Board 351: NSF S-STEM Track 3: Scaling Up Student Success through Broadening Participation Beyond our S-STEM Cohort

Dr. Maryam Darbeheshti, University of Colorado, Denver

Dr. Maryam Darbeheshti is Associate Professor of Mechanical Engineering at the University of Colorado, Denver. She is the PI of a recent NSF award that focuses on STEM identity at Urban Universities. Darbeheshti's primary research is in the area of Engineering Education and Multi-phase fluid flow.

Miriam Howland Cummings PhD, University of Colorado, Denver

Miriam Howland Cummings is a mixed methods social science researcher. She earned a BA from Rice University and recently completed a PhD from the University of Colorado Denver while serving as a graduate research assistant for the Urban STEM Collaboratory. Dr. Howland Cummings' research focuses on engineering education, K-12 education, and the measurement of latent constructs.

William Taylor Schupbach
Dr. David J. Russomanno, Indiana University - Purdue University, Indianapolis

David J. Russomanno is dean of the Purdue School of Engineering and Technology and a professor of electrical and computer engineering at Indiana University-Purdue University Indianapolis (IUPUI). Before joining IUPUI, he was the R. Eugene Smith Professor

Dr. Stephanie S Ivey, The University of Memphis

Dr. Stephanie Ivey is the Associate Dean for Research with the Herff College of Engineering and a Professor with the Department of Civil Engineering at the University of Memphis. She directs the U of Mâ€™s Southeast Transportation Workforce Center and th

Dr. Karen D Alfrey, Indiana University - Purdue University, Indianapolis

Karen Alfrey is a Clinical Associate Professor in Biomedical Engineering and Associate Dean for Undergraduate Academic Affairs and Programs in the School of Engineering and Technology at IUPUI. She has been a member of ASEE since 2003.

Prof. Tom Altman

Tom Altman received his B.S. degrees in Computer Science and in Mathematics, and M.S. and Ph.D. (1984) in Computer Science, all from the University of Pittsburgh. Dr. Altman specializes in optimization algorithms, formal language theory, and complex syste

Dr. Michael S. Jacobson,

Professor of Mathematics for over 40 years, with a keen interest in STEM Education.

Craig O. Stewart, University of Memphis
Prof. Katherine Goodman, University of Colorado, Denver

Katherine Goodman is associate professor at the University of Colorado Denver, and curriculum lead at Inworks, an interdisciplinary innovation lab. Her research focuses on transformative experiences in engineering education. She has served as program chair and division chair of the Technological and Engineering Literacy - Philosophy of Engineering (TELPhE) Division.

NSF S-STEM Track 3: Scaling Up Student Success through Broadening Participation Beyond our S-STEM Cohort

Introduction

First year programs in engineering education are commonly used to help improve student success and retention at engineering colleges. Such attendant programs often involve student interventions such as learning communities, student mentoring, and bridge programs or boot camps that provide external motivations and supplementary learning objectives aimed at helping first year students in engineering succeed academically, [1]. Moreover, urban universities often have student populations with a wide array of hurdles that impede their success in engineering and STEM fields. Of these includes financial instabilities, insufficient background in mathematics, and lack of role models, especially for first generation students, [2], to name a few. In this work, the leadership from three separate but similar programs operating at independent urban research universities, collaborate in a Track 3 NSF S-STEM funded project with the overall goal of not only increasing student success but in studying and extending their programs to better reach student populations in need. This collaboration team refers to itself as '*The Urban STEM Collaboratory'*, and consists of three unique intervention programs, one from each university, that support student success and have demonstrated positive student outcomes throughout the duration of the project, [3, 4, 5]. Although there are three separate intervention programs, the collaboration provides a platform on which each university can extend their support structures to further meet the needs of diverse urban populations, as well as to study and understand the needs of these populations more nearly.

