Assessment of the Effects of Participation in a Summer Bridge Experience for Women

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The ESCape program was started in 2008 as a bridge program for incoming women students in the College of Engineering at NC State University [1]. The program was first outlined in 2009 at the ASEE Annual Conference. When the program was started, admitted students with the lowest math SAT scores were invited to attend. This decision was taken, because internal research indicated that math performance was predictive of engineering retention, and it was desired to increase the retention of engineering students who identify as female. Over time, the SAT scores of admitted engineering students have increased significantly. Additionally, the activities designed to instill confidence in mathematics were determined through assessment to have little effect. Therefore, the activities of the camp were redesigned to focus more on community-building and connection-making with engineering faculty and industry partners. More emphasis has been placed on introducing students to engineering in both academic and industrial settings. In 2016 a change was made to invite all admitted female-identifying engineering students and institute a selection process that values an essay about what the student anticipates they would get from participation in the bridge program. The tenth anniversary of the program was in the summer of 2018, so a more comprehensive longitudinal study of outcomes for participants has been undertaken.

As a living program that has been evolved based on formative assessment, the same essential goals of increasing the retention, success (measured by GPA) and graduation of women engineering students have been retained. The outcomes for student cohorts over the years compared to the general engineering student population of women who did not attend the program and of men have been collected. This paper presents some of the results for eight cohorts of forty to fifty students each from the longitudinal study for student retention (to the second year), six year graduation rates and GPA.

Prior Research

The literature identifies many student characteristics that influence postsecondary success. Terenzini and Reason define a success model that accounts for the students' experiences before entering college, the student experience in college and the college environment [9]. Because prior to entering postsecondary education, students have a variety of educational and home experiences, those experiences might be assumed to have a significant impact on college outcomes [10] [11] [12]. Brown, Halpin, & Halpin found that the ACT math (or the linear equivalent ACT math score from the reported SAT math score) was a better predictor of a student's success (measured by GPA) than any other single factor [13]. Corroborating the test score finding, Chang et al. found that controlling for SAT scores, high school grades, and high school course-taking moderated the relationship between student demographic characteristics and STEM persistence [14]. For students at NC State University, the grade in the first math class has been shown to be the strongest predictor of students retention [18]. For that reason, we use the math SAT score as a proxy predictor.

Summer bridge programs are a widely adopted feature of postsecondary education. The National Center for Education Statistics What Works Clearinghouse reviewed 31 studies of summer bridge programs in their 2016 intervention report [15]. Evidence is mixed on the efficacy of these programs when looking at persistence and retention. Barnett et al. find no evidence of program effect on credit earning or persistence but do find an effect on completion of math and writing courses [16]. That study is notable as it uses randomization to assign students to eligibility for the summer programs and has a much higher sample size than most other studies on summer bridge programs. Tomasko et al. find higher persistence rates for 3rd year students in engineering in a program targeted to help first-generation and underrepresented minorities [17]. Murphy et al. use survival analysis and find higher graduation rates for students who attend the summer bridge program in their study [18]. This is the largest of the studies we are aware of at 2,222 students and the program was also targeted to underrepresented groups.

For our longitudinal analysis, we have looked at cohorts of students who attended a summer bridge program named ESCape. Each year, students are invited to attend, and between 40 and 50 are selected. Students were accepted based on the lowest SAT math scores, because our data have shown math performance to be a strong predictor of engineering persistence to graduation. In order to ascertain whether the summer bridge program has had an impact on persistence (to the second year in engineering) and six year graduation in engineering and at the university, the cohorts from years 2009 to 2013 were tracked and their outcomes compared to all students and all women who entered in the same year.

The program was described in an ASEE paper in 2009 [1]. The program was custom designed for the institution where it resides, and was created based on data from that institution with regards to impediments to retention for female-identifying engineers. The table below, modified from one originally published in [1], summarizes the original design. By 2016 the SAT scores of admitted students had become so high, the SAT math score as a way to identify students to invite was removed, and all female students were invited to apply. The application contains short answer questions that ask what students hope to gain and hope to contribute. The answers to these questions are now used to select students who might gain the most from the program. In addition, formative assessments revealed that math review sessions were having a negative effect rather than the intended positive effect. In essence, students were becoming MORE worried about their math skills by being treated as if they NEEDED to be worried about their math skills. Instead of math review sessions led by the math department, the camp now includes activities that lead students to interact with spatial visualization skills and identify their level of comfort with them. They are then led to understand that these skills can be developed and are taught how to do so [8].

