ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #37614

Summer Bridge Programming for Incoming First-Year Students at Three Public Urban Research Universities

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Introduction

This Complete Evidence-based Practice paper describes how three public urban research universities designed, implemented, and iterated Summer Bridge programming for a subset of incoming engineering students over the course of three consecutive years (2019-2021). There were commonalities among each institution's Summer Bridge, as well as unique aspects catering to the specific needs and structures of each institution. Both these commonalities and unique aspects are discussed, in addition to the processes of iteration and improvement, target student populations, and reported student outcomes. Finally, recommendations for other institutions seeking to launch or refine similar programming are shared.

Background: The Urban STEM Collaboratory

The Summer Bridge programs described take place at three public urban research universities participating in an NSF S-STEM project called the Urban STEM Collaboratory [1]. The purpose of the Urban STEM Collaboratory is to award scholarships of up to $10,000 per year to academically talented students majoring in engineering or mathematics who have financial need. Students receiving this S-STEM scholarship are referred to as Urban STEM Scholars (Scholars). These three institutions share some commonalities in how they execute the Urban STEM Collaboratory at their individual campuses, while also engaging in some unique campus-specific aspects. For example, Scholars at all three institutions participate in Summer Bridge programming through their home campus, but each Summer Bridge program has unique aspects catering to the specific needs and structures of each institution.

Purpose of Summer Bridge

At all three institutions, Summer Bridge serves several purposes. In the broadest sense, the purpose of Summer Bridge is to provide additional academic and social support for incoming Scholars (that is, students receiving the S-STEM scholarship). More specifically, the purpose of each Summer Bridge is to create community among these students, prepare them for the academic rigor of first-year engineering curriculum, and build their STEM identity and sense of belonging. Considering that the COVID-19 pandemic had an effect on STEM identity development [2], Summer Bridge offered an especially important opportunity to build community during the pandemic.

Commonalities among the three institutions' Summer Bridge programming

There were several common elements that the three Summer Bridge programs shared. Each Summer Bridge was a 3-5 day experience held in the week immediately prior to the start of the Fall semester and included workshops, academic preparation sessions, and community-building times among students. Each Summer Bridge program had a target student population of incoming Scholars, though at some campuses additional students (e.g., second-year Scholars or other incoming first-year engineering students) were also invited to participate. As part of the

tri-campus Urban STEM Collaboratory, all students were expected to participate in an academic social communication platform called CourseNetworking (the CN). During Summer Bridge, students were introduced to the CN during a synchronous tri-campus workshop, where Scholars from all three institutions met each other for the first time using a video conferencing platform. Other activities primarily focused on helping with the transition from summer break into impending coursework, through mathematics review, special-interest presentations, and other development activities (such as communication and growth mindset workshops) in the initial year. All institutions conducted Summer Bridge in person in 2019 for the first cohort of Scholars, and then shifted to a synchronous online Summer Bridge in 2020 due to the COVID-19 pandemic. Because Institution #1 had only two cohorts of Scholars, they conducted just two Summer Bridge programs, but Institutions #2 and #3 conducted a third Summer Bridge in 2021, which was offered in an in-person format.

Summer Bridge at Each of the Three Institutions

Institution #1

At the first institution, a larger, campus-wide Summer Bridge program was already in existence for incoming first-year students. Upon the establishment of the Urban STEM Collaboratory, a specialized version of the institution's Summer Bridge was developed just for Scholars. This specialized Summer Bridge was focused on increasing college readiness through the transition from summer break into impending coursework and included STEM special-interest presentations (such as biomedical or electrical engineering) and other development activities (such as communication and growth mindset workshops). Additionally, this institution's Summer Bridge continued into the Fall semester via a 1-credit hour First Year Seminar class, which built and reinforced student networking and community beyond the summer experience.

Participants

At Institution #1, the Urban STEM Collaboratory Summer Bridge program took place in August of 2019 and 2020 and comprised two cohorts of new Urban STEM students. Each cohort included both first-time entering first-year students, as well as rising sophomores from University College, who were not directly admitted into their STEM program as incoming first-year students. Special emphasis was placed on increasing readiness for Calculus I during Summer Bridge, which all students in the cohorts would be taking in the Fall semester. Including all cohorts, there were 45 total Scholars. The group of Scholars was 27% female, 58% White, 11% African-American, 11% Hispanic, and 20% other races. Scholars were majoring in one of the following disciplines: biomedical engineering, computer engineering, computer science, mathematics, electrical engineering, energy engineering, mechanical engineering, or motosports engineering.

