Summer Engineering Enrichment Program Results Exceed Expectations

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Abstract

A long term ten week residence summer engineering enrichment program for incoming first year engineering majors with ACT Math scores of 17-25 (equivalent SAT Math scores of 470-620; 35%-80%) is exceeding retention/graduation in engineering expectations, especially time to graduate. Relatively unique program aspects are the ten week residence length, 8 semester hours of College credit [College Algebra (3), Trigonometry (3), University Success (2)], zero cost for the student, and 100% underrepresented minorities (not required). The first two cohorts produced twelve (20% or 12/61) 4 year engineering graduates which quadrupled the historical 4 year graduation rate of less than 5%. The five year engineering, STEM and university graduation rates for the first cohort (2009) were 29%, 42%, and 50% respectively. The 2009 and 2010 cohorts produced 19 engineering graduates to date with an average time to graduate of 4.18 years, a reduction of a year in the historical rate. Part of this larger than expected decrease in time to graduate is most likely due to the periodic offering of some upper division required courses in one or two departments due to small student numbers. Additionally, 15/19 (79%) graduates had ACT Math scores of 20-25 and 4/19 (21%) had ACT Math scores of 17-19 with similar numbers in each group (32 and 29 respectively). The program is increasing retention in engineering and increasing graduation rates.

Background

A Summer Engineering Enrichment Program (SEEP) was initiated in summer 2009 with the objective of increasing retention and graduation (BS) rates in an engineering major (civil, computer, electrical [since fall 2012] and telecommunications engineering and computer science) for first year students with ACT Math scores of 17-25 (equivalent SAT Math scores of 470-620). Students with ACT Math scores in this range are usually not deemed to be calculus ready. An analysis of historical (2005 to 2009) retention and graduation rates for first year engineering majors revealed that most changed majors (or left the university) because of difficulties with the calculus course sequence. The program is described in some detail in [1,2]. Briefly, for completeness, students are eligible to apply for the program if they have applied for and been granted admission to the university in an engineering or computer science major. The program is cost free to the student except for incidental expenses. Acceptance includes tuition, room and board, books and other fees associated with the academic courses. The two summer sessions combined last 10 weeks. During the first summer term students are enrolled in College Algebra (3 hours) and University Success (2 hours). In the second summer term, they are enrolled in Trigonometry (3 hours) and a non-credit introduction to engineering course. Courses are taught in the Engineering Building to establish an early sense of pride and belonging to the engineering student community. Students are located in the dormitory together with the objective of fostering a community of engineering learners. A full time mentor (same person since inception) is assigned during the summer and is part time during the academic year. Another part time mentor/counselor is available during the entire year and the Administrative Manager for the

Program is full time, 12 months a year. The Administrative Manager has been with the Summer Engineering Enrichment Program since inception in 2009. Students meet program alumni during the summer and visit engineering employers in the area where alumni (and others) brief them in their job setting. The summer students meet with an engineering advisor during the second summer term and enroll in classes for the fall semester.

Our engineering program serves a different first year student population than most engineering programs with respect to college preparedness. Seventy five (75) percent of the first year engineering students from 2009-2013 (years of this study) had ACT Math scores from 17-25 (equivalent SAT scores of 470-620). This was 461 of 615 first year students. There were 19% of first year students with ACT Math scores below 17, 4% with scores above 25 and 2% with no ACT Math score recorded. This clearly shows that our SEEP is directed toward the correct population to have maximum impact. There have been many summer bridge programs [3, 4, 5, 6, 7, 8, 9] for engineering students over the last three decades. We are unaware of any that lasted for the full ten week summer term and that enrolled students for credit in both College Algebra and Trigonometry. Most last for two to four weeks and are aimed at exposing students to college life (somewhat similar to the University Success course our students take in the first summer term) and reviewing/honing mathematics skills. We found no other summer bridge programs that were as consistent and sustained as long as the SEEP program. Summer 2015 will be the seventh consecutive cohort and the total engineering students enrolled for 2009-2015 will be well over 200. The engineering cohorts averaged over 30 students per summer. The SEEP program has three unique aspects that set it apart from other summer bridge programs: (1) relatively low level of mathematics college preparedness for first year engineering students, (2) 10 week length of the program that earns 8 semester hours of college credit, and (3) the consistency and sustainment of the program.

Analyses Performed

We chose to compare the one, two, and three year engineering retention rates for Summer Engineering Enrichment Program (SEEP) participants with identical groupings of Non- SEEP students (with respect to ACT Math scores). Comparisons will be made for summer cohorts of first year SEEP students for the five summers of 2009 through 2013. Non-SEEP students used for the comparison were first year engineering students who enrolled in the fall semester of identical years, 2009 through 2013 respectively. This should provide the best possible side by side comparisons since many of these SEEP and Non-SEEP students were in the same engineering classes with the same professors. A number of students who begin an engineering major transfer to another STEM (Science, Technology, Engineering and Mathematics) major (in our case either Technology, Biology, or Earth System Science) or to some non-STEM major (usually Business, Education, English or Criminal Justice). We also compared graduation rates in engineering, STEM and the university for the ACT Math 17-25 first year engineering students (both SEEP and Non-SEEP). After a series of graphical and tabular analyses, there is a discussion of possible limitations of the analyses performed. Conclusions are drawn from the side by side comparisons (SEEP and Non-SEEP) of retention and graduation rates and from the ACT Math score sub-group (17-19 and 20-25) comparisons.

SEEP and Non SEEP Characteristics

Tables 1 to 4 below contain characteristics and data describing the SEEP and Non-SEEP cohorts of first year engineering majors. Tables1 and 2 show data for SEEP cohorts. Table 1 provides the number and cumulative number of students in the ACT Math group 17-25 (all cohort students) while Table 2 shows the number and cumulative number of students in ACT Math subgroups of 17 to 19 and 20-25.