Table 1: Research-based practices considered in original program design

Research-based idea	**Goal**	**Action/content**
Parental support important to Success [4]	Inform parents about how to support their students	Parent meeting
Need to understand variety in engineering [7]	Expose students to broader variety of engineering than they had seen before	Departmental meetings/tours

Success in first math class strong predictor of success [2,3,6]	Increase student confidence/success in first math class	Math review session
E115 class impediment to retention of women (internal data)	Increase student confidence in first computing class	Introduction to computing at _____(E115)
Connecting to what engineers do on the job a strong motivator	Increase student commitment to engineering	Company tours
Selected from experienced Advisors [5, 8]	Increase student success in first semester classes	Strategies for success session

Data

Data were collected for each of the students that attended the summer program. Math and verbal SAT scores and high school GPAs were collected for each cohort from admissions records. The academic plan (major), semester GPA and cumulative GPA for each semester a student was enrolled were obtained from College of Engineering records. There are also records for each degree the students were awarded and the year and semester of degree awarded. Demographic information is coded as reported to the Integrated Postsecondary Education Data System (IPEDS).

The students are grouped by cohorts of their attendance at ESCape. These cohorts also correspond to the students' first semester in college. All of the participants were first-time, first-year students. Comparison data comes from the College of Engineering and the Office of Institutional Research and Planning. Using these sources, a comparison can be made between the ESCape attendees and the wider College of Engineering for pre-college characteristics as well as retention and 6-year graduation rates.

The goal of the study was to determine whether the bridge program was having a differential effect on participating students with respect to retention and graduation. Information on grade point average was collected as a sanity check.

Results

Data on demographics and pre-college academic preparedness are shown in Table 2. The ESCape attendee data were compared with the College as a whole using a simple t-test to determine with 95% confidence that the means are the significantly different. P-values are listed in the same table. On average, ESCape attendees have high school GPAs that are comparable to their peers, except for a large difference in the 2016 cohort. The 2016 attendees were the most academically prepared of the ESCape cohorts. Without the 2016 cohort, the GPA averages are nearly identical (4.50 for ESCape students and 4.51 for the College of Engineering as a whole). Only in 2009 is there a statistically significant disadvantage for the ESCape women and only in 2011and 2016 is there a statistically significant advantage for them. As expected, the ESCape attendees have lower average standardized test scores than their first-time, first-year College of Engineering peers. This difference is pronounced in the SAT Math scores and drives

the difference in the SAT Total scores, but the SAT Verbal scores show a similar pattern to the high school GPAs: there are very few cohorts with statistically significant differences for SAT Verbal scores. In nearly every cohort there is a large and statistically significant disadvantage for ESCape women in SAT Math scores. These data indicate that, even though students were invited to the program with lower math scores, the attendees have similar high school GPAs and verbal SAT scores to the rest of the admitted class.

Table 2: Pre-College and Demographic Comparison Statistics

	2009			2010			2011		
	Cohort	CoE	p-val	Cohort	CoE	p-val	Cohort	CoE	p-val
High School GPA	4.32 (.027)	4.33 (0.31)	0.026	4.34 (0.25)	4.4 (0.31)	0.195	4.54 (0.24)	4.44 (0.29)	0.029
SAT Scores									
Total	1156.12 (56.11)	1251.39 (119.87)	0.000	1171.74 (84.38)	1252.41 (116.5)	0.000	1173.75 (70.41)	1256.53 (113.85)	0.000
Math	601.02 (33.49)	657.87 (63.93)	0.000	587.39 (35.87)	657.17 (62.78)	0.000	601.50 (24.13)	657.6 (62.65)	0.000
Verbal	555.1 (48.14)	593.52 (76.41)	0.001	584.35 (66.35)	595.24 (73.90)	0.324	572.25 (57.80)	598.93 (72.23)	0.038
Demographics									
Female	100.00%	18.00%		100.00%	19.70%		100.00%	18.90%	
Nonresident Alien	0.00%	2.96%		2.17%	1.65%		2.44%	2.36%	
Unknown	0.00%	2.96%		2.17%	1.87%		0.00%	1.69%	
Hispanic	4.08%	3.53%		4.35%	2.92%		2.44%	3.90%	
Am Indian/AK Native	0.00%	0.29%		0.00%	0.30%		2.44%	0.29%	
Asian	0.00%	4.90%		6.52%	4.87%		7.32%	5.60%	
Black	12.24%	5.98%		13.04%	7.11%		4.88%	4.20%	
White	79.59%	76.78%		71.74%	79.04%		78.05%	79.31%	
Two or more races	4.08%	2.60%		0.00%	2.25%		2.44%	2.65%	
Number of Students	49	1387		46	1336		41	1358	

