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STUDENT ENGAGEMENT IN A SUMMER BRIDGE PROGRAM FOR ENGINEERING CALCULUS SUCCESS

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Synopsis:

A summer precalculus bridge program to support entering college freshmen who aspire to become engineers is described. Results of student's evaluation of the program's success in strengthening their mathematics skills are discussed.

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Abstract
Freshmen entering college with the goal of attaining an engineering degree often lack the necessary mathematics and problem solving skills to be successful. A summer bridge program was designed to assist students in gaining the requisite skills for success in Engineering Calculus I. Students who enrolled in a pre-calculus bridge program during the summers of 2011, 2012, and 2013, completed a survey at the end of the program ($n = 100$). Correlations were calculated between the number of sessions attended and survey responses about self-reported improvement in mathematics and problem solving skills. Correlations of variables in the study were positive and statistically significant ($p < .05$).

Key words: Bridge program, precalculus, engineering calculus

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Most STEM majors, particularly engineering, rely on a solid mathematics background. Thus, the engineering workforce is depending on higher education to recruit and retain students in engineering fields (Augustine, 2007; PCAST, 2012). More specifically, college calculus success is very important for engineering degree completion (Waits & Demana, 1988). However, more than half of entering college freshmen are not prepared for university studies (National Center for Public Policy and Higher Education, 2010), with mathematics being the most common area of weakness (Parsad & Lewis, 2003). Bridge programs are one avenue to increase assessment scores for placement. Although there are programs in the sciences, the majority of bridge programs focus on mathematics, which is most often the subject area identified as a barrier to matriculation to college. (Ohland & Crockett, 2002). Most bridge programs are voluntary, and universities struggle with convincing students of their need to take advantage of the opportunity and of retaining them throughout the program rather than losing them as soon as they feel they have garnered just enough knowledge and skills to retake and pass the placement exam. However, the small percentage of students who choose to complete the program generally increased their mathematics scores (Diefes-Dux, 200; Papadopoulos & Reisel, 2008). Online formats first emerged in 2007, but they were asynchronous and not particularly successful (Papadopoulos & Reisel, 2008). Online programs have had more success in recent years, with the expansion of technological capabilities, especially the ability to interact with a live tutor and classmates in the online environment (Nite, 2012; Nite, Morgan, Capraro, Allen, & Capraro, 2014; Nite, Morgan, Allen, Capraro, & Capraro, 2015).

Program Description

The mathematics department at Texas A&M University has supported freshman mathematics classes, including the engineering calculus sequence, for a number of years. Resources have included past exams with answer keys on the website, "week-in-review" live sessions over the week's material. Although these supports were in place for students in the courses, there was a need to serve incoming freshmen with support to help them improve mathematics skills. They were required to take a mathematics placement exam (MPE) and answer at least 22 out of 33 questions correctly. If they did not meet the cut score, they were required to take a precalculus class, which delayed their ability to enroll in the first engineering class on time. The Personalized Precalculus Program (PPP) was established to strengthen precalculus skills needed for calculus. This bridge program was designed to strengthen mathematics skills needed for calculus so that students could retake the MPE and place into Engineering Calculus I. In this way, they were able to enroll in engineering courses on time and increase their chances of graduating with the desired degree (Nite, Morgan, Allen, Capraro, & Capraro, 2015). Students were grouped into cohorts of 20 or less students and assigned a live tutor. They met with the tutor for 6 weeks, 2 hours 3 times a week in the summers of 2011-2013 (Allen, Nite, Pilant, & Whitfield, 2013). The program was revised to have students meet with the tutor 3 weeks, 4 times a week for 3 hours (Nite, Morgan, Allen, Bicer, & Capraro, 2016).

Method

Freshman engineering students enrolled in a summer bridge program, the PPP, to increase their mathematics knowledge and skills for success in Engineering Calculus I. The program took place at a large research university in Texas. Although participating the bridge program was optional, students were invited to the program only if their MPE (mathematics placement exam) scores were below 22 as identified mathematics achievement cut score. Students who enrolled in the PPP participated in a 6-week long intervention in gaining the requisite skills for success in engineering calculus. A total number of engineering freshmen (N = 100; 25 female; 54 male; 21 not reported; 4 African American, 19 Hispanic, 3 Asian, 53 White, 21 not reported) received the bridge program intervention in three consecutive years during the summers of 2011, 2012, and 2013, and completed a pre-designed survey measuring their confidence that the program had increased their mathematics and problem solving skills. Additionally, they reported how satisfied they were with the program. The Likert-type survey asked them to rate each statement (see Appendix) as “Strongly Agree,” “Agree,” “Neutral,” “Disagree,” or “Strongly Disagree.” Descriptive statistics and Pearson’s r correlation coefficients in SPSS 23 were conducted to measure to what extent the variables of interest in the present study were correlated to each other, both survey variables, and grades and other program variables, such as the number of sessions attended and the mean score in the online quizzes.

