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ALA MOANA HOTEL, HONOLULU, HAWAII

INCREASING CALCULUS II SUCCESS WITH A BRIDGING PROGRAM

NITE, SANDRA B.

TEXAS A&M UNIVERSITY

DEPARTMENT OF TEACHING, LEARNING, & CULTURE

G. DONALD ALLEN

TEXAS A&M UNIVERSITY

DEPARTMENT OF MATHEMATICS

Sandra B. Nite
Department of Teaching, Learning, & Culture
Texas A&M University

G. Donald Allen
Department of Mathematics
Texas A&M University

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Synopsis:

To improve success in Calculus II, we launched a one-week Bridge Program to strengthen skills of students who earned a B or C in Calculus I. Preliminary results are promising; 150 students enrolled. The 60 students who completed the survey at the end were very positive about the experience, believing it helped them recall previous skills and refine their calculus knowledge. The program was completely online with 15 hours of instruction through live tutors and online practice problems.

Increasing Calculus II Success with a Bridging Program

Sandra B. Nite
Aggie STEM
Department of Teaching, Learning, & Culture
Texas A&M University

G. Donald Allen
Department of Mathematics
Texas A&M University

Abstract

It is well known that success in any mathematics course is very dependent upon a high degree of success in prerequisite courses. STEM majors generally require a sequence of mathematics courses, and grades tend to drift downward throughout the sequence of courses. The mathematics department at Texas A&M University launched a one-week Bridge Program to improve calculus skills for students who earned a B or C in Calculus I in order to better prepare them for success in Calculus II. 122 students participated at least 25 minutes, and 41 completed the survey at the midpoint of the Calculus II the following semester. Students participated online with headsets to interact with a live tutor for 3 hours per day for 5 days in a mini session between the fall 2013 and spring 2014 semesters. Students who completed the survey ($n = 41$) felt better prepared for Calculus II.

Increasing Calculus II Success with a Bridging Program

Calculus success is important for students who aspire to STEM degrees and careers, but many students have difficulty successfully completing the required sequence of calculus courses needed to attain the desired degree in a STEM field (Bressoud, Carlson, Mesa, & Rasmussen, 2013; Hensel & Hamrick, 2012; Pyzdrowski, Sun, Curtis, Miller, Winn, & Hensel, 2012). The level of success in the first year of calculus study in college is one important predictor of persistence in engineering degrees (Minichiello & Hailey, 2013).

There are a number of factors that have been identified that have an important effect on mathematics success that is too important for majors that rely heavily on mathematics knowledge and understanding. Moreover, success in mathematics motivates students to persist (Halcrow & Dunnigan, 2012), and self-regulated students are more likely to achieve academic success (Cardetti & McKenna, 2012). The self-discipline needed to spend the required time and practice homework problems is an important aspect of motivation and self regulation.

Students in a study of intermediate algebra classes did not believe their performance was relevant to subsequent mathematics courses and that their attendance did not have a major influence on achievement on course content (Wheland, Konet, & Butler, 2003). However, results showed that student achievement in intermediate algebra did impact achievement in subsequent mathematics classes (Wheland), and there was a strong, statistically significant positive relationship between attendance and achievement (Thomas & Higbee, 2000; Wheland). A strong statistically significant positive correlation with calculus achievement was attitude towards the study of mathematics (House, 2001; Pyzdrowski, Sun, Curtis, Miller, Winn, & Hensel, 2012; Schoenfeld, 1989; Thomas & Higbee, 2000).

Research Questions:

- 1) How are background variables associated with midterm success in Calculus II?
- 2) How do specific features of the Bridge Program relate to student experiences and perceptions of the program?

Methodology

The participants were 41 students in a large southwestern United State university, who passed Calculus I with B or C and participated for at least 25 minutes in a one-week Bridge Program to improve skills before beginning Calculus II. Students met online with a tutor three hours per day for five days. Three sessions were scheduled, two sessions meeting from 9 a.m. – 12 noon, and two sessions meeting from 2-5 p.m. Topics studied were 1) derivative rules, including exponentials, logarithms, trigonometric and inverse trigonometric functions, and the chain rule; 2) graphing, including increasing and decreasing intervals, concavity, critical points, and optimization problems; 3) integration, including u -substitution and definite integrals; 4) partial fractions; and 5) using algebra to simplify derivative results.