Table 2: Pre-College and Demographic Comparison Statistics (continued)

	2012			2013			2014		
	Cohort	CoE	p-val	Cohort	CoE	p-val	Cohort	CoE	p-val
High School GPA	4.51 (0.25)	4.53 (0.28)	0.66	4.58 (0.27)	4.62 (0.26)	0.323	4.66 (0.26)	4.61 (0.28)	0.265
SAT Scores									
Total	1182.94 (109.78	1281.84 (104.27)	0.000	1227.57 (47.86)	1304 (94.44)	0.000	1230.80 (63.24)	1303 (100.26)	0.000
Math	591.18 (40.28)	671.25 (56.82)	0.000	622.97 (26.55)	679.34 (54.49)	0.000	605.20 (30.16)	679.34 (54.49)	0.000
Verbal	591.76 (83.68)	610.59 (68.39)	0.092	604.59 (40.46)	623.66 (71.25)	0.081	625.60 (47.18)	623.66 (71.25)	0.864
Demographics									
Female	100.00%	21.70%		100.00%	23.40%		100.00%	24.80%	
Nonresident Alien	0.00%	4.59%		0.00%	5.47%		0.00%	5.19%	
Unknown	0.00%	1.82%		0.00%	1.52%		0.00%	1.57%	
Hispanic	7.69%	3.72%		6.98%	3.87%		10.00%	4.64%	
Am Indian/AK Native	0.00%	0.29%		2.33%	0.76%		0.00%	0.34%	
Asian	5.13%	5.90%		4.65%	5.22%		10.00%	5.53%	
Black	15.38%	4.45%		4.65%	2.86%		0.00%	3.96%	
White	69.23%	75.58%		72.09%	77.02%		72.50%	74.80%	
Two or more races	2.56%	3.64%		9.30%	3.28%		7.50%	3.96%	
Number of Students	39	1372		43	1188		40	1464	

	2015			2016		
	Cohort	CoE	p-val	Cohort	CoE	p-val
High School GPA	4.55 (0.25)	4.62 (0.26)	0.082	4.74 (0.27)	4.27 1.41	0.021
SAT Scores						
Total	1243.55 (63.33)	1322.26 (94.85)	0.000	1301.47 (83.89)	1330.78 (97.89)	0.041
Math	626.45 (40.21)	685.32 (55.33)	0.000	667.06 (50.00)	688.46 (55.64)	0.009
Verbal	617.10 (45.47)	636.94 (65.41)	0.049	634.41 (58.48)	642.32 (67.75)	0.425
Demographics						
Female	100.00%	25.85%		100.00%	25.10%	
Nonresident Alien	0.00%	7.07%		8.33%	12.12%	
Unknown	0.00%	1.95%		12.50%	3.94%	
Hispanic	4.65%	3.68%		0.00%	3.58%	
Am Indian/AK Native	0.00%	0.08%		0.00%	0.44%	
Asian	2.33%	5.41%		6.25%	7.30%	
Black	6.98%	4.06%		4.17%	3.14%	
White	81.40%	73.16%		66.67%	66.28%	
Two or more races	4.65%	4.59%		2.08%	3.21%	
Number of Students	43	1330		48	1370	

Table 3 and Figure 1 show the educational outcomes for the ESCape students by cohort. We report students who are retained in engineering to the second year, students who complete degrees at the university and students who complete engineering degrees at the university. Of note, using 6-year graduation rates only allows us to report through the 2013 cohort. Also, our data do not allow us to report on students who leave the university, so if a student transfers and subsequently completes a degree they do not count towards degree completion. Because of this, the academic success of the students is a lower bounded estimate.

