

Online Engineering Bridge Summer Program Created and Focused on Preparing Students for Calculus

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Work In Progress: Online Engineering Bridge Summer Program Created and Focused on Preparing Students for Calculus

Abstract

The Louisiana State University Bridge to Engineering Excellence (BEE) Program was developed in response to the cancelation of an in-person minority focused university wide-residential bridge program due to COVID-19 in 2020, and it is a work in progress. The BEE program has been continued each summer to provide preparation for incoming students who cannot participate or choose not to participate in a traditional in-person full-time bridge program. BEE program goals through all three summers has been to provide first-year engineering and computer science students review and preparation for differential and integral calculus, build connections with current successful engineering students, and introduce skills for becoming a successful student in STEM courses. The ultimate desired outcome is to increase retention and improve academic performance, particularly in math courses.

The initial major concern when creating the program was that incoming students would not be prepared for college-level calculus due to lack of any bridge opportunities. The BEE program includes synchronous math classes over six weeks, required daily tutoring sessions, and weekly academic and professional success workshops. The BEE program is taught online by university-based PhD mathematics faculty with extensive experience in these fields. The calculus class topics include inverse functions, logarithms, trigonometry, limits and continuity, differentiation, applications of differentiation, integration, and applications of integration.

Initially, the course material was presented in a PowerPoint format, and based on student and tutor feedback this evolved to presenting all materials using an iPad in conjunction with the app GoodNotes. This iPad format has several advantages including material being presented in a classical 'whiteboard-like' setting, and giving the presentation a more traditional theme, and a format that allows for recording, posting, and editing the virtual class for future study. The class structure also utilized breakout rooms to change the pace and encourage interaction with other class members and tutors. Another change was the use of mandatory quizzes and final exam. Although, the course 'grades' were not 'real,' it gave students immediate feedback on their level of knowledge and simulated a credit course providing more motivation, thus, increasing student participation in the assessments. Another element of the program was daily one-hour tutoring sessions and these have been a part of the program from the beginning. Tutors are current engineering and computer science students and are assigned to the same participants throughout the program. The sessions are designed for homework assignments and attendance was required. The BEE program assigned weekly readings on topics to establish a foundation for engineering success. The topics ranged from mental health to internships with current engineers and the material was presented as a featured speaker or a panel. Tutors initiated discussions about the weekly topics during their sessions. Based on the feedback the utilized book was changed to *The Secrets of College Success* and the readings were targeted toward success in STEM courses.

The program so far has helped BEE students increase their mean calculus readiness ALEKS math scores from 58 to 82/100, and the first-year GPAs have improved to 3.20 versus the historical average of 2.75 for CoE majors. Historically, 2nd-year retention in LSU CoE majors has been 67 percent and for BEE students this is now 77 percent.

1. Background

Since 1991, the Louisiana State University Summer Scholars Program has been providing incoming, under-represented first-year students with a residential program to transition to college academics and life. The Summer Scholars program is for students the summer before their freshmen year, and it provides participants the opportunity to take academic courses for credit, develop leadership skills, and build social and cultural connections. The structured environment included scheduled homework sessions, tutoring sessions, academic counseling, and group activities [1]. Faced with the suspension of all in-person programs including Summer Scholars, activities, and classes due to COVID-19 in 2020, the Bridge to Engineering Excellence (BEE) Program was developed by the LSU College of Engineering.

The initial major concern when creating program was that incoming CoE students would not be prepared for college level calculus due to lack of high school math preparation and any opportunities that connected with LSU and current students.

The LSU CoE is focused on meeting the demands of the engineering industrial community for low-income, diverse populations. Due to historic segregation, unprecedented natural disasters, and economic hardship, Louisiana public schools place 49th in the nation [2]. Poverty is the primary reason, and many incoming students, despite their best academic efforts, have limited access to earn credit in Dual Enrollment or Advanced Placement math and other STEM courses. Thus, these talented students are ‘underprepared’ for the rigors of engineering and more specifically calculus.

Based on data collected for the State of Louisiana [3] 10% (1,889) and 11% (2,058) of all math classes were taught by out of area teachers and uncertified teachers, respectively. Teacher deficits in math likely transmit to student math academic deficits thereby affecting their pursuit of STEM fields.