SEEP Summer Cohort	Number of Students	Cumulative Number of Students	Characteristic
2009	24	24	5 Year Graduation
2010	37	61	4 Year Graduation
2011	29	90	3 Year Retention
2012	31	121	2 Year Retention
2013	38	159	1 Year Retention

Table 1: Basis for SEEP Computations for (ACT Math 17-25)

SEEP Summer Cohort	ACT Math (17-19)		ACT Math (20-25)		Total in Cohort (Cumulative)
	Number	Cumulative Number	Number	Cumulative Number	
2009	11	11	13	13	24
2010	18	29	19	32	61
2011	11	40	18	50	90
2012	10	50	21	71	121
2013	12	62	26	97	159

Table 2: Basis for SEEP Computations by ACT Math Subgroups (17-19 & 20-25)

Tables 3 and 4 below display analogous data (to Tables 1 and 2) for the Non-SEEP first year engineering majors.

Non-SEEP Fall Cohort	Number of Students	Cumulative Number of Students	Characteristic
2009	61	61	5 Year Graduation
2010	42	103	4 Year Graduation
2011	67	170	3 Year Retention
2012	56	226	2 Year Retention
2013	76	302	1 Year Retention

Table 3: Basis for Non-SEEP Computations (ACT Math 17-25)

Non-SEEP Fall Cohort	ACT Math (17-19)		ACT Math (20-25)		Total in Cohort (Cumulative)
	Number	Cumulative Number	Number	Cumulative Number	
2009	29	29	32	32	61
2010	20	49	22	54	103
2011	38	87	29	83	170
2012	32	119	24	107	226
2013	39	158	37	144	302

Table 4: Basis for Non SEEP Computations by ACT Math Subgroups (17-19 and 20-25)

Retention and Graduation Rates