Description of Summer Bridge Program

The Summer Bridge program at Institution #1 was a 5-day experience that took place the week prior to the start of classes in the Fall semester. It was intended to help incoming students increase their readiness for college by transitioning from summer break into impending

coursework through Calculus I readiness review, STEM special-interest presentations (such as biomedical or electrical engineering), and other development activities (such as communication and growth mindset workshops). Also, for the specialized version of the Summer Bridge for the Urban STEM Collaboratory, rising sophomores from University College were also important members of the bridge. The Summer Bridge program at Institution #1 included additional topics to assist students in their transition to college. Example topics included:

- Campus Technology Resources
- Core Academics – How to approach college classes
- What does it mean to be a STEM professional?
- Clifton Strengths: Top 5 Strengths and your STEM Identity
- Time Management
- Discussion of Diversity and Cultural Competency topics and exercises
- Finding your Fall Classrooms on a large urban campus

For targeted bridge sections, including the Urban STEM Collaboratory, after the summer Bridge, students continued to meet weekly throughout the Fall semester via a 1 credit hour First Year Seminar class to build and reinforce the student networking and community beyond the summer experience.

Unique Aspects

The summer bridge week was designed to engage the Urban STEM Collaboratory cohort students in ice breaker activities that allowed them to become acquainted with each other, including students from Institution #2 and Institution #3, as well as faculty engaged in the overall Collaboratory project. An important aspect of Summer Bridge week was an introduction to the CN, which was used for students and instructors to interact throughout the project and implement the seed and badge systems that were used to track students' participation in the project and attainment of certain knowledge, abilities, skills, or other characteristics associated with developing a STEM identity. A joint tri-campus session was held via web conferencing software. Students at each site were able to interact with each other utilizing the CN. An activity was facilitated by Institution #1 using CN to engage the students in polling questions and interactive posts. Students were also provided with an opportunity to ask questions about the program at the end of the session.

Process of Iteration and Improvement

The campus-wide Summer Bridge program at Institution #1 was moved to an online environment in 2020 because of the COVID-19 pandemic, therefore the Collaboratory curriculum was dramatically changed for cohort 2 as well as compared to cohort 1. A total of 6 synchronous online sessions were held with the students in cohort 2, which addressed a series of STEM related topics, such as:

- Introduction to the CN and the E-portfolio feature
- What is the Study of Calculus? (with a professor of mathematics)
- Getting to know your cohort
- The Importance of Teamwork in the STEM field
- What does it mean to be a STEM professional?

In addition, some of the curriculum items that were covered during Bridge Week for cohort 1 were moved to the fall semester for cohort 2 as part of the First Year Seminar course that the students took together, such as:

- Discussion of the Engineering Design Process
- Developing an approach to Problem Solving
- Clifton Strengths: Top 5 Strengths and your STEM Identity
- School of Engineering and Technology Faculty Panel

Reported Student Outcomes

At Institution #1, Scholars demonstrated a higher overall GPA, math GPA, major GPA, and outperformed in math overall (Calculus I) while also taking more credits on average when compared with all students. Figure 1 shows the grade distribution for Calculus I in Fall 2019, comparing Scholars with the entire population of students who took Calculus I that semester. In that semester, Calculus I had a DFW rate of 27.63%, but no Scholars received grades of D, F, or W in that semester. Performance data for Calculus I is summarized in Table 1.