A follow-up survey consisting of 14 questions was sent by email after the second exam in Calculus II to determine perceptions of the effectiveness of the program at that point and whether students were interested in the possibility of another bridge program from Calculus II to Calculus III (see Appendix). In addition, the number of minutes spent online with the tutor was collected from the online conferencing software used for the tutoring sessions. To analyze the data, the number of minutes spent online with the tutor was grouped such that 1 represented 1-146

minutes, 2 represented 157-497 minutes, 3 represented 509-820 minutes, and 4 represented 822-987 minutes.

Results

Students who earned a grade of B or C in Calculus I were invited to participate in the Bridge Program. Of the 41 participants, 23 had earned a grade of C and 18 earned a grade of B in Calculus I. Less than half (49%) of the students reported that they understood what was happening in the Calculus I class, while 39% said they sometimes understood, and 12% said they did not understand the materials in the Calculus I class they had just completed. Only 2 of the 41 students said they often participated in class discussion, and 51% said they never spoke up in class. 34 of the 41 students (83%) believed that the Bridge Program helped them become better prepared for Calculus II, and 34 of the 41 students believed the online environment used was just as effective or almost as effective as a face-to-face session with the tutor would have been.

The Department of Mathematics provides free help sessions, conducted by students who have successfully completed the class, so that current students in the class can bring questions and problems on which they need assistance. In addition, there are weekly review sessions conducted by one of the instructors, in which concepts are reviewed and example problems are worked and explained to the students. They also have the opportunity to ask questions during and after the session. There are commercial tutoring services also available off campus. Table 1 shows the number of students from the 41 participants who reported participating in various activities outside class to try to increase their understanding of Calculus I topics. Some of the students participated in more than one of the activities.

Table 1.
Number of Students Participating in Additional Activities

Activity	Number Participating
Help sessions provided by the mathematics department	13
Commercial tutor	15
Week-in-Review	18
Attended instructor office hours	15

There was a negative correlation ($r = -0.261$, $p = 0.099$) between time spent on the Bridge Program and student-reported understanding of concepts in Calculus I, indicating that students who did not understand Calculus I concepts did not spend as much time in the Bridge Program as students who did understand more of the Calculus I concepts. There was also a negative correlation between time spent on the Bridge Program and grade in Calculus I, but it was not statistically significant. There was a positive correlation with time spent on the Bridge Program and students feeling they were better prepared for Calculus II. In addition, the positive correlation between the student grade in Calculus I and estimate of grade in Calculus II at midterm was statistically significant.

Table 2 shows the Pearson correlation coefficient and p -values for correlations with time spent working in the Bridge Program. Figures 1 and 2 show the 95% confidence intervals for the effects for grades in Calculus I versus time spent on the Bridge Program and feeling better prepared for Calculus II after participating in the Bridge Program, respectively.

Table 2.

Pearson Correlation Coefficients and p-values for Time Spent in the Bridge Program

Calculus Attribute	Pearson Correlation Coefficient	p-value
Understood concepts in Calculus I	-0.261*	0.099
Grade in Calculus I	-0.169	0.292
Felt better prepared for Calculus II	0.313**	0.046

* $p < 0.10$; ** $p < 0.05$

There were three other interesting correlations that were statistically significant. 1) Student perception of feeling better prepared for Calculus II was positively correlated with their beliefs that the online environment was as effective or almost as effective as face-to-face sessions ($r = 0.368, p = 0.018$). 2) Student willingness to have spent a reasonable fee for the free Bridge Program was positively correlated with their belief that they were better prepared for Calculus II after participating in the Bridge Program ($r = 0.315, p = 0.045$). It is not surprising that the students who felt the Bridge Program helped them prepare for Calculus II would have paid a reasonable fee to participate in the program. 3) Student final letter grades in Calculus I were positively correlated with their estimated grades at midterm in Calculus II ($r = 0.413, p = 0.007$). This result is important because grades tend to drift downward in mathematics courses that build upon concepts from the previous course. Figures 1 and 2 show the 95% confidence intervals for the grade in Calculus versus time spent on the Bridge Program and student's feeling of preparedness for Calculus II versus time spent on the Bridge Program, respectively.

