Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #47414

BOARD # 460: Supporting pre-STEM Majors while Closing Equity Gaps: Mentoring in a Multi-Disciplinary S-STEM Program

Erica Cline

Associate Professor in Sciences and Mathematics, and Director of ACCESS in STEM, an NSF S-STEM supported program that supports students in natural science, mathematics, and engineering at UW Tacoma.

Dr. Heather Dillon, University of Washington

Dr. Heather Dillon is Professor and Chair of Mechanical Engineering at the University of Washington Tacoma. Her research team is working on energy efficiency, renewable energy, fundamental heat transfer, and engineering education.

Amanda K Sesko,

Dr. Sesko received her PhD in Social Psychology from the University of Kansas in 2011 and is now an Assistant Professor at the University of Washington Tacoma. Dr. Sesko is a stereotyping, prejudice, and discrimination researcher. Her work focuses on how stereotypes guide judgments of, memory for, and behavior directed at individuals belonging to stereotyped groups. For example, in her primary line of research Dr. Sesko examines the processes and outcomes of intersectional invisibility—a form of discrimination characterized by not being attended to, remembered, represented, differentiated from others, or given recognition for contributions—experienced by individual's with multiple stigmatized identities (e.g., Black women; Sesko & Biernat, 2010, 2018).

Emily Cilli-Turner, University of San Diego
Zaher Kmail

Zaher Kmail, PhD is an Assistant Professor of Statistics at the University of Washington Tacoma in the School of Interdisciplinary Arts and Sciences' Division of Science and Mathematics. His general areas of research are in theoretical and applied statistics with a specialization in the design and analysis of experiments. His current research focuses on causal structure modeling, optimal design and its applications, multivariate analysis, and mathematics and statistics education. In addition to applied statistics, Dr. Kmail has published in a wide variety of fields including agronomy, engineering education, special education, student success in higher education, nursing, and environmental chemistry.

Seung-Jin Lee, University of Washington

Seung-Jin Lee, Ph.D., is an Assistant Professor of Mechanical Engineering at the University of Washington Tacoma. His research focus is on the life cycle sustainability of emerging technologies, such as transportation, biofuels, green buildings, and consumer products. His tools of research include life cycle assessment (LCA), industrial ecology, material flow analysis, energy efficiency, market diffusion models, reuse and recycling, and sustainable development. He has published in leading journals in sustainability and environmental engineering, including the Journal of Cleaner Production, Environmental Engineering Science, Waste Management & Research, Journal of Industrial Ecology, International Journal of Life Cycle Assessment, Sustainability, and Resources, Conservation & Recycling. Prior to his position at UWT, he was an Associate Professor in Mechanical Engineering at the University of Michigan-Flint (UM-Flint). During his time at UM-Flint, he was the recipient of the Dr. Lois Matz Rosen Junior Faculty Excellence in Teaching Award (2017). He completed his postdoctoral fellowship at the U.S. Environmental Protection Agency's National Risk Management Research Laboratory in Cincinnati, Ohio.

Raghavi Sakpal

Supporting pre-STEM Majors while Closing Equity Gaps: Mentoring in a Multi-Disciplinary S-STEM Program

Abstract

The S-STEM supported program ACCESS in STEM started at the University of Washington Tacoma as a Track 1 grant in 2018 and continued as a Track 2 grant in 2022. Since its inception, it has supported 124 students over 7 cohorts. Program scholars receive full scholarships for their first two years, and partial scholarships for their third and fourth years. Students can participate in a summer bridge precalculus or research experience course, and project-based Introduction to Engineering or Introduction to Research courses in their first year. Individual faculty mentoring, quarterly Success in STEM seminar courses, and an optional on-campus STEM living learning community help scholars form a cohesive community through group mentoring. Our S-STEM program is distinctive in focusing on pre-STEM majors in their first and second years on campus to facilitate the entry into STEM majors, and we provide mentor training for ~30-40 faculty in teaching and mentoring diverse student populations, thus impacting all students in our majors.

Our goal was to evaluate how the program supports retention and academic success of our program scholars, and whether this program helps to close equity gaps for students who identify as low socioeconomic status, underrepresented minorities, women or non-binary, or first generation in college. Data comparison to a control group of students indicates consistently higher retention levels for all students in the S-STEM program. Survey and interview responses emphasized the importance of mentoring and access to resources, particularly during the pandemic. In future work, we will use survey and interview data to better understand student experiences and impacts on faculty mentors participating in the program.