The next task was to track each student's collegiate record to accurately identify retention and graduation information. This was an arduous task for the 461 students (159 SEEP and 302 Non-SEEP who entered an engineering program as first year students from 2009 to 2013. A student was defined as retained in engineering if they registered as an engineering major in the fall semester following year 1, the fall semester following year 2, and the fall semester following year 3. If a student graduated in an engineering major, we computed both 4 year graduation rates and 5 year graduation rates in engineering. Likewise, if the student changed their major to another STEM major (Biology, Chemistry, Earth System Science, Mathematics, Physics or Industrial Technology) and graduated, we added these to those that graduated in engineering to compute a STEM graduation rate. Analogously, if a student graduated in a Non-STEM major we added those students to compute a university graduation rate. Figures 1-3 contain retention and graduation in engineering data in graphical form for SEEP Cohorts (2009-2013) by ACT Math score (17-19, 20-25 and 17-25). Figures 4-6 contain retention and graduation in engineering data in graphical form for Non-SEEP Cohorts (2009-2013) by ACT Math score (17-19, 20-25 and 17-25).
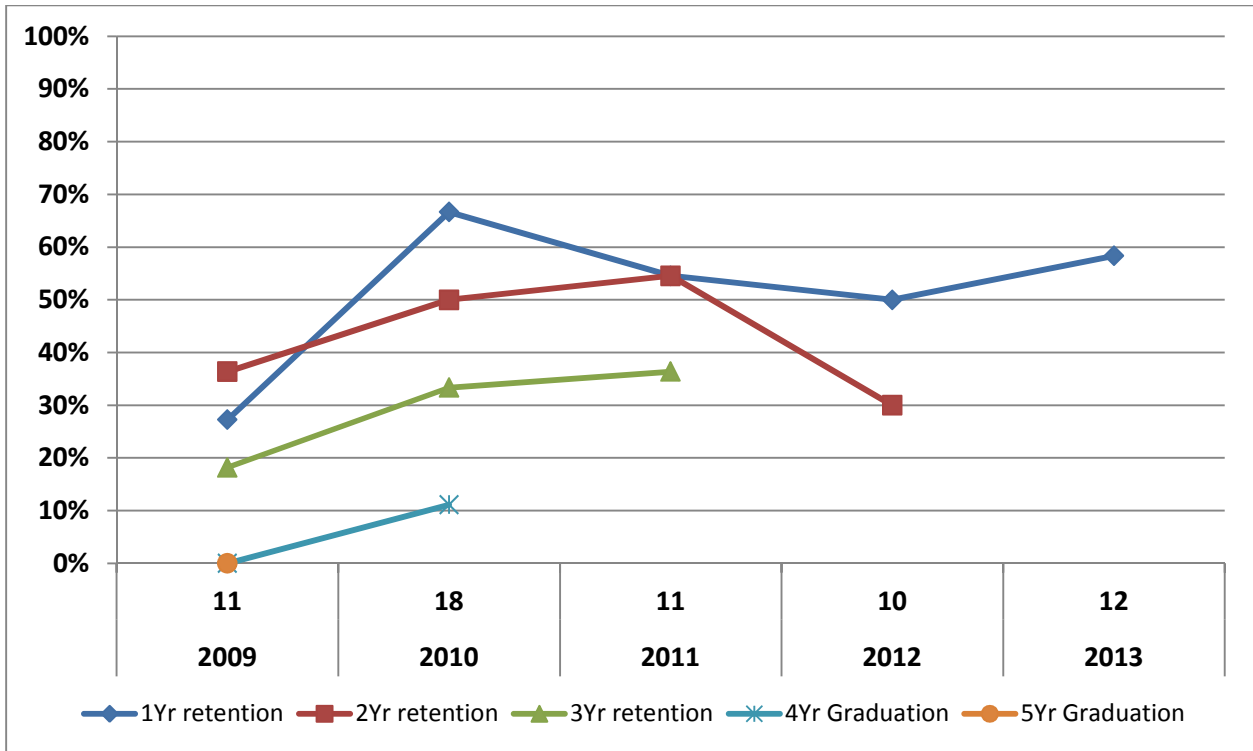
Figure 1: SEEP ACT Math 17-19 Retention and Graduation in Engineering by Cohort Year
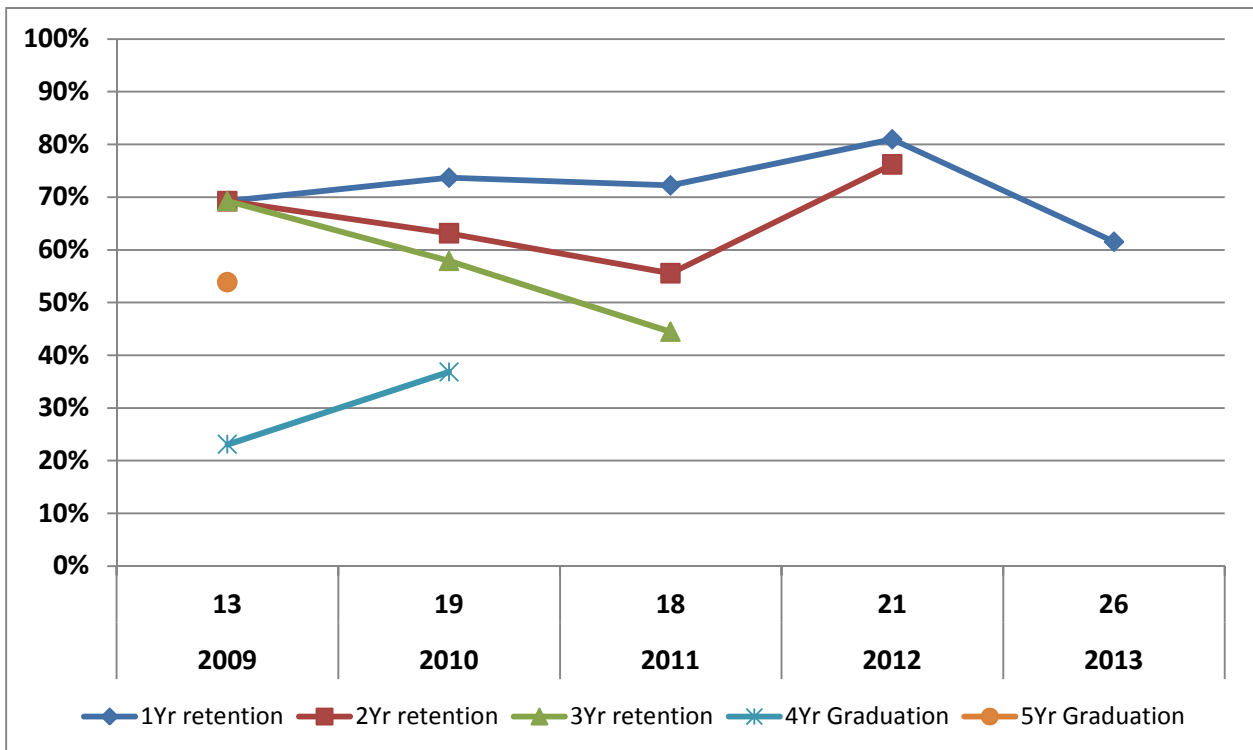

