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Expanding Access to and Preparation for Engineering through a Summer Bridge Program

Dr. Ricky T Castles, East Carolina University

Dr. Ricky Castles is a professor in the Department of Engineering at East Carolina University and the Associate Dean for Student Affairs in the College of Engineering and Technology. He serves as Executive Director of the East Carolina University College of Engineering Student Success Center. He is interested in various aspects of engineering education research including broadening participation in engineering for low-income and rural students.

Valerie A DeBellis, East Carolina University

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Abstract

This Complete Evidence-Based Practice paper integrates known best practices in supporting the transition of students from high school into first year engineering programs. This work couples a summer bridge program with early career exposure and innovative teaching methods to prepare students for success in the required calculus course sequence. Engineering remains an in-demand profession and many students are interested in pursuing careers in the field. Despite strong interest in engineering careers, many high school graduates cannot meet rigorous admissions standards of university engineering programs. One of the major reasons students may not be accepted to the engineering program of their choice is mathematics preparation as demonstrated through high school coursework and standardized test scores. While mathematics readiness has been an ongoing challenge for students interested in engineering for many years, the Covid-19 pandemic resulting in major changes in high school mathematics instruction has further exacerbated students readiness for advanced mathematics. Many students, especially those from rural and/or low-income backgrounds, were limited in their access to highly qualified mathematics instructors, as well as experienced difficulties in maintaining continuity of instruction during the global pandemic. Many high schools have also had challenges in hiring qualified mathematics instructors. Students who experienced limited access to quality mathematics instruction present themselves on college campuses with mathematics content gaps. For many students, these gaps present a barrier to entry into engineering degree programs.

In 2025, engineering and mathematics faculty at East Carolina University (ECU) partnered to offer a five-week summer bridge program. The primary target audience for this bridge program were students who were unable to be admitted to ECU's BS in Engineering program or students who were admitted to the program but were not yet ready for calculus. Students were given an in-person mathematics assessment upon arrival and targeted, personalized instruction was developed to address any gaps in preparation that were identified. The bridge program also allowed students early access to two introductory engineering courses, allowing students to earn 3 total semester hours of engineering credit prior to starting the fall semester. To motivate students to persist in their mathematics preparation and to continue their pursuit of an engineering degree, the program also included field trips to local industrial sites where students were able to meet engineering alumni working in various careers.

This paper presents the results of a pilot summer bridge program designed to improve math readiness. Outcomes in math readiness are showcased including gains in math readiness for all program participants. Lessons learned in implementation of such a program are also addressed.

Background

Approximately one third of new engineering jobs in the United States go unfilled due to a shortage of available talent [1]. To meet the demand for technically talented workers, colleges and universities need to be able to recruit more engineering students. The challenge in recruiting more engineering majors, however, is that many students who may have an interest in the field of

engineering may not yet be prepared to be successful in the mathematics courses that provide the foundation for engineering study and are prerequisite to advanced engineering courses. Recruiting engineering students thus requires engineering programs to screen applicants for their mathematics readiness as a way of predicting the potential of applicants to be successful in their academic program. Unfortunately, once students who do not meet the selection criteria are removed from consideration for admission, a significant portion of applicants are denied the opportunity to study engineering.

Thus, to ensure students are successful in their pursuit of an engineering degree and to increase the number of students who are prepared to enter an engineering degree program, more intervention strategies need to be implemented to ensure that a broader pool of talent is prepared to study calculus. Students who are able to be placed into an engineering program often drop out due to poor performance in calculus courses [2]. To be successful in its mission to increase the available talent with the training in engineering to fill technical jobs, an intervention program should work to increase interest in engineering among participants and should work to ensure that more students can fulfill the requirements necessary for entry into competitive majors.

During the Covid-19 global pandemic, many students did not receive quality mathematics instruction. Many courses were shifted online with students forced to learn at home, prohibiting access by students who may come from homes without access to quality internet connections to support online learning. Furthermore, 16% of public high schools and middle schools nationwide report a shortage of mathematics teachers. This shortage is even greater in rural areas and areas with a higher percentage of the population living in poverty [3].

The literature showcases several strategies that have been successful in preparing students for entry into college. Summer bridge programs have been used as an intervention strategy at several universities to acclimate students to campus living prior to the start of collegiate studies. Summer bridge programs typically last from one to several weeks. Successful bridge programs have demonstrated the ability to better prepare students for entry into college programs, to reduce the need for remedial coursework, and to increase retention and development of a sense of belonging [4-8]. In addition to summer bridge programs, early career programs allowing students to interact with role models in a variety of industries have also been proven to increase awareness of more opportunities and to motivate students through impactful interaction. When coupled with summer bridge programs, early career programs have demonstrated the ability to positively impact the likelihood of students pursuing STEM careers and this is particularly true when students are exposed to a diverse group of role models [9].