To assess the effect of math preparedness on students’ success in engineering, LSU engineering students’ retention and graduation rates were compared for students taking Calculus I (MATH 1550) or Algebra / Trigonometry (MATH 1020,1022,1023) in year 1. Students taking Calculus I in year 1 graduated at a rate 12.4% higher than those who did not. African American students had the lowest graduation rate of all ethnic groups. Thus, math preparedness has a critical correlation of success in graduating with an engineering degree, particularly for diverse and underserved populations.

Newman [4] discussed moving from remediation classes, especially in mathematics, to a co-requisite model of education and highlighted that the assumption that all high school students are prepared for college-level work is incorrect. This especially impacted students interested in STEM fields. Students being ill prepared students is a national problem [5] which is further evidenced by reduced numbers of students pursuing math-based disciplines [6]. While K-12 institutions try to solve the problem, higher education must develop ways to address these issues. The Bridge to Engineering Excellence (BEE) program is part of several LSU CoE initiatives that results in a co-requisite model preparing students in mathematics their first year along with necessary support programs for retention.

The initial BEE program goals were to provide first-year engineering and computer science students an online synchronous program that reviews and prepares for differential and integral calculus, builds connections with current successful students, and introduces skills for becoming a successful student. The BEE program has been continued each summer since the initial program in summer 2020. The same goals have continued through all three summers, and the 2022 bridge program incorporated more student accountability and flexibility. The ultimate desired outcome is to increase retention in College of Engineering majors and improve academic performance, especially for students who may be underprepared for college level calculus. The following is a presentation of this work in progress.

2. Program Design and Evolution

The BEE program was six-weeks long and included a synchronous math class, daily tutoring sessions, and weekly academic and professional success workshops.

Math Class

The BEE math class met four days a week for one hour, and it was taught online by university-based PhD mathematics faculty with extensive experience in the math topics presented. The calculus class topics covered were inverse functions, logarithms, trigonometry, limits and continuity, differentiation, applications of differentiation, integration, and applications of integration. Class attendance was required. To reinforce the need to complete daily homework, BEE participants were also required to meet with a tutor for one hour each class day to complete assignments.

The text for the course for all three years has been *Calculus: Early Transcendentals*, 8-th Ed. by James Stewart, Chapters 1-3. Initially the assigned homework was completed through WebAssign, which is the method utilized by most calculus classes at LSU. Due to tutor accessibility to WebAssign and costs, this was changed to written homework assignments submitted via Moodle in 2022.

There were several other changes implemented in the *LSU Bridge to Engineering Excellence* (BEE) program for the 2022 summer that improved overall course efficiency, student learning, and assessment.

Presentation Method: GoodNotes & iPad

Based on feedback from students and tutors in the 2021 summer program, it was decided to move away from presenting course material via a PowerPoint format and to present all materials using an *iPad* with the purchased app *GoodNotes*.

Advantages

- The material was presented in a classical ‘whiteboard-like’ setting, which gave the presentation a more traditional theme, even though the class itself was virtual.
- The *GoodNotes* technology offered multiple colors, drawing tools, fonts, font sizes, etc., that are generally not available in a PowerPoint presentation, and not even for many in-person classes. Figure 1 is a graphical example of one of the class notes.
- Using this whiteboard setting allowed the students and instructor to engage more (which is crucial in an online class) and work problems together in unique ways.
- All class notes were recorded, posted, and even edited, for future study. This is even more advantageous than an in-person class.

Engagement: Zoom Breakout Rooms

Another revision implemented for 2022 was the regular use of *Zoom Breakout Rooms* throughout the week. During this time, the class would separate into groups of 3-4 using the Breakout Room tool in Zoom and work on Math problems directly related to the lesson of the day. For each breakout session the groups were randomly assigned by Zoom.

Advantages

- The Breakout Rooms allowed for a ‘change of pace’ in the class and helped avoid monotony.
- By implementing in-class work, the students were exercising their mental faculties and were more engaged in the class.
- The Breakout Sessions encouraged direct participations and allowed students to interact with one another and cooperate with each other, which is something crucial in a learning environment and often lost in a virtual class setting. This, in turn, is believed to help increase the retention of information presented in the class.

