Launching the Urban STEM Collaboratory

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Abstract

The Urban STEM Collaboratory is a tri-institution collaboration of University of Memphis (UofM), University of Colorado Denver (CU Denver), and Indiana University Purdue University Indianapolis (IUPUI). Each of the three partner universities is embedded in a large city, and serves similar student populations, i.e. students who tend to be first generation, minorities, and/or commuters. These universities encounter similar challenges in first-year retention and graduation rates, especially in the STEM disciplines. As they strive to improve the first year engineering and/or mathematics student experience at their campuses, they have engaged in different approaches; including Peer Led Team Learning (PLTL), formation of an Engineering Learning Community (ELC), and engaging students in outreach as STEM Ambassadors. Incorporating these individual strengths with new activities that will be shared across institutions, the team is currently embarking on a multi-year research project to uncover how students develop STEM identity in an urban context, identify interventions that support this development, and determine the impact that STEM identity has on student success. Through the support of an NSF S-STEM grant, the three universities are also providing scholarships to students engaged in the project.

Here, we share the initial efforts of our tri-campus interaction and collaboration, our overarching goals, our systems of recruiting students, and our initial collection of preliminary data and findings for Year 1.

Introduction

The Urban STEM Collaboratory project supports academically talented students with demonstrated financial need from the colleges/schools of engineering and mathematics departments at the University of Memphis (UofM), the University of Colorado Denver (CU Denver), and Indiana University-Purdue University Indianapolis (IUPUI). However, awarding talented students is only one element that this collaboration is using to promote the growth of a STEM identity in their students. The Collaboratory is expected to generate new knowledge in STEM education by investigating a variety of mechanisms for supporting a diverse set of students in an urban context in their development of a STEM identity--the lack of which is a fundamental reason students often select out of STEM majors and careers [1].

The funding for this project was awarded on October 1, 2018. Because this was after the academic year had already begun, the team decided to delay funding of the first cohort of scholars until 2019-20 so that the program could be implemented with fidelity to the original project/cohort design. Thus, the remainder of the 2018-19 academic year was used for planning and program development purposes.

The Urban STEM Collaboratory project goals are to:

1. Increase at each institution the recruitment, retention, student success, and graduation rates of academically talented and financially needy undergraduate mathematical sciences and engineering majors;
2. Implement ambitious but feasible strategies contributing to student academic success, development of STEM identity, and workforce readiness;

3. Implement mechanisms to ensure substantial student participation in project activities through a special badge system, incentivizing participation;
4. Implement activities for mathematics and engineering classes leading to a high probability of student success, and conduct formative and summative evaluations with special focus on determining effectiveness and impact of the project activities, strategies, and adjustments;
5. Conduct a research study that will focus on developing an evidence-based understanding of factors influencing development of STEM identity and the resulting impact on student success, attitudes, workforce readiness, and STEM self-efficacy, with particular attention to impact on first-generation and underrepresented students.
6. Conduct formative and summative evaluations of the project that explore the extent to which each objective is being met. A particular impetus will be placed on determining effectiveness and impact of the project activities, strategies, and adjustments made throughout the project.

Given the urban setting of the three institutions, the research described in goal 5, above, focuses not only on formation of STEM identity itself, but also looks for ways that urban context impacts the formation of STEM identity of the students.

Recruitment of the First Cohort (2019-2020)

In general, each institution's recruitment process was very similar. Each institutional Collaboratory project team shared related items throughout this development process to help foster consistency and produce the best product for each university. They shared verbiage for recruitment flyers and outlines of the brief applications. All three made their applications available online, two through their campus's overall application process, and the other through an external online system. All three had notices distributed via internal networks, particularly to applying students who expressed interest in engineering and mathematics majors, and had flyers sent via external recruitment networks and events. Once the applicant pools were developed, each campus team reviewed applications (including recommendation letters) and developed a prioritized list of students to consider for awards. The respective financial aid offices then determined the exact scholarship eligibility. Note that CU Denver recruited only first-time freshman; however, both IUPUI and UofM also recruited rising sophomores with an aim of recruiting students who would be prepared to take Calculus I with the incoming freshman in the case of IUPUI, and to develop a multi-level peer group in the case of UofM.

Table 1: Scholars Recruited by Campus

	Incoming Freshman Scholars Accepted	Existing Student Scholars Accepted
CU Denver	14*	3
IUPUI	14	11
UofM	8	9

* CU Denver's Engineering Learning Community includes nine students who did not receive scholarships for two reasons: FAFSA requirements and project's budget limitations.