Table 3: Academic Outcomes for Cohorts with 6 Year Graduation Rates

	Cohort											
	2009			2010			2011			2012		
	Escape	All	Women	Escape	All	Women	Escape	All	Women	Escape	All	Women
N	49	1388	250	46	1337	265	41	1358	260	39	1373	300
Number who Left Engr After 1st Year	6	225	43	11	195	35	5	157	30	6	157	34
Received Degree from NC State	39	1047	203	34	1006	220	35	1067	226	31	1109	260
Received Engineering Degree from NC State	24	759	138	22	752	154	25	808	170	17	898	196
% Left Engr After 1st Year	12.2%	16.2%	17.2%	23.9%	14.6%	13.1%	12.2%	11.6%	11.7%	15.4%	11.4%	11.4%
% Retained to 2nd Yr in Engr	87.8%	83.8%	82.8%	76.1%	85.4%	86.9%	87.8%	88.4%	88.3%	84.6%	88.6%	88.6%
% Degree from NC State	79.6%	75.4%	81.2%	73.9%	75.2%	82.9%	85.4%	78.6%	87.1%	79.5%	80.8%	86.6%
% Engr Degree from NC State	49.0%	54.7%	55.2%	47.8%	56.3%	58.2%	61.0%	59.5%	65.2%	43.6%	65.4%	65.4%

Table 3: (continued) Academic Outcomes for Cohorts with 6 Year Graduation Rates

	2013		
	Escape	All students	All women
N	43	1190	280
Number who Left Engr After 1st Year	5	104	30
Received Degree from NC State	33	996	251
Received Engineering Degree from NC State	22	802	177
% Left Engr After 1st Year	11.6%	8.7%	10.8%
% Retained to 2nd Yr in Engr	88.4%	91.3%	89.2%
% Degree from NC State	76.7%	83.7%	89.6%
% Engr Degree from NC State	51.2%	67.4%	63.2%

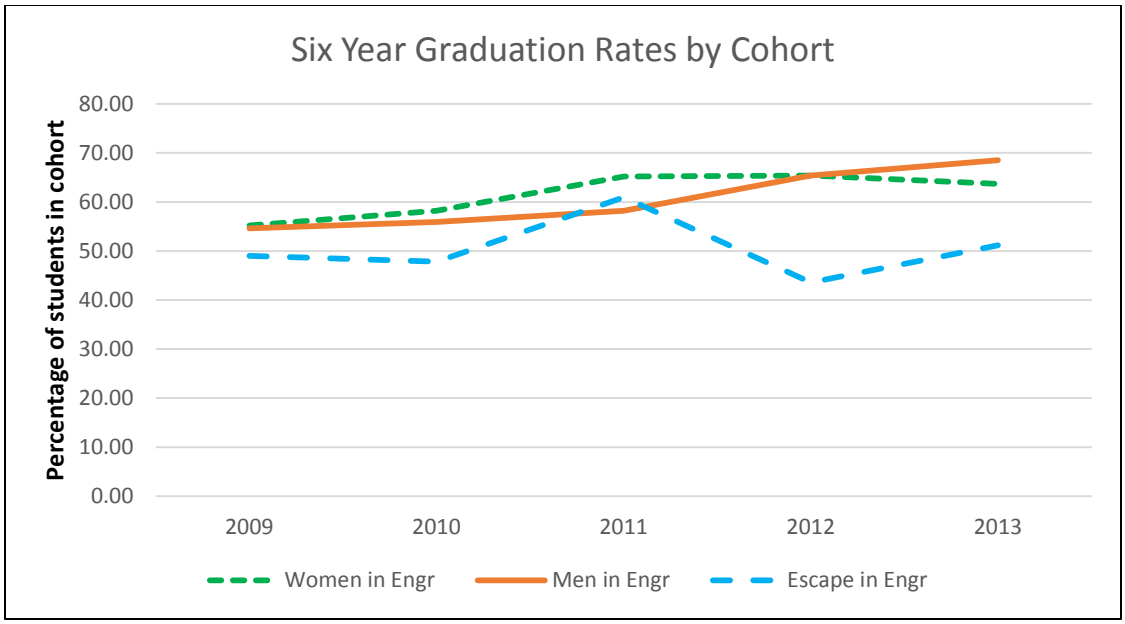

Figure 1: Comparison of Six Year Graduation Rates in Engineering

ESCape attendees stay in engineering majors to the second year, with the rate of movement out of engineering degrees only rising above 20% in one year. On average, only 13% of the women who attended ESCape leave engineering majors after the first year. The large majority of ESCape attendees graduate at the university. The rate of degree completion within 6 years across all cohorts of the program is 79%. Further, all of the students who attended ESCape graduated in less than 5 years. An average of 51% of ESCape attendees earn degrees in the College of Engineering. These statistics trail the larger College of Engineering averages with the exception of degree attainment. Figures 2 and 3 compare graduation rates for ESCape women to those of men and other women from the same cohort years. Both ESCape attendees and women tend to perform better than men.