Figure 1. Calculus I Grade Distribution

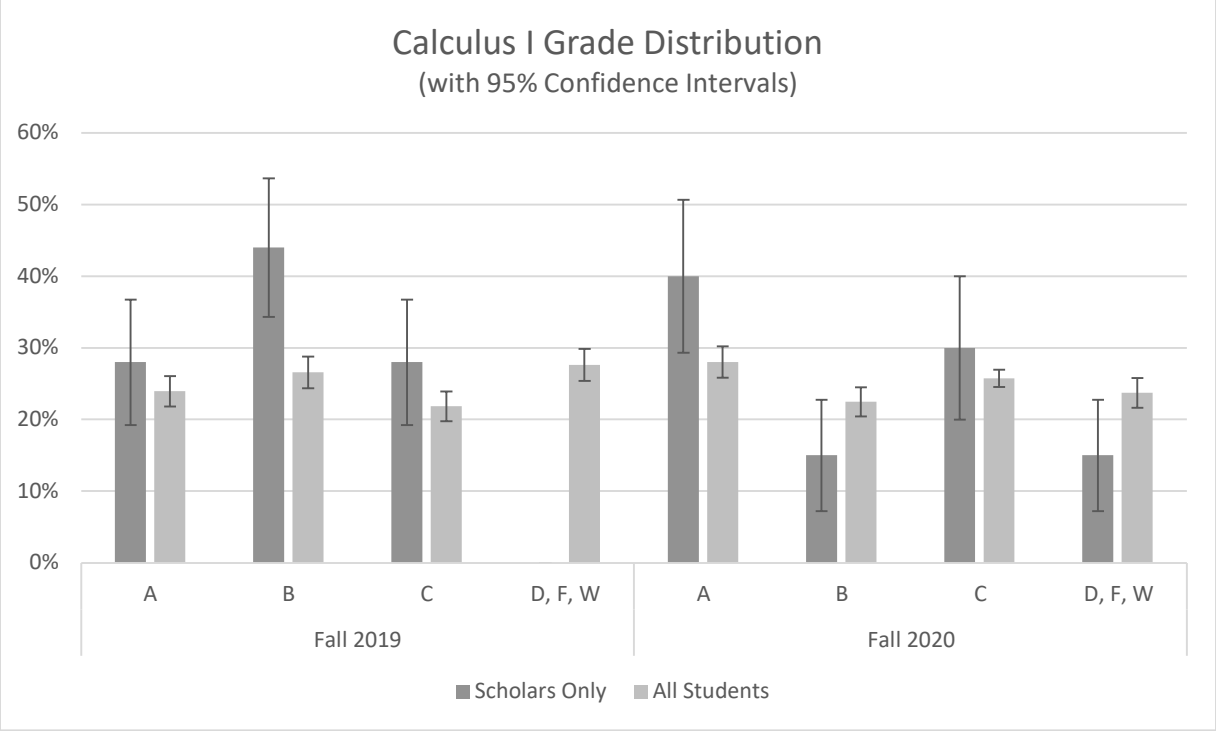


Table 1. Calculus I Grades, Fall 2019 and Fall 2020

	Fall 2019				Fall 2020			
Letter Grade	All Students		Scholars Only (Cohort 1)		All Students		Scholars Only (Cohort 2)	
	n	%	*n*	%	*n*	%	*n*	%
A	91	23.95%	7	28%	111	28.03%	8	40%
B	101	26.58%	11	44%	89	22.47%	3	15%
C	83	21.84%	7	28%	102	25.76%	6	30%
D	27	7.11%	0	0%	25	6.31%	2	10%
F	49	12.89%	0	0%	50	12.63%	0	0%
W	29	7.63%	0	0%	19	4.80%	1	5%
D, F, W	**105**	**27.63%**	**0**	**0%**	**94**	**23.74%**	**3**	**15%**
Total	380	100%	25	100%	396	100%	20	100%

Institution #2

At the second institution, all students receiving the NSF S-STEM scholarship (not only those who are first-year students) participate in Summer Bridge. This means that Scholars at this institution participate in Summer Bridge multiple years in a row. Relatedly, after the first year, Summer Bridge transitioned to a student-led and student-delivered program, affording sophomore and junior students leadership opportunities, which not only serve as marketable experience after graduation, but also potentially builds their sense of STEM identity and belonging by affording opportunities in enact STEM identities and to relate to others as "STEM people" [3].

Participants

The Summer Bridge program at Institution #2 began in 2019 with a cohort of 17 Scholars (first-year students and sophomores). An additional 21 Scholars were added to the program in 2020, and another 12 in 2021. Scholars are majoring in one of six engineering disciplines (biomedical, civil, mechanical, electrical, computer, or engineering technology). The overall cohort was 38% female, 41% White, 38% African-American, 8% Hispanic, and 13% other races.