Introduction

For many years the NSF S-STEM program has provided financial support to institutions of higher education to fund scholarships for academically talented low-income STEM majors. The program also provides funding for activities that support their recruitment, retention and graduation of low-income students. At the University of Washington Tacoma the S-STEM program was launched in 2018 and has supported 7 cohorts of students. The program provides focused faculty mentoring, a living/learning community, course based undergraduate research experiences (CUREs), and scholarships. Mentoring includes focus groups, faculty mentors, near-peer mentors, skills workshops and community building. Students are recruited to the program by identifying eligible students accepted at the institution, and then inviting them to apply. For each year of the program we had more applicants than funding could support, confirming the strong need for programs like this.

The mentoring facets of the program include several high impact practices tied to mentoring. One example is through direct faculty mentoring, which is a high value aspect of the program. Near peer mentors are more advanced scholars who served as role-models for the cohorts. Peer mentors also volunteered to serve on panels and share their insights. As part of the program seminar course, we held social gatherings to allow students from different cohorts to create community with each other and with faculty mentors.

The low-income students in the program often share intersectional identities with PEERs (persons excluded due to ethnicity or race), women, and first generation students. In this study, we used PEERs, gender, and first generation status to understand how the program was addressing the equity gap in STEM. To assess the impacts of the program we asked the following research questions:

1. To what extent does the program help close the equity gap for historically excluded groups?
2. In what ways does the mentoring structure support students in the program?

Background

The program has been designed around high-impact practices to support student retention and growth. Underrepresented students, including women and PEERs, have reported that mindset and mentoring are important factors in succeeding in STEM fields [1], [2]. Mentoring has been identified in large surveys as a key element in STEM identity [3]. One way to provide mentoring for students is through a research experience [4], [5]. A CURE is a research experience that is included in an undergraduate class with the goal of providing an authentic research journey to students. Research experiences for undergraduates are well established as an important tool to support students in moving to graduate programs, in particular for underrepresented students [6], [7]. Structuring the research experience in a class provides more access to larger groups of students, and has been demonstrated to be successful for different student populations [4].

First-year scholars are invited to engage in authentic research which can enhance their self-efficacy, STEM identity, and sense of belonging and help them to overcome the expected challenges of their early coursework, as represented by the Persistence Framework model developed by Graham et al. [8]. Through multi-year faculty mentoring, our scholars develop the type of stable positive relationships that have been shown in previous research to increase retention and graduation rates and prepare students for their career paths [8], [9]. By establishing the crucial networks that help students navigate stress, students can overcome many of the difficult challenges that otherwise might serve as insurmountable barriers to their success in STEM.

The ACCESS project is unique in combining direct mentoring, CUREs, group mentoring, and scholarships to provide mentoring experiences to S-STEM students. We have evaluated the impact using both surveys and a control group.

Methods

Mentoring Structures

While the program mentoring had many structures, two were included as courses. This provides a more formal structure for the material, incentivizes students to participate, and creates a faculty loading to recognize in part the time faculty spend mentoring the students.

- **Success in STEM Seminar course:** The later cohorts of the program have enrolled in a required 1 credit seminar course designed to help students build community and receive group mentoring by a faculty member. The seminar courses have included workshops on topics like mindset and stereotype threat. Seminars also include STEM professional panels that help students explore different careers. Near peer mentors participate in the seminar courses to support less experienced students.
- **CURE course:** The research CURE course introduces first year students to scientific research by inviting students to use a multidisciplinary team-based approach to collect data on environmental pollution in their communities. This course is optional for the program students, and has experienced relatively low enrollment.
- **Direct faculty mentoring:** Faculty meet bi-weekly with 1:1 meetings with students mentees. The faculty mentors are provided training sessions and community of practice discussions each year. Over time, a very committed group of faculty mentors have continued to support the program. Students value this direct mentoring relationship, but it is time intensive and difficult to scale.

Control Group Comparison

To address the research questions, the program students were compared to a control group at the institution. These students are part of the same institution and would be eligible to participate in the program but were not selected or did not apply for the program. This control group is referenced as “Eligible non-program” for the purpose of this paper. The demographic data for the two groups is similar, as shown in Table 1.

Table 1. Demographic data for the program population and the control group, eligible non-program students.

