



Examining the effectiveness of the Engineering Launch program for first-year engineering students

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Motivation and Background

This COMPLETE EVIDENCE-BASED PRACTICE PAPER examines whether participating in the Engineering Launch program at a large Midwestern land-grant university - Kansas State University influences the academic readiness of engineering students before they enter Calculus I. Many students enrolled in Calculus I are not prepared for it. Even students that previously took the course in high school may struggle in Calculus I as many high schools are allowing students to skip Trigonometry. The summer bridge program Engineering Launch aims to improve students' math preparation in Algebra I, Geometry, Algebra II, and Trigonometry, and bridge the perceived gaps in math preparation to get students ready for Calculus I.

Many universities around the country have implemented similar remedial programs. There are two common approaches. One is a workshop-style course, which typically requires weekly class time in addition to regular lectures [1]. The other one, which is a more common approach, is to offer a bridge course before the semester starts, with duration from one-week long [2] to several weeks [3-5]. For example, Cancado, Reisel, and Walker [3] examined the impact of a 4-week summer residential bridge program on engineering student retention. Students with low math preparedness were admitted into the bridge program since these students historically had a low level of success and graduation rate in the College of Engineering. The 4-week program focused on math preparation but also had team building and academic skills preparation components. They tracked student improvement in math placement exam scores in the short term; the 1-year, 2-year, and 3-year retention rates; and the 5-year graduation rates among three ACT ranges (low: 17-23, middle: 24-27, and high: 28+). They found the retention rates were statistically significant for the middle ACT range group only, but the 5-year graduation rates were not statistically significant for any group.

In a similar residential 5-week summer bridge program [4], both math classes and hand-on activities, such as lab experiences, field trips, and a community service project, were offered in

order to prepare students to be successful in calculus and excited about engineering. This program improved retention of students in STEM fields overall by 12% after three years.

In another hybrid summer bridge program [5], both online and in-person components were included to improve math preparation among incoming students who initially place into a math course below Calculus I. The results indicated that both student preparation before enrolling in the summer bridge program as measured by ACT scores and the amount of time the student spent learning during the bridge program were positive predictors of student success. Taken together, these programs have shown overall positive results by increasing student academic performance and retention.

The Engineering Launch program described in this study took the second approach by offering a summer bridge course prior to the fall semester. This course was offered as a zero-credit hour course, which consisted of a three-week online component and several in-person events the week before classes started. The in-person events provided opportunities for the participants to meet administrators, faculty members, the Calculus I tutors employed by the College of Engineering, and each other. The online course consisted of synchronous lectures delivered via Zoom, but recordings were posted for students who were unable to attend or wanting to watch a lecture multiple times. Students completed online and written homework similar to the formats used in Calculus I. The Engineering Launch program was conducted during the pandemic, which likely improved online course offerings and made both faculty and students more comfortable with different modalities of instruction. All online instruction and module content was provided and delivered by a seasoned Calculus I instructor, who has over 15 years of experience teaching courses in the calculus sequence. The course also included one-on-one tutoring from a graduate teaching assistant in the Department of Mathematics.

Learning about the usefulness of the Engineering Launch program can inform researchers, instructors, and administrators how to improve the readiness of first year engineering students in Calculus I and make it an effective approach in helping engineering students succeed academically.

Methods

This study examines whether participating in the Engineering Launch program influences: a) the academic readiness of engineering students before they enter Calculus I, and b) their academic performance in Calculus I. In this quasi-experimental quantitative study, we focused specifically on students who are not ready to enroll in Calculus I for three reasons: a) Calculus I is a required course for all engineering students, b) delayed enrollment in Calculus usually leads to delays in the time to graduation, and c) Calculus I is a strong predictor of whether or not a student will be retained in engineering.