Lessons Learned in Recruiting

In general, delays in recruitment were tied to miscommunication with the financial aid departments. These were sometimes caused by student/family error in completing the FAFSA, and at other times it was tied to institutional delays. On two of the campuses, students were selected who were later found to have no unmet need, and the project teams needed to draw further recipients from a waitlist. Also, the IUPUI team found that the inclusion of rising sophomores who would be "calculus ready" by the following fall improved the diversity of their cohort.

Table 2: Demographics of 2019-2020 Cohort

Percentages	UofM (n=17)	CU Denver (n=17)	IUPUI (n=25)
Male/Female*	53% / 47%	71% / 29%	68% / 32%
White	76%	35%	48%
Hispanic	6%	18%	16%
Asian		35%	16%
African American	18%	12%	12%
2 or more			8%

* No students selected other/ prefer not to identify

Bridge Programs

The summer bridge programs were designed to engage the Urban STEM Collaboratory students in ice breaker activities and allow them to become acquainted with each other as well as the faculty and staff. Because our fall semesters did not start the same week, CU Denver held their bridge program one week earlier than the other two campuses. One aspect specific to the Urban STEM Collaboratory summer bridge was an to introduce the social communications platform, called Course Networking (the CN). A virtual joint (all campus) session was held on August 19, 2019 (the first day of school for CU Denver) via zoom. Students at each site prepared a skit or other introduction to share with the other students engaged in the program.

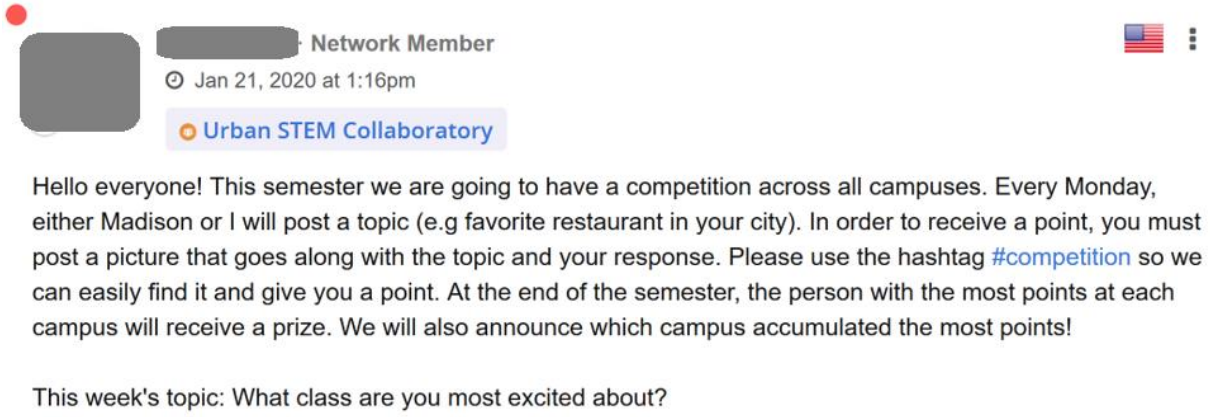
Other aspects of the Bridge programs included quick design or problem solving challenges (CU Denver, IUPUI), a mathematics review (UofM and IUPUI), locating campus resources such as where tutoring sessions are held (CU Denver, IUPUI) and other workshops and activities intended to support the transition to college. Project teams observed that students worked in small groups, were highly engaged with one another and with faculty, and had visibly developed a sense of community by the end of the program.

More about the CN

Course Networking (thecn.com) is a social media platform designed to connect students from around the world. The Urban STEM Collaboratory is endeavoring to use this platform to connect students from all three campuses in a more direct manner. After the initial meeting and training during the bridge programs, organic use of the CN has been minimal, and one significant change to the team's strategy is now to guide that engagement more directly. For instance, the engagement badges, described below, which students need to earn to remain scholars, are recorded on the CN, and a few are tied to actual CN activity. Also, we have appointed two scholars from each campus to be CN leads, who will try to increase engagement by adding

unique content, developing contests, and other posts that encourage the other students to both post their own ideas and comment/reply to that of other students. The goal of the CN usage is to help students reinforce their own STEM identity and by having a sense of belonging to not only their local group of scholars, but also with students at the other campuses.