One of the core objectives this collaboration aspires to achieve is to understand student STEM identity. In other words, we seek to understand which constructs can be used to help students consider themselves to be engineering or STEM students, in hopes that the first-year support structures provided by the participating universities can reach struggling populations of students and help them to be resolved during their first years at the engineering college. In this regard, the S-STEM scholarship is offered to engineering students with demonstrated financial needs, and preference is given to those who are more academically talented. Moreover, students offered scholarship are encouraged to participate in the intervention program completely and are asked to periodically give optional interviews and fill out surveys that help the leadership group to study how their support structures influence STEM identity. More information regarding the outcomes of such studies can be found in [6, 7].

On the other hand, the focus of this poster paper is to discuss the potential ways in which each respective program has scaled up their program, or how it intends to or hopes to scale up their program as the S-STEM project comes to conclusion, and local campus administration seeks to continue such efforts on larger scales. Figure 1 illustrates the structure of this collaboration and where the application of best practices and scaling up each program fits into the overall project as it has been an ongoing effort, however future scaling of local intervention programs from each campus will be done independently.

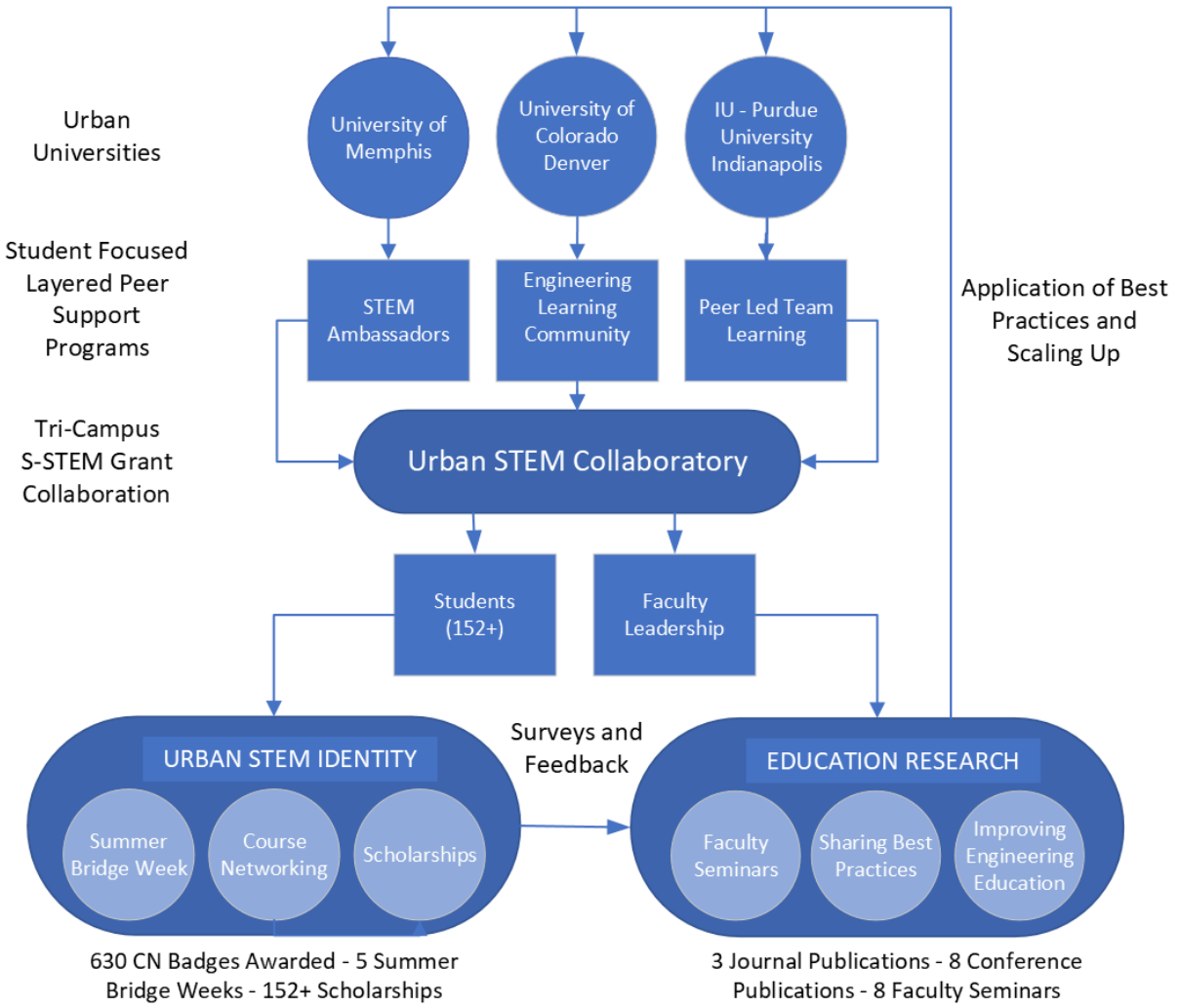

Figure 1: Urban Stem Collaboratory Flow Chart, highlighting the key components of the tri-campus collaboration. Three separate urban research universities provide individual support interventions for first year engineering students as well as unified support structures that give rise to STEM identity in engineering students.

The University of Memphis (UofM) integrated its STEM Ambassador program as a component of the Urban STEM Collaboratory, providing priority consideration to students within the cohort for STEM Ambassador positions. The program engages undergraduate students in paid positions supporting STEM teaching and learning with local school districts and community organizations. Ambassadors develop strong leadership and communication skills and deeper connections to their disciplines all while getting paid and making a positive impact in the community. The program has been successful in creating connections and a sense of community for the Ambassadors that has led to positive outcomes in both academic and career pursuits. The leadership team is now exploring opportunities to extend these successes with other populations where a strong sense of community can lead to better retention outcomes, such as community college and other transfer students, and greater success in recruiting students from a local HBCU to graduate STEM programs at UofM.