Figure 2: SEEP ACT Math 20-25 Retention and Graduation in Engineering by Cohort Year
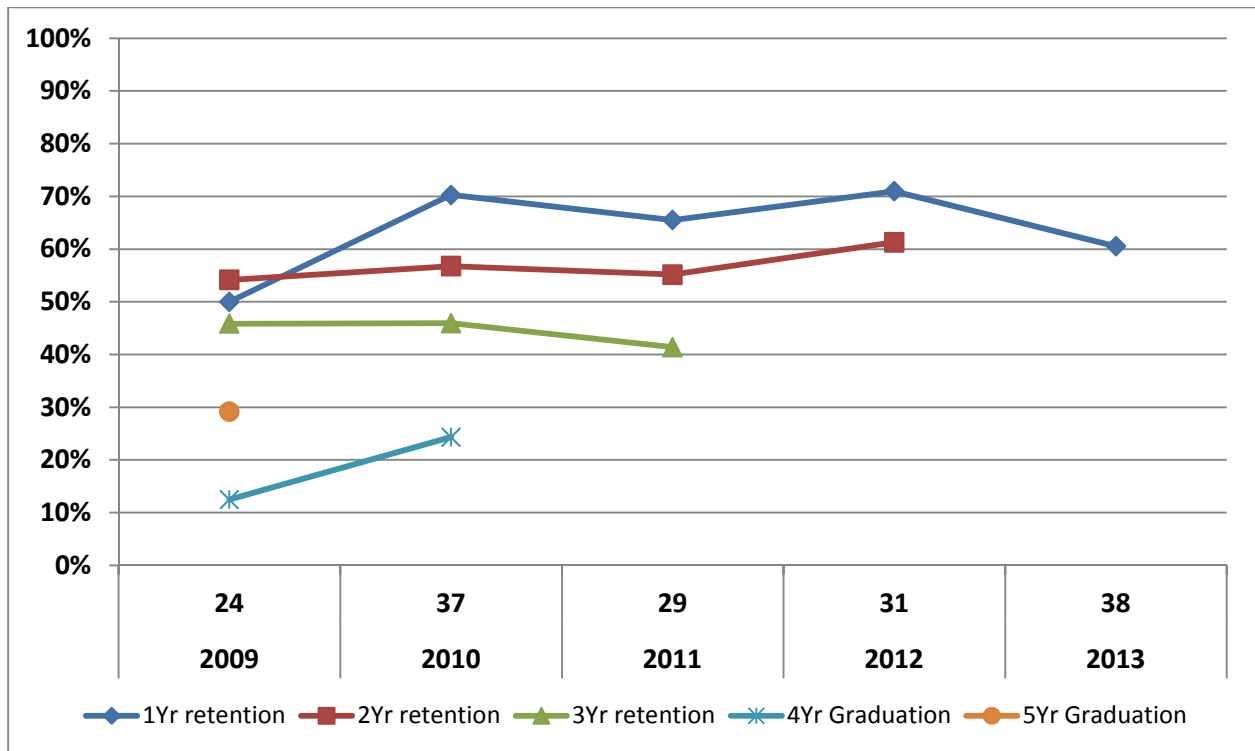
Figure 3: SEEP ACT Math 17-25 Retention and Graduation in Engineering by Cohort Year
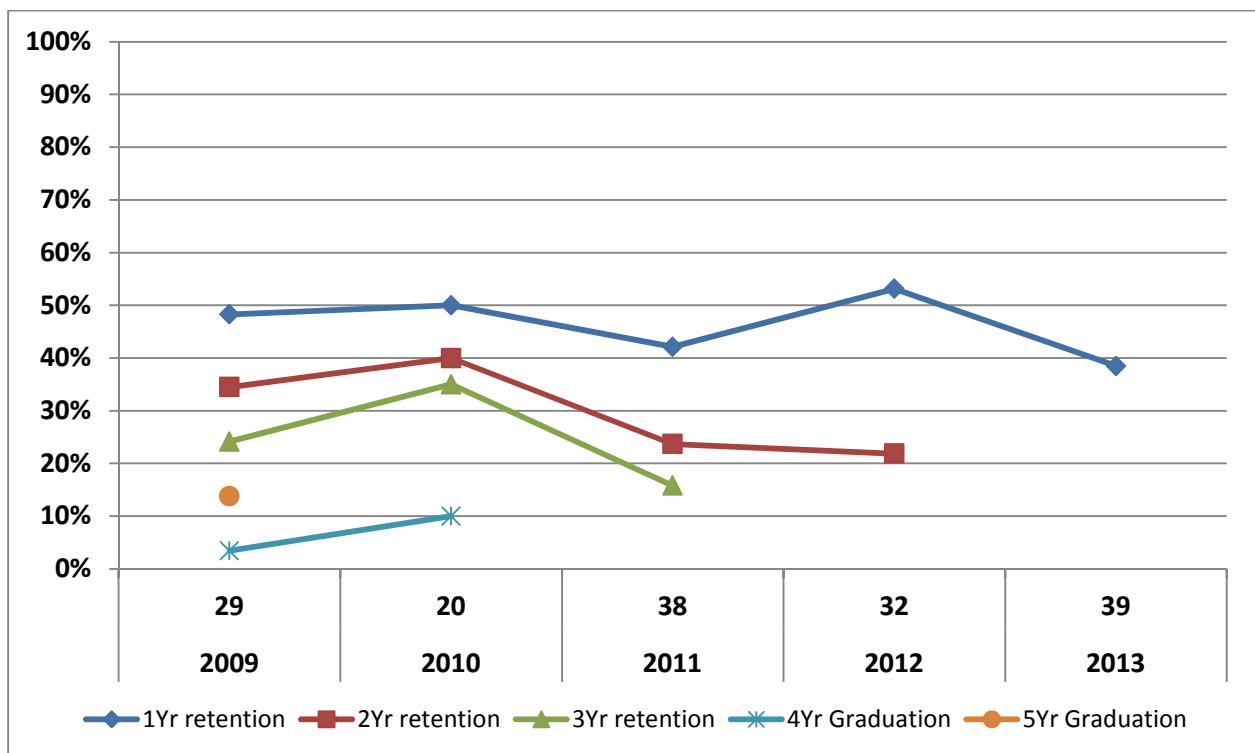