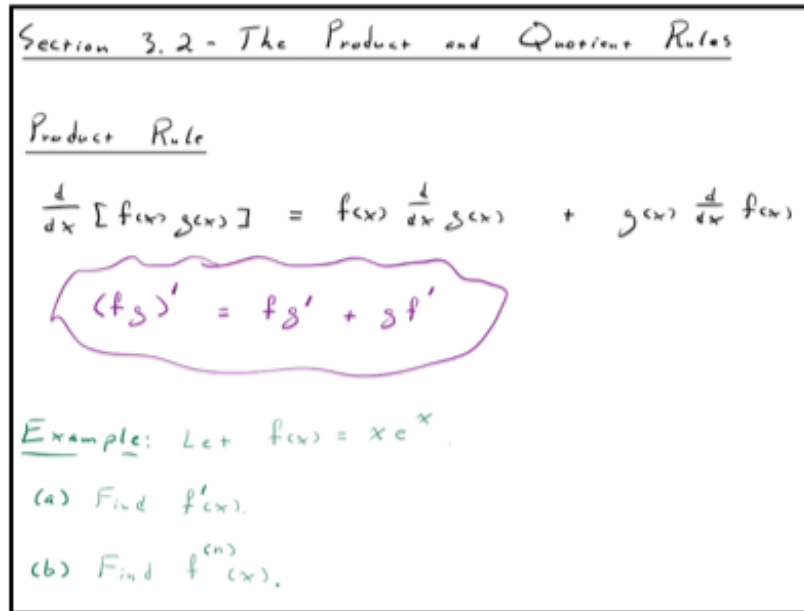


Figure 1. GoodNotes Lesson

Attendance: Zoom Usage Reports

In the 2021 summer program, attendance was taken manually using an Excel spreadsheet, although, attendance was not included as part of the final course grades. However, for 2022, *Zoom Usage Reports* was implemented, and attendance points were assigned the following grades based on the amount of time students spent in each Zoom session:

- A (3 Points): 46-60 min
- B (2 Points): 31-45 min
- C (1 Point): 16-30 min
- F (0 Points): 0-15 min

Moreover, an extra point was deducted for students who left the Zoom Meeting just before a Breakout Session or participation-based class activities.

Advantages

- Zoom Usage Reports (Figure 2) were automatically recorded on the LSU Cloud server. Thus, if the instructor forgets, is unable, or does not have time, to take attendance then he/she can simply look up the usage reports later/date. This technological advancement is unavailable in an in-person classroom.
- By not having to focus on attendance, the instructor devoted more time and attention to the students and the daily lesson.

Meeting Participants			
<input checked="" type="checkbox"/> Export with meeting data		<input type="button" value="Export"/>	
<input checked="" type="checkbox"/> Show unique users			
Meeting ID : 929 5486 9384	Topic : LSU BEE Math	User Email : imichael@lsu.edu	
Duration (Minutes) : 84	Start Time : 06/13/2022 08:42:51 AM	End Time : 06/13/2022 10:06:50 AM	
Participants : 18			
Name (Original Name)	User Email	Total Duration (Minutes)	Guest
[REDACTED]		84	Yes
[REDACTED]		74	Yes
Isaac Michael	imichael@lsu.edu	74	No
[REDACTED]		67	Yes

Figure 2. Zoom Usage Reports

- By including attendance as a part of the final program ‘grades,’ the students’ participation significantly increased in 2022 as opposed to 2021 when enforcement of attendance was more lenient.

Performance Evaluation: Mandatory Assessments

In 2021, student participation in quizzes/exams was not rigorously enforced. However, for 2022 mandatory participation in quizzes/exams was emphasized and included an end-of-program Final Exam.

Advantages

- Although the course grades were not taken as part of the students’ university GPA, it gave students immediate feedback on their level of knowledge and simulated a credit course providing more motivation, thus, increasing student participation in the assessments
- The assessments were helpful in determining which students held the most potential for future success at the university, and thus could potentially be considered for scholarships and merit-based funding.
- Assessments offered insights and direct feedback on students’ abilities to the tutors for the program and helped them tailor sessions to the needs of individual students.