Results

Several positive correlations were found between variables in the study. The number of tutoring sessions students attended was positively correlated with student belief that the sessions were beneficial, the cost was worth it, the tutor was organized and interesting, and they would recommend their tutors, all statistically significant ($p < .05$). The number of sessions attended was positively correlated with whether they would recommend the PPP and whether the tutor thoroughly explained the precalculus concept, but the Pearson correlation was not statistically significant ($p > .05$). There was no appreciable difference in results among ethnicities or between genders. The results of correlations are shown in Table 1. Refer to the Appendix for statements corresponding to the numbers.

One interesting result is that the mean score of the quizzes in the PSP was positively correlated with the student belief that the program strengthened their skills in algebra, trigonometry, and precalculus. This seems to indicate that students were able to judge whether their skills had increased because their average score in the online materials was correlated with their belief that they gained understanding of the mathematical concepts addressed in the PPP ($r = .456$, $p = .050$). Self-reported improvement in problem solving was statistically significant and positively correlated with all 9 variables from the survey, but the strongest correlation was between their perception and their skills in algebra, trigonometry, and precalculus ($r = .712$, $p < .01$).

Grades in Engineering Calculus I, Engineering Calculus II, and Engineering Calculus III were not correlated well with the number of sessions attended or the mean score in the online quizzes. However, as might be expected, the grades in Engineering Calculus I and Engineering Calculus II were positively correlated ($r = .603$, $p < .01$). Additionally, the grades in Engineering Calculus II and Engineering Calculus III were positively correlated ($r = .481$, $p = .037$). Grades in Engineering Calculus I and Engineering Calculus III had a lower Pearson correlation coefficient, and were not statistically significant ($r = .332$, $p = 0.90$), which was interesting in view of the fact that each course was correlated with the one immediately preceding or following.

Table 1.
Pearson Correlations For Survey Items and Personalized Study Plan (PSP)

	2	3	4	5	6	7	8	9	No. of sessions	Completed PSP	Mean Score
1	.712**	.452**	.555**	.554**	.584**	.463**	.550**	.505**	.254*	0.098	.456*
2		.424**	.603**	.503**	.489**	.403**	.463**	.452**	0.155	0.161	0.374
3			.398**	.270**	.405**	.296**	.332**	.379**	.260**	0.014	0.007
4				.590**	.540**	.497**	.518**	.609**	0.135	0.055	0.161
5					.532**	.434**	.653**	.593**	.279**	0.147	0.094
6						.756**	.701**	.732**	0.176	0.141	0.095
7							.745**	.723**	.224*	0.135	-0.238
8								.755**	.215*	-0.022	-0.199
9									.234*	-0.028	0.095
No. of sessions										0.187	0.037
Completed PSP											.559*
Mean Score											

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

Discussion

Bridge programs have most typically involved either face-to-face instruction or asynchronous online instruction. However, an online bridge program with a live tutor can be successful in strengthening mathematics skills in order to reduce attrition in engineering majors as a result of difficulties in mathematics. One of the struggles these programs face is convincing students that they need to take advantage of the opportunity to strengthen mathematics skills. Results of surveys from participants can help prospective participants recognize the value of the program. Bridge programs for entering freshmen as well as support throughout the mathematics sequence can be a viable option. If results from bridge programs such as this one continue to benefit at risk students and retain them in the STEM pipeline, it seems likely not only that such support programs would be effective for other STEM course sequences such as those in chemistry and physics but that at least part of the instruction could be brought right into the students' homes through technology.

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Appendix. Survey Questions

1. The summer PPP helped me improve my understanding of algebra, trigonometry, and other precalculus concepts.

2. The summer PPP helped me improve my ability to solve mathematical problems.

3. The summer PPP was NOT beneficial nor a good use of my time.

4. I highly recommend the summer PPP to other prospective TAMU students.

5. The summer PPP was well worth the $100 fee.

6. My tutor thoroughly explained the precalculus concepts to me.

7. My tutor was organized in presenting and reviewing the material.

8. My tutor kept the online sessions interesting and interactive.

9. I recommend my tutor be hired to teach in this program next year.