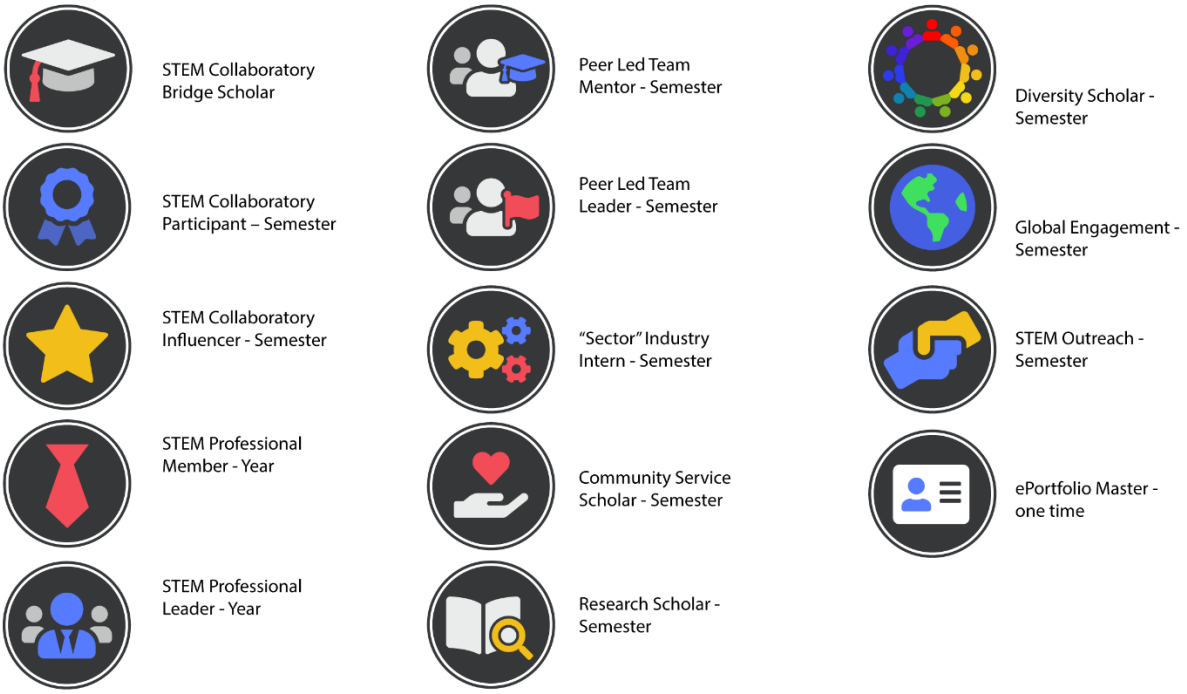
Figure 1: a post on the CN by one of the student CN Leads



Badges

Another method of engagement is our badging system. Badges are intended to nudge students into behaviors that support them connecting to each other and to the campus, as well as encouraging them to enact their STEM identity in the broader community. For instance, students earn badges for participating on the CN, being active in the student chapters of groups such as SWE or ASME, working at internships related to their majors, joining a research team, or helping with campus STEM outreach programs. The badges are meant to be varied; no one needs to earn them all to satisfy requirements for the Collaboratory. Badge work is documented by creating a showcase on the CN, a small part of their profile that allows them to describe what they did, insert a photo, or link to external websites. This provides practice for documenting their work in portfolios as well as for presenting themselves to the world as STEM professionals.

Figure 2: The Urban STEM Collaboratory Badges



Unique Programs by Campus

There are unique aspects to each campus's program. CU Denver's program centers on the Engineering Learning Community. The group of 25 students, 17 of which are scholars, take some of their courses together and participate in weekly peer mentoring sessions. For Fall 2019, all of the ELC took an introductory engineering design class, and many also took specific sections of Calculus I and English Composition I. In Spring 2020, many are taking an introductory computing course and Calculus II together. There is also a section of English Composition II with reserved spaces for ELC students. In prior years, the ELC had only mechanical engineering majors, and did not have scholarship support, and ELC participation correlated positively with improved outcomes for students[2]. The ELC now spans all of the engineering majors offered at CU Denver.

At IUPUI, the unique feature of their program is Peer-led Team Learning (PLTL), an internationally used method for guiding students who have recently, successfully completed a course to assist students. PLTL has been applied to various STEM disciplines; IUPUI has implemented it in its math courses as part of its cohort model [3].

At UofM, Collaboratory students have the opportunity to serve as STEM Ambassadors, students who engage in outreach throughout Memphis. There is some evidence that representing the STEM fields to others increases students' STEM identity, and this robust program gives the students opportunities to do just that [4]. It is a stated goal of the Collaboratory to investigate how each campus might replicate these features, in part or in whole, from the others.

Research Progress

Our initial research efforts have focused on deploying a STEM Identity survey. We intend to distribute this periodically to the students to gauge changes in their sense of self related to STEM work and their urban setting. At the time of writing, all three campuses have scheduled interviews and are making progress on other means of gathering data related to our goals. Here we present the initial results of the first administration of the STEM Identity Survey.

