Sustainable bridges from campus to campus: Aggregate results for Engineering Ahead Cohorts One to Three (#1525367)

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Dr. Peter J. Shull is an associate professor of engineering at Penn State University. He received his undergraduate degree from Bucknell University in mechanical engineering and his graduate degrees from The Johns Hopkins University in engineering science. Dr. Shull's research has two main foci—nondestructive evaluation methods as applied to process control (NDE) and pedagogical methodology. Dr. Shull's pedagogical efforts include meta-cognitive strategy learning to improve student academic success, an interest in women's issues within the engineering environment, integrated, experiential techniques to improve engineering students' social emotional development as applied to teamwork and communication, and program assessment methods that minimize stakeholders' efforts while maximizing the effectiveness of the measurement tool.

Dr. Peter J Butler, Pennsylvania State University
Dr. Tonya L. Peeples, Pennsylvania State University

Professor Tonya Peeples joined the Penn State College of Engineering in August of 2018, as the Inaugural Associate Dean for Equity and Inclusion and Professor of Chemical Engineering. Prior to joining Penn State she worked at the University of Iowa and in her 23 years at UI, served to advance diversity and

promote opportunities for all students to pursue education and careers in Science Technology Engineering and Mathematics (STEM). As an individual researcher, an administrator and as a leader in the state and national community, Dr. Peeples has made an impact on improving access to STEM careers through personal commitment, local partnerships, institutional leadership and effective collaboration. Dr. Peeples is biochemical engineering researcher and served as Associate Director of the UI Center for Biocatalysis and Bioprocessing and on the coordinating committee for the National Institutes of Health (NIH) training grant in biotechnology. As a Professor, she has mentored a diverse group of high school, undergraduate and graduate students including three high school students, 64 undergraduate and 13 graduate students, and three postdoctoral fellows. Several of her graduate and undergraduate student researchers have won local, regional and national awards for their work. Dr. Peeples is influencing faculty and institutional leaders through leadership in the Aspire Alliance, an NSF INCLUDES collaborative effort. On her academic leadership roles she has implemented search committee training on implicit bias and best practices for recruiting diverse faculty. As a leader in the University Center for Exemplary Mentoring funded by the Alfred P. Sloan Foundation, she trains faculty in mentoring minority students. These activities are ”game changers” in helping engineering programs enhance enrollment growth and increasing numbers of women and minority students, faculty and staff. She has established collaborations to extend a welcoming environment to all students. She has received numerous awards for service to the local state and national STEM communities, including Outstanding Service Award from the American Institute of Chemical Engineers (AIChE) Minority Affairs Committee, the Collegiate Service Award from the UI CoE, the Michael J. Brody Award for Faculty Excellence in Service, the UI Diversity Catalyst Award. In 2015 she was the recipient of the Pioneers of Diversity Award from AIChE. In 2016 she was a fellow of the Executive Leadership in Academic Technology and Engineering and Sciences (ELATES) program. She is a fellow of the American Institute of Medical and Biological Engineering.

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Abstract

Purpose: The purpose of the *Sustainable Bridges from Campus to Campus* project (NSF IUSE #1525367, known locally as *Engineering Ahead*) is to establish summer bridge programs that serve Engineering students at regional campuses of The Pennsylvania State University. Summer bridge programs for incoming Engineering students were started at the Abington, Altoona, and Berks regional campuses. Recruitment focuses on enrolling racially underrepresented domestic students in Engineering (i.e., African American, Hispanic American, Native American, Pacific Islander) into the bridge programs. The project also supports an established summer bridge program for racially underrepresented incoming Engineering students at the flagship University Park campus. As of this writing, we are completing Year 4 of the 5-year project. This paper presents aggregated data through their second year of college the entrance-to-major process for the first three cohorts of Engineering Ahead participants and a sample of matched comparison students who did not participate in the program.

