check-ins, consolidated communication) increase the likelihood that scholars experience repeated interactions necessary for mentoring, validation, and career development supports to have plausible developmental influence. Conversely, when supports are offered as stand-alone activities that compete with employment and commuting schedules, participation may concentrate in the few components with the lowest logistical burden, limiting the breadth of students' exposure to the full layered model.

Program Description

The S-STEM Scholars Program (SOSP) serves Pell-eligible first-year computer science majors and is supported through NSF S-STEM scholarships. The program combines direct financial support with a coordinated set of academic, advising, and community-based activities intended to support students' early academic progress and adjustment to the computer science major.

SOSP includes several core components implemented across the first academic year. These begin with early recruitment and scholar group formation, through which eligible students are identified and offered scholarships prior to the start of the term. A Summer Bridge program is offered before matriculation to support students' transition into college-level computer science and mathematics coursework. Early in the fall semester, students participate in a welcome orientation focused on program expectations, available supports, and cohort formation. During the academic year, educational forums address topics such as financial literacy and pathways within computer science.

As shown in the Figure 1, SOSP also provides ongoing academic support through peer tutoring and faculty mentoring. These supports are emphasized during periods aligned with key academic milestones, such as introductory CS courses and early advising decisions. Peer mentoring from more advanced scholars is incorporated when available, offering informal guidance and opportunities for connection within the major. At the conclusion of the academic year, the program hosts a structured end-of-year gathering that serves both a community-building function and a mechanism for collecting participant feedback. Table 1 summarizes SOSP components, their intended functions, and modes of delivery.

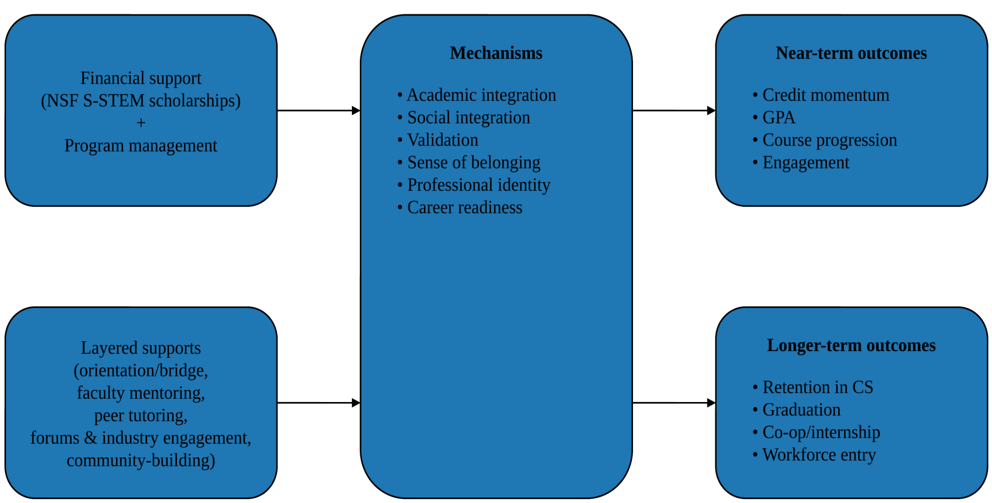

Figure 1. Program theory for the SOSP layered-support model.

Table 1. SOSP components and intended mechanisms

Component	Intended function	Delivery format and intended timing
Recruitment and scholar group formation	Identify Pell-eligible first-year CS majors and extend scholarship and program participation	Administrative identification of eligible students; scholarship offers and onboarding communications prior to term start
Summer Bridge	Support transition to college-level CS and mathematics; introduce institutional resources	Optional pre-matriculation program focused on CS/math expectations and available supports
Welcome orientation	Establish cohort expectations; introduce program structure and evaluation activities	High-contact onboarding held early in the fall semester
Educational forums (financial education; CS forum)	Increase financial literacy and awareness of CS academic and career pathways	Optional workshops offered during the academic term
Peer tutoring	Provide targeted academic support for CS coursework	Optional tutoring coordinated with existing course supports (e.g., TA hours), offered as needed
Faculty mentoring	Provide academic and career guidance and support navigation of departmental norms	Strongly encouraged mentoring relationship with recommended meetings aligned to academic milestones
Peer mentoring	Provide informal, near-peer guidance and community support	Implemented once an upper-level scholar cohort is available
End-of-year celebration and feedback	Support cohort cohesion and collect formative feedback	End-of-term gathering with structured feedback activities

Taken together, these program elements provide financial assistance alongside coordinated academic and advising supports during students' first year. The program structure is intended to support early academic progress (e.g., credit accumulation, GPA, course completion) while establishing conditions that may contribute to longer-term outcomes such as persistence in the major.

