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BOARD # 413: NSF S-STEM Urban STEM Collaboratory: Lessons Learned and Sustainable Strategies

Seyedehsareh Hashemikamangar, The University of Memphis
Dr. Stephanie S Ivey, The University of Memphis

Dr. Stephanie Ivey is a Professor with the Department of Civil Engineering at the University of Memphis. She directs the University of Memphis Southeast Transportation Workforce Center and the West TN STEM Hub.

Craig O. Stewart, University of Memphis

Dr. Craig O. Stewart is a professor of Communication at the University of Memphis.

Dr. Karen D Alfrey, Purdue University

Karen Alfrey is a Professor of Engineering Practice and Assistant Director of EPICS at Purdue University in Indianapolis. She previously served as the Associate Dean for Undergraduate Academic Affairs and Programs and Clinical Associate Professor of Biomedical Engineering at Indiana University-Purdue University Indianapolis. She has been a member of ASEE since 2003.

Prof. Tom Altman

Dr. Altman received his Ph.D. in Computer Science from the University of Pittsburgh. He specializes in optimization algorithms, formal language theory, and complex systems. He has published a book and over 90 journal/refereed papers. He received numerous research and teaching awards. An ABET CAC Program Evaluator, Dr. Altman has expanded his research interests into STEM and, in particular, Engineering Education.

Dr. Michael S. Jacobson, University of Colorado Denver

Dr. Mike Jacobson received his B.S. in Mathematics from the State University of New York @ Stony Brook in 1975. He completed his MS and PhD. In Mathematics at Emory University in 1977 and 1980, respectively. Dr. Jacobson's mathematics specialization is Graph Theory and Combinatorics. He also has been actively involved in training pre-service and in-service teachers. He joined CU Denver in 2003 as Professor and Chair, after spending 23 years at the University of Louisville as Assistant, Associate and Professor, Chair, as well as Associate Dean for Research and Graduate Studies. Dr. Jacobson has published over 150 journal, conference, and technical papers. He has been a recipient, as PI or co-PI, of numerous research awards, including awards from the Office of Naval Research and the National Science Foundation (in both Mathematical Sciences and Education and Human Resources).

Tony Chase, Indiana University (IUPUI)
Dr. Maryam Darbeheshti, University of Colorado Denver

Maryam Darbeheshti is an Associate Professor in the Department of Mechanical Engineering at the University of Colorado Denver. She earned her Ph.D. from the University of Denver in 2009. She has been teaching at CU Denver since 2010. Darbeheshti's research interests are in the area of Fluid Mechanics and Engineering Education. She is the PI of a recent NSF award that focuses on STEM identity at Urban Universities.

William Taylor Schupbach, University of Colorado Denver

William is working towards a PhD in Mechanical Engineering at the University of Colorado Denver and is a research assistant and a part time instructor.

NSF S-STEM Urban STEM Collaboratory: Lessons Learned and Sustainable Strategies

1. Introduction

Although increased numbers of STEM graduates are crucial for economic progress in the US [1], fewer than 40% of students entering college in a STEM major graduate with a STEM degree [2]. Since 2018, the Urban STEM Collaboratory has engaged faculty and 165 students at three urban campuses, University of Memphis (UM), University of Colorado Denver (UCD), and Indianapolis University Purdue University (IUPUI), in an NSF S-STEM project involving collaborative research and activities designed to support engineering student success. The research focus is on understanding factors that support students in development of STEM identity and community. Effective interventions were implemented in combination with financial support. The interventions, described below, include peer mentoring, summer bridge, CN, academic year workshops, learning communities, a STEM Ambassador program, and PLTL, and were refined across the project period to address a variety of challenges.

1-1. Peer mentoring program

Starting with faculty mentoring in the first year of the project and based on feedback from the students, the mentoring program evolved to be conducted by upper division scholars in the second year. The current model helps scholars to develop leadership skills.

1-2. Summer Bridge Program (SBP)

Designed collaboratively by faculty and students, SBP is offered to each new cohort and continuing students across the three institutions as a starting point for them to become part of a local STEM community and engage in a larger community across the Collaboratory. Students get to know one another and program faculty and learn about the support services available to them on campus.

1-3. Course Networking (CN)

CN is an online academic networking platform that provides scholars an opportunity to showcase their accomplishments and verify their project participation, knowledge, and skill sets. CN posting and reflection tools enhance student self-reflection, student-student and student-faculty interactions and facilitate intercampus activities. ‘Seeds’ and ‘badges,’ are features of the CN used to incentivize, monitor, reward, and celebrate scholars’ participation and achievements.

