2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC

Host Sponsor UNC Charlotte

Paper ID #52659

Analyzing the Effectiveness of Cohort-Based Pathways on Retention and Sense of Belonging for Advancing Two-Year Engineering Technology Students to Higher Degrees

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Background and Rationale of the Project

A recent NSF report [1] highlighted sizable imbalances in the composition of groups pursuing higher education in STEM areas. Specifically, at the national level, the participation of women in computer science and engineering programs stands at 16% and 21-25%, respectively. The *primary objective* of this project is to enable students with demonstrable talent and potential to attain more advanced education, despite financial constraints. A multi-tier plan, extending from recruitment to new pathways for a Master's level degree, was designed for this project. It has been synthesized on the understanding that scholarships cannot, in and of themselves, yield the necessary, sustainable gains in enrollment and graduation. The path to higher-level degrees is beset by incompatible curricular requirements, often requiring students to retake courses due to missing learning outcomes associated with prerequisites; this program addresses these gaps through targeted bridge modules and newly defined pathways into BS and MS programs, particularly for technology students and first-generation learners.

The pursuit of higher education from Associate to Bachelor's and Master's degrees in engineering and computer science is driven by several critical factors, including the growing demand for STEM graduates, as STEM occupations are projected to grow 10.4% between 2023 and 2033 compared to 3.6% for all other fields, and advanced degrees are associated with substantially higher earnings, with Master's degree holders earning 18–33% more than those with only a bachelor's degree [2,3]. At the same time, many students face significant challenges, including financial constraints, family obligations, and academic difficulties, with over one-third receiving Pell grants. These barriers disproportionately affect low-income and non-traditional students attending regional campuses or community colleges with fewer resources [4].

In response, Miami University has developed clear curricular pathways that enable progression from Associate to Bachelor's and Master's degrees through aligned programs such as AAS-CIT and AAS-MET at the associate level, BS-CSE and BS-MME at the bachelor's level, and MS-CS and MS-ME at the graduate level, supporting upward mobility and meeting workforce needs [5]. Miami University provides a unique institutional structure for this work, spanning regional campuses offering Associate in Applied Science degrees through main-campus Bachelor's and Master's programs, enabling vertically integrated pathways. The program specifically targets both traditional and non-traditional students, many of whom face socio-economic challenges, thereby broadening access across multiple entry points. Complementing these pathways, supportive interventions, including scholarships, mentoring, advising, and community-building, are essential in reducing financial and administrative barriers and in improving student enrollment, retention, and graduation outcomes [6].

To build a sense of community among S-STEM scholars, students can connect with others through a Canvas site. In addition, there are co-curricular activities (speaker series, networking opportunities) that help students feel connected to their discipline and to each other.

Program Overview

The program is designed to recruit, retain, and graduate low-income, academically talented students in engineering and computer science by providing scholarships, reducing curricular barriers, and fostering a strong sense of community among S-STEM scholars, to award a total of 128 scholarships to students pursuing associate, baccalaureate, or graduate degrees in *Computer Science*, *Software Engineering*, *Computer Information Technology*, *Mechanical Engineering Technology*, and *Mechanical and Smart Manufacturing Engineering*; facilitating students' progression and relocation across degree levels from associate to bachelor's and from undergraduate to graduate programs; and ensuring successful degree completion through academic support, faculty mentoring, learning communities, and enrichment activities.

Program Components

Miami University's S-STEM program is built around several structured components, including a targeted recruitment process that engages students from regional campuses, local community colleges, high schools, and career and technical programs, supported by a comprehensive website outlining the scholarship and associated curricular pathways. Applications are submitted online and require applicants to provide demographic information and respond to open-ended questions addressing academic challenges and career goals; the process also includes information sessions, faculty review based on established criteria, notification of award decisions, and completion of a standard S-STEM release form to accept the scholarship and arrange disbursement.

Scholarship cohorts are selected through a faculty-led evaluation using a scoring rubric that considers academic achievement, financial need, recommendation letters, essay quality, and alignment with career goals. Cohort development is supported through advising and mentoring, with a dedicated Canvas site that fosters community through announcements, discussion forums, and shared resources. Faculty mentors from engineering and technology programs provide ongoing guidance and academic monitoring, using tools and referring students to career services. In addition, scholars participate in cohort-based activities, including guest speakers, networking opportunities, job and internship fairs, research experiences, pre-internship programs, and rapid certification opportunities aligned with the semiconductor industry [7]. Regular cohort meetings provide a forum for students to share experiences and advice, fostering informal peer mentorship and role modeling within and across cohorts.