Goals: The overarching goal of this project is to increase retention and graduation among racially underrepresented Engineering students, with a focus on students who start their Penn State education at a regional campus. Institutional retention data indicate that retention in Engineering among students at a regional campus is nearly half that of Engineering students who start at the flagship campus. Part of that difference in retention is likely related to social integration and access to academic support. Thus, an intent of this project is to implement academic and social support strategies (pre-college summer bridge program & clustered enrollment in the same first-year seminar) to improve junior-year retention among racially underrepresented and underserved Engineering students. We aim to improve retention in Engineering in the junior year by 20 percentage points. The central research question is to examine whether academic outcomes and retention in Engineering differed as a function of participation in the support strategies. To examine variation in outcomes among participants in our program, we will examine contextual factors such as whether the bridge program was residential or non-residential, whether the bridge program was located at a student's assigned campus for the fall or at a different campus in the Penn State system, and whether the student completed the degree at one campus or transitioned from a regional campus to the flagship campus (native vs. 2+2 students).

Method: Accepted incoming Engineering students at the Abington, Altoona, Berks, and University Park campuses in the Penn State system were encouraged to apply to a summer bridge program to support success in math and science during the first year via letter, email, and presentations at accepted student programs. The bridge programs for incoming first-year students consist of 5 summer bridge programs across 4 campuses in the Penn State system. The total sample size is 490, with 245 participants and 245 comparison students. To assess the effectiveness of these academic and social support strategies for incoming undergraduate Engineering majors, we will examine math course grades, grade point average, entrance-to-major status (i.e., did a student enroll in an Engineering major, another STEM major, or a non-STEM

major), and enrollment status (i.e., whether or not still at Penn State). Students were matched on gender, race, campus assignment, and SAT Math score (within 1 standard deviation).

Results: Compared to a matched comparison sample, the Engineering Ahead students earned statistically higher grades in their first college math course by half a letter grade, were less likely to drop their first math course, and earned a higher grade point average at the end of their first year of college.

Conclusions: The significantly higher math course grades for the bridge students compared to the matched comparison students suggest that the bridge programming and cohort building benefitted the students. We will continue to track Cohorts 1 to 3 as well as Cohort 4 (2019). Plans are underway to enroll Cohort 5 in the summer of 2020. Future analyses will involve an examination of whether STEM-major status and retention status are related to transfer status within the University, that is whether students matriculate at one campus in the University system or transfer between campuses within the University system to complete their degree.

Sustainable bridges from campus to campus:
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The purpose of this interim progress report at the end of Year 4 of a 5-year project is to document the aggregate performance of the Engineering Ahead students in Cohorts 1 to 3 (2016 to 2018) and a matched comparison sample of similar students who did not participate in the Engineering Ahead bridge program. The Engineering Ahead summer bridge program prepares incoming first-year students in Engineering for the first year of core courses required for successful completion of the Engineering pre-major. Recruitment focuses on racially underrepresented Engineering students and those who start their Penn State education at a regional campus.

The Engineering Ahead first-year bridge program is part of the broader Sustainable Bridges project which also includes a bridge program for rising second-year Engineering students and a transition program for juniors. The Sustainable Bridges project seeks to apply and compare bridge solutions to first- and second-year populations who participate in one of five bridge programs depending on the campus where they start their Penn State education. The guiding framework for these bridge programs is the Minority Engineering Program (MEP) Model [1, 2]. The MEP Model strives to increase student academic achievement by increasing student engagement through activities such as formal freshmen orientation, clustering students in core curriculum, and study groups.

Engineering Ahead encompasses five bridge programs. There are three summer bridge programs at three regional campuses in the Penn State system in which incoming Engineering students assigned to that campus participate in their own local bridge program (two were 4 weeks and residential, one was 6 weeks and non-residential). There is one bridge program at the University Park flagship campus for incoming Engineering students assigned to matriculate there in the fall (6 weeks, residential). Lastly, there is one bridge program at the University Park flagship campus for incoming Engineering students assigned to matriculate at regional campuses in the fall not served by a local bridge program (6 weeks, residential).

To enter the Engineering major, students must receive a C or better in core courses and achieve certain grade point averages (GPA) for entrance into enrollment-controlled majors. The intention is that the academic support and community building will increase retention, particularly those at regional campuses who expect to transfer to the University Park flagship campus. Central research questions focus on the academic success and retention of the participants and the comparison students through the entrance to major (end of the second year). We will also examine whether there is variation in student success as a function of transfer status within the institution (native student vs transition from regional campus to flagship campus) and location of bridge program (matches fall campus assignment vs different campus than fall campus assignment). We have limited follow-up data for this report, so the analyses will focus on academic performance and retention over the first year of college.