1-4. Academic year workshops

The academic year workshops provide networking opportunities for students and faculty. They also help students to be aware and take advantage of support services on campus. Topics such as time management, stress management, student organization involvement, and campus career services are included, along with panels of recent graduates or industry leaders.

1-5. STEM Ambassador Program

The UM STEM Ambassador program engages undergraduate STEM majors in paid work experiences providing on-site support for teachers, community agencies, or companies that wish to engage K-12 students in STEM learning activities. This program benefits K-12 students with tutoring, STEM competition coaching, and other support. Ambassadors learn essential professionalism, communication, and leadership skills.

1-6. Engineering Learning Communities (ELCs)

The UCD developed ELCs, integrated with peer-mentoring, and implemented this intervention for all scholars. The ELCs included a series of three common courses in which scholars were enrolled, beginning with their first semester. The goal of the ELC initiative was to establish a community of like-minded peers and create a sense of belonging from the outset of a student's engineering program. The peer-mentoring, termed 'layered mentorship', engaged upper division peer mentors, establishing mentoring relationships with scholars with support from faculty.

1-7. Peer-led Team Learning

IUPUI applies a Peer-Led Team Learning (PLTL) model to recruit and train students who have previously been successful in a class to serve as facilitators for small group activities that reinforce and apply concepts from lecture to applied problems explored in a recitation section. Scholars who perform well in their 1st-semester math courses are actively recruited as PLTL peer leaders in subsequent semesters, thus strengthening their connection to the STEM community both as mentors (to their PLTL students) and mentees (to the faculty mentoring the peer leaders).

2. Literature review

A strong sense of community (SOC) is needed for STEM students to retain their major and complete their degree. Place and intentional interaction among community members are crucial factors in creating and sustaining SOC [3]. In a strong community, members learn from one another, help one another through academic or personal struggles, share their experiences, expand their perspectives and encourage new students to join [4]. Peer relationships and peer mentoring are key factors in building a STEM community. A recent study showed that these factors play an important role in scholars' journeys into becoming engineers. Peer mentoring relationships motivated them to participate in STEM activities and led them to feel connected to and recognized by other STEM students. Informal peer relationships helped scholars know how others share the same interests in STEM fields and the same issues with STEM courses [5]. This foundational literature underscores the importance of the activities chosen for the project to student success.

3. Methodology

Over the course of the project, data has been gathered each year at each institution. This data, including demographics, academic performance, and progress toward degree completion, is collected for the scholar cohorts (Scholars) as well as for a comparison group of students who were eligible for the program, in terms of entering GPA and unmet financial need, but who are not participating. The latter group is called Non-scholar in this paper.

4. Results

The table below shows credit received for Scholars at each institution as compared to Non-scholars. Scholars consistently earned more credits than their program-eligible peers.

Year	UM – Credits Earned		UCD- Credits Earned		IUPUI – Credits Earned	
	Scholars	Non-scholars	Scholars	Non-scholars	Scholars	Non-scholars
2019-2020	13	12.76	13.29	11.42	15.2	12.9
2020-2021	13.9	11.5	13.35	12.66	14.34	12.85
2021-2022	15	12.84	12.52	12	13.3	12.5
2022-2023	13.46	12.06	12.13	11.74	N/A	N/A
2023-2024	13.24	12.05	12.98	12.11	13.05	12.95

As indicated below, Scholars also earned higher GPAs than Non-scholars in almost all cases.

Year	UM - GPA		UCD - GPA		IUPUI -GPA	
	Scholars	Non-scholars	Scholars	Non-scholars	Scholars	Non-scholars
2019-2020	3.09	2.9	3.45	3.03	2.93	2.87
2020-2021	3.35	2.95	3.14	2.99	3.17	2.79
2021-2022	3.48	2.98	2.97	3.03	3.13	2.82
2022-2023	3.27	3.02	2.97	2.92	3.08	2.82
2023-2024	3.32	3.07	3.11	2.93	3.03	2.84

4-1. STEM Ambassador Program

The STEM Ambassador program has resulted in positive trends for Scholars at the UM. A total of 22 Scholars participated as STEM Ambassadors, while the remaining 34 did not. Analysis of data revealed that scholars who are also part of the STEM Ambassador program are retained at higher frequency in Urban STEM, in their original major, and in a STEM major than the Scholars who did not participate (Scholar-Only). They also earn higher GPAs and a greater percentage are on track for 4-year graduation. These results require further study to better understand the role the Ambassador program plays in student success and the implications of self-selection.