Participants and Procedure

As of the end of spring 2025, three cohorts of S-STEM scholars have been selected and participated in this program, summarized in Table 1. We have recruited students continuously in both the Fall and Spring semesters and work with them regarding their plans for higher degree attainment. The scholarship award amounts ranged from $2500 (for Associate & Bachelor level students) to $4500 (for Master level students) per student/semester.

Table 1: Snapshot of S-STEM scholars in the program

	# of Applicant Pool reviewed	# of selected new S-STEM scholars	# Total number of S-STEM scholars	Scholarship awarded (in $)
Cohort 1 (F22-Sp23)	65	12	12	111,900
Cohort 2 (F23-Sp24)	70	16	25	110,675
Cohort 3 (F24-Sp25)	113	17	29	98,663
Total (before Fall 2025)	**248**	**45**	**66**	**329,676**

Participants complete an online survey of the measures during the application process and each spring thereafter. All continuing and graduating students take these surveys, though data are not disaggregated by student graduation status. While demographic data were collected, analyses were not disaggregated by gender identity in this phase; such analyses are planned in future work.

Measures

Demographics, Retention, and Graduation

Demographics were collected from students' program applications (self-reported). A master database was used to collect and archive all student data, including application and survey data, producing a single record for each student. Students' progress and matriculation were followed and updated each semester, resulting in reports on scholarship status, retention, and graduation for each term. The selected metrics align with prior work on retention, belonging, and identity in STEM [6, 9], and comparisons with a waitlist control group whose demographics and academic profiles were similar support the validity of the observed differences.

The total number of S-STEM scholars differs from the original recruited cohort numbers, as students receive scholarships when they continue to pursue their degrees and/or advance to higher degrees. For example, in Cohort #1 (12 students), eight have graduated, six advanced from Associate to Bachelor's Degree before graduation, and one advanced from Associate to Bachelor's to Master's Degree. Similarly, of Cohort #2 (16 students), six have graduated, four advanced from Associate and Bachelor's Degree, and of Cohort #3 (17 students), seven have graduated, one advanced from Associate and Bachelor's Degree, and three advanced from bachelor's to Master's Degree before graduation. A summary of student graduation across different curricular pathways is presented in Table 2 below.

Table 2: Graduation of Scholar Cohort in various curricular pathways

Curricular Pathways	# Scholars
Associate degrees earned	9
Associate continuing to Bachelors	7
Bachelor's degrees earned	19
Bachelor's continuing to Master's	6
Master's degrees earned	4

Clarity of Professional Identity

The Clarity of Professional Identity scale [8] assesses the participants' perception of who they are in their profession. The participants received the following directions: "Please indicate your level of agreement with the statements below," with the following response options: (1) strongly disagree to (4) neutral to, (7) strongly agree. There are four items, and an example item is: "I have developed a clear career and professional identity." The Clarity of Professional Identity scale had a Cronbach's alpha of .72 (pre-test; M = 5.07; SD = 1.13) and .75 (post-test; M = 3.54; SD = .90).

Sense of Belonging

The researchers adapted Good, Rattan, and Dweck's measure [9] to assess students' sense of belonging in engineering or computer science, which was originally developed for mathematics.

There are 30 items with the following response options: (1) strongly disagree to (8) strongly agree. The instructions indicated: "There are no right or wrong answers to any of these statements; we are interested in your honest reactions and opinions. Please read each statement carefully, and indicate the number that reflects your degree of agreement. When I am in a [engineering or computer science] setting…" There are five subscales: Membership (four items; "I feel like I am part of the [psychology or chemistry/biochemistry] community."), Acceptance (eight items; "I feel neglected"; reverse coded), Affect (eight items; "I feel anxious"; reverse coded), Trust (four items; "I have trust that I do not have to constantly prove myself."), and Desire to Fade (four items; "I enjoy being an active participant."). The overall scale had a Cronbach's alpha of .94 (pre-test) and .96 (post-test). The subscales had the following alphas: Pre: Membership =0.98 (*M*=6.63; *SD*=1.42); Acceptance=0.96 (*M*=6.13; *SD*=1.38); Affect= 0.96 (*M*=5.72; *SD*= 1.63); Trust=0.42 (*M*=5.92; *SD*=1.11); and Desire to Fade=0.72 (*M*=5.70; *SD*=1.24). Post: Membership=0.96 (*M*=4.59; *SD*=0.68); Acceptance=0.94 (*M*=5.43; *SD*=0.61); Affect=0.89 (*M*=4.97; *SD*=0.85); Trust=0.80 (*M*=4.08; *SD*=0.77); and Desire to Fade=0.73 (*M*=5.71; *SD*=0.93).