Method

Participants

Engineering Ahead students were recruited through letters and emails sent to accepted Engineering students at Penn State University. Recruitment focused on students who were racially underrepresented in Engineering, female, and first-generation college students. To establish a benchmark against which to evaluate the efficacy of the Engineering Ahead program, we assembled a matched control sample. There was a total of 490 students in this analysis across Cohorts 1 to 3 (245 participants and 245 comparison students). Each Engineering Ahead student was matched with a non-participant who was similar on date of entry to the University, sex, race/ethnicity, SAT Math scores (within 1 standard deviation), and regional campus assignment. In some cases (25, 10% overall), a match could not be identified at a participant's regional campus. In that case, a match was identified at a different regional campus. Regional campus students were never matched with a University Park flagship campus student.

Background characteristics for each cohort are shown in Tables 1a (data aggregated) and 1b (data separated by program). Sixty-eight percent were male, and 64% were racially underrepresented (i.e., African American, Hispanic American, Native American, Pacific Islander). Twenty-nine percent of the bridge students and comparison sample were first-generation college students. The two groups did not differ on first-generation college student status $\chi^2(1) < 1$, *ns*. As intended, the two groups did not differ on SAT Math scores (see top half of Table 2). Similarly, participants and comparison students did not differ on high school GPA or their ALEKS math placement exam scores (see top half of Table 2). The average ALEKS math placement score for the two groups corresponded to placement in plane trigonometry. Taken together, these results suggest that the two groups are similar on pre-college academic indicators that might predict college performance.

Procedure

The Engineering Ahead summer bridge participants provided informed consent to allow examination of their background characteristics and academic performance drawn from institutional data. The informed consent approval included examination of academic data for the matched comparison sample. Participants enrolled in a math-intensive summer bridge program (late June through July or early August). Two programs were 4 weeks and residential. Two programs were 6 weeks and residential. And one program was 6 weeks and non-residential. All programs focused on success in pre-calculus and calculus. Some programs also prepped students for chemistry, physics, and English. To continue student contact and support, the participants at the three regional campuses also enrolled in a fall semester first-year seminar taught by their faculty bridge leader. Participants at the flagship University Park campus were invited to participate in local support programming during the academic year (e.g., Multicultural Engineering Program programming, National Society of Black Engineers student organization, Society of Hispanic Professional Engineers student organization).

Table 1a. Background Characteristics for Cohorts 1 to 3 Bridge Students and the Matched Comparison Sample

	Bridge Students		Matched Comparisons	
Variables	N	%	N	%
Gender				
Male	166	68	166	68
Female	79	32	79	32
Ethnicity				
African American	89	36	89	36
Asian	15	6	15	6
Hispanic	63	26	63	26
Native Am/Pacific Islander	5	2	5	2
White	71	29	71	29
International	2	1	2	1
First-Generation College Student	72	29	70	29

Note: Total *N* = 490.

Table 1b. Background Characteristics of the Summer Bridge Participants Cohorts 1 to 3 by Program

	Summer Bridge Program											
	PSU Abington		PSU Altoona		PSU Berks		Academic Summer Experience		Pre-First Year in Engineering and Science		Grand Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Total N to Date	44		42		49		27		83		245	100
Gender												
Male	30	68	25	60	38	78	20	74	53	64	166	68
Female	14	32	17	40	11	22	7	26	30	36	79	32
Ethnicity												
African Am	8	18	12	29	4	8	17	63	48	58	89	36
Asian	8	18	2	5	3	6	0	0	2	2	15	6
Hispanic	9	21	3	7	12	25	9	33	30	36	63	26
Native Am	1	2	1	2	1	2	1	4	1	1	5	2
White	18	41	22	52	29	59	0	0	2	2	71	29
International	0	0	2	5	0	0	0	0	0	0	2	1
First-Gen College Student	18	41	12	29	19	39	11	41	12	15	72	29

Note: *N* = 245.

