
AC 2012-5373: INCREASED RETENTION AND GRADUATION RATES OF ENGINEERING STUDENTS

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Increased Retention and Graduation Rates of Engineering Students

1. Abstract

In earlier publications^{i ii} we reported that the City College of New York Grove School of Engineering had adopted a new admissions criterion for freshmen and transfers based on an analysis of predictors of early and long-term retention. This paper focuses on freshmen and explores the impact of the new admissions criterion on retention and graduation rates, ethnic composition of the student body, and academic achievement by ethnicity.

2. Introduction

The retention and ultimate graduation of engineering students, especially those from underrepresented groups, is a challenge that must be met if the United States is to remain competitive in a technology driven world.^{iii iv v} Engineering schools must improve the chances for graduation of entering freshmen. With fewer opportunities for scholarships and grants and diminished college savings, caused in part by the 2008 economic downturn, students are more vulnerable to dropping out of college^{vi}. Colleges that once offered add-on programs designed to improve the retention of students are no longer able to do so, because of limited funds due to the poor economic climate^{vii viii}. To increase the retention and graduation rates of engineering students, colleges are going to have to do it with little or no additional financial resources. We wish to demonstrate how significant improvement in the retention of engineering students, particularly those from underrepresented groups, was achieved by systematically modifying the admissions requirements over a five-year period.

3. A change in admissions criteria

Before the fall of 2006, entering freshmen had to satisfy an admissions index that considered numerous parameters such as high school GPA, SAT scores, and when applicable, TOEFL scores, to be admitted to Engineering. In addition, they were required to take a placement examination for math that had no bearing on their admission.

Starting in the fall of 2006, entering freshmen were required to place in pre-calculus or a higher level of math in order to gain entry to engineering, in addition to the existing minimum index score. Entering freshmen who intended to major in engineering and who satisfied the “index” but did not place in pre-calculus or higher, were referred to a special program called the “Gateway Academy” administered by the College. They were admitted to one of their other choice options (e.g., physics, economics), or as “undecided” in the College of Liberal Arts and Sciences (CLAS), a division of the college consisting of programs in the humanities (e.g., language, English), social sciences (e.g., sociology, economics), and the sciences (e.g., biology, mathematics, chemistry). These prospective engineering students could transfer internally (within the college) into engineering upon satisfying the admission requirements for transfer students, which required an overall GPA of 2.50, the completion of calculus I with a C or higher grade, and demonstrated proficiency in mathematics and science.

Starting in the fall of 2008 the minimum SAT and high school GPA requirements for admission were raised incrementally every year, leading to an increase in the average combined verbal + math SAT scores from 1093 for the fall 2008 cohort, to 1125 for the fall cohorts of 2009 and 2010. Freshmen placing in pre-calculus or higher in previous cohorts averaged SAT scores around 1060 (fall 2004 and 2005) and 1080 (fall 2006 and 2007).

4. Retention and graduation from fall 2004 to fall 2010.

In our earlier paper we showed that 33 out of 193 (17.1%) of the fall 1999 freshmen cohort had graduated by the fall of 2005, and 3.1% were still enrolled, leading to a combined 6-year retention + graduation rate of 20.2%. Had the current admission criterion been applied at the time, 42 out of 123 (35.0%) would have graduated, with 1.6% still enrolled after six years. The 6-year retention + graduation rate would have been 36.6%. This would have meant an increase of 16.4%.

Table 1. shows the retention and cumulative graduation rates for the cohort fall 1999 and the cohorts fall 2004 through fall 2010, with the shaded area indicating the cohorts falling under the old freshmen admissions criterion. The fall 1999 cohort contains a number of special program students who typically do not fulfill the regular admissions criteria and a number of freshmen who started part-time, which tends to suppress the retention and graduation rates. The pattern in

table 1. shows that the new admissions criterion of eligibility to start in pre-calculus or higher, could lead to an increase in 6-year graduation rates of at least 10%, possibly even more for the fall 2009 and later cohorts. Attrition once students reach the fourth year tends to be negligible and they graduate eventually, the earlier the more credits and higher GPA they have accumulated. Therefore, we will consider cumulative GPA and credits obtained.

Cohort	Status	Retention and Cumulative Graduation rates (% of N)						
		Start	1-yr	2-yr	3-yr	4-yr	5-yr	6-yr
Fall 1999 N=193	Enr. + grad.	100.0	47.7	35.8	26.9	21.8	21.2	20.2
	Grad.	0.0	0.0	0.0	0.0	1.6	9.8	17.1
Fall 2004 N=327	Enr. + grad.	100.0	77.1	47.1	36.7	31.8	29.7	27.8
	Grad.	0.0	0.0	0.0	0.0	6.4	16.2	22.9
Fall 2005 N=317	Enr. + grad.	100.0	70.3	49.2	36.0	29.3	27.8	26.8
	Grad.	0.0	0.0	0.0	0.0	2.5	14.2	20.5
Fall 2006 N=177	Enr. + grad.	100.0	76.3	59.9	48.0	41.8	40.1	
	Grad.	0.0	0.0	0.0	0.0	6.8	20.3	
Fall 2007 N=260	Enr. + grad.	100.0	79.6	59.2	48.1	39.2		
	Grad.	0.0	0.0	0.0	0.0	7.7		
Fall 2008 N=278	Enr. + grad.	100.0	79.9	59.4	46.0			
	Grad.	0.0	0.0	0.0	0.0			
Fall 2009 N=306	Enr. + grad.	100.0	79.7	61.4				
	Grad.	0.0	0.0	0.0				
Fall 2010 N=297	Enr. + grad.	100.0	84.5					
	Grad.	0.0	0.0					
Fall 2011 N=259	Enr. + grad.	100.0						
	Grad.	0.0						

Table 1. Retention and graduation for full-time regular Grove School of Engineering freshmen. The fall 1999 cohort includes some non-regular and part-time students which tend to suppress the rates. The shaded cohorts are admitted before the new criterion went into effect.