Table 4 displays a different kind of metric. The percentages of each cohort that left engineering are displayed next to the percentage of leavers who left after their first semester. This measure may be a different kind of success measure. If students, who are going to leave, do so earlier in their academic careers, they tend to take less time to graduate. Whether this measure indicates greater eventual success on the part of the students who leave engineering earlier is one of the potential outcomes that will be examined in future work.

Table 5 gives performance indicators for students who have not yet reached the six year mark. There are no comparison statistics calculated for this group yet, but, if the differences observed turn out to be statistically significant, there may be early indication that changes in the programming have had different effects. These, too, are left for future work.

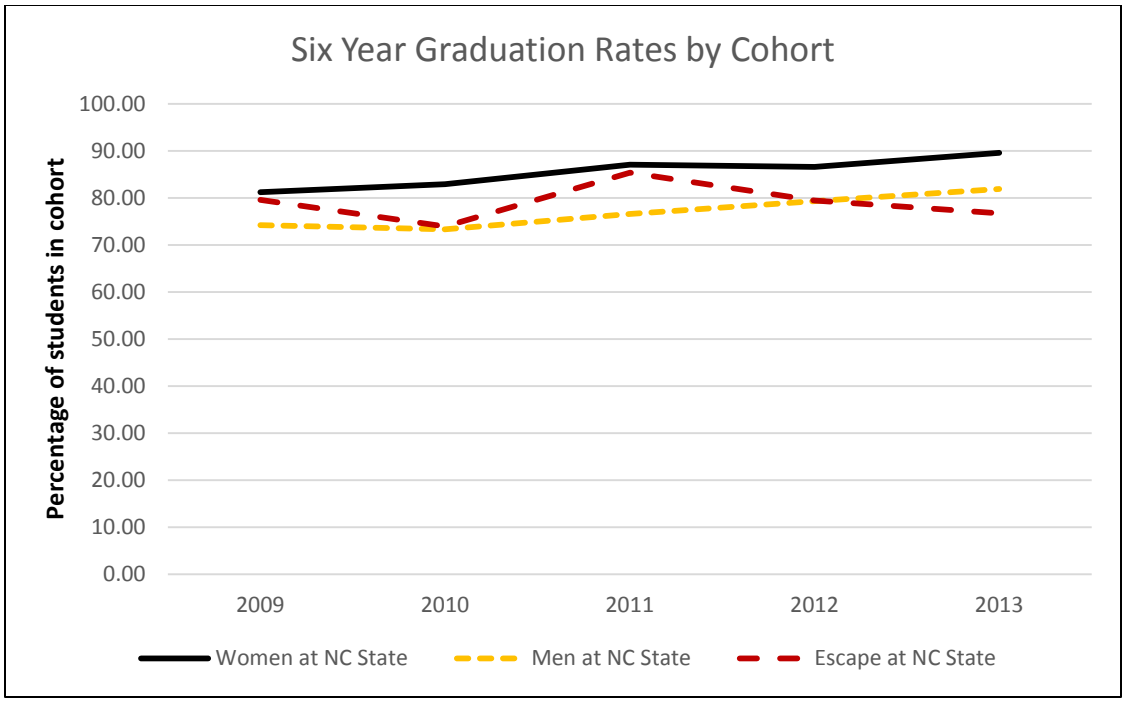

Figure 2: Comparison of Six Year Graduation Rates at the University

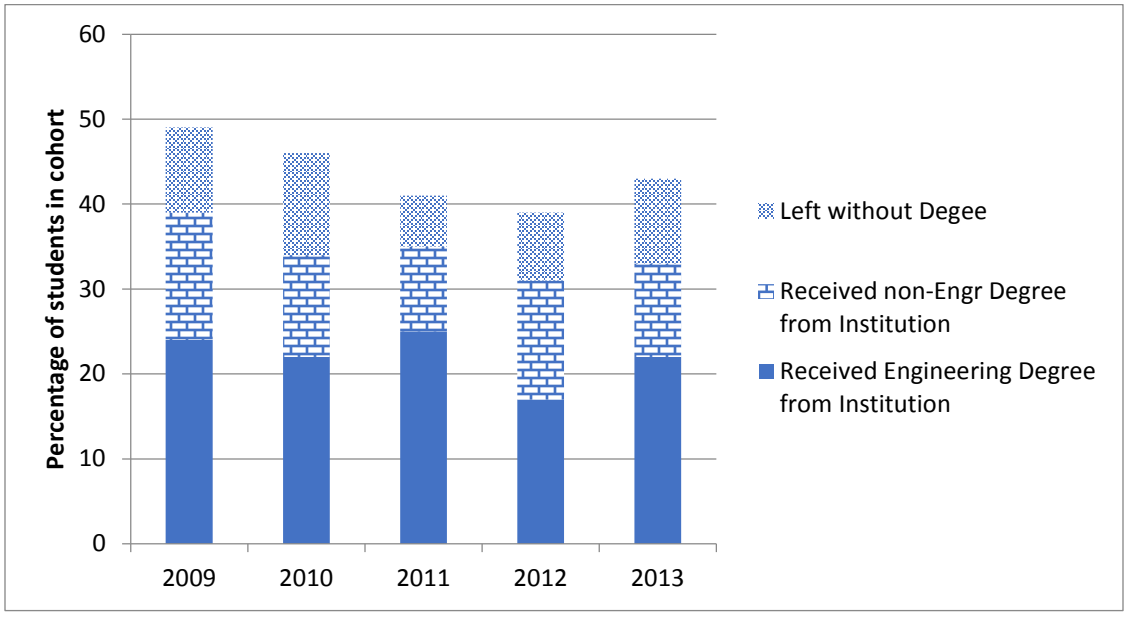

Figure 3: Program Participant Outcomes by Cohort

Table 4: Comparison of Percent of Leavers who Leave Early (after 1st year)

	2009			2010			2011		
	Escape	All students	All women	**Escape**	All students	All women	**Escape**	All students	All women
Percent who Left Engr	**51.0%**	45.3%	44.8%	**52.2%**	43.7%	41.8%	**39.0%**	40.5%	34.8%
Percent of Leavers who Left After First Year	**24.0%**	35.8%	38.4%	**45.8%**	33.4%	31.3%	**31.3%**	28.5%	33.6%

2012			2013		
Escape	All students	All women	**Escape**	All students	All women
56.4%	34.6%	34.6%	**48.8%**	32.6%	36.8%
27.3%	33.0%	32.9%	**23.8%**	26.8%	29.3%

Table 5: Academic Outcomes for Cohorts without Six Year Graduation Rates

	2014			2015			2016		
	Escape	All students	All women	Escape	All students	All women	Escape	All students	All women
N	40	1465	360	43	1331	347	48	1370	347
Number who Left Engr After 1st Year	4	144	41	6	115	30	4	152	50
% Left Engr After 1st Year	10.0%	9.8%	11.3%	14.0%	8.6%	8.7%	8.3%	11.1%	14.5%
% Retained to 2nd Yr in Engr	90.0%	90.2%	88.7%	86.0%	91.4%	91.3%	91.7%	88.9%	85.5%

Discussion and Future Work