Figure 4: Non-SEEP ACT Math 17-19 Retention and Graduation in Engineering by Cohort Year
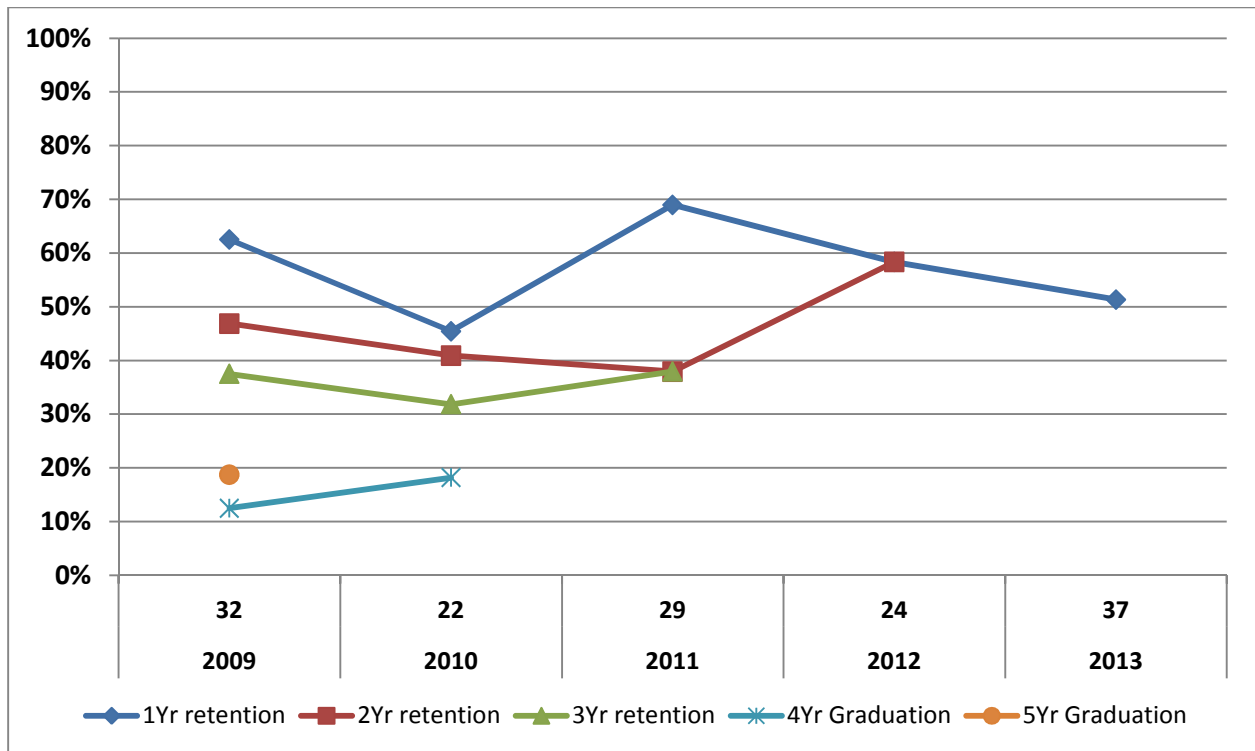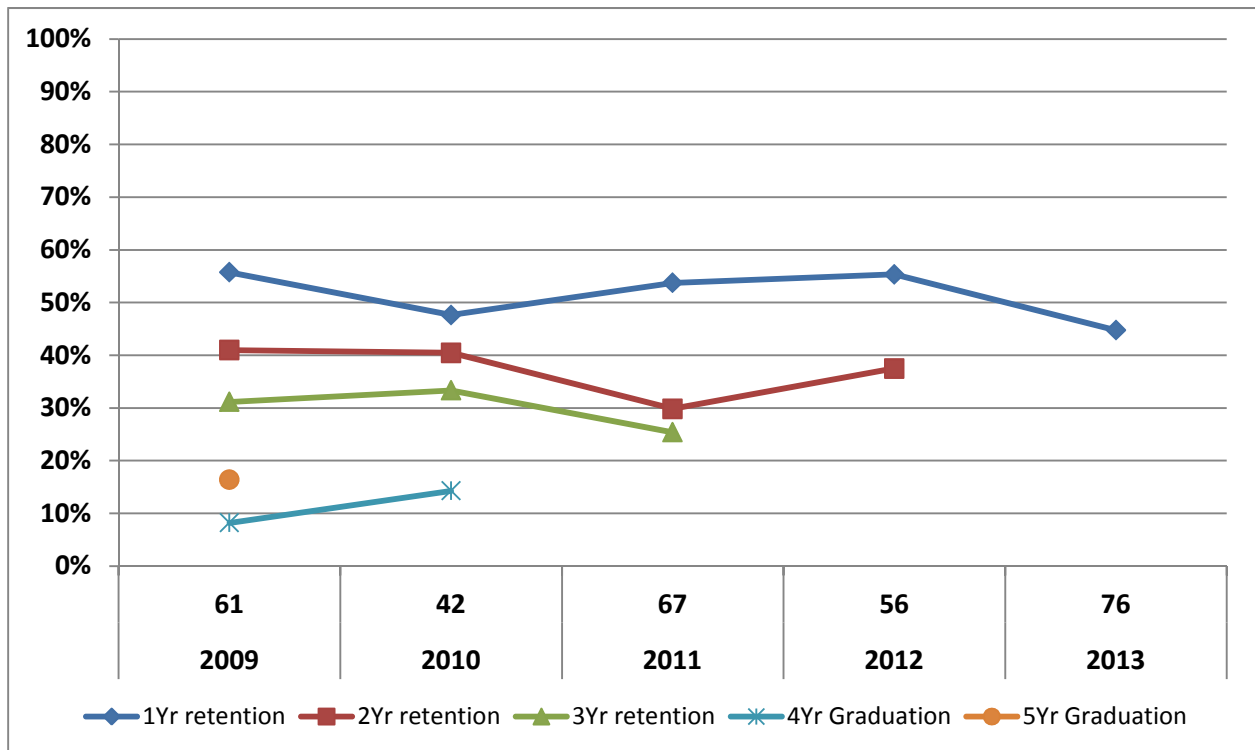
Figure 5: Non-SEEP ACT Math 20-25 Retention and Graduation in Engineering by Cohort Year