To recruit participants, in April 2021, an email was sent to all incoming students who had been admitted to College of Engineering for Fall 2021 to invite them to participate in the Engineering Launch program. To increase the appeal of the program, a small scholarship of \$200 upon completion of the program was offered in the invitation email. Students who were interested were asked to fill out a Qualtrics screening survey. To identify students who were not ready for Calculus I, the Qualtrics screening survey included questions about ACT scores and students' self-assessment of their confidence in the following five areas: Algebra I, Geometry, Algebra II, Trigonometry, and Calculus I. To be eligible, a student must have indicated some self-perceived deficit in at least one of the first four areas in their self-assessment. Priority was given to students who have not taken a calculus course before or had an ACT score below 28, the typical cutoff score being used among engineering programs. These criteria were chosen given the existing literature on the importance of factors, such as ACT scores, self-perceived attitudes and preparedness toward math, on first-year engineering retention [6]. Out of 75 students who responded to the Qualtrics survey, many respondents either had high SAT scores or had already taken Calculus and thus were not selected. 30 met the criteria and were selected to participate in the Engineering Launch program.

Procedure and Measures

24 students agreed to participate in the Engineering Launch course, and they first took a pre-test to assess baseline knowledge and competency in algebra, geometry, and trigonometry before

being exposed to the learning materials. Once they completed the pre-test assessment, they were then given an orientation about the online course and what was expected of them in order to complete the course. The course included 15 synchronous lectures via Zoom, each offered in the morning and evening, and recordings were made for students unable to attend or wanting to watch a lecture multiple times. Students were asked to complete 11 online homework sets in the WebWork system used in Calculus I and 13 written homework sets. Immediately after the conclusion of the course, all participants took a post-test to assess their knowledge and competency in algebra, geometry, and trigonometry again. The pre-test and post-test had the same 15 questions; these questions required students to utilize algebra, geometry, and trigonometry skills that are needed to complete certain problems in Calculus I. Additionally, all participants' demographic information, including ethnicity, gender, first-generation status, and ACT record were retrieved from the College of Engineering's main student database.

Results

SPSS v. 25 was used for all statistical analyses. Missing data and statistical assumptions were first checked. The pre-test and post-test total scores were calculated. The test scores ranged from 0 to 30 on each test. Descriptive analysis was conducted on both average pre-test score, $m = 9.14$, $SD = 4.05$, and post-test score, $m = 19.19$, $SD = 7.02$. A paired-sample t-test was conducted to examine the statistical differences of the scores in the pre-test and post-test. The results showed a statistically significant increase in the post-test performance, compared to the pre-test performance, $t(20) = 6.97$, $p < .001$, 95% Confidence Interval (0.88, 2.15). The statistical difference indicates a very large effect size, Cohen's $d = 1.68$. The findings suggest that the Engineering Launch program made a significant positive impact on students' readiness before they entered Calculus I in Fall 2021.

Furthermore, at the end of the Fall semester, these students' academic performance in Calculus I was retrieved for further analysis. For comparison, among all first-year engineering students that started Calculus I in Fall 2021, an overall rate of 69.5% earned a 'C' or better in the course. If the Engineering Launch program did not have any impact, we would expect those enrolled in the program to have an overall rate of 69.5% earning a 'C' or better in Calculus I. It turned out 75%

of the students who completed the Engineering Launch program earned a 'C' or better in the course.

Discussions and Conclusion

This paper looked at the effect of the Engineering Launch program on math preparedness among incoming first-year engineering students in the College of Engineering at a large Midwestern land-grant university, Kansas State University. The Engineering Launch program is a newly developed summer bridge program to help prepare students who scored low on a math placement exam to be successful in Calculus I. We examined whether participating in a 3-week long summer program influenced the academic readiness of engineering students before they enter Calculus I as well as their academic performance in Calculus I. The results from the first cohort of students showed significant improvement in math readiness before they entered Calculus I. Once enrolled in Calculus I, the students that completed the Engineering Launch program were 6% more likely to earn a 'C' or better, compared to all first-year engineering students who started Calculus I in the same semester. These results suggest that the Engineering Launch program makes a positive impact on student math preparation in engineering programs.

We intend to offer the Engineering Launch program and potentially accept more students into the program in the near future if the funding is available. The priority will be given to first generation, and/or historically underrepresented minority students. With the COVID vaccines and other mitigation strategies, it is highly likely the program will be offered in person fully. We want to note that there may be students who met the criteria to participate in the Engineering Launch program but chose to not apply to the program for various reasons. In future semesters, we will increase our efforts to reach out and recruit these students who are likely to benefit academically from such a program.

References:

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