Table 2. Academic Performance Indicators Aggregated to Date for Engineering Ahead and the Matched Comparison Sample Cohorts 1 to 3

	Bridge Students		Matched Comparisons			
Variables	*M*	*SD*	*M*	*SD*	*t*(488)	*p*
			Pre-College			
GPA High School	3.5	.4	3.5	.4	< 1	*ns*
SAT Math	577	76	579	67	< 1	*ns*
ALEKS Math	66	19	67	19	< 1	*ns*
			College			
Fall Math Course Grade[1]	2.4	1.3	2.1	1.2	2.3	.05
GPA Fall Semester	2.8	.9	2.7	.9	1.8	*ns*
GPA Year 1 Cumulative	2.8	.8	2.6	.8	2.3	.05
	N	%	N	%	$\chi^2(1)$	
# in Bridge Program	245	--	245	--	--	--
# Dropped Fall Math Course	31	13	48	20	4.4	.05
# Enrolled Fall Year 2	206	84	211	86	< 1	*ns*

Note: Fall semester data: *N* = 490. *M* = Mean. *SD* = Standard Deviation. *ns* = Not significant. [1]df = 4.9 because 79 students dropped their fall math course.

Results

Differences in College Academic Outcomes

A central research question is whether the Engineering Ahead students, who received intensive math preparation and community building in the summer before their first year, would demonstrate better academic outcomes than similar Engineering students who did not receive that academic support and a community building program. The bottom of Table 2 shows a series of academic performance indicators including grades in the first fall semester math course, fall semester GPA, cumulative GPA at the end of the first year of college, the number who dropped their first college math course, and the number who were enrolled at the beginning of the sophomore year. (Course letter grades were converted to the numerical equivalent.) The Engineering Ahead students earned **significantly higher grades in their first college math course** (1/2 letter grade, B- vs. C+), had a **significantly higher Year 1 cumulative GPA** compared to the matched comparison students (2.8 vs 2.6).

Because success in the Engineering major depends on successful completion of a series of required math courses, we examined whether students dropped their first college math course (see lower half of Table 2). **Fewer Engineering Ahead students (31) dropped their first**

college math course compared to the comparison students (48). That difference was statistically significant [$\chi^2(1) = 4.36$, $p < .05$.]. There was no difference between the two groups in terms of retention at the University in the fall semester of the sophomore year [$\chi^2(1) < 1$, ns].

Predicting First Math Course Grades from Pre-College Academic Indicators

Table 3 shows the bivariate correlations between the study variables for the summer bridge students and the matched comparison sample. The associations were very similar for the two groups. A higher high school grade point average was significantly associated with higher SAT Math scores, ALEKS math scores, grades in their first college math course, and first semester grade point average. There was a robust positive association between SAT Math scores and ALEKS math scores. SAT math scores and ALEKS math scores were positively associated with first semester math course grades.

To put the correlations in context, high school grade point average accounted for a modest 4 to 10% of the variance in the two central outcomes of interest—first semester math course grades and first semester GPA. Similarly, SAT Math scores accounted for 5 to 12% of the variance in the two central academic outcomes of interest. ALEKS math placement scores accounted for 3 to 5% of the variance in first semester math course grades and first semester GPA. In other words, although we observed statistically significant associations, much of the variance in first semester math course grades and GPA were *not* explained by the pre-college academic indicators of high school GPA, SAT Math scores, or ALEKS math scores.

Table 3. Correlations Between the Study Variables for Cohorts 1 to 3 for the Summer Bridge Students (above diagonal) and Comparison Students (below diagonal)

		High School GPA+	SAT Math Score	ALEKS Math Score	Fall Semester Math Course Grade	Fall Semester GPA
High School GPA	*r*	--	.26***	.31***	.31***	.31***
	n		243	243	212	243
SAT Math Score	*r*	.34***	--	.56***	.34***	324***
	n	241		245	214	245
ALEKS Math Score	*r*	.32***	.59***	--	.23**	.18**
	n	241	245		214	245
Fall Semester Math Course Grade	*r*	.20**	.31***	.19**	--	.85***
	n	195	197	197		214
Fall Semester GPA	*r*	.27***	.23***	.17*	.78***	--
	n	239	243	243	197	

Note: +Two bridge students and four comparison students did not report a high school GPA. *r* = Correlation. *n* = Sample size. *$p < .05$. **$p < .01$. ***$p < .001$.

As shown in Table 4a, multiple regression analysis was used to test if pre-college academic indicators (high school grade point average, SAT Math score, ALEKS score) significantly predicted grades in students' first college math course independently, controlling for the other variables. Student status (bridge student vs. comparison student) was also included as a predictor of the first college math course grade. The regression analysis indicated that the four predictors explained 15% of the variance in first math course grades [$R^2 = .15$, $F(4, 402) = 17.06$, p < 001.]. There was a significant result for student status ($\beta = -.25$, $p < .05$), which indicated the results of the regression were different for the two groups of students. Separate analyses were conducted for each group (see Table 4b).