Methods

Participants

The study took place at a large public research university that implemented the S-STEM Scholars Program (SOSP), an NSF S-STEM scholarship-plus-support program for Pell-eligible computer science (CS) majors.

The focal group included 12 first-year CS majors who participated in SOSP and met program eligibility criteria (domestic status, Pell eligibility, full-time enrollment, declared CS major, and high school GPA ≥ 3.0). For comparison, we selected 12 first-year CS majors from the same entering cohort who met the same eligibility criteria but did not participate in SOSP. For descriptive institutional context, we also summarized outcomes for all other first-year CS nonparticipants across the two cohorts ($n = 336$); this group was not used for primary inference.

Qualitative data were collected from SOSP scholars through end-of-term surveys and semi-structured interviews and were supplemented with stakeholder interviews and focus groups. In total, 25 individuals contributed qualitative input: 12 students, 1 peer tutor, 6 faculty mentors, 1 program coordinator, 3 administrators, and 2 industry partners. These data were used to describe how supports were delivered and how participants experienced them.

Materials

Data sources included SOSP participation logs, institutional research (IR) records, and program-generated surveys and interviews. Participation logs documented attendance and engagement by component (e.g., onboarding events, mentoring, tutoring). IR records provided demographic and academic information of first-year CS students. SOSP scholars completed mentor intake questionnaires and end-of-year surveys and participated in interviews focused on program experiences. Focus groups were conducted with stakeholders (e.g., project team members and partners). Sessions were recorded and transcribed when applicable; de-identified notes were used when recordings were not available.

Procedure

We used a convergent mixed-methods design. Quantitative (participation logs, IR records and surveys) and qualitative (surveys, interviews, and focus groups) data were analyzed separately and then brought together during interpretation. Institutional review board procedures were followed, and data were de-identified prior to analysis.

Data analysis

Measures were selected to align with the research questions and the program theory [19]. Implementation fidelity was operationalized as (a) whether planned program components occurred and (b) participant engagement, summarized as counts of participation by component and mentoring meeting frequency. Eligibility and uptake were based on institutional eligibility criteria; uptake was computed as the number of SOSP scholars divided by the total number of SOSP-eligible first-year CS students in the same entering cohort. Early academic outcomes were measured using end-of-first-year IR indicators: credit momentum (on track defined as ≥ 32 credits earned) and cumulative GPA. Quantitative analyses were primarily descriptive (frequencies, percentages, and means). For additional institutional context, we report results from an independent-samples t-test comparison of SOSP scholars with all other first-year CS nonparticipants as documented in internal reporting; these results are interpreted cautiously given group differences and the nonexperimental design.

Qualitative data (focus group transcripts, open-ended survey responses, and de-identified interview notes) were summarized using a qualitative descriptive approach to remain close to participant language and accounts [20]. A five-member research team coded the qualitative data using a shared codebook developed through team discussion. Codes were organized to reflect the stakeholder levels represented in the data and SCCT-related categories (e.g., self-efficacy, outcome expectations, perceived supports and barriers). Themes were compared across stakeholder groups. Team meetings were used to resolve coding differences and document decisions. Quantitative analyses were conducted in IBM SPSS Statistics (Version 29.0) [21].

Results

Results are presented by research question. Quantitative results draw on participation logs and institutional records; qualitative results draw on surveys, interviews, and focus groups.

To what extent was SOSP implemented as intended, and what factors supported or constrained implementation fidelity?

Two constraints affected implementation. First, FAFSA delays limited advance notice for recruitment and reduced time for pre-semester contact. Second, participation in co-curricular activities could not be required beyond standard scholarship eligibility, so participation depended on voluntary attendance and communication about the purpose of program activities [22].