**Figure 6: Non-SEEP ACT Math 17-25 Retention and Graduation in Engineering by Cohort Year**

Figures 1 and 3 show a larger 2 year retention rate than the 1 year retention rate for the 2009 cohort. This is not an error. There were two engineering students who changed to another STEM major during year one and who changed back to an engineering major during year two. Therefore, they were not retained in year one but were both retained in year two. Likewise one other engineering student who was retained in year one, changed to another STEM major and was not retained in year two. There was a net gain of one retained student from year one to year two.

An attempt was made to combine results from Figures 1-6 into two graphs to clearly display major results from this paper with respect to SEEP influence on engineer graduation rates. Figure 7 vividly illustrates that 4 year graduation rates for the ACT Math score group of 20-25 (green lines, both SEEP and Non-SEEP) greatly exceed the graduation rates for the 17-19 ACT Math score group. The SEEP program nominally doubles the graduation rate relative to the Non-SEEP group for ACT Math scores of 20-25. Figure 7 contains data from the 2009 and 2010 summer cohorts and there is no discernible difference in SEEP and Non SEEP students for the ACT Math score 17-19 group. In all cases the graduation rate was between 0-11% for this group. Figure 8 displays 5 year SEEP and Non-SEEP graduation data for the two groups. SEEP ACT Math score 20-25 group showed a remarkable 54% 5 year graduation rate, almost triple the graduation rate for comparable (20-25) Non-SEEP group. There were no engineer graduates from the SEEP 17-19 group. Two or three more years of graduation data with similar trends may result in far reaching highly significant conclusions relative to structure and investment in summer bridge programs to gain maximum benefit.
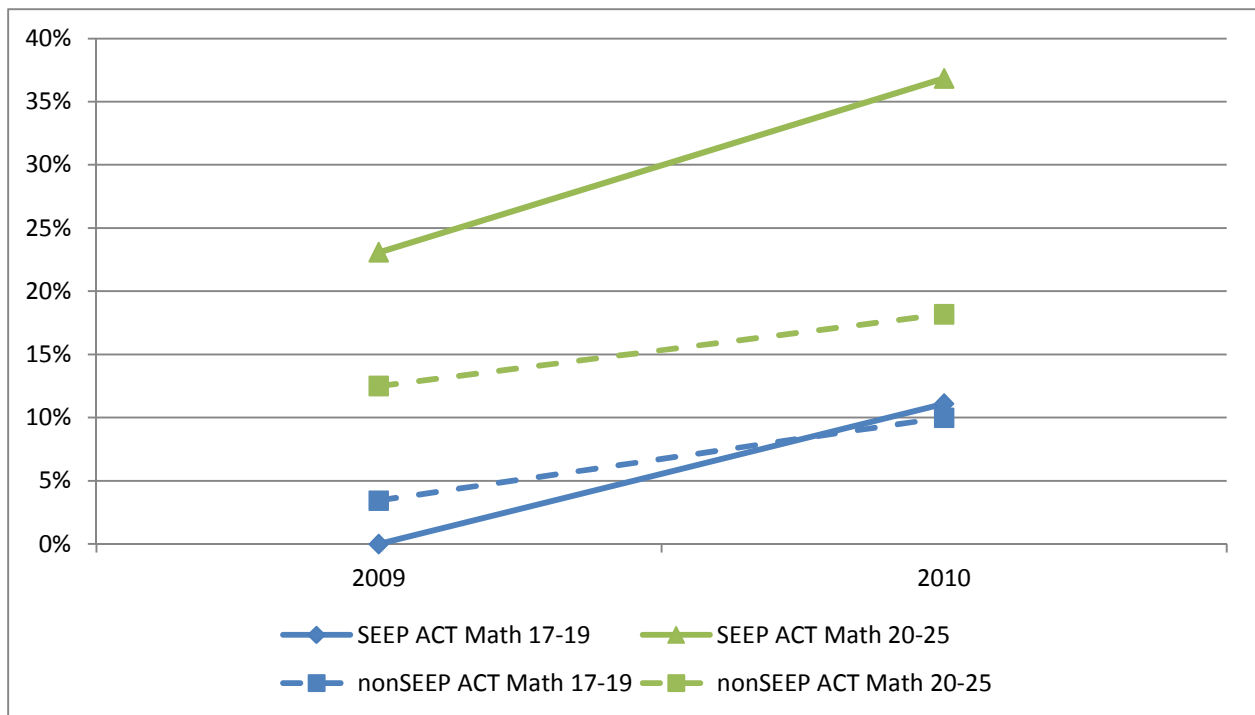
Figure 7: Compare SEEP and Non-SEEP 4-Yr Graduation Rate by Cohort
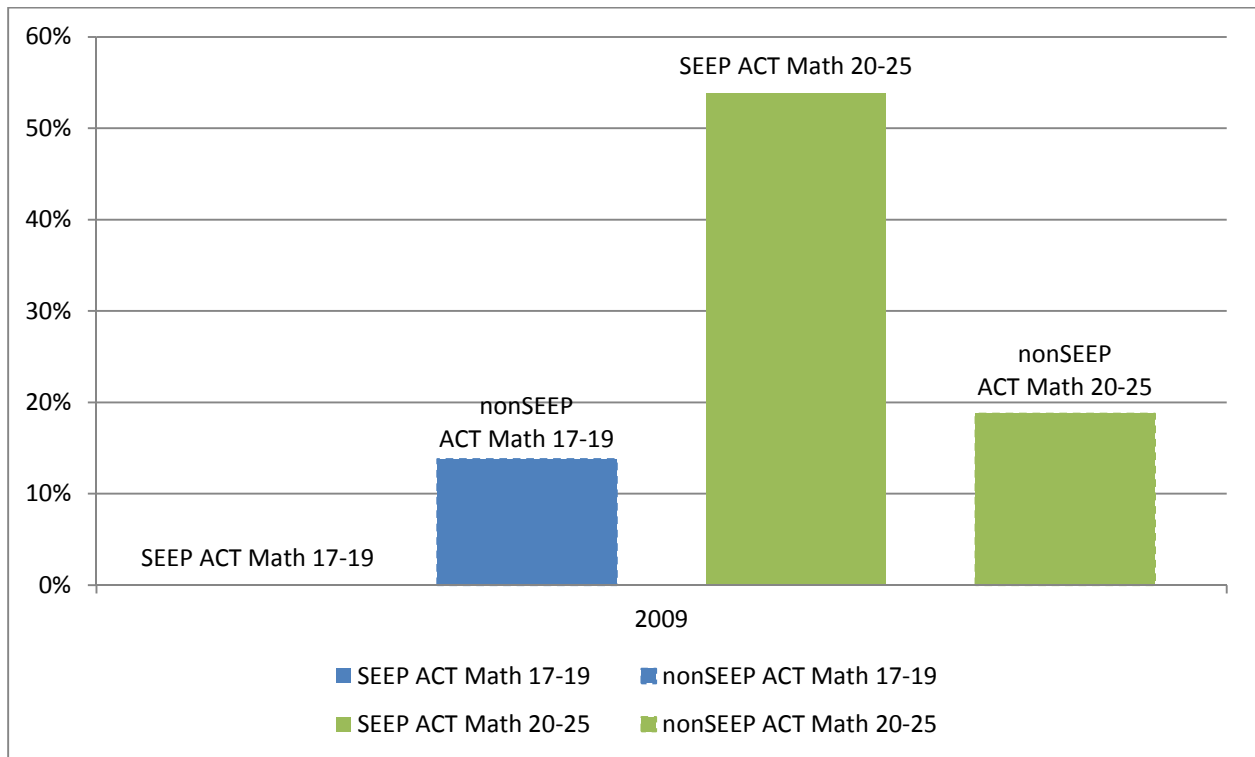
Figure 8: Compare SEEP and Non-SEEP 5-Yr Graduation Rate; 2009 Cohort