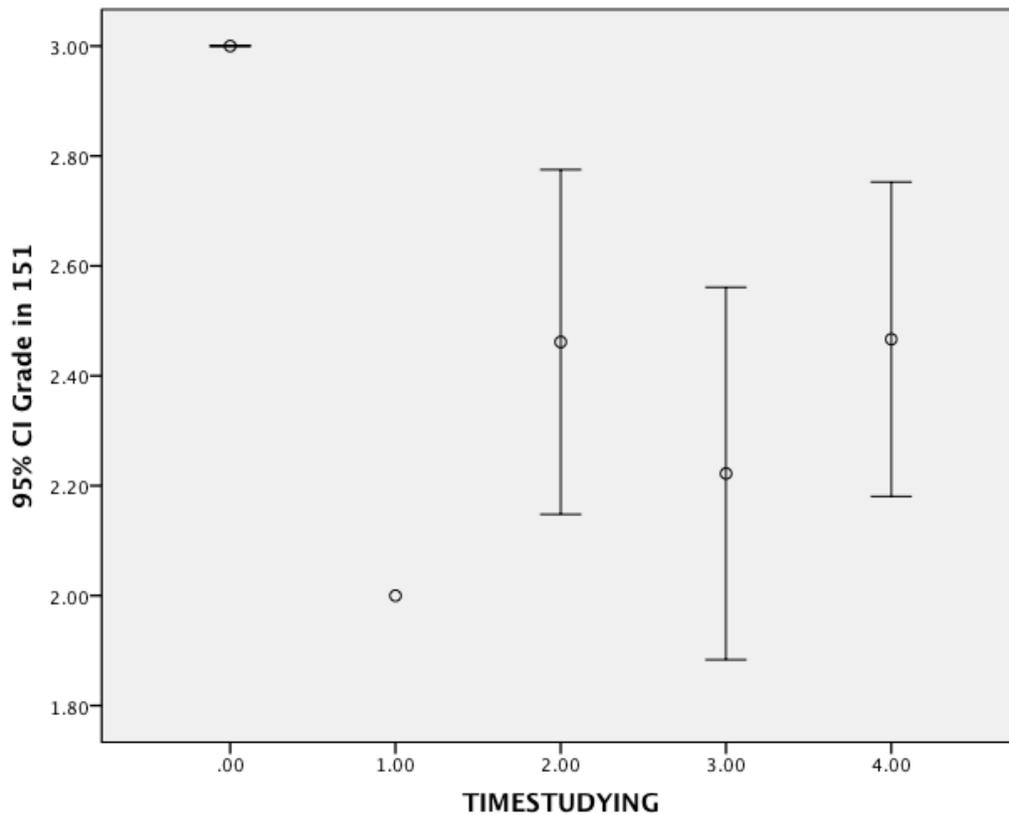


Figure 1. 95% Confidence Interval for Calculus I Grade vs Time Spent on the Bridge Program