Table 2 reports participation counts and percentages across program components (n = 12). Participation was high for the welcome orientation and moderate for faculty mentoring when defined as at least one meeting. Participation was low for most optional activities.

Table 2. Scholar participation by program component (n = 12)

Component	Scholars participating (n)	Participation rate
Welcome orientation	11	91.7%
Summer Bridge	2	16.7%
Financial education forum	1	8.3%
CS forum	0	0.0%
Program-specific peer tutoring	0	0.0%
Faculty mentoring (≥ 1 meeting)	10	83.3%
End-of-year celebration	1	8.3%

As shown in Figure 2, mentoring over the academic year varied across scholars. Two scholars had no mentoring meetings, most scholars met with a mentor once (8 of 12), and a smaller subset engaged in more sustained mentoring (five or more meetings; 2 of 12). When meetings occurred, reported durations ranged from approximately 10 minutes to one hour.

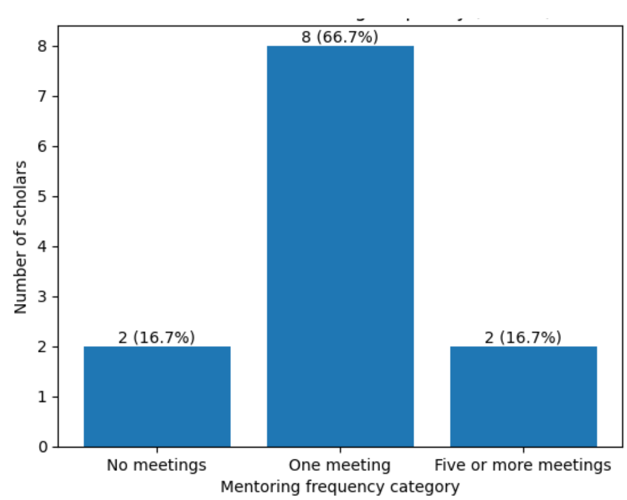

Figure 2. Distribution of Mentoring Frequency (n = 12).

Scholars most often cited time and logistics as barriers to sustained participation; research question 4 provides additional detail on student constraints and priorities. Stakeholders identified factors that supported implementation (e.g., centralized coordination by a program manager; mentor preparation; and use of existing departmental advising/co-op and industry advisory structures). Stakeholders also described operational issues that reduced participation in voluntary activities, including high message volume and overlap with existing course-based supports.

Across focus groups and interviews, several patterns recurred:

- Centralized coordination reduced scheduling barriers (e.g., mentor matching, meeting scheduling, reminders).
- Communication practices affected visibility of events; short-notice messages and high email volume reduced attention. Stakeholders recommended a predictable schedule and a single communication channel.
- Overlap with existing supports reduced uptake; when program activities duplicated course-based resources (e.g., TA office hours), students often used the option requiring less coordination.
- Career activities were viewed as more useful when timed to milestones (e.g., internship/co-op application windows) and when they produced tangible outputs (e.g., résumé drafts, portfolio materials, mock interviews). Stakeholders also noted increasing interest in guidance on responsible use of AI-enabled tools in professional contexts.
- Students were not always clear about what the program provided; stakeholders suggested that the lack of required early check-ins reduced follow-through.

  "They did not know what it really was... It was hard to explain why students should attend." - Peer Tutor

  "We had great mentors and good events - but no required check-ins, and no follow-through." - Staff Coordinator

How were eligible students identified and enrolled, and how did participation change over time?

Institutional records indicate that SOSP eligibility represented a stable proportion of the first-year CS population across two entering years. In Fall 2023, 36 of 187 first-year CS majors (non-transfer) met the program's eligibility criteria (19%), compared with 24 of 138 in Fall 2024 (17%) as shown in Table 3. Eligibility rates were thus similar across these two entering years, suggesting that the eligibility criteria consistently identified a substantial subset of first-year CS majors rather than a highly variable or idiosyncratic group. In Fall 2024, 12 of the 24 eligible students enrolled in SOSP, corresponding to 50% uptake among eligible students. This uptake rate provides important context for interpreting subsequent outcome comparisons because it indicates that program participation reflects both institutional eligibility and student enrollment decisions, which may be shaped by constraints and perceived value of the program supports.