Institutional Background and Motivation

ECU draws many of its students from a rural region of a state where many students live below the poverty line. Most of the student body at ECU (55%) come from families where neither parent earned a bachelor's degree. Student mathematics outcomes in the counties surrounding ECU have indicated that relatively few students are prepared to study precalculus. Presented in Table 1 are admissions data from the most recent two years of engineering applications at ECU. In both admissions cycles, the engineering program at ECU drew over 1,000 applicants. These applicants are screened to determine if they meet the requirements for admission to the engineering program. These include: 1) an unweighted high school GPA of 3.0 or higher, 2) mathematics test scores (AP, SAT, ACT, etc) or transfer credit that would place a student into at

least precalculus, and 3) successful completion of a precalculus (or higher) math course. More than half of these applications received were incomplete with students not providing enough information to be able to make an admissions decision such as not submitting a transcript or a test score. A little more than one in three applicants had a complete application that demonstrated the admission requirements were met. Among applicants with completed applications who were denied admission to the engineering program, over 60% of those denied admission (63/91 in 2024 and 96/149 in 2025) were denied for reasons related to mathematics preparation.

Table 1. Engineering freshman applicant data from Fall 2024 and 2025 admissions cycles

Admission Term	Engineering Applicants	Incomplete Application	Accepted Applicants	Denied Applicants	Denial Related to Math Preparation
Fall 2024	1025	555	379	91	63
Fall 2025	1364	730	485	149	96

In recent years, the engineering faculty have noticed a decline in students' math readiness. Student outcomes in required mathematics coursework also showcase a decline in preparation for calculus. Table 2 showcases the grades earned by engineering students in 2019, the last year before the onset of the Covid-19 pandemic and 2025, a few years post Covid. In order to progress to the next mathematics course in the sequence, a grade of C or higher must be earned. A grade of W is assigned to students who withdrew from the course prior to semester's end. As can be seen in Table 2, a higher percentage of students did not meet the standard to progress from Precalculus to Calculus 1 with 44% of students earning a grade below C and another 2% withdrawing from the course. Compared with data from Fall 2019 where 29% of students did not achieve a passing grade and 4% withdrew from the course, a significant decline in mathematical readiness is demonstrated. Similar trends are presented in the data for Calculus 1 and Calculus 2 with more students failing to meet the standard for progression in both courses. It is important to note that this table represents all engineering students in these courses in each given semester. These students were not necessarily all in the same section of the course and may have had classmates from other majors in those courses who are not represented in these data.

Table 2. Engineering student mathematics grades pre/post pandemic (Fall 2019 and 2025)

		A/A-	B+/B/B-	C+/C	C-	D+/D/D-	F	W
		Passing Grade Allowing Progression			*Does Not Meet Standard for Progression*			
Precalculus	*F19*	5 21%	7 29%	4 17%	2 8%	2 8%	3 13%	1 4%
	F25	9 20%	11 24%	4 9%	4 9%	5 11%	11 24%	1 2%
Calculus 1	*F19*	18 47%	9 24%	4 10.5%	1 3%	2 5%	0 0%	4 10.5%
	F25	18 28%	24 37%	6 9%	1 2%	4 6%	9 14%	3 5%
Calculus 2	*S19*	23 39%	14 24%	10 17%	1 2%	2 3%	6 10%	3 5%
	S25	18 34%	18 34%	5 9%	2 4%	2 4%	4 8%	4 8%

Aims of the ECU Engineering/Math Summer Bridge Program

Based upon an examination of the admissions data indicating that math readiness was a barrier to entry into the engineering program and an examination of math grade outcomes for admitted engineering students, it was determined that a summer bridge program may be an opportunity to improve student readiness for engineering including allowing students to be admitted and setting students up to be more likely to succeed in their required engineering mathematics courses.

Project goals include: 1) Enabling more engineering program applicants to be accepted into the program by improving their mathematics readiness 2) Improving the mathematics readiness of students already admitted to the program through mathematics workshops designed to move students from precalculus readiness to calculus readiness 3) Motivating students who are at risk for dropping out of an engineering program to persist in the engineering major through career exposure and networking opportunities with engineering program alumni.