Instant Feedback: Zoom Polls

For 2022, Zoom polls were created by the instructor and were frequently used during each class session. These polls were to help adjust teaching delivery, and for simplicity only three simple polls were developed. The polling questions and options were:

Poll 1: Yes or No?

Answer the instructor’s question with either Yes or No.

Poll 2: Pacing

The pace is: Too fast, Too slow; Right pace

Poll 3: Understanding

The topic is: Clear; Somewhat clear; Not clear

Advantages

- The Zoom polls allowed the students to provide instant feedback to the instructor. This allowed the instructor to adjust the flow of the lesson as needed to best foster student learning.
- The poll responses were anonymous, which made students more willing to provide honest feedback in case they did not understand a particular topic.
- Tutors were made aware of the feedback, so they had insight into topics that were unclear.

Tutor/Mentor Selection, Training, and Implementation

Peer instruction and tutoring has been shown to be effective for engineering students struggling in courses during traditional academic terms (fall, winter, and spring) [7-11]. Following this model, upperclassmen engineering students were employed to help tutor and mentor incoming freshmen in the BEE program. Tutors and mentors were selected for the BEE Program through an advertisement and recruitment method (Handshake) used at the home institution for job searches. All tutors were vetted by a careful scanning of their academic history, their resume and through an interview. During the interview, applicants were asked about why they wanted to be a tutor, their previous experience with tutoring and their thoughts on being a mentor. Although some of the applicants did have professional tutoring experience, all tutors interviewed mentioned a strong desire to help others and a history of helping friends and classmates with their homework assignments. A sufficient number of tutors were hired to provide individual or paired tutoring sessions.

Every year of the program, students with a GPA of 2.7 and above, not less than a B- or better in their Calculus courses and a strong desire to help others were selected to be tutors in the program. For the first two years, students who did not meet the academic criteria or who could not commit to the daily meetings with students were asked to be mentors only. In the third year of the program, tutors were asked to assume both the mentor and tutor role, because previous years had shown that the mentoring meeting attendance dwindled greatly after the first two weeks because the weekly topics were discussed during free time in tutoring sessions. Tutors were given access to all the lecture topics for the entire six weeks the week before the program started to have time to review the topics. Also, before the program began, tutors and students were matched based on availability first, then by major. This was done to ensure that all students met with tutors when both parties had time. These pairings were done before the program started to facilitate meetings on the first day. Tutors were encouraged to attend the daily math sessions to hear the topics the students were covering. Sessions were held outside of lecture and the BEE instructor's office hours and were an hour each. Tutors went over the daily assignments with the students in the program and helped to cover fundamentals needed to solve the problems in the assignments. Tutors noted a concerning trend of students, though knowledgeable in advanced math, had forgotten fundamental algebra and geometry techniques.

Academic and Professional Workshops

It was decided that BEE students would need additional opportunities to connect with current students and advice on how to become a successful LSU CoE student. A weekly one-hour workshop with near peer mentoring sessions was determined to be the best format to provide information about academic and professional success topics. The six workshop topics for 2020 were stress management; time management; classroom practices and professor office hours; how to learn, study and do homework; procrastination and hurdles; and connecting with industry.

These workshops followed the lessons presented in the Guaranteed 4.0 book and system. In 2021 and 2022, the topics remained basically the same although time management and the study cycle was combined into one workshop, and the procrastination and hurdles workshop was replaced by a broader ‘Advice from Students Who Have Been There’ workshop. The team decided to utilize the book *The Secrets of College Success*, Lynn F. Jacobs and Jeremy S. Hyman and provided specific assigned and recommended readings.

Program Cohorts

The initial cohort in 2020 was recruited primarily from incoming first-year CoE students who submitted applications to the traditional residential Summer Scholars program. The 2021 and 2022 participants were recruited from the incoming CoE declared majors with targeted emails sent to under-represented minorities and females. This program was also promoted at recruitment and orientation sessions for all students. Other criteria for participation included a minimum 25 ACT composite score and minimum 3.0 high school GPA. The number of participants has grown each year and has become increasingly diverse (Table 1). The 2020 cohort had 9 students; 2021 cohort had 17 students, and 2022 cohort had 31 students. As the program has grown, the number of underrepresented groups has increased with 68.4% of the participants in 2022 being a part of at least one underrepresented minority. The program

Table 1. The demographic composition of the BEE program and majors in the LSU College of Engineering.