Table 5 and 6 show the mean and standard deviation of the ACT Math scores for each of the subgroups (17-19 and 20-25) for the SEEP and Non-SEEP students respectively. The mean for each was below the median of the range. This tends to indicate that there is probably little bias in the results from the two groups due to a heavy concentration of scores at the low end of the 17-19 group and concentration of scores at the high end of 20-25 group.

Cohort Year ACT Math Score	2009	2010	2011	2012	2013	Mean & Standard Deviation
17-19	18.25	17.94	18.55	18.20	18.25	18.20±0.75
20-25	21.70	22.58	22.67	22.57	22.23	22.40±1.61

Table 5: Average ACT Math score for SEEP Groups by Cohort

Cohort Year ACT Math Score	2009	2010	2011	2012	2013	Mean & Standard Deviation
17-19	17.76	17.70	17.76	17.94	17.80	17.80±0.78
20-25	21.65	21.91	21.80	21.83	22.21	21.88±1.60

Table 6: Average ACT Math score for Non-SEEP Groups by Cohort

One, two and three year engineering retention rates are analyzed by comparing SEEP and Non-SEEP Cohorts in tabular form with the data aggregated for all cohorts for ACT Math scores from 17-25 in order have as large a population as possible for comparison. Table 7 illustrates a side by side comparison of the 1, 2 and 3 year retention rates and the 4 year and 5 year graduation rates in engineering, for the cohorts to date.

Engineering		
Characteristic	**SEEP**	**Non-SEEP**
1 Yr. Retention	102/159=64%	155/302=51%
2 Yr. Retention	69/121=57%	83/226=37%
3 Yr. Retention	40/90=44%	50/170=29%
4 Yr. Graduation	12/61=20%	11/103=11%
5 Yr. Graduation	7/24=29%	10/61=16%

Table 7: Comparison of SEEP/Non-SEEP Engineering Retention/Graduation Rates ACT Math (17-25)

Table 8 provides a comparison of SEEP and Non-SEEP 4 year and 5 year graduation rates in an Engineering major, in a STEM major and in any university major.

Charac-teristic	Engineering		STEM		University	
	SEEP	**Non-SEEP**	**SEEP**	**Non-SEEP**	**SEEP**	**Non-SEEP**
4 Yr. Graduation	12/61= 20%	11/103= 11%	13/61= 21%	13/103= 13%	13/61= 21%	17/103= 17%
5 Yr. Graduation	7/24= 29%	10/61= 16%	10/24= 42%	13/61= 21%	12/24= 50%	15/61= 25%

Table 8: Comparison of SEEP/Non-SEEP Engineering, STEM and University Graduation Rates: ACT Math (17-25)

The Table 7 and 8 increases in retention and graduation rates for SEEP Cohorts are shown in Table 9 and 10 which illustrate an increase of 13% to 25% for 5 year graduation (engineering, STEM or university) and an increase of 13% to 20% for retention in engineering. This difference is expected to increase when six year graduation data are available. Several students in the 2009 Cohort remain enrolled in year six, two in engineering, one more in a STEM major and two more in another outside STEM university major.

Characteristic	Engineering
1 Yr. Retention	+13%
2 Yr. Retention	+20%
3 Yr. Retention	+15%
4 Yr. Graduation	+9%
5 Yr. Graduation	+13%

Table 9: Increase in Engineering Retention and Graduation Rates for SEEP Students.

Characteristic	Engineering	STEM	University
4 Yr. Graduation	+9%	+8%	+4%
5 Yr. Graduation	+13%	+21%	+25%

Table 10: Increases in Engineering, STEM and University Graduation Rates for SEEP Students

It appears relatively certain that the SEEP Program will result in an increase in graduation rates of well over twenty percent when based on the six year graduation metric. The STEM and university graduation rates do not show a marked increase in the 4 year graduation rate because it simply takes longer than 4 years (in most cases) for a student to graduate when changing majors. This shows up in the jump in STEM and university graduation rates for year five. It is expected that all three graduation rates will increase even more when year six graduation data are available in May 2015. (2009 cohort)

In working with these data, it seemed there was a substantial difference in engineering retention and graduation rates for students with 17-19 ACT Math scores and those with 20-25 ACT Math scores. Retention and graduation data were recomputed for engineering majors in an attempt to ascertain if this were true. The rationale for only using students in engineering was that the correlation of graduation rate with ACT Math score should be much stronger for engineers. Biology and Technology curricula only require one semester of calculus. Non-STEM majors are not required to complete calculus except for Business Calculus in some majors.