Description of Summer Bridge Program and Process of Iteration and Improvement

The Summer Bridge program at Institution #2 engaged the Scholars in ice breaker, academic preparation, and other interactive activities that allowed them to become acquainted with each other, the faculty engaged in the project, the campus, and its resources. All Scholars were required to attend the program each year.

The Summer Bridge activities at Institution #2 have evolved over the course of the project based upon feedback from Scholars, the COVID-19 pandemic, and faculty assessment of impact. In the initial year (2019), the program activities were developed and delivered by the Urban STEM faculty team over the course of three days immediately preceding the start of the fall semester. While students reported enjoying these sessions and learning from them, they most valued the activities that built community, promoted networking, and provided opportunities for Scholars to learn more about the campus. Faculty agreed with the students' assessment, having noted that students were much less engaged during academic preparation and technical presentations.

To address findings from the first year, a team of Scholars was selected to develop the agenda and lead the sessions in year 2 (2020). Because of the pandemic, the 2020 program was held virtually. Rather than being conducted in consecutive days the week prior to the start of the semester, the sessions were held weekly beginning in July, were no more than 2 hours at a time, and were hosted via Zoom. A tiered-mentoring framework was introduced such that Scholars from the first cohort were assigned to mentor students in the second cohort. The 2020 program included many similar activities from 2019 but eliminated technical presentations and increased activities designed to help scholars develop relationships with one another. Additionally, more emphasis was placed on virtual interactions between campuses. In addition to a joint session introducing the CN, a Collaboratory-wide student panel was included with students from the 2019 cohort sharing about their experiences. This format was well-received by the new cohort of scholars and was also highly rated by returning Scholars, who enjoyed the opportunity to lead sessions and serve as mentors. For 2021, the same structure was maintained (and included two cohorts serving as mentors). Math preparation was dropped from the program and more extensive networking activities were introduced. A Scholar-led joint session across the collaborating campuses was also added to the agenda. 2021 Bridge sessions were once again held in person on consecutive days the week prior to the start of the fall semester.

Unique Aspects

One unique aspect of the Summer Bridge program at Institution #2 was the formation of a Scholar leadership team. The Scholars demonstrating strong leadership skills in the initial Summer Bridge program were invited to plan activities during the academic year as well as the subsequent summer sessions. This group was also tapped to develop and lead the peer mentoring program. The shift from faculty-led to student-led programs resulted in greater overall participation and engagement of the Scholars.

Reported Student Outcomes

Several important differences in academic performance and retention were found in comparing the Urban STEM Scholars to their peers who are not engaged in the program. Students in both the first and second cohorts earned higher GPAs in math courses (2.92/2.48 (2019); 2.52/2.06 (2020)) than their peers who were eligible for but not participating in the Urban STEM program (see Figure 2). First year retention rates were also higher for the Urban STEM Scholars versus their program-eligible peers (86%/61% (2019); 86%/76% (2020); see Figure 3). The difference

in retention rates for the 2019 cohort is of particular interest as the pandemic disrupted the spring semester and led to significant learning losses and disengagement campus-wide. Urban STEM Scholars were retained at a rate 25% higher than their program-eligible peers. Informal discussions as well as semi-structured interview findings indicate that scholars felt the connections they formed with peers and faculty through the Urban STEM program were instrumental in their ability to persevere, remain engaged, and access support resources in the midst of the pandemic.

Figure 2. Math GPAs.