At the University of Colorado Denver (CU Denver), there is an Engineering Learning Community (ELC) where first-year engineering students take three classes together: math, English, and first-year design innovations. The ELC began in Fall 2016 with mostly mechanical engineering students. In Fall 2019, the first S-STEM scholarships were awarded and the ELC included students from a variety of engineering majors. In the ELC, students build community and increase their sense of belonging at a primarily commuter campus. Through the S-STEM project, the ELC has grown to continue into students' second semester of math and English, as well as to include a peer mentorship program. The demonstrated success of the ELC has increased buy-in from campus leadership to scale up the project to create additional, expanded learning communities for all first-year engineering students.

Indiana University--Purdue University Indianapolis (IUPUI) piloted Peer-Led Team Learning (PLTL) in calculus 1 recitation sections specifically for students in the Urban STEM cohort. PLTL pairs small groups of students with a student mentor who has recently taken the class who facilitates hands-on team-based problem-solving. PLTL is well-established in introductory chemistry classes at IUPUI and has previously been employed in some sophomore-level engineering courses with high rates of D, F, or Withdrawal (DFW) grades. The Urban STEM intervention, the first attempt to offer PLTL in IUPUI math classes, was an overwhelming success: both Urban STEM cohorts showed significantly lower DFW rates in calculus 1 compared to students not engaged in PLTL, including no failing grades (compared to a 13.5% failure rate for non-PLTL participants). Building on that success, we have continued to expand PLTL in key sophomore engineering classes and have plans to expand into a sophomore Computer Information Technology class. We are also laying the groundwork for future opportunities to support PLTL in foundational mathematics courses that support engineering students.

University of Memphis: STEM Ambassador Program

The STEM Ambassador Program is one of the primary initiatives developed by the West Tennessee STEM Hub (Hub) to support K-12 students' preparation and interest in STEM majors and careers. The Hub is led by the University of Memphis (UofM) Herff College of Engineering, with over 50 active partners from other parts of the UofM campus, K-12 faculty and administrators from local districts, local institute of higher education, and industry and community organization partners. The UofM chose to integrate this program as a component of the Urban STEM Collaboratory to support scholars with paid work experiences that deepen connections to their majors while also helping them to develop strong communication and leadership skills. All Urban STEM Collaboratory Scholars (Scholars) at the UofM are eligible for STEM Ambassador positions and are made aware of the program and encouraged to apply as soon as they are selected for the Collaboratory.