The program will be considered successful if 1) students who otherwise would not be admitted to the program are able to meet entry requirements, 2) students in the engineering calculus sequence achieve at least a grade of C in the mathematics course they enroll in during the subsequent semester, and 3) bridge program students persist in the engineering major towards graduation.

Recruitment and Student Selection

As students were screened for admission, members of the application review team were asked to identify students who may benefit from the summer bridge program to improve their readiness for calculus. The program was also advertised at a university admitted students day (open house for those admitted to the university) to all engineering program applicants in attendance. The opportunity to participate was also shared at the first two summer orientation sessions for incoming engineering and engineering-intended majors.

To be accepted into the program, students were asked to complete an online application. This application was embedded in the university's financial aid system, so it also allowed program administrators to determine if students were eligible to receive financial aid to support their participation in the program.

Student Profiles

Ten students were selected for participation in the pilot bridge program. The students had diverse backgrounds and preparedness for engineering mathematics. The following demographic information may provide some insight to the students who participated in the program.

Student A- This student was not originally accepted into the engineering department. His high school GPA was slightly below the minimum 3.0 required for admission into the engineering department. His ACT score and the levels of the mathematics courses he took in high school also did not meet the entry requirements.

Student B- The student was admitted to the engineering department prior to enrollment in the summer bridge program. His highest level of mathematics completed before enrollment in the summer bridge program was a community college precalculus course. This student participated in the bridge program for a little over one week and then withdrew and did not communicate with the faculty again.

Student C- This student was admitted to the engineering program. He took Calculus 1 twice during high school and recognized that he would need to improve his math readiness to be successful in engineering.

Student D- This student had a strong high school GPA but was conditionally admitted to the engineering program based upon not taking a higher-level mathematics course in high school. He was informed that he could be admitted to the program if he enrolled in and passed a precalculus course during the summer or if he successfully completed the summer bridge and placed into at least precalculus.

Student E- This student was admitted to the engineering program and was placed into Calculus 1 by the university's math placement test. The undergraduate engineering program coordinator and math faculty had concerns about his readiness for calculus based upon his low standardized test scores that would have placed him into remedial math.

Student F- This student was denied admission into the engineering program. He had a GPA that was lower than the minimum required for acceptance. The grades he earned in his high school math courses also did not indicate a strong aptitude for mathematics. This student also had a pre-planned family vacation that was scheduled for the middle of the bridge program so he missed a full week of the five-week program.

Student G- This student was a non-traditional student, a military veteran who had earned a previous degree. She was a working professional in a technology field and reached out to her academic advisor from her first degree program to express interest in pursuing an engineering degree. Her advisor connected her with the bridge program faculty so she could improve her mathematics readiness as the highest level of math required in her first degree program was college algebra.

Student H- This student learned about the summer bridge program during freshman orientation. While she was already fully admitted into the engineering program, she was not confident in her mathematics abilities and expressed interest in pursuing the bridge program to be more prepared for engineering.

Student I- This student was denied admission into the engineering program. His high school GPA did not meet the minimum entry requirement and the grades earning in his high school mathematics courses did not indicate a strong aptitude for mathematics.

Student J- This student was an honors student who was fully admitted to the engineering program. She had already earned credit for both Calculus 1 and 2 and was placed into Calculus 3 through her transfer credits. She expressed interest in the program because she wanted to pursue a double major in engineering and mathematics and thought the early access to engineering courses would allow her to be able to plan a schedule that would be able to fit in both majors in four years of study. While she was not the target demographic the bridge program was intended for, she was admitted to the program and hired to be a mathematics peer tutor, working alongside

the mathematics faculty to help her fellow students. It was determined through conversations during the bridge program that she had completed Calculus 2 by the end of her junior year of high school and was not enrolled in a math course during her senior year.

Summer Bridge Program Structure

The program was structured as depicted in Figure 1. The summer bridge program was designed to be a residential program with students living on campus unless they resided close enough to commute. It was scheduled for late June through the end of July during the second summer session. This timeline allowed participation by recent high school graduates who may still be in school during the first summer session. It featured three primary components: 1) Enrollment in two first year engineering courses, 2) Participation in mathematics workshops design to improve readiness for engineering mathematics, and 3) exposure to various career opportunities through industry tours. By having a small group of students together for five weeks, it was a goal of the program to develop a sense of belonging and a building of a strong cohort of students who develop a positive relationship with faculty in both the engineering and mathematics department.