There appear to be observable differences between the academic outcomes of ESCape attendees and those of the other students that are first-time, first-year students in the same year. The ESCape students are somewhat less academically prepared than their College of Engineering peers from admissions data. While the GPAs of both groups are similar on average, the SAT Math score deficits are large. The academic performance of the students while in school falls below the College of Engineering average. Retention in engineering is, on average, lower for the ESCape students, however their retention is only noticeably lower in one cohort year.

The ESCape students have an average 6-year graduation rate for engineering degrees of 51% rate as compared to the College of Engineering average of 61%. Their 6-year graduation rate for any degree is 79%, which is almost identical to the institutional average rate of 78%. ESCape attendees that were retained in the institution, all graduated within 5 years and most who took more than 4 years earned minors or second majors. These completion rates may or may not indicate any correlation with ESCape attendance, because the academic preparation of ESCape attendees is intentionally biased. With lower math SAT performance, ESCape attendees leave engineering at a higher rate than average students, but they are retained at the university. Of those ESCape attendees who leave engineering, a substantial portion are retained in other STEM degrees. More data will be collected to allow comparison of overall retention in STEM for all students who start in engineering. Additional analysis will be performed to see if these students are underperforming relative to their peers controlling for pre-college preparation. In addition, analysis will be performed to examine whether there is an indicator that is predictive of ESCape attendee success as compared to the general engineering population. While there are potential indicators of differential performance for ESCape attendees, future work will need to look at the effects of input variables. Additionally, the different measures of table 4 will need to be considered more carefully.

These data represent the individual journeys of hundreds of young women, and they cannot capture all of the nuances of those journeys. With the next statistically work will also be paired several case studies to illustrate the kinds of immeasurable quantities that statistics cannot capture.

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