	Program Phase 1 (2018 to 2021 cohorts)	Eligible non-program	Program Phase 2 (2022 to 2024 cohorts)	Eligible non-program
Asian	30%	35%	30%	42%
Black or African American	22%	13%	22%	16%
Hispanic or Latino	7%	20%	10%	19%
Hawaiian/Pacific Islander	2%	1%	0%	1%
Not Indicated	2%	1%	3%	1%
Two or More Races	11%	7%	7%	4%
White	26%	23%	28%	16%
PEERs	40%	39%	38%	40%
1st Generation	73%	75%	64%	75%
Female/Non-binary	56%	49%	48%	38%

Student Survey

After year six of the program, a post-graduate survey was sent to all students that had completed the program in the summer of 2024. The total responses (N=15) are relatively small, but provided excellent insights about the mentoring program and experiences. This cohort of students included students that started the program in the pandemic, so strong experience reports are particularly encouraging. While we did not have a large enough sample to disaggregate the survey responses by demographic data, we hope to do so in future work.

Results

A summary of the student outcomes for the S-STEM program are shown in Table 2. Over time, the retention outcomes for the S-STEM program have been consistently positive when compared to the control group (Figure 1). In the most recent phase of the program (cohorts starting 2022 and 2023), the retention rates over the first year for all students in the program is very good. The retention rate for women, PEERs and 1st generation students is also higher than the control group, indicating the program is helpful in closing the equity gap for historically underserved students. We have previously reported that the GPA performance of the S-STEM student population is also higher for all groups [10].

Table 2. Student outcomes from the program for cohorts from 2018-2024 as of Jan 2025. PEERs = persons excluded due to ethnicity or race. 1st Gen = first generation to four year degree.

Cohorts 2018 to 2024 as of Jan 2025	PEERs	Women, non-binary	1st Gen	All Program
Entering students	48	63	80	123
Still in program	29	30	39	67
Graduated in STEM	8	15	20	24
Graduated in non-STEM major	1	4	2	5
Switched to non-STEM major, not yet graduated	0	1	1	1
Transferred to a different institution	2	6	5	8
Dropped from program or left program	8	7	13	18

The student survey results are shown in Table 3. This cohort of students included students that started the program in the pandemic, so strong experience reports are particularly encouraging. Students felt strongly

that the program helped them to achieve academic goals, explore interests, and that the relationships they built helped them to achieve their academic goals.

Table 3. Student survey results for the S-STEM program graduates. Likert rated on 1-not at all, to 7-very much scales.

Questions	Mean (SD)
The program helped me to achieve my academic goals.	6.07 (1.10)
The program helped me to explore my academic interests.	6.13 (1.06)
The relationships I built (e.g. with faculty, peers) through the program helped me to achieve my academic goals.	5.87 (1.41)

The survey also asked open-ended questions related to these questions. Many students mentioned the importance of relationships and mentoring. Example quotes are included below with emphasis added for statements related to mentoring and community.

- "...it helped my academic goals by **providing mentorship and guidance beginning in my freshman year when it's most important.** The program also provided me guidance for my whole time in undergrad which helped me when I needed it."
- "[The program] helped me **connect with my peers and connected me to a fantastic mentor** that helped me with not only my academic obstacles, but my mental obstacles as well."

Faculty mentoring was consistently named by students as one of the most impactful components of the program. As one student said: "my mentor was like... the best mentor I could have gotten and we just like we talked about school and also just everything else and I feel like she's like a real friend now. And I'll always be able to come back and talk to her". In exit interview data, students identified seminar meetings and faculty mentoring as the second and third most important components of the program, only following scholarships.

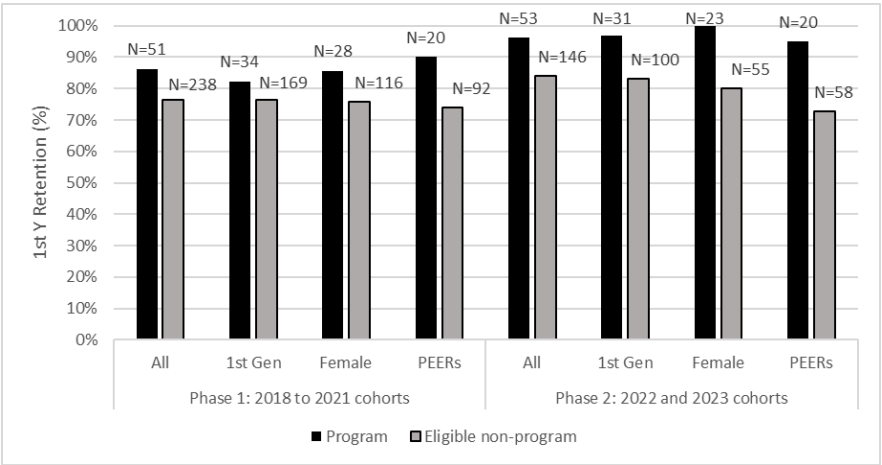

Figure 1. First year retention for phase 1 and phase 2.