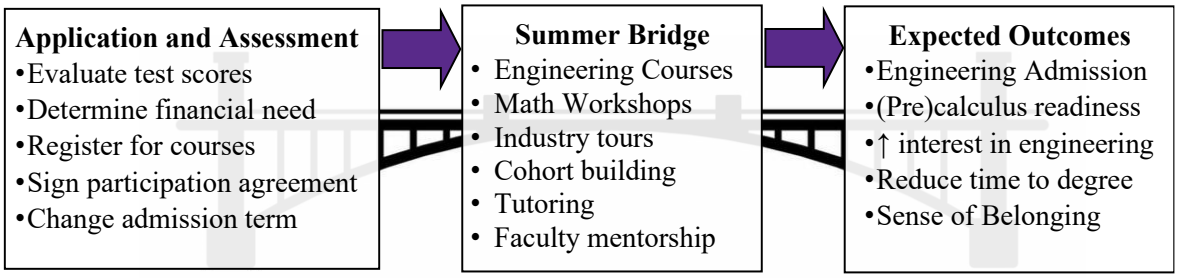

Figure 1 Bridge program structure

Engineering Coursework

The program included two first year engineering courses, Introduction to Engineering and Engineering Graphics. The Introduction to Engineering course allowed students to learn about the various engineering disciplines, introduced university resources, showcased engineering problem solving and the engineering design process, introduced engineering ethics, and allowed students to develop a professional resume. The course emphasized metacognition and examining their learning process. The engineering graphics course introduced various hand drawing skills and solid modeling using SolidWorks software. Students worked through laboratory exercised in SolidWorks and finished the course with an open-ended design project requiring them to model various components of an assembly and model how the pieces are put together.

Mathematics Workshops

The mathematics workshops were developed by a team of two mathematics faculty members; one faculty member is a research mathematician with earned teaching awards and experienced in teaching calculus to engineering students. The other faculty member is a research mathematics educator with experience in teaching entry-level college mathematics courses and directing a

high school mathematics transition program for college readiness in mathematics; both are members of ECU's mathematics department.

Afternoons were spent in mathematics workshops where students worked with mathematics faculty. On Day #1, an initial proctored math placement assessment was administered to all students using ALEKS Placement, Preparation and Learning (PPL) software. Students spent anywhere from 34 minutes to 1 hr 39 minutes on the assessment with an average time spent of 1hr 6 minutes. Initial placements were as follows: three students placed into remedial mathematics; two students placed into College Algebra; one student placed into Precalculus, two students placed into Calculus I, and two students placed into Calculus 2. This information provided us with a baseline for mathematical readiness.

From this initial assessment, program math faculty reviewed mastered topics, asked students what topics they never understood from high school yet wanted to learn, partitioned students into two learning groups, and identified curricular topics for customized modules designed to prepare students for entry into the next math course in the sequence.

Two-hour afternoon workshop sessions were spent with one group focusing on topics in Precalculus and Calculus; the other group focused on topics in College Algebra, coupled with discussions on remediation skills, with the goal of making this student-group ready to enroll in a Precalculus course for the Fall. Five students were placed into the Precalculus/Calculus group, four students were placed into the Remediation/College Algebra group, and one student, assessed as on-the-border, was placed to start in the Precalculus/Calculus group but had permission to float between workshops, as needed.

Students progressed through a series of face-to-face instructor designed mathematics sessions, working both individually and in small groups. Quizzes and tests were administered over the course of the summer to hold students accountable and to simulate collegiate-level expectations in learning. After these learning sessions, students then progressed through a set of recommended modules in ALEKS PPL to fill in any gaps in mastery determined by the assessment tool. Our goal in these mathematics workshops was to strengthen student mathematical abilities at their level of demonstrated mastery so that all students are "engineering ready" in mathematics. While we are aware these gains may seem lofty for the lower-level group to achieve during a five-week summer bridge program, we designed the math learning to take place outside the context of a transcript grade so we could have honest discussions with students about what mathematics they did not understand, so they could fail (i.e., get problems wrong and fix them), without recourse, so we could find and fix their misconceptions, model for them what it takes to have a mathematical habit of mind, and to build supportive relationships that show them how mathematics is a human endeavor. All this, to model what it means to be mathematically ready to major in engineering.

Industry Tours

Fridays were industry days. Chartered vans drove students to various industrial sites so they could learn about several engineering career opportunities and the education required to obtain them. Most of the tours allowed students in the bridge program to interact with alumni from the <university> engineering program. Students toured a warranty lab for a materials handling company, a wastewater treatment plant, a natural gas facility, an electric substation, a

pharmaceutical manufacturing facility, and a training facility for professionals to learn how to do validation and testing of pharmaceutical production facilities.