STEM Identity Survey

The first quantitative data collection cycle for this cohort of students began in Fall 2019 with a survey of students' perceptions of their identity as an engineer, their self-efficacy in engineering, and their sense of belonging in their campus community overall. Questions for this survey were pulled from a STEM identity survey developed by Godwin, Potvin, Hazari, and Lock [5], with some added items relating to feelings of safety from the National Survey of Student Engagement (NSSE) [6]. In total, 35 students across the three campuses completed the survey. One additional student completed most of the survey and their responses were retained (see N=36 in Table 1 for questions completed by the partial response case). The response scale for the survey is as follows: 1 – Strong Disagree, 2 – Disagree, 3 – Somewhat Disagree, 4 – Somewhat Agree, 5 – Agree, 6 – Strongly Agree, such that a higher mean for an item indicates a stronger level of agreement from the students. A sample list of survey items and descriptive statistics can be found in Table 1. This shows 11 of the 45 items.

Table. 1. Sample Items with Descriptive Statistics from STEM identity survey

	N	Mean	Std. Deviation
My parents see me as an engineer.	36	4.94	.86
My instructors see me as an engineer.	36	4.67	.76
My peers see me as an engineer.	36	4.64	.99
I am interested in learning more about engineering.	36	5.89	.32
I enjoy learning engineering	36	5.75	.44
I find fulfillment in doing engineering.	36	5.53	.61
I am confident that I can understand engineering outside of class.	36	5.03	.77
I can do well on exams in engineering.	36	4.83	.66
I understand concepts I have studied in engineering.	36	4.94	.63
Others ask me for help in this subject.	36	4.08	.976
I can master the content in the engineering-related courses I am taking this semester	36	4.94	.75

Overall, most student responses fell in the Somewhat Agree to Strongly Agree range (x=5.00), indicating that most students feel positive, confident and comfortable in their identities as engineering students. Students rarely used the "Strongly Disagree" category to respond to questions and frequently used the "Strongly Agree" response. Anomalies of note include six items with an average score of less than 4.50. Most interestingly, half of these lower scoring items were related to the topic of design: "I have trouble recognizing the changes needed for a design solution to work (reverse coded)," I can develop design solutions" and "I can evaluate a design." The other low scoring variables were: "I can build machines," "Others ask for my help in this subject" and "I am not confident that I can understand engineering in class (reverse coded)." It should be noted that these low items include two of the three reverse coded items, which may have lower averages due to survey response error. Responses to items related to feeling safe on campus all averaged in the "Agree" range, indicating that students generally feel safe and included in their engineering departments across all three campuses.

Discussion

While these initial survey results are highly encouraging to the project team, we are also aware that our students will likely experience struggles during their college careers that cause these indicators of STEM identity to fluctuate. They may also be responding out of a desire to fit in, a phenomenon known as *social desirability*, which can skew survey results. As students refine and clarify their own definitions of being STEM students becoming STEM professionals; we will look for indicators that show this identity is becoming more robust or being challenged.

As urban serving institutions, UofM, CU Denver, and IUPUI are well situated to develop and evaluate interventions to strengthen and diversify the STEM workforces in their cities and across the country. While sharing an urban serving mission, these campuses also vary along a variety of dimensions—region, demographics, economics. Likewise, the interventions at each campus vary to serve these different urban communities. These variations will be a challenge for the research team, as they limit how much direct comparison among the three schools' cohorts can be made. However, they also represent opportunities to evaluate the common program components within different contexts as well as to learn what unique components may or may not be adaptable across them.

UofM found that the entering freshmen in their cohort struggled significantly both academically and with the college transition. Individualized interventions (tutoring, counseling, and connections to other campus resources) were necessary, and even with this several students failed courses and were put on probation for the spring semester. The students that ended up on probation were also the students that failed to participate in Collaboratory activities and meet regularly with project faculty serving as mentors in the fall. These students are participating in required meetings with the project team this spring to develop a structured plan for ensuring success, and also appear to now be more open to support. Part of that support, on each campus, is a system of mentoring.

As part of the continued research work, we also aim to gather secondary information from mentors, who are older students at CU Denver and faculty at UofM and IUPUI. As feedback from mentoring meetings is gathered, and this data may be used to create a fuller picture of the students' development of identity, alongside the survey results.

Summary of Progress in the Collaboratory

Research efforts are increasing, including scheduling the spaced re-administration of the STEM identity survey, adapting survey instruments to measure identity "gaps," and a new survey to understand students' commuting patterns (part of the urban influence on their STEM identity). At the time of writing, semi-structured interviews with students had begun and focus group interviews with mentors had been scheduled. We have some concerns about survey fatigue, and are investigating the use of brief surveys, such as the visually-based, one-item STEM identity survey from McDonald and colleagues [7].

There are indicators that the project team is making progress on the overall goals of the Collaboratory as well. The feeling of community among students is well-underway on the individual campuses as well as across the Collaboratory. This community (students and project team) has already been fostered through work on CN, the bridge programs with individual and joint efforts, online meetings, and, although in initial stages, interclass interactions.

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