Table 3. SOSP eligibility among first-year CS majors

Metric	Fall 2023	Fall 2024
First-year CS majors (non-transfer)	187	138
SOSP-eligible (meets all criteria)	36	24
Eligibility rate (eligible / CS majors)	19%	17%

How do early academic outcomes for SOSP participants compare with those of similarly eligible nonparticipants, particularly with respect to credit accumulation and GPA?

Early academic outcomes were examined using institutional end-of-first-year indicators: credit momentum (defined as being "on track," ≥ 32 credits completed) and cumulative GPA as shown in Table 4. In the primary comparison between SOSP scholars (n = 12) and SOSP-eligible nonparticipants from the same cohort (n = 12), the proportion on track was identical (83%; 10/12 in each group), and cumulative GPAs were similar (3.09 for scholars vs. 3.16 for eligible nonparticipants). These patterns indicate no observable difference in these first-year academic indicators between participating scholars and similarly eligible peers in this implementation period. Given the small sample size and the nonexperimental design, these results should be interpreted as descriptive early signals rather than evidence for or against program effects.

Table 4. End-of-first-year academic indicators

Outcome	SOSP scholars (n = 12)	SOSP-eligible nonparticipants (n = 12)
Cumulative GPA (M)	3.09	3.16
On track (≥ 32 credits)	10/12 (83%)	10/12 (83%)

To provide additional institutional context, internal IR analyses compared SOSP scholars (n = 12) with all other first-year CS nonparticipants across two cohorts (n = 336) as shown in Table 4a. In this supplemental descriptive comparison, scholars completed more credit hours on average than nonparticipants (32.18 vs. 29.72; $t = 2.48$, $p = .028$), while first-semester GPA was similar (3.26 vs. 3.23; $t = 0.23$, $p = .822$). End-of-year cumulative GPA was also comparable in magnitude (3.09 vs. 3.24; $t = -1.82$, $p = .070$). However, this comparison does not support causal inference because the groups differ structurally by design; for example, SOSP scholars were uniformly Pell-eligible (1.00) whereas the broader nonparticipant group had substantially lower Pell representation (0.28). Accordingly, the observed credit accumulation difference is best interpreted as descriptive institutional context rather than attributable program impact.

Table 4a. Supplemental institutional comparison of academic indicators

Outcome	SOSP scholars (n = 12)	All other first-year CS nonparticipants (n = 336)	t	p
Credit hours completed	32.18*	29.72	2.48	.028
High school GPA	3.90	3.89	0.11	.916
Pell Grant eligibility	1.00**	0.28	23.74	< .01
First semester GPA	3.26	3.23	0.23	.822
Cumulative GPA	3.09	3.24	-1.82	.070

* $p < .05$; ** $p < .01$

Stakeholder input from industry partners further underscored that academic indicators alone may not fully capture the forms of readiness associated with early career progress in CS. Partners emphasized foundational technical competencies (e.g., development workflows, application writing) and professional competencies (e.g., initiative, networking, proactive problem solving), and they noted the increasing relevance of experience with AI-enabled tools and human–AI collaboration. These observations reinforce the importance of monitoring near-term developmental outcomes (e.g., career artifacts and skill-building milestones) alongside institutional academic indicators as the program matures.

What structural constraints and support needs do scholars report, and how do these conditions shape participation and help-seeking behavior?

Across scholar interviews and open-ended survey responses, three intersecting themes contextualized participation patterns and help-seeking behaviors: (1) belonging and self-efficacy through informal support networks, (2) structural constraints that increase cognitive load and limit co-curricular engagement, and (3) expectation misalignment and underutilized program assets.

Belonging, self-efficacy, and informal support networks: Although formal participation in optional SOSP activities was low, scholars described building confidence and academic identity through informal pathways such as collaborative study routines, peer accountability, and faculty encouragement during lab sessions.

> *"I was kind of scared at first... But doing the practice assignments, I was like - okay, wait - I kind of get it." – Scholar 1*

> *"My study group really saved me... we did not just talk about code, we talked about careers too." - Scholar 2*

Students also identified residence halls, libraries, and online spaces (e.g., Discord) as important environments for community-building and sustaining momentum.