Program Schedule

The program kicked off with a welcome dinner on the night before the second summer session. This dinner allowed students and their families to meet the faculty and to learn about the expectations of the program. The first day of classes was on a Thursday. Students attended their first engineering class that day and took the ALEKS math placement exam that afternoon. There was no engineering tour that first week, but students engaged in their first mathematics workshops based upon their math placement. Once the second week of the program started, the students began a consistent weekly schedule as depicted in Table 3.

Table 3. Weekly Bridge Program Schedule

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>7:30-8:15 AM</td><td colspan="5">Breakfast</td></tr>
<tr><td>9 AM-noon</td><td>Introduction to Engineering</td><td>Engineering Graphics</td><td>Engineering Graphics</td><td>Engineering Graphics</td><td rowspan="4">Industrial Tours and Presentations</td></tr>
<tr><td>Noon-1 PM</td><td colspan="4">Lunch</td></tr>
<tr><td>1-3 PM</td><td colspan="4">Mathematics Workshops
-Customized lessons based upon needs identified on pre-test
-Topics include: trigonometry, functions, graphing, and other topics of need as identified by ALEKS assessment</td></tr>
<tr><td>3-5 PM</td><td colspan="4">Open Lab time and tutoring available. Faculty Office Hours</td></tr>
<tr><td>5-6 PM</td><td colspan="5">Break</td></tr>
<tr><td>6 PM-7 PM</td><td colspan="5">Dinner</td></tr>
<tr><td>7-9 PM</td><td colspan="5">Studying, Completing Assignments, Recreation</td></tr>
</table>

Bridge Program Expenses and Financial Aid

To make the program affordable, students were encouraged to submit FAFSA forms to the university financial aid office to determine their eligibility for aid to support their participation. Of the ten students committed to attend the summer bridge program, four were determined to have high financial need and were given a scholarship to reduce the cost to attend. The scholarship covered the cost of tuition and fees for 3 credit hours of engineering coursework, the dorm fees, and a campus meal plan. The total value of each of these scholarships was $2,250 per student.

As part of a University of North Carolina system-wide agreement, the ALEKS PPL licenses may be purchased at a cost of approximately $25 per student. One of the faculty teaching one engineering course was paid the usual summer pay for teaching a course. The other faculty member is a 12-month employee and was not paid any additional salary to teach the summer

course. The mathematics faculty members were compensated with stipends equivalent to approximately one month's summer salary.

ECU also hosted the bridge program participants and their families at a catered welcome dinner on the night before the bridge program at a cost of approximately $600. Each bridge program participant was also given a notebook and some supplies to use during the program including engineering paper, a mechanical pencil, an eraser, and other office supplies at a cost of approximately $20 per student.

Student Outcomes in Mathematics

On the last day of the summer bridge program, a final ALEKS PPL proctored math placement assessment was administered to nine students (one student had left the program, initially placed into Calculus I, for personal reasons without entry into the university). One student placed into Calculus 3, two students placed into Calculus 2, four students placed into Precalculus, one student placed into College Algebra and one student placed into remedial mathematics (the student who missed one week of the summer program).

At the closing session, bridge program faculty held individual meetings with each student to recommend enrollment into a Fall math course that would yield student success. Most students took our advice; one student did not. Table 4 shows student outcomes for this group at the end of the summer bridge program. In this table, success is measured by student growth in mathematics readiness. Even if students remained placed in the same mathematics course for the fall semester as they would have placed into prior to the bridge, and improved ALEKS score is counted as a success. All 9 students who participated in the bridge program for at least 4 weeks increased their ALEKS score and thus were more prepared for mathematics. Student D was able to be admitted to the engineering program after completion of the summer bridge program. Students A, F, and G remained in the engineering intended program and student I elected to pursue another major.