STEM Ambassadors are undergraduate STEM majors who serve as math and science tutors, STEM activity leads, robotics coaches, and in a host of other capacities in support of STEM teaching and learning in K-12 classrooms and after school settings. The STEM Ambassadors

meet as a group monthly with the Hub leadership (faculty, staff, and graduate assistants) to share how their assignments are going, troubleshoot with one another, and learn about new STEM resources that can assist them in preparing activities for K-12 students. They also participate in training retreats at the beginning and end of each semester. Many of the job assignments for STEM Ambassadors are completed in small groups or teams, thus, the Ambassadors build strong connections to one another and the leadership team through the program.

Since the inception of the Urban STEM Collaboratory, 20 scholars have been engaged as STEM Ambassadors. The UofM research team has tracked retention in the Urban STEM Scholars cohort, progression within the major (on-track/graduating within 4 years), retention in original major, and retention in a STEM major for all scholars. The data was analyzed for scholars who are part of the STEM Ambassador program versus those who are not. Results indicate positive trends for students participating in the STEM Ambassador program in all the areas assessed as shown in Table 1. below. Scholars who are also part of the STEM Ambassador program are retained at higher frequency in the program, in their original major, in a STEM major, and are progressing to on-time degree completion at a higher percentage than the Scholar-Only cohort. These results, while promising, require further study to better understand the role the Ambassador program plays in building community and student success and differences that may exist between the populations that self-selected into the Ambassador program versus those that did not.

Table 1. Urban STEM Scholars: Comparison of Scholar-STEM Ambassador and Scholar-Only Cohorts

	Scholar - STEM Ambassador (N=20)	**Scholar Only (N=32)**
Retention in Urban STEM Scholars Program	95%	72%
Retention in original major (major declared upon program entry)	90%	56%
Retention in STEM major	100%	72%
On-track progression (to graduation in 4 years)	100%	56%

The STEM Ambassador program has grown to the point that the program leaders are considering opportunities to recruit students from other institutions of higher education in the area to meet the local demand for STEM Ambassador support. This approach has the added benefit of creating recruitment pipelines, such as from community colleges to the university, or from a local HBCU to graduate programs at the UofM. The STEM Ambassador community has the potential to engage students from these institutions, build connections for them to the UofM, and make the transfer process more comfortable as they have a ready-made peer group and faculty

contacts as well as a seamless transition process with their STEM Ambassador role between institutions. These aspects as well as deeper study of the impact of the Ambassador program will be examined in future research.

University of Colorado Denver: Engineering Learning Community

The Engineering Learning Community (ELC) is a first-year program designed to promote community-based learning from the early stages of an engineering program and to increase first year retention. It is commonly known that first year engineering students often take difficult coursework such as calculus, physics, chemistry and so on, which can become overwhelming. Originally, the ELC began as a pilot program to offer first year students an introductory design course that would lighten the load and help to maintain interest in engineering. Moreover, this learning community also aligned a few of the commonly taken general courses, English, and Math, so that incoming students could more readily form a community with their engineering peers early on.

Then, the faculty leadership joined with two other urban research universities in a Scholarships for STEM program and referred to the larger group as the Urban STEM Collaboratory. As the program grew, it integrated a layered near peer mentorship program where second year engineering students would mentor first year engineering students, and the second year students would also receive guidance from a junior/senior level engineering student or from a graduate student in engineering. This mentorship program aimed to further build community among fellow students and to guide the incoming students over the hurdles of their first year. Lastly, an engineering bridge week was incorporated into the program that allowed these ELC students to interact with each other for an entire week before the first semester at the college. This bridge week includes math and design talks as well as fun challenges with the overall goal of boosting math skills and interest in the program, as well as building the community before the semester begins.