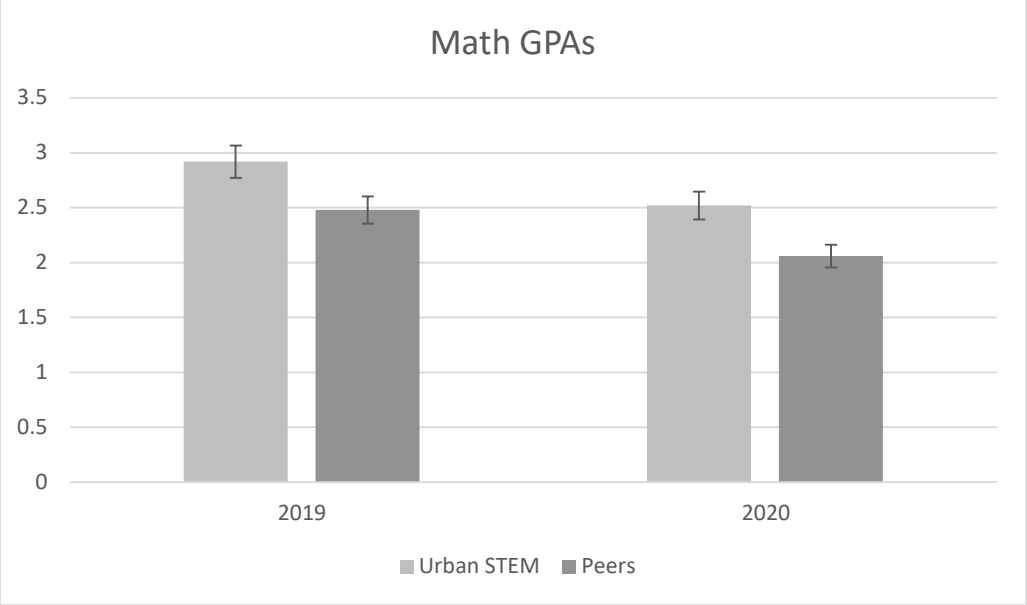
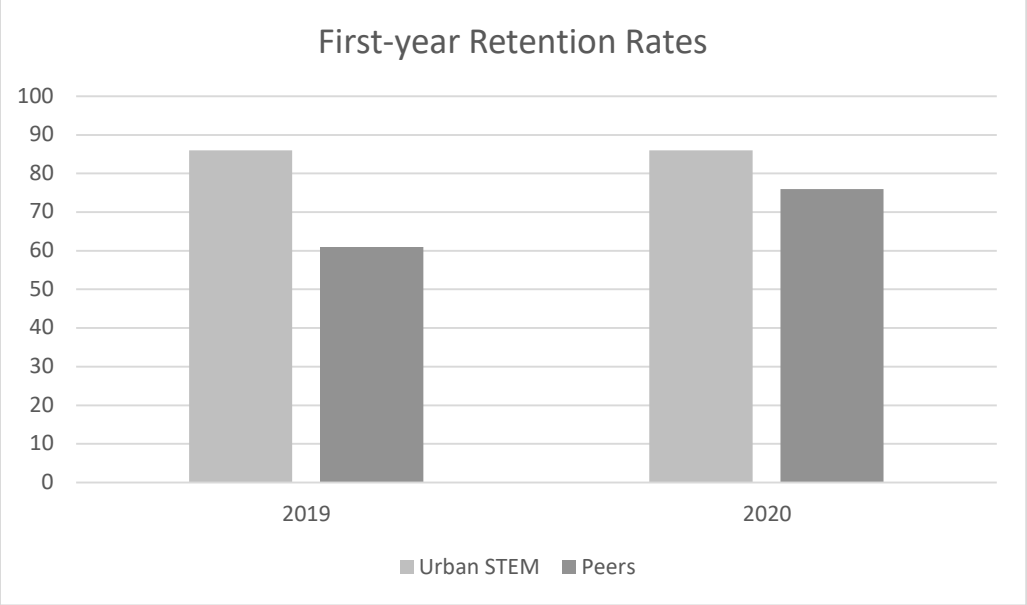


Figure 3. First-year Retention Rates.



Institution #3

At the third institution, a special focus was placed on building community. This was achieved through several means. First, each day of Summer Bridge included a unique team-oriented design challenge where students worked together and learned about each other within an engineering context, also reinforcing their STEM identities [4]. Second, students at this institution's Summer Bridge met their future instructors in an informal, conversational, lunch setting; many students reported this was one of their favorite aspects of Summer Bridge. Finally, Summer Bridge facilitated a first connection between incoming first-year students and their peer mentors (sophomore and junior students also receiving the NSF S-STEM scholarship), with whom they would meet regularly throughout the following Fall and Spring semesters.