Table 4. Student Mathematics Outcomes After Bridge Program Participation

Bridge 2025 Student Name	Bridge Math Placement Beginning	Bridge Math Placement End	Enrolled FALL 2025 Math Course	Admitted to ENGR?	Success?
Student A	College Alg	Precalculus	Precalculus	Intended	YES
Student B	Calculus 1	withdrew	Dropped out	Yes	NO
Student C	Calculus 1	Calculus 2	Calculus 2	Yes	YES
Student D	Precalculus	Precalculus	Precalculus	Yes	YES
Student E	Remedial	College Alg	Precalculus	Yes	YES
Student F	Remedial	Precalculus	Precalculus	Intended	NO
Student G	College Alg	Precalculus	Precalculus	Intended	YES
Student H	Calculus 2	Calculus 2	Calculus 1	Yes	YES
Student I	Remedial	Remedial	Remedial	No	NO
Student J	Calculus 2	Calculus 3	Calculus 3	Yes	YES

Table 5 indicates which mathematics course students enrolled in during the Fall 2025 semester, the grade earned in that course, and the mathematics course students enrolled in for the Spring

2026 semester. Unfortunately, two students earned a grade of F in their math courses in Fall 2025 and other student withdrew from a math course. Student A had overall poor performance in several classes in Fall 2025 and is not enrolled in any courses for the Spring 2026 semester. Student B did not return to the university after the bridge program and was not enrolled in Fall 2025. Student F has decided to pursue a major other than engineering and is not enrolled in many mathematics courses in Spring 2026. Student I is still working through passing a remedial mathematics course and has decided to pursue an engineering technology degree that requires only completion of college algebra instead of the calculus sequence in the BS in Engineering degree program. Success in this table is defined as achieving a minimum grade of C in the mathematics course the student enrolled in during the Fall 2025 semester and enrolling in a subsequent mathematics course in Spring 2026. Overall of the 9 students who completed the bridge program, 6 were successful in advancing along the calculus sequence and are well on track to earning an engineering degree.

Table 5. Student Mathematics Outcomes in Fall 2025 and Beyond

Bridge 2025 Student Name	**Enrolled FALL 2025 Math Course**	**Final Grade**	**Success?**	**Spring 2026 Math?**
Student A	Precalculus	F	NO	Not enrolled
Student B	Not enrolled	N/A	N/A	Not enrolled
Student C	Calculus 2	A	YES	Calculus 3
Student D	Precalculus	B+	YES	Calculus 1
Student E	Precalculus	B -	YES	Calculus 1
Student F	Precalculus	F	NO	No math
Student G	Precalculus	A	YES	Calculus 1
Student H	Calculus 1	B	YES	Calculus 2
Student I	Remedial	W	NO	Remedial
Student J	Calculus 3	A	YES	Linear Algebra

Unexpected Outcomes

Bridge students from both groups sought mathematical assistance from program math faculty during the Fall semester, even though they were no longer students enrolled in their courses. This assistance was key to their success. Student E originally enrolled in Calculus 1 for the Fall 2025 semester, not heeding the advice of the mathematics faculty. Upon enrolling in the Calculus 1 course for the first week, he realized that he needed to drop down to a lower-level mathematics course to be successful. He changed his schedule to enroll in a precalculus course and was successful in completing this course and moving on to Calculus 1 in the Spring 2026 semester.

While Student J was not in the target demographic for the summer bridge program, she gained in her mathematical readiness through her enrollment in the program. Having a peer tutor taking engineering courses and living in the residence halls alongside the other students was a contributing factor to other students developing a sense of belonging and achieving success through the encouragement of a peer. Due to the development of relationships with engineering

faculty as part of this program, this student has also engaged in undergraduate research opportunities with faculty member in her first semester of engineering study.

Lessons Learned and Recommendations

One recommendation for engineering programs considering a similar program would be to work with the university disability support services to identify students who may benefit from their services. Some of the faculty found that students who were less successful may not have been able to access all of the university resources they may have benefitted from and having the ability to take tests in a distraction free environment or with extended time may have benefited them.

It was also determined that some students felt the need to work during the bridge program and this resulted in one student missing some of the industry field trips. For future bridge programs, we intended to also fund stipends for program participants so they do not need to work while enrolled and can fully concentrate on studying the material.

Conclusions

This program was largely successful and preparing students to be successful in the calculus sequence required for the engineering major. While some students were not successful in the program, those students still gained in their mathematics readiness. The students who were not able to be successful in their mathematics courses after participating in the summer bridge program were also the students who were not accepted to the engineering program based upon more than just math readiness, but also a lower grade point average. The summer bridge program is thus likely going to be most successful for students who are highly motivated as determined by high school grade point average, but who are not as prepared in for mathematics based upon test scores and the highest level of math taken prior to matriculation to the university. It thus becomes critical to develop a relationship with students earlier, potentially while they are still enrolled in high school, to build a mentoring relationship leading to stronger readiness for engineering and mathematics.

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