Structural constraints meet cognitive load: Scholars reported commuting, employment, caregiving responsibilities, and fragmented schedules that made stand-alone events difficult to attend even when perceived as valuable. In the end-of-term barriers survey (n = 3; n = 2 provided demographic/work data), respondents described themselves as commuters and first-generation students and reported substantial paid work (mean 38 hours/week; range 30-46).

> *"I had to choose - go to an event, study for exams, or show up for work. That is just how it is." – Scholar 3*

> *"Emails were constant... I missed things even when I wanted to go." - Scholar 4*

Work schedule conflicts were the most frequently reported barrier to attending optional activities; commuting/evening timing and family responsibilities were also cited. These constraints help explain why lower-friction supports (e.g., informal peer networks and course-based resources) were often preferred.

Expectation misalignment and underutilized program assets: Several scholars entered SOSP expecting early, proactive career navigation (e.g., co-op guidance) and targeted skills support. When these expectations were unmet or delayed, disengagement occurred even as students maintained strong academic performance.

> *"I expected help finding a co-op or at least someone to guide me through the CS world. But we did not get to that part." – Scholar 5*

Across interviews, scholars and mentors recommended practical refinements that reduce friction and clarify pathways, including:

- 1:1 academic and career coaching with tangible outputs (e.g., resume drafts, portfolio artifacts).
- Required mentor check-ins early in the semester to clarify expectations and normalize help-seeking.
- A single, visible communication hub (e.g., Discord or a course-management dashboard) to reduce missed information.
- Niche programming aligned with student interests (e.g., AI, cybersecurity) and timed to internship/co-op cycles.

Consistent with these themes, across importance ratings and open-ended prompts, scholars prioritized paid experiential opportunities (e.g., summer research and internships) [23], career navigation support, and practical commuter supports (e.g., parking assistance) and suggested strengthening community-building and accessible academic support. Mentor intake questionnaires indicated interests aligned with software development/engineering (10/12), AI/machine learning (3/12), cybersecurity (3/12), and research or graduate pathways (5/12).

Table 5 summarizes small-sample scholar-reported barriers and priority supports that contextualize participation patterns.

Table 5. Scholar-reported barriers and priority support

Domain	Indicator	Result
Survey participation	Barriers survey respondents	n = 3 (n = 2 provided demographics/work data)
Time constraints	Reported paid work hours	Mean 38 hours/week (range 30-46; n = 2)
Primary barrier	Work schedule conflicts with program events	Selected by 2/2 checklist respondents
Additional barriers	Commuting/evening timing; family/childcare; low perceived relevance	Selected by 1/2 each (checklist respondents)
Highest-priority supports	Paid summer research; paid internship matching/referrals; parking assistance	Mean importance = 4.0/5 for each (n = 2)

Open-ended suggestions	Community-building and academic support	"Building more of a community..."; "Maybe more tutoring."

Discussion

This study investigated a scholarship-plus-support model intended to reduce financial barriers and support academic and social integration for Pell-eligible first-year computer science majors. During the first year of implementation, nearly all scholars completed onboarding, but participation in most optional activities was low and mentor contact varied widely. These participation patterns are necessary for interpreting the year-one academic results and for understanding what the program functionally delivered to students.

The early outcomes should be interpreted in light of actual student contact with program components, not merely the availability of services. Many processes emphasized in persistence and integration research—such as frequent validation experiences, regular help-seeking habits, and sustained mentoring relationships—depend on repeated interaction over time [1], [3], [4]. In this first year, SOSP scholars and SOSP-eligible nonparticipants showed similar credit momentum and cumulative GPA by the end of year one, which is consistent with limited participation in optional supports and with eligibility criteria that may yield a cohort with relatively strong preparation.

From an SCCT perspective [18], scholar narratives emphasized strong expectations that the program could support paid experiential opportunities (e.g., internships/co-ops) and a clear trajectory toward computing careers, even among students with limited formal participation. At the same time, students more often described confidence-building through peer routines, coursework, and informal academic supports than through optional co-curricular events. For program design, this suggests that career-focused supports should be explicit, scheduled around predictable milestones, and initiated through required early steps (e.g., an initial mentor meeting and a follow-up tied to a course planning or career milestone), rather than relying primarily on voluntary attendance.