Because of the various success patterns associated with this project, such as increased retention and higher performance in Math and English courses, the college leadership group has taken interest in expanding the learning community to reach all the incoming engineering students, especially those of various underrepresented groups at the engineering college that could greatly benefit from a learning community and from the mentorship program. One of the primary aspects of the learning community is that students take combined courses during their first year. Scaling the program up would naturally benefit from similar strategy where a series of smaller learning communities would form each year. Since the goal would be to scale up and also maintain a high quality program that works for all incoming students, a series of smaller learning communities would allow a more targeted and individualized approach.

Moreover, the Layered Mentorship Program should be scaled up in parallel with the ELC. Such scaling would require a more robust recruitment program that paired sophomore and junior level students with incoming freshmen students. More specifically, we would promote students from under-represented minority groups to be chosen for mentoring and leadership roles so that incoming students from similar groups would naturally benefit from a stronger community and

the mentors themselves would build leadership skills and best practices. Since the current program often supports qualified mentors with scholarship funding through the S-STEM project, a scaled program would also benefit from financial aid to participating students, and this type of funding would attract students who have stronger financial needs but are also more talented academically.

Lastly, a Summer Bridge Program for ELC students the week before fall semester classes start could also be scaled up. The current program has only a few participating faculty members giving lectures on math and design topics. These lectures are thought to boost the student's math skills and interest in engineering before the first week of classes. The rest of the bridge week is designed to build the community and introduce students to their mentors. Moreover, they participate in fun design and team building activities. A scaled up version of the summer bridge week would require an increase in participating faculty, spaces on campus for activities, and organizing/planning staff that would help in facilitating a larger bridge week. During this bridge week, the smaller sets of learning communities would be formalized and would participate in activities together, but would also leave room for larger design challenges across all of the participating LC's.

Indiana University--Purdue University Indianapolis: Peer-Led Team Learning

IUPUI piloted Peer-Led Team Learning (PLTL) in calculus 1 and 2 recitation sections specifically for students in the Urban STEM cohorts. PLTL pairs small groups of students with a student leader who has recently taken the class and performed well and received additional training in PLTL pedagogical techniques. The student leader subsequently facilitates hands-on team-based problem-solving. PLTL is well-established in the literature with initial success demonstrated for introductory chemistry classes at IUPUI with D/F/W rates (final grades of D, F, or Withdrew) substantially higher than average for courses in STEM programs of study before PLTL was applied.

As an Urban STEM intervention, the first attempt to apply PLTL in math classes was an overwhelming success. The Urban STEM cohorts showed significantly lower D/F/W rates in calculus 1 and 2 compared to students with similar traditional academic credentials (high school GPA), but not engaged in PLTL.

PLTL is based on the teaching principle of informed redirection (analogous in some ways to a Socratic style method); during which Peer Leaders ask questions to guide student colleagues toward a solution through their own problem-solving skills. The goal is to provide a framework for students to think about and approach difficult problems in a team environment. Furthermore, PLTL focuses on small student groups and peer leadership as this environment is less intimidating for students to ask questions and to not be reluctant to be observed making errors while iterating toward a better understanding of the material. The position of a student leader consists of directing students every week within a recitation or laboratory format (depending on the course) running in parallel with the overall course section.

Building on the success observed in the calculus 1 and 2 courses, the School of Engineering and Technology (E&T) at IUPUI has continued to expand PLTL with 34 PLTL student leaders in spring 2023 from E&T, with a leader to student ratio of approximately 10 to 1 for a given recitation section. E&T at IUPUI continues to expand and invest in PLTL for several engineering courses with D/F/W rates above average. The goal continues to be to increase student persistence and retention in engineering majors by supplementing in class experiences with outside of class informed peer support. One benefit that is continuing is the high proportion of underrepresented students (both women and those whose ethnicity is underrepresented in engineering programs) who have participated as peer leaders. This benefits both the student leaders themselves, who are provided leadership training as part of their PLTL responsibilities, and the underrepresented students taking the course, who may more easily envision themselves as successful engineering students when seeing the example of a successful peer.