The regression analysis for the **bridge students** indicated that the three predictors explained 17% of the variance in first college math course grades [$R^2 = .17$, $F(3,208) = 14.08$, $p < .001$]. **High school grade point average** ($\beta = .24$, $p < .001$) and **SAT Math scores** ($\beta = .28$, $p < .001$) independently and significantly predicted the first math course grade in a positive direction. The regression analysis for the **matched comparison sample** indicated that the three pre-college academic indicators explained 10% of the variance in first college math course grades [$R^2 = .10$, $F(3,191) = 7.35$, $p = .001$]. **SAT Math scores** ($\beta = .28$, $p < .01$) independently and significantly predicted the first college math course grade in a positive direction. Interestingly, ALEKS math placement exam scores were not associated with first math course grades for the two groups.

Table 4a. Regression analyses examining fall semester math course grade as a function of high school GPA, SAT Math score, and math placement exam score

Variable	***B***	***SE B***	**β**
Comparison Status	-.25	.12	-.10*
HS GPA	.51	.15	.17**
SAT Math Score	.01	.00	.27***
ALEKS Math Placement Score	.00	.00	.00
R2		.15	
F for change in R2		17.06***	

Note: n = 407. * p < .05. ** p < .01. *** p < .001.

Table 4b. Simple Regression Analyses Predicting fall semester math course grade for summer bridge students and the matched comparison sample

	Bridge Students			Comparison Students		
Variable	***B***	***SE B***	**β**	***B***	***SE B***	**β**
HS GPA	.72	.20	.24***	.27	.21	.10
SAT Math Score	.01	.00	.28***	.01	.00	.28**
ALEKS Math Placement Score	.00	.01	.00	.00	.01	.00
R2		.17			.10	
F for change in R2		14.08***			7.35***	

Note: n = 212 bridge students and 195 comparison students. * p < .05. ** p < .01. *** p < .001.

Retention in STEM and at the University Beyond the First Year

Students in the College of Engineering at Penn State are pre-majors for the first four semesters while they complete required math, chemistry, and physics courses. Most students go through an entrance-to-major process during the fourth semester and enter a specific Engineering major (e.g., aerospace, chemical, mechanical) during the fall semester of the junior year. At the time of this analysis, Cohorts 1 and 2 but not Cohort 3 had gone through the entrance to major process. Cohorts 1 and 2 are in their senior and junior years, respectively. Table 5 shows retention by type of major and whether a student left the University. For the students in Cohorts 1 and 2, 88 of the Engineering Ahead participants became STEM majors, whereas 77 of the comparison students did. More students in the comparison sample left the University for academic reasons (29, e.g., GPA < 2.0) compared to the Engineering Ahead students (21). A similar number of students from each group left the University for reasons other than their grade point average.

Of those students who went through the entrance to major process (see Figure 1), we examined whether there was a group difference in entering a STEM or a nonSTEM major. A Chi square analysis tested that question and the difference was not statistically significant $\chi^2(1) = 1.23$, *ns.* Similarly, we examined whether there was a group difference in terms of whether students were retained at the University or not to date (see Figure 2). The Chi square analysis was not statistically significant $\chi^2(1) = 1.23$, *ns.*

Table 5: Entrance to Major Results for Cohorts 1 and 2

	Major after Entrance to Major							
Type of Student	Science	Tech-nology	Engin-eering	Math	Non-STEM	Not Enrolled, Academic Reasons	Not Enrolled, Other Reasons	Total
Bridge Participant	2	11	71	4	17	21	18	144
Matched Comparison	8	4	64	1	21	29	17	144
Total	10	15	135	5	38	50	35	288

Note: Cohort 3 data not included here because they have not gone through the entrance to major process yet.