Description of Reasons to Study

The Reasons for Studying Engineering or Computing scale asked students to respond to a series of items describing the reasons they chose to study engineering or computing. Students selected the degree to which each statement applied to them or their situation. The scale for these items was (1) not a reason, (2) minimal reason, (3) moderate reason, and (4) major reason. Students also had the option to select "I prefer not to respond" for any item. This 9-item subscale had a Cronbach's alpha of .63, the lowest of all subscale measures on the instrument. Sample items included "Technology plays an important role in solving society's problems" and "Engineers and computer scientists make more money than most other professionals."

Results

Table 3 summarizes the demographic profiles of Cohort 1, 2, and 3 S-STEM Scholar groups, highlighting the demographics and the number of students selecting higher degree attainment through this scholarship support.

A total of 248 students applied, and 43 completed at least one year of the program. Across the first three years, 96% of students in the program have been retained at the university. The program cohort reflects ongoing national diversity challenges in STEM, with 27% of students female and 64% white, using NCES-aligned categories to enable comparison with national benchmarks. At baseline, the participants did not significantly differ from those in the waitlist control condition.

Over the course of the program, participants reported decreases in Clarity in Professional Identity and Sense of Belonging across all scales, except Desire to Fade, as reported in Table 4.

In addition to the analyses in Table 4, subsequent dependent t-tests examined changes in participants' attitudes regarding several self-assessments. A series of dependent t-tests examined several attitudes and beliefs before and one year into the program. Their reasons for choosing to study engineering or computing significantly increased over time, $p = .035$. Their global sense of belonging in STEM increased over time ($p = .014$). Their self-assessment in comparison to their peers did not change over time ($p = .889$). Their feelings about the importance of skills and abilities for becoming a successful engineer or computer science professional also did not change over time ($p = .552$).

Table 3: S-STEM Cohort Demographics

		Cohort 1 **(# students)**	Cohort 2 **(# students)**	Cohort 3 **(# students)**	Total Cohort **(# students)**	Total Cohort **(% students)**
Gender	Male	8	11	14	33	73.3%
	Female	4	5	3	12	26.7%
Race/ Ethnicity	White/non-Hispanic	8	11	10	29	64.4%
	White/Hispanic	0	2	1	3	6.7%
	Black/non-Hispanic	1	1	3	5	11.1%
	Black/Hispanic	1	1	0	2	4.4%
	Asian/non-Hispanic	2	1	2	5	11.1%
	Not reported/Other	0	0	1	1	2.2%
First-Generation Status	First-generation student	5	7	12	24	53.3%
	Not a first-generation student	4	4	3	11	24.4%
	Both parents attended college	2	5	2	9	20.0%
	Not reported	1	0	0	1	2.2%
Starting Program	Entering – Associate Degree	6	3	0	9	20.0%
	Entering – Bachelor's Degrees	6	4	8	18	40.0%
	Choosing Associates to Bachelors	0	8	5	13	28.9%
	Choosing Bachelor's to Master's	0	1	4	5	11.1%

Table 4: Dependent t-tests Comparing Pre and Post Tests

	Pre	Post	t	Df	p-value
Clarity of Professional Identity	M=5.07 SD=1.13	M=3.54 SD=.90	5.37	17	<.001
Belonging - Membership	M=6.63 SD=1.42	M=4.59 SD=.68	7.50	18	<.001
Belonging - Acceptance	M=6.13 SD=1.38	M=5.43 SD=.61	2.15	17	.023
Belonging – Affect	M=5.72 SD=1.63	M=4.97 SD=.85	1.97	17	.033
Belonging – Trust	M=5.92 SD=1.11	M=4.08 SD=.77	7.94	17	<.001
Belonging - Desire to Fade	M=5.70 SD=1.24	M=5.71 SD=.93	-.36	17	.36

Discussion

While the S-STEM program was linked to excellent retention rates among the participants, gains in clarity of professional identity and sense of belonging did not trend in the anticipated direction, despite S-STEM graduates' interview statements that they had a high level of Trust that their instructors were committed to helping them learn and had faith in their potential. Participants reported lower clarity and a weaker sense of belonging on the scales. However, on individual items, participants reported more reasons for studying their STEM field, and their global sense of belonging increased. Post-surveys were administered at the end of the spring term to all current program students, including those graduating and those mid-program. Separating data from existing students from those who had not yet completed their programs could provide insight into the seemingly contradictory findings. Changes in the S-STEM program are being discussed for

future cohorts. The project is ongoing, and additional cohort data will be added annually. While this study focuses on retention and progression, comparative analyses of academic performance between scholarship recipients and non-recipients are planned for future work. The program structure is adaptable for scale through increased scholarship numbers and expanded pathways; however, scaling requires additional administrative capacity and greater faculty participation for advising and program delivery. The model may also be extended through partnerships with two-year institutions that serve as recruitment pipelines.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 2130384.

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