Cohort	BEE 2020	BEE 2021	BEE 2022	All	CoE (2021)
Number	9	17	31	57	3396
Race/Ethnicity					
American Indian		6%	3.2%	3.5%	0.6%
Asian		12%	3.2%	5.3%	7.2%
Black	100%	24%	25.8%	40.4%	11.6%
Hispanic		12%	6.5%	7.0%	7.6%
White		12%	51.6%	31.6%	67.5%
2 or more		35%	9.7%	12.3%	1.6%
Gender					
Male	56%	53%	61.3%	57.9%	78.6%
Female	44%	47%	38.7%	42.1%	29.4%
Residency					
Louisiana	67%	65%	77.4%	71.9%	70.4%
Other	33%	35%	22.6%	28.1%	29.6%
Majors					
BE	22%	-	6.5%	7%	6.1%
ChE	11%	6%	6.5%	7%	10.8%
CE	11%	-	6.5%	5%	9.1%
CompE	22%	6%	6.5%	9%	3.6%
CSC	-	24%	22.6%	19%	15.3%
EE	-	6%	9.7%	7%	6.8%
EVEG		-	3.2%	2%	2.6%
IE	-	-	3.2%	2%	4.7%
ME	22%	59%	29.0%	37%	18.8%
PETE	11%	-	6.5	5%	3.5%
CM	-	-	0%	0%	18.3%

also serves a higher percentage of female students than what is common currently in the CoE at LSU.

Academically, the students had mean ACT scores of 26.7 composite and 26.4 Math. The LSU Math department requires students to take the ALEKS Math test for placement into math, and minimum score of 76 is required to enroll in the first calculus course, Math 1550. All students were asked to take the ALEKS Math test prior to starting the BEE program, and 43.9 percent scored 76 or higher with the overall mean score of 70.2 (Table 2).

3. Outcomes

To measure the impact of the program on the outcomes of academic performance and retention, ALEKS math scores, first calculus GPA, first semester GPA, second semester GPA, overall GPA, retention in CoE, and retention at LSU were tracked.

The ALEKS math scores and calculus ready percentage were tracked and calculated for all BEE participants (Table 2). A minimum score of 76 determines if a student is calculus ready. Of the participants not calculus ready, 66.7 percent increased their scores and the mean score improved to 82.0. This improvement is comparable to the 83.6 mean of the subset of participants who qualified for calculus prior

to the BEE program. It was observed that the students who initially qualified for calculus with an ALEKS score 76 or above also had higher ACT scores. The academic performance including GPAs of calculus, first semester, second semester, and overall year 1 and year 2, was tracked for all participants and those retained in the CoE (Table 3). Historically, the mean GPA for CoE students for their first semester has been 2.75 and after the first year has been 2.75 (std 0.80). While the BEE participants had a first semester GPA of 3.200 (std. 0.735), and year 1 GPA of 3.177 (std 0.652). This indicates that BEE participants performed better academically than the overall CoE students.

Table 2. Math readiness for BEE participants 2020-2022

Math Indicator	All	ALEKS>75	ALEKS<76
Pre-Program Calculus ready	43.9%	100%	0%
ALEX Pre-Program Mean Score	70.2	83.6	57.8
Post Program Calculus ready	73.7%	100%	66.7%**
ALEX Post Program mean score*	NA	NA	82.0
ACT Composite	26.5	27.5	26.0
ACT Math	26.1	26.6	25.8

*Mean of students who took the ALEKS who had a pre-program ALEKS <76 and took the test mid-program or later.

** four students decided not to take calculus 1 the first semester and did not take the ALEKS test again.

Retention in the CoE was a major goal of the program, and it has been tracked each year (Table 4). When compared to the historical data, the BEE participants from the 2020 and 2021 cohorts are persisting in the CoE at a much higher rate; i.e., 10 percent higher for year 2 retention based on 2020 and 2021 cohorts, and 34 percent year 3 retention based on 2020 cohort. The three changed majors and went into business majors (2) and art (1). Three participants additional students from cohort 2020 and 2021 are no longer LSU students for several reasons.