Participants

At Institution #3, the incoming cohort of first-year S-STEM scholarship recipients (Scholars) are required to participate in the Engineering Learning Community (ELC), which is a bundle of courses including English composition, mathematics, and a first-year design course. The ELC contains a mix of Scholars and non-scholars. This means that every Scholar is an ELC member, but not every ELC member is a Scholar. The ELC has demonstrated positive outcomes for students over several years [5]-[8].

The first Summer Bridge program occurred in the summer of 2019 in an in-person format. Attendees included 18 incoming first-year Scholars. The second Summer Bridge program occurred in the summer of 2020 in a synchronous online format. Attendees included 9 incoming first-year Scholars and 3 non-scholar ELC members. In addition to requiring all incoming first-year Scholars to attend, all non-scholar ELC members were also invited to join if they wished. The third Summer Bridge program occurred in the summer of 2021 in an in-person format. Attendees included 5 incoming first-year Scholars, 9 non-scholar ELC members, and 9 returning sophomore-level Scholars (whose initial Summer Bridge experience the summer prior was virtual). For this third year of Summer Bridge, in addition to requiring all incoming first-year Scholars and inviting all non-scholar ELC members to attend, returning sophomore-level Scholars were also encouraged to attend. This was not only because their initial Summer Bridge experience the summer prior was virtual, but also because these sophomore-level students would serve as peer mentors to the incoming first-year students, and it was thought that meeting in advance of the Fall semester would be beneficial for the mentorship relationship. All Summer Bridge attendees were majoring in one of 5 engineering programs (mechanical engineering, civil engineering, electrical engineering, construction engineering, bioengineering, and computer science). Among all three cohorts of Scholars, 25% were female, 62.5% White, 10% Black, and 25% Hispanic or Latino.

Description of Summer Bridge Program

At Institution #3, Summer Bridge was a 3-4 day experience occurring in the week immediately prior to the start of the Fall semester. Summer Bridge was designed for Scholars as a way to prepare for the academic rigors of a first-year engineering curriculum, establish the development of engineering identity through design activities, and build community among Scholars.

For each year of the Summer Bridge program, activities included: academic preparation workshops for mathematics and English composition, design activities and competitions, a campus resource scavenger hunt, talks from engineering and mathematics professors on topics of interest, and informal unstructured times (e.g., lunches) to connect with engineering professors and fellow students.

The first two Summer Bridge programs (2019 and 2020) were developed and organized by faculty members and graduate students. However, the third program (2021) was developed and organized nearly entirely by undergraduate student leaders who had participated in the first Summer Bridge program.

Unique Aspects

One of the unique features of Summer Bridge at Institution #3 was the focus on engineering design. During each day of Summer Bridge, students participated in at least one design activity or competition. Students would work together in small groups to, for example, build a tower out of dried spaghetti and marshmallows, or build a backpack out of only printer paper and tape. The incorporation of design activities was conceptualized to serve as a precursor to the first-year engineering design course all ELC members take in their first Fall semester. However, in addition to this continuity between Summer Bridge and the first-year design course, these design activities also served to promote STEM identity and allowed students to socialize and work together toward building a community [4].

Similar to Institution #2, Institution #3 shifted from a program planned and executed by faculty to one planned and executed entirely by student leadership. These student leaders took over planning and implementation for the 2021 Summer Bridge, and they each had participated in the 2019 Summer Bridge.

Lastly, another unique feature of Summer Bridge at Institution #3 was the way faculty members were included in the program. In addition to delivering talks and facilitating workshops during Summer Bridge, faculty members also socialized with the students during lunch breaks and other informal contexts. The students reported that this was one of their favorite aspects of Summer Bridge, and that they felt much more at ease starting the Fall semester after having met and gotten to know some of their professors in the week before classes began.

Process of Iteration and Improvement

The Summer Bridge program at Institution #3 underwent several changes between each iteration. After each Summer Bridge, participants submitted a satisfaction survey where they reported on what they found helpful and what they did not. This student input, as well as assessment from faculty members involved with the program, were the main impetus for changes between iterations.