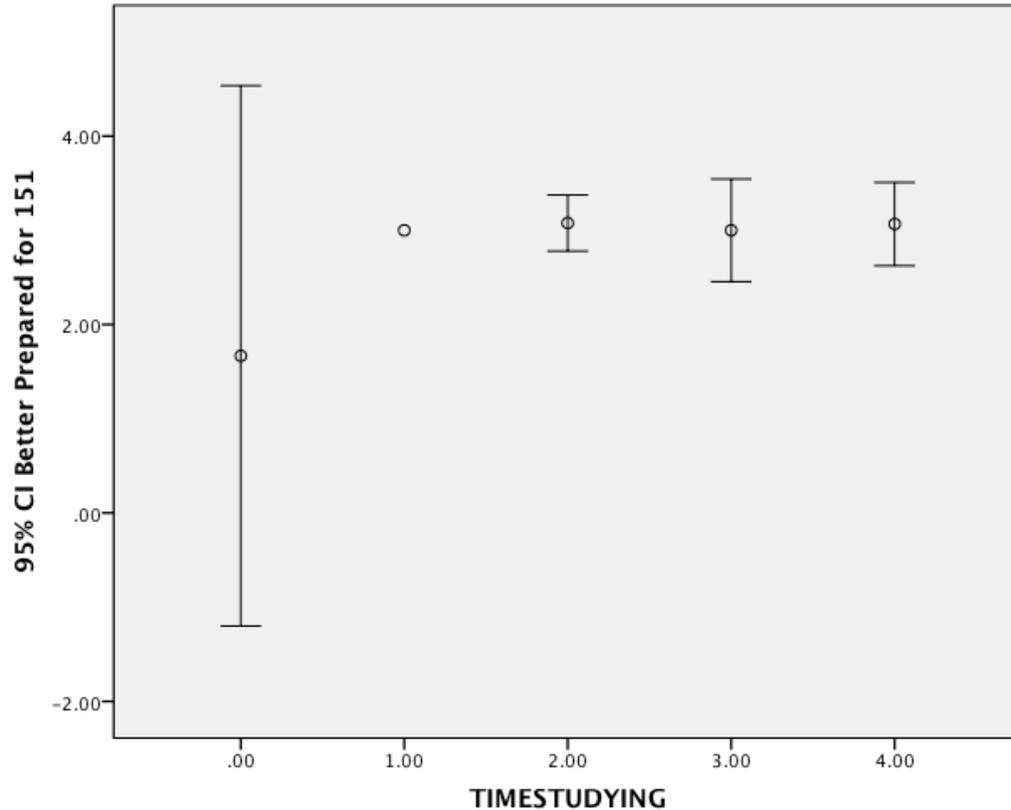


Figure 2. 95% Confidence Interval for Feeling Better Prepared for Calculus II versus Time Spent on the Bridge Program

Discussion

Students who participated in the Bridge Program were pleased with the program. They felt that they were better prepared for Calculus II at the midpoint of the course. Their grades at that point were positively correlated with their grades in Calculus I. This is important because mathematical concepts build on one another, and students who do not achieve high success in the initial course in a mathematics sequence tend to achieve at lower rates throughout the sequence. The students who participated in the Bridge Program after earning a B or C in Calculus I increased the possibility of higher success in Calculus II by strengthening their skills. Time spent on the Bridge Program was important in student success in Calculus II as well as their feeling of preparedness. For future Bridge Programs, tutors can share these results to encourage students in persisting and spending the necessary time to be successful, not only in the Bridge Program but also in subsequent calculus courses needed for their STEM majors.

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Appendix. Survey Questions

1. What grade did you make in Math 151 (Engineering Calculus I)?

- A
- B
- C
- D

2. Did you feel better prepared for Math 152 (Engineering Calculus II) after the Bridge Program?

Very true of me

True of me

Not very true of me

Not at all true of me

3. Last semester in Math 151 (Engineering Calculus I),

I understood what was going on in class.

Sometimes I understood what was going on in class.

Usually I did not understand what was going on in class.

4. Last semester in Math 151 (Engineering Calculus I),

I participated in class discussion often.

I spoke up a few times.

I did not speak at all.

5. When I was confused or did not understand calculus topics in class, (select all that apply),

I went to the Math 151/171 help session.

I used one of the local commercial tutoring services.

I went to the Week-in-Review sessions.

I visited my professor during office hours.

I continued studying until I understood.

Other (please specify)

6. Which of the following is true of you last semester in Math 151 (Engineering Calculus I)?

(select all that apply)

I was not confident enough to speak up in math class.

I thought I might be ridiculed.

The large class size made it intimidating to speak up.

7. Would you have signed up for the Bridge Program if it had required a reasonable fee?

Yes

No

8. In the Bridge Program, how effective was the online environment with your tutor, compared to a face-to-face class?

Online was just as effective as face-to-face.

Online was almost as effective as face-to-face.

Online was not quite as effective as face-to-face.

Online was not at all as effective as face-to-face.

9. The Bridge Program lasted for a total of 15 hours (5 days, 3 hours a day). How do you feel about that length? (check all that apply)

The time span should be longer – 2 weeks.

The hours per day should be longer – 4 hours

The hours per day should be shorter – 2 hours

It was just right.

Comments:

10. Why did you decide to sign up for the Bridge Program?

11. At this point in Math 152 (Engineering Calculus II), do you feel that the Bridge Program helped you gain the success you have so far?

Definitely

Somewhat

Not much

Not at all

12. What would you estimate your grade in Math 152 (Engineering Calculus II) to be at this point?

A

B

C

D

F

13. What do you expect your grade to be at the end of the semester in Math 151 (Engineering Calculus II)?

A

B

C

D

F

14. If there is a bridge program from Math 152 to Math 251 (Engineering Calculus III), do you intend to participate?

Very likely

Somewhat likely

Not very likely

Not at all likely