Comments and actions from multiple BEE participants indicate that the program was beneficial academically and helped them connect with the LSU CoE students. Student

HR noted she ‘would not have survived the first semester without BEE;’ and student CW said that ‘Calculus review and prep made the first month of calculus less stressful and easier.’ Multiple BEE participants are now leading organizations, serving as tutors, and receiving 14 National Action Council for Minorities in Engineering (NACME) scholarships.

4. Lessons Learned and Future Plans

The Bridge to Engineering Excellence was created as an urgent response to a COVID-related suspension of in-person learning and bridge programs, not effort to study a particular engineering education research hypothesis. Meanwhile, several lessons were learned;

- Creating a program that captures in-person type activities i.e., slides versus GoodNotes.
- Using Zoom technology to streamline administrative tasks while the instructor focuses on creating an engaging class. This allowed enforcement of video engagement.
- Simulating the homework, quiz, and test expectations of a credit course will elicit student behavior as if it were for credit.
- Moving group work to the beginning of class and the addition of attendance points decreases the number of students who leave class early. Some students were hesitant to participate in group work and would drop off when group activities were held at the end of class.
- Scheduling tutoring sessions with the same tutor modeled the expected college-level study habits and allowed the participants to truly connect with a current student.

Table 3. Academic performance of three cohorts. Mean data presented.

Academic Indicators	Cohort 1	Cohort 2	Cohort 3	All	Retained
First Calculus GPA	2.857	2.608	3.216	2.895	2.966
First Semester GPA	3.101	3.103	3.284	3.200	3.261
Second Semester GPA	2.916	2.953	-	2.941	2.832
Overall GPA Year 1	3.146	3.192	-	3.177	3.084
Overall GPA Year 2	2.912	-	-	2.910	2.912

Table 4. Retention of BEE compared to CoE historical data 2008-2019. Year 2 cohorts 2020 and 2021. Year 3 data only 2020 cohort.

Retention	Year	BEE All Cohorts	Historical CoE Mean
In CoE	Year 2	77%	67%
	Year 3	89%	55%
At LSU	Year 2	81%	83%
	Year 3	89%	75%

- Gathering feedback from tutors provided another source about the calculus delivery methods and content and student level of comprehension. One example is decreasing the amount of homework type problems done in class.

The program is still in the early phase and second year academic and retention data are limited to only 26 students, thus it is too early to draw significant conclusions, although the retention and first semester mean GPAs looks promising. First semester GPA data for the 2022 cohort showed an overall increase in performance compared to cohort 1 & 2.

The in-person Summer Scholars Program residential bridge program was restarted in summer 2022, and the program was modified from the years prior to the COVID19 hiatus. This program admits underrepresented minority students from all majors at the University; is administered within the first-year college of the university and has many more contact hours with the students including credit course work. The outcomes (retention and GPA) for the two programs will be compared at the end of the 2022-2023 academic year with a focus on CoE majors.

The administrators of the BEE program continue to collect student, tutor, and instructor feedback and plan to implement changes to the program annually. One change for the 2023 BEE program is to limit the number of assigned problems solved during class. Doing this will allow the tutors to have more material to cover with the students in a smaller setting. This will also encourage students to work more problems on their own, thereby helping them to retain the math topics being taught and should result in increased scores in their first calculus course.

The academic team plans to develop an educational research plan for the program and gauge the effectiveness of aspects of the program, particularly for underrepresented groups. One hurdle for this endeavor (and institutional data safeguards) has been gathering the appropriate comparative data, thus the ability to calculate informative statistics has been lagging. The BEE program will develop more detailed pre- and post- surveys of the participants, and the goals of these surveys are to gather expectations, motivations, and perceived program efficacy. In 2021, the LSU CoE was awarded an NSF S-STEM grant (PRISE Program) to offer scholarships to high achieving but underprepared low socioeconomic status students and to study the relative success of early academic and professional development intervention on the ability of this group to obtain gainful employment upon graduation with of 10 out of 11 CoE undergraduate degrees. The PRISE students are strongly encouraged to enroll in the BEE program and will, therefore, have their progress through the CoE programs assessed thoroughly. The CoE plans to continue this online bridge program based on the initial positive indicators.

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