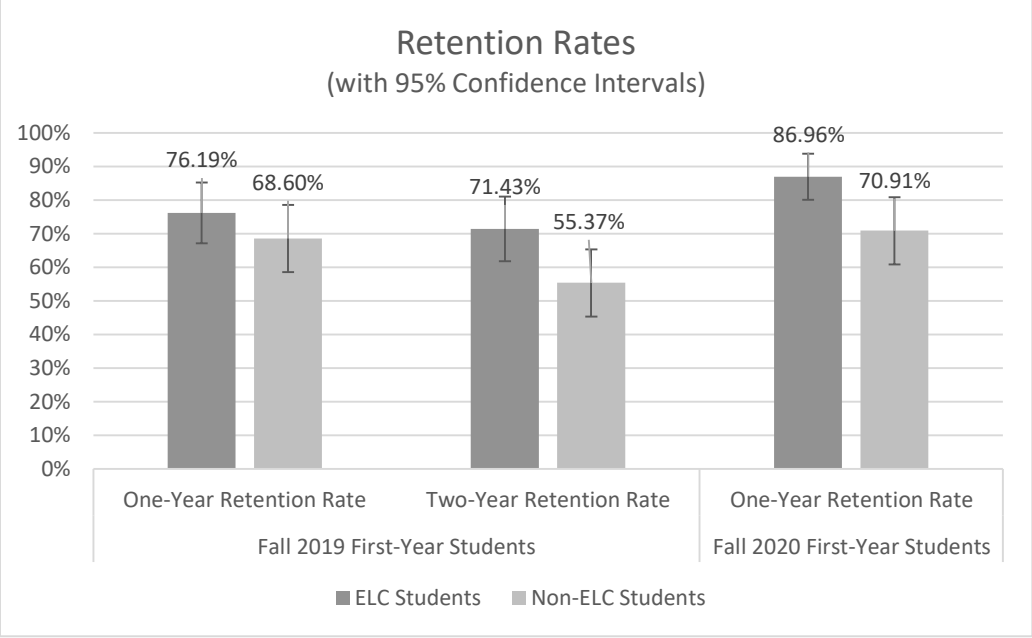
When the Summer Bridge program shifted to being student-run in 2021, the student leaders were given freedom to choose how to design the program. While the students decided to keep much

of the program the same, one large change they did make was to invite sophomore-level students, who would serve as the first-year students' mentors in the Fall semester, to attend Summer Bridge. Additionally, the student leaders developed some separate sessions for the sophomore students, meaning that most of the time all students were together during Summer Bridge, but occasionally the sophomore students were separated from the first-year students. Most notably, during the mathematics and English composition academic review sessions, the sophomore students split off to receive training on how to be a mentor. This structure was considered a success among students and faculty through informal feedback, and this change was made due to the ideas and planning of student leaders.

Reported Student Outcomes

ELC members, both Scholars and non-scholars, have demonstrated higher rates of retention than other engineering majors at Institution #3. For example, for first-year students who began in Fall 2019, ELC members demonstrated a two-year retention rate of 71% (n=21), while non-ELC engineering majors had a two-year retention rate of 55% (n=121). For first-year engineering students who began in Fall 2020, ELC members had a one-year retention rate of 87% (n=23), while non-ELC members had a one-year retention rate of 71% (n=110; see Figure 4). It is difficult, however, to determine how much the Summer Bridge program contributed to these increased retention rates since ELC students receive a number of additional supports including peer mentorship throughout the first year and being part of a learning community.

Figure 4. Retention Rates.



During the Fall 2020 semester, interviews were conducted with five first-year Scholars. Because they were Scholars, all five had attended the Summer Bridge program, but the interview purpose was for research separate from Summer Bridge and no interview questions were asked about Summer Bridge. However, one of the questions asked how connected they felt to their peers in

their classes, and three of the five interviewees brought up Summer Bridge, unprompted, as something that helped them feel more connected to their peers. This is worth noting because this group of students started their college careers in Fall 2020 when both classes and Summer Bridge were completely remote. It is possible that remote learning offers fewer opportunities for peer connection and community building than in person learning, and Summer Bridge may have mitigated that impaired community building.