5. Cumulative GPA and credits obtained by freshmen cohorts fall 2004 to fall 2010.

Table 2. shows the credits and GPA accumulated by retained students over the years before, e.g., if a student starting in fall 2004 is retained in the fall of 2007 (column 3), table 2. shows the accumulated credits and GPA over the three years before fall 2007, in the column numbered “3”.

The number of credits and GPA obtained by graduated students were not included, and since this group tends to have the higher GPAs and highest number of credits obtained, we see a slowing down in the accumulation of credits and a drop in the GPA for the students still enrolled after the fourth year, when the first group has graduated. The non-zero numbers for GPA and credits at

the start are due to students who take advantage of the opportunity to take one or two courses during the summer before their first fall semester.

Obtained	Cohort	Cum. GPA and Credits obtained by retained students for each year retained						
		Start	1	2	3	4	5	6
GPA	Fall 2004	0.34	24.7	51.7	80.2	103.5	110.5	104.8
	Fall 2005	0.43	24.5	48.8	75.8	103.0	107.4	
	Fall 2006	0.20	26.1	51.3	77.8	101.5	111.9	
	Fall 2007	0.12	26.1	51.9	77.2	98.8		
	Fall 2008	0.05	26.0	51.8	76.6			
	Fall 2009	0.02	26.1	49.6				
	Fall 2010	0.07	25.1					
	Fall 2011	0.22						
Credits	Fall 2004	3.27	2.64	2.81	2.96	2.93	2.62	2.43
	Fall 2005	3.31	2.76	2.82	2.91	2.96	2.51	
	Fall 2006	3.63	2.96	2.94	3.00	2.99	2.76	
	Fall 2007	3.04	2.94	2.92	2.96	2.89		
	Fall 2008	3.25	2.85	2.90	2.90			
	Fall 2009	3.20	2.94	2.86				
	Fall 2010	3.19	2.85					
	Fall 2011	3.71						

Table 2. Cumulative GPA and credits for full-time regular Grove School of Engineering freshmen. Shaded area indicates cohorts before the new admissions criterion.

Table 2. shows a higher GPA and number of credits obtained over the first year for the cohorts under the new admissions criteria, fall 2006 through fall 2010. The differences between the cohorts before and after the new admissions criterion disappear when we consider the credits and GPA accumulated over two and three years. This can be attributed to the fact that by the third year in all cohorts most of the students with the weakest math credentials have dropped out. Of course, in the first year the early cohorts have more students with weak to very weak math credentials, leading to lower academic achievement. This assumption is confirmed when we analyze retention, graduation and academic achievement by the level of math taken in the first semester, which will be addressed in section 7.

6. Ethnic composition upon entry and retention before and after the new admissions criterion.

In earlier work we expressed concern over the impact that higher admissions criteria would have on the ethnic composition of the student body at the Grove School of Engineering. At the time, it appeared based on analyses on the fall 1999 freshmen cohort, that we would admit less students, but that in terms of percentages, the percentage of Black students would only drop from 34% to 32% and the percentage of Hispanic students from 28% to 21%.

Cohort	Status	Black USA students. Retention and Cumulative Graduation rates (% of N1).							N1 (%) in cohort	Average over cohorts
		Start	1-yr	2-yr	3-yr	4-yr	5-yr	6-yr		
Fall 2004 N=327	Enr. + grad.	100.0	58.2	19.4	10.4	7.5	4.5	4.5	67 (20.5%)	63 (19.6%)
	Grad.	0.0	0.0	0.0	0.0	1.5	3.0	3.0		
Fall 2005 N=317	Enr. + grad.	100.0	61.0	39.0	28.8	20.3	18.6	16.9	59 (18.6%)	
	Grad.	0.0	0.0	0.0	0.0	0.0	5.1	10.2		
Fall 2006 N=177	Enr. + grad.	100.0	80.0	56.0	32.0	20.0	16.0		25 (14.1%)	
	Grad.	0.0	0.0	0.0	0.0	0.0	8.0			
Fall 2007 N=260	Enr. + grad.	100.0	91.4	54.3	48.6	42.9			35 (13.5%)	
	Grad.	0.0	0.0	0.0	0.0	2.9				
Fall 2008 N=278	Enr. + grad.	100.0	90.9	54.5	39.4				33 (11.9%)	29 (12.2%)
	Grad.	0.0	0.0	0.0	0.0					
Fall 2009 N=306	Enr. + grad.	100.0	74.4	59.0					39 (12.7%)	
	Grad.	0.0	0.0	0.0						
Fall 2010 N=297	Enr. + grad.	100.0	88.9						27 (9.1%)	
	Grad.	0.0	0.0							
Fall 2011 N=259	Enr. + grad.	100.0							26 (10.0%)	
	Grad.	0.0								

Table 3. Retention and graduation for Black full-time regular Grove School of Engineering freshmen. The shaded cohorts are admitted before the new criterion went into effect. E.g., For a given cohort, column “5-yr” shows the percentage of students enrolling after the 5th year and cumulative graduation rate over the previous 5 years.

Tables 3. and 4. show the retention and graduation for Black and Hispanic students in the regular freshmen cohorts fall 2004 through fall 2011, for USA citizens and permanent residents who started full-time.

The right-most column in table 3. shows that the percentage of Black freshmen dropped from on average 19.6% in the fall 2004 and 2005 cohorts to on average 12.2% in the 2006 through 2011 cohorts, with especially low percentages in the fall 2