Figure 1: STEM Major Status After Entrance to Major for Cohorts 1 and 2

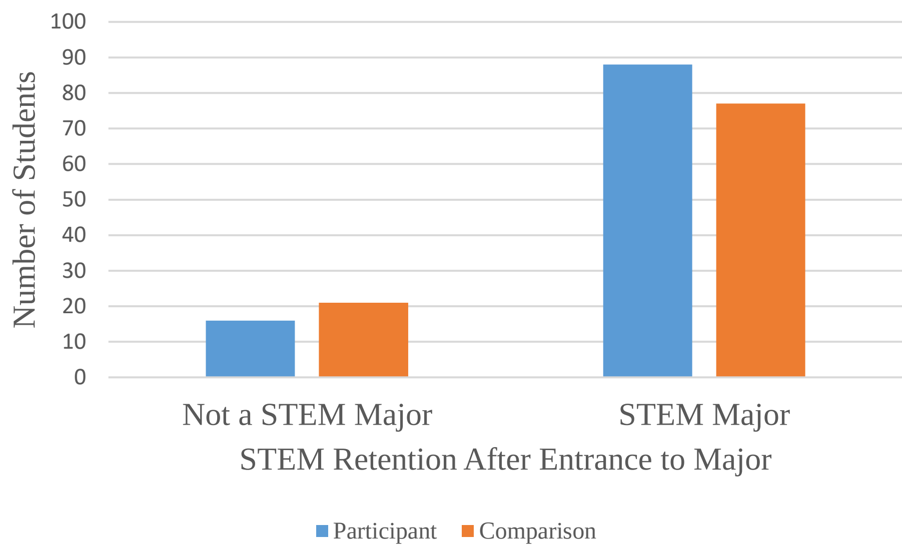
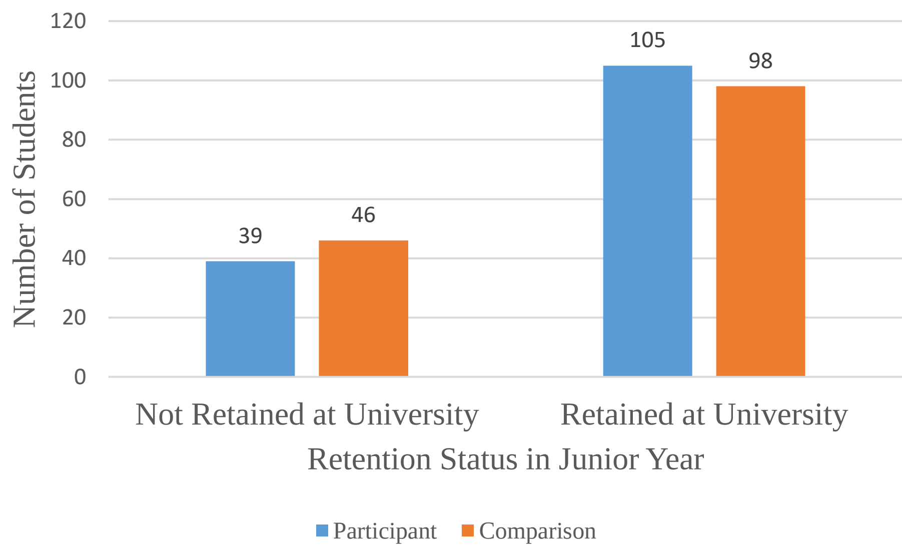


Figure 2: Retention at the University for Cohorts 1 and 2



Discussion and Conclusions

We are grateful to the National Science Foundation for supporting the Sustainable Bridges project. Please note that any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The data presented here on the first three cohorts of the

Engineering Ahead first-year bridge program for pre-major Engineering students is part of the larger Sustainable Bridges project (#1525367).

The preliminary results are promising for the first three cohorts of the first-year bridge program. To benchmark the academic success and retention of the bridge participants, we compared them to similar students who did not participate in the bridge programs. We focus on passing math course grades (C or better) because they are crucial for successful progression in the Engineering major. Compared to a matched comparison sample, the Engineering Ahead students earned statistically higher grades in their first college math course by half a letter grade, were less likely to drop their first math course, and earned a higher grade point average at the end of their first year of college. The significantly higher math course grades for the bridge students compared to the matched comparison students suggest that the bridge programming and cohort building benefitted the students.

Visual inspection of the retention data beyond the first year indicated that retention in STEM and the University was higher among Engineering Ahead students, but that difference was not statistically significant.

We will continue to track Cohorts 1 to 3 as well as Cohort 4 (2019). Plans are underway to enroll Cohort 5 in the summer of 2020. Future analyses will involve an examination of whether STEM-major status and retention status are related to transfer status within the University, that is whether students matriculate at one campus in the University system or transfer between campuses within the University system to complete their degree.

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