Conclusion: Recommendations for Other Institutions

Summer Bridge programs typically focus on transitioning students from high school to college and remediating academic content and skills [9]. Our bridge programs extended the purpose and participants for Summer Bridge, based on details of the Urban STEM programming, student feedback, and the pandemic. At Institution #1, because of the make-up of the cohorts and shared courses, the bridge included not only first-year students transitioning from high school to college, but also second-year students transitioning from University College to Engineering. At Institutions #2 and #3, the bridge programs included returning students transitioning from mentee to mentor roles, shifted from faculty to student leadership, and evolved to de-emphasize academic content in favor of community building. Due to the COVID-19 pandemic, all three bridge programs shifted from on-campus, to remote, back to on-campus formats, ultimately transitioning students from remote to on-campus learning.

At Institution #1, there was a significant positive impact of combining both incoming first-year students and returning sophomores into the specialized Summer Bridge for the Urban STEM program. Although there were some redundancies for the sophomores, as many of them participated in the general Summer Bridge the prior year, their participation in the Urban STEM specialized version of Summer Bridge strengthened the networking among the students, and created an unanticipated, informal peer mentoring network. The common theme of all students, both incoming first-year students and returning sophomores was taking Calculus I in the Fall semester further strengthened the bond and networking among the students.

Other institutions considering launching similar programming should consider increased participation of rising sophomores in Summer Bridge to help establish peer mentoring networks with incoming first-year students with the common theme that the students would be taking some courses together in the Fall (at Institution #1, all students were taking Calculus I). This seemed to make Summer Bridge an even better experience for all, because so many of the students in the classroom already had some college experience to share with the group.

For Institution #2, one of the central lessons learned to date from this program is the importance of community building to student success. The close relationships forged between students and faculty at Institution #2 has resulted in Scholars feeling more connected, being better able to access support resources, and being more successful than their peers who are not part of the program, particularly given the disruption of the pandemic. The Summer Bridge was instrumental in developing these relationships, as the program provided an opportunity for Scholars to meet one another and faculty prior to the start of the academic year. A shift from a faculty-driven to a Scholar-driven approach to developing and delivering program components was also important for increasing engagement and sense of community among the Scholars.

For Institution #3, the most successful and engaging iteration of Summer Bridge was the program that was designed and executed almost entirely by student leaders. The student leaders came up with ideas and made changes to the program that would otherwise not have been identified through typical program evaluation means, such as satisfaction surveys and faculty assessment. Specifically, student leaders thought to involve sophomore-level students in Summer Bridge and create breakout times when the sophomore-level students received training on how to embody the role of peer mentor.

In addition to student leadership, another recommendation for other institutions seeking to launch Summer Bridge programming for STEM, and specifically engineering, students is to incorporate design challenges. The daily design challenges employed at Institution #3 were frequently reported as participants' favorite aspect of Summer Bridge, and the small group structure helped to build community. Additionally, STEM identity was not only fostered by engaging in design activities, but also socially reinforced through teamwork with other students.

There is a strong body of prior work on summer bridge programs (e.g., [10]), yet future work may need to focus on remote versus in-person effects, as well as faculty/staff led versus student-led versions. Although a component of the Urban STEM Collaboratory since it was first proposed, the Summer Bridge programs were never intended to be a focus of research. Yet, student feedback indicates that these programs may have positive impact on student belonging and identity. There is significant variability among the three institutions, such as the number of cohorts (scholarships being awarded to two, three, or four years of incoming students), and variability in how the programs were offered, including in-person versus remote delivery due to the pandemic. Investigating which elements are most important will take additional study. However, since each institution's summer bridge demonstrated positive student outcomes, it is possible that any social interaction among peers before the start of the semester is beneficial, and the actual programming of summer bridge may be less important than the broader experience of socialization that a summer bridge provides.

Summer bridge programs are common to many universities, and are used for a variety of reasons, including academic review, orientation to the physical campus, and introduction to campus technology. In the summer bridge programs specific to the Urban STEM Collaboratory, we found the most important elements to be those that helped incoming students connect to each other, to student mentors, and with faculty. These were not random groupings, but people they would meet again -- "familiar faces" in classes and mentoring meetings. The iterations described here follow the feedback from students: shifts from individual work to team-based design activities, from faculty-designed sessions to student leaders guiding the program content. For both in-person (2019/2021) and remote delivery (2020), these programs lessened feelings of isolation for students, whether they entered physical classrooms or online ones, because these programs emphasized connecting with their new community.

Acknowledgment

This work is supported by NSF S-STEM #1833983.

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