	Scholar - STEM Ambassador (N=22)	Scholar Only (N=34)
Retention in Urban STEM	84%	59%
Retention in original major	90%	65%
Retention in STEM major	95%	68%
Cumulative GPA	3.5	3.0
On-track for 4-year graduation	86%	50%

4-2 Engineering Learning Communities (ELCs)

The ELC program continues to show positive effects on student success. Here we compare several success metrics, averaged across 5 years, for the S-STEM scholars (N=53) participating in the learning community against those for the S-STEM eligible students who did not participate in the program (N=454). We define S-STEM eligible as a full-time, first-time, first-year student in Engineering, Mathematics, Physics, or Chemistry. Specifically, we highlight that the scholars participating in the ELC have higher retention rates within Engineering, within their declared major, and in STEM majors. Moreover, the average overall GPA is found to be greater for participants. It should be noted that it is difficult to separate the effects of receiving an S-STEM scholarship from those of the learning community and that here we believe the resulting increase in success metrics may come from a combination of both. Future studies will focus on more qualitative metrics to better understand the student experience and impact on persistence.

	S-STEM Scholar (N=53)	S-STEM Eligible (N=454)
Retention in Engineering	80%	75%
Retention in original major	66%	53%
Retention in STEM major	66%	60%
Cumulative GPA	3.0	2.7

4-3 Peer-Led Team Learning

At IUPUI, PLTL was implemented into foundational courses that historically have had high DFW rates (grades of D, F, or Withdraw) to improve the percentage of students passing. Our two scholar cohorts participated in special PLTL recitation sections of Calculus 1 [7]. All scholars in the first cohort (Fall 2019) passed the course, for a DFW rate of 0% compared to 27.5% in the course overall. In the second cohort (Fall 2020), the PLTL section had a DFW rate of 15.0%, compared to 23.2% overall. The support of PLTL was particularly impactful to the success of students traditionally underrepresented in engineering [6]. In 2023-24, PLTL was included in introductory C programming. The overall course DFW rate dropped from an average of 30.6% to 22.4% for PLTL sections. The table below shows pass rates over the last five years, with PLTL again appearing to make the most difference for underrepresented students.

C Programming Pass Rates (C- or higher)	2023-24 (PLTL)	2022-23	2021-22	2020-21	2019-20 (pandemic)
Overall	77.6%	70.1%	70.8%	67.4%	76.1%
Underrepresented POC	65.5%	55.4%	55.6%	49.1%	60.0%
Male	77.5%	74.4%	71.1%	67.2%	74.8%
Female	78.0%	55.9%	69.4%	68.2%	81.5%
First Generation	64.6%	56.5%	70.2%	67.4%	69.4%

5. Discussion

Overall, the Urban STEM scholars performed as well or better than their S-STEM eligible peers across a variety of metrics. Each campus' unique interventions (learning communities, peer-led team learning, and STEM ambassadors) also proved to be successful. The summer bridge programs across all three campuses were successful. Less successful was integrating CN into the Urban STEM program, as many students were able to quickly earn the seeds required for the participation badge and did not continue participating. While some scholars were intrinsically motivated to use the CN, the purpose and benefits of doing so were not clear to all scholars.

Our research efforts focused on how our Urban STEM Scholars constructed and experienced their STEM identities. Through semi-structured interviews, we learned how they enacted their STEM identities through relationships with their Urban STEM peers, as well as with faculty mentors. This qualitative research also offered a more complicated view of STEM identities in contrast to our quantitative survey results. In interviews, students reported uncertainty and gaps in their STEM identities that were not apparent in quantitative survey instruments, which suggested strong and consistent STEM identities. This research helped us build a theoretical framework for STEM identities that explained not only how our interventions helped support the development of STEM identities but also generated further research questions. Methodologically, we successfully used Interpretative Phenomenological Analysis (IPA) to facilitate collaboration with team members across all three campuses and all disciplines (social scientific, engineering, and mathematics) in analyzing and interpreting our data.

6. Conclusion

The Urban STEM Collaboratory has been successful in meeting its original objectives, including engaging a minimum of 150 students, creating a community of scholars and faculty, and realizing increased academic and degree achievement outcomes for scholars. Scholars at all three campuses have achieved higher GPAs and more credits toward their degrees than their S-STEM eligible peers. The individual interventions varied in effectiveness, and more research is needed to better understand the influence of interventions and potential self-selection biases.

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