A supplemental comparison to the broader first-year CS nonparticipant group suggests that credit accumulation may respond earlier than GPA to this type of program. Scholars completed more credits on average while maintaining comparable GPA. This pattern is consistent with the possibility that financial support and advising can support steady course-taking even when grades do not change in the short term. Because this comparison is descriptive and groups differ in systematic ways, it is presented as institutional context rather than a program effect.

The main implementation lesson is straightforward: offering multiple supports does not guarantee that students experience multiple supports. When participation was voluntary, engagement tended to cluster in a small number of activities that were either required at entry (onboarding) or easy to complete (a single mentoring meeting). Work hours, commuting, and schedule constraints likely contributed to low participation in optional programming, which raises concerns about who is positioned to benefit from “add-on” services. To improve access, supports should be built into students' existing academic routines and communicated in a clear, consolidated way.

Mentoring appears to be a feasible component for sustained contact if it is structured. A small number of scheduled mentor meetings aligned to key academic and career points (course planning, early performance check, internship/co-op preparation) may be more realistic than a broad menu of activities with low attendance. Effective mentoring can support navigation of the major (course sequencing, use of office hours, internship planning) and reinforce belonging and validation, consistent with prior work on the importance of early supportive relationships and social community [2], [24], [25].

Stakeholder feedback suggests that career programming is more likely to attract participation when it is concrete, aligned with key decision points, and results in tangible outputs (e.g., a resume draft, a portfolio plan, or a mock interview). This emphasis is particularly relevant given ongoing changes in computing work, including the growing use of AI-enabled tools and human–AI collaboration [26]–[28]. Monitoring a small number of practical indicators during the term—such as mentor contact frequency, completion of specific career-related tasks, and brief measures of belonging—may help identify uneven participation early and allow for timely adjustments, rather than relying solely on end-of-year outcomes.

Overall, the year-one participation patterns support a shift toward fewer, structured program contacts and better integration with existing academic supports. They also suggest that some program offerings may have been perceived as redundant or not worth the time (e.g., no use of program tutoring when course-based teaching assistant supports were already available).

Recommended refinements include:

- Expand onboarding into a short sequence (orientation, mentor introduction, and an early-semester check-in linked to a specific academic milestone).
- Standardize mentor contact and meeting structure (default scheduling, short meeting guides aligned to milestones, and simple tracking with follow-up expectations).
- Integrate academic support with existing course structures (e.g., guided use of TA office hours and course-linked study groups) rather than adding stand-alone tutoring.
- Offer career supports that produce concrete outputs and align with internship/co-op timelines (resume and portfolio artifacts, mock interviews), including guidance on AI-enabled tools.
- Add near-peer mentoring as cohorts grow, using returning scholars to share strategies and normalize early challenges.
- Reduce logistical barriers (publish schedules early; offer hybrid/asynchronous options when feasible; use a single communication hub; consider commuter supports such as parking assistance).

Limitations

This study has several limitations. First, the comparison group was defined by eligibility and nonparticipation rather than random assignment; therefore, observed similarities and differences cannot be interpreted as program effects. Enrollment and participation may also correlate with unmeasured characteristics related to credit accumulation and GPA. Second, participation varied across program components, and several supports had minimal uptake, which limits what can be concluded about the full program model. Participation measures primarily captured counts of attendance and mentoring meetings and did not assess the content or quality of interactions. Program records may also miss informal contacts with mentors, advisors, teaching assistants, or staff. Finally, survey and interview data were limited in size and representativeness. Survey responses came from a small subset of scholars, and only some respondents provided demographic or work-hours information; these findings should be treated as formative rather than representative.

Conclusion

The SOSP results indicate that implementation feasibility and consistent student contact are important design considerations for scholarship-plus-support programs serving students with high financial need. Onboarding reached nearly all scholars, mentoring participation was common but varied in intensity, and most optional activities had low participation given work and commuting constraints. Year-one academic outcomes were similar for scholars and SOSP-eligible nonparticipants, while a descriptive comparison suggested higher credit accumulation relative to the broader nonparticipant group. Together, these findings support an emphasis on structured onboarding, a deliberately managed mentoring approach, and the use of simple mid-semester participation checks to identify uneven engagement and allow for timely adjustments.

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