Within E&T at IUPUI, PLTL has augmented courses in Freshmen Engineering (ENGR), Biomedical (BME), Electrical and Computer (ECE), and Mechanical Engineering (ME). Specific courses include ENGR: Introduction to Programming Concepts; BME: Intro to Biomeasurements and Intro to Biomechanics; ECE: Circuits I, Intro to Electronics Analysis and Design, and Electric and Magnetic Fields. ME: Statics, Dynamics, and Thermodynamics. PLTL student leaders receive hourly pay over the semester and are required to take leadership courses to acquire knowledge of PLTL pedagogy and leadership skills to support PLTL leader development through the School of Engineering and Technology's Department of Technology, Leadership, and Communication (TLC). TLC faculty coordinate closely with engineering faculty for those courses in which PLTL is deployed. Assessment and evaluation of the expansion of PLTL in these engineering courses are ongoing.

Conclusion

The Urban STEM Collaboratory is a tri-campus collaboration in which engineering colleges in different urban environments work together to share best practices for engineering student success. Moreover, this collaboration has received funding from the NSF to provide scholarships that help participating students on each campus. This poster-paper shares information about each program and how they have scaled up their program, or plan to scale up. In general, each campus has grown their respective program in its own way resulting from this collaboration and each has gained interest from academic leaderships. This paper is a brief summary of such scaling or plans to scale up and is offered as insight to readers who have interest in student success programs for engineering and STEM students at urban universities.

Acknowledgment

This work is supported by NSF S-STEMs #1933987 (UofM), #1833983 (CU Denver), and #1833817 (IUPUI).

References

[1] A. Windsor, A. Bargagliotti, R. Best, D. Franceschetti, J. Haddock, S. Ivey and D. Russomanno, "Increasing Retention in STEM: Results from a STEM Talent Expansion Program at the University of Memphis," *Journal of STEM Education,* vol. 16, no. 2, 2015.

[2] S. Ivey, J. Campbell, A. Robinson, C. O. Stewart, D. Russomanno, K. Alfrey, J. Watt, T. Chase, M. Darbeheshti, M. Cummings and K. Goodman, "Urban STEM Collaboratory After Two Years: A Multi-institutional Approach to the Success of Financially Disadvantaged Students," *Journal of STEM Education,* vol. 24, no. 1, 2023.

[3] M. Cummings, M. Darbeheshti, S. S. Ivey, C. O. Stewart, D. J. Russomanno, D. King, K. Goodman, J. T. Campbell, T. Altman and M. S. Jacobson, "Summer Bridge Programming for Incoming First Year Students at Three Public Urban Research Universities," in *ASEE Annual Conference & Exposition*, Minneapolis, 2022.

[4] M. Darbeheshti, M. Cummings, S. Ivey, D. J. Russomanno, M. S. Jacobson, T. Altman, K. Goodman, K. D. Alfrey, C. O. Stewart and J. Watt, "Three Years of the Urban STEM Collaboratory," in *ASEE Annual Conference & Exposition*, Minneapolis, 2022.

[5] K. Goodman, S. S. Ivey, C. O. Stewart, S. O'Brien, M. Darbeheshti, W. Schupbach and K. Alfrey, "Launching the Urban STEM Collaboratory," in *Zone 1 Conference of the American Society for Engineering Education*, Remote, 2020.

[6] C. Stewart, "STEM Identities: A Communication Theory of Identity Approach," *Journal of Language and Social Psychology*, vol. 41, no. 2, pp. 148-170, 2021.

[7] C. O. Stewart, J. T. Campbell, T. Chase, M. Darbeheshti, K. Goodman, S. Hashemikamangar, M. Cummings, S. S. Ivey, D. J. Russomanno and G. E. Simon, "Communicating identity in the Urban STEM Collaboratory: toward a communcation theory of STEM identities," *International Journal of Science Education,* vol. Part B, pp. 1-17, 2023.