Conclusions

After analysis of the program data we returned to our research questions.

RQ1: To what extent does the program help close the equity gap for historically excluded groups?

All students in the program were retained at higher rates than eligible non-program students. This finding confirms the high impact practices in the program are particularly important for the low-income students in the target population. Future work will focus on better understanding how different aspects of the program contributed to the student success. Retention rates are higher for all historically disadvantaged groups including women, PEERs, and first generation students when compared to the control group. Retention rates were particularly high for women/non-binary students and PEERs. The program is making measurable progress in closing the equity gap for low-income students with intersectional identities. Expanding funding for programs like this will be critical to increase the number of students successfully completing STEM degrees.

RQ2: In what ways does the mentoring structure support students in the program?
Student survey data indicates that mentoring structures and community formation are critical to the success of the program. While it is not possible to disaggregate the preliminary graduate survey data, the student comments indicate that mentoring and community formation are the most important program features after financial support. The literature indicates that this support is particularly important to close the equity gap, and should be continued in the program in future years.

Acknowledgments

The funding for this work was provided by the National Science Foundation (NSF) S-STEM program (DUE Award #1741595 and #2130239) to the University of Washington Tacoma. Special thanks to the students who made this project possible, our peer mentors and program assistants, and the faculty mentors.

References

[1] K. Kricorian, M. Seu, D. Lopez, E. Ureta, and O. Equils, "Factors influencing participation of underrepresented students in STEM fields: matched mentors and mindsets," *Int. J. STEM Educ.*, vol. 7, no. 1, p. 16, Dec. 2020, doi: 10.1186/s40594-020-00219-2.

[2] T. Chavous, S. Leath, and R. Gámez, "Climate, Mentoring, and Persistence Among Underrepresented STEM Doctoral Students," *High. Educ. Today*, 2018, [Online]. Available: https://www.higheredtoday.org/2018/06/25/climate-mentoring-persistence-among-underrepresented-stem-doctoral-students/

[3] S. Lunn, M. Ross, Z. Hazari, M. A. Weiss, M. Georgiopoulos, and K. Christensen, "How Do Educational Experiences Predict Computing Identity?," *ACM Trans. Comput. Educ.*, vol. 22, no. 2, p. 12:1-12:28, Nov. 2021, doi: 10.1145/3470653.

[4] H. Dillon *et al.*, "Work in Progress: Transformation Course-Based Undergraduate Research Experience (T-CURE)," presented at the 2024 ASEE Annual Conference & Exposition, Jun. 2024. Accessed: Oct. 07, 2024. [Online]. Available: https://peer.asee.org/work-in-progress-transformation-course-based-undergraduate-research-experience-t-cure

[5] H. E. Dillon, "Development of a Mentoring Course-Based Undergraduate Research Experience (M-CURE)," *Scholarsh. Pract. Undergrad. Res.*, vol. 3, no. 4, pp. 26–34, 2020, doi: 10.18833/spur/3/4/7.

[6] L. O. Flowers, "Course-Based Undergraduate Research Experiences at HBCUs," *J. Educ. Soc. Policy*, vol. 8, no. 1, p. 33, 2021, doi: 10.30845/jesp.v8n1p4.

[7] A. Carpi, D. M. Ronan, H. M. Falconer, and N. H. Lents, "Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM," *J. Res. Sci. Teach.*, vol. 54, no. 2, pp. 169–194, Feb. 2017, doi: 10.1002/tea.21341.

[8] M. J. Graham, J. Frederick, A. Byars-Winston, A.-B. Hunter, and J. Handelsman, "Increasing Persistence of College Students in STEM," *Science*, vol. 341, no. 6153, pp. 1455–1456, Sep. 2013, doi: 10.1126/science.1240487.

[9] Z. S. Wilson *et al.*, "Hierarchical Mentoring: A Transformative Strategy for Improving Diversity and Retention in Undergraduate STEM Disciplines," *J. Sci. Educ. Technol.*, vol. 21, no. 1, pp. 148–156, 2012, Accessed: Jan. 17, 2025. [Online]. Available: https://www.jstor.org/stable/41413293

[10] E. C. Cline *et al.*, "Institutional Practices to Close the Equity Gap," presented at the 2024 ASEE Annual Conference & Exposition, Jun. 2024. Accessed: Jan. 17, 2025. [Online]. Available: https://peer.asee.org/board-317-institutional-practices-to-close-the-equity-gap