Table 11 reveals that retention and graduation rates are consistently larger for engineering students with ACT Math scores of 20-25 relative to those with scores from 17-19. The difference is usually more than 20% for the SEEP Cohorts and usually more than 10% for the Non-SEEP Cohorts for the identical time period (2009-2013). Several more years of results should stabilize this difference as large numbers of participants become included in the data. Premature conclusions without more data are discouraged.

Charac-	SEEP ENGINEERING			NON-SEEP ENGINEERING		
teristic	17-19	20-25	Difference	17-19	20-25	Difference
1 Yr. Retention	33/62=53%	69/97=71%	+18%	72/158=46%	83/144=58%	+12%
2 Yr. Retention	22/50=44%	47/71=66%	+22%	34/119=29%	49/107=46%	+17%
3 Yr. Retention	12/40=30%	28/50=56%	+26%	20/87=23%	30/83=36%	+13%
4 Yr. Graduation	2/29=7%	10/32=31%	+24%	3/49=6%	8/54=15%	+9%
5 Yr. Graduation	0/11=0%	7/13=54%	+54%	4/29=14%	6/32=19%	+5%

Table 11: Comparison of SEEP and Non-SEEP Retention/Graduation by ACT Math Subgroup (17-19 and 20-25)

Time to Graduate

A more detailed analysis of graduation data for the 2009 and 2010 Cohorts is given in Table 12 which provides graduation data for May and December with December graduates labeled as 4.5 year graduates or 5.5 year graduates as the case may be. There were no summer graduates

Graduation	2009 Cohort			2010 Cohort		
Time	Date	Number	Cumulative	Date	Number	Cumulative
4 Years	May 2013	3	3	May 2014	9	9
4.5 Years	Dec. 2013	4	7	Dec. 2014	3	12
5 Years	May 2014	0	7			
5.5 Years	Dec. 2014	0	7			

Table 12: Engineering Graduation Times by Semester for SEEP Students

The average time to graduate can be computed more accurately using the data above. Table 12 shows that 12 students graduated in 4 years and 7 additional students graduated in 4.5 years: The average time to Graduate is displayed below:

Average Time to Graduate: = (12 students) x (4 years) + (7 students) x (4.5 years) = 4.18 years
19 students

The main takeaway is that a large majority of SEEP engineering graduates, graduate in either 4 years or 4 ½ years. This is a larger reduction in time to graduate than expected. Starting the calculus and calculus based physics sequences when scheduled in the four year curriculum impacts the prerequisite sequencing and consequently time to graduate more than anticipated. This is due to the fact that all required undergraduate courses are not taught every semester in every major (due to student numbers) which, in some cases, can add an extra semester to the

time to graduate. Relative to historical time to graduate for all engineers since 2005, this is slightly more than a 1 year decrease.

Limitations

There are several limitations to consistency of results that need to be pointed out. Graduation data to date have limited numbers (19 SEEP graduates to date) and statistical significance and reliability can only be improved with more years of data including six year graduation data. Another two or three years should be sufficient to stabilize four and five year graduation data and produce a couple of years of six year graduation data. There is an unavoidable, albeit relatively small, scatter in both retention and a graduation rate caused by differences in the distribution of ACT Math scores between the SEEP and Non-SEEP groups and the difference varies from year to year. The increase in retention and graduation rates for SEEP students could be partially influenced by the positive effects of the community of engineering learners mentoring encouraged by the SEEP program rather than exclusively due to exposure to College Algebra and Trigonometry courses. We have not attempted to try to isolate the contributions of each to the increase in SEEP graduation rates. We are gratified by the 20+% increase in graduation rates for SEEP participants regardless of mathematics/mentoring relative contributions. I am personally confident both contribute to the success. However, Non-SEEP first year students are also highly encouraged to join engineering clubs and become a part of the community of engineering learners. The SEEP program is composed 100% of students from our state because the university declined to waive out-of-state tuition for summer SEEP students even though it may be waived for the same students, in some cases, during the regular academic year. Consequently, no out-of-state students participated in SEEP Cohorts.

Conclusions

The preceding analyses lead to the following conclusions regarding retention and graduation rates and time to graduate from a sustained Summer Engineering Enrichment Program for first year engineering students with ACT Math scores of 17-25 (equivalent SAT Math scores of 470-620).

a. Engineering 4 year and 5 year graduation rates for SEEP students were increased by nominally 10% relative to Non-SEEP students for the same years. The increase in 4 year graduation rates was four-fold relative to historical 4 year graduation rates.

b. The STEM 5 year graduation rate for SEEP students was increased over 20% relative to the NON-SEEP graduation rate for the same period.

c. The University 5 year graduation rates for SEEP students was increased nearly 25% relative to the graduation rate for Non-SEEP students for the same period.

d. 1, 2, and 3 year retention rates in an engineering major for SEEP students increased nominally by 13-20% relative to those for Non-SEEP students for the same period.

e. Retention and graduation rates for SEEP students with ACT Math scores of 20-25 (50%-80%) were over 20% higher than those for SEEP students with ACT Math scores of 17-19 (35%-49%).

f. Retention and graduation rates for Non-SEEP students with ACT Math scores of 20-25 were nominally over 10% higher than those for Non-SEEP students with ACT Math scores of 17-19.

g. Time to graduate for SEEP graduates (19) to date is 4.18 years. This is about a year less than the historical time to graduate in an engineering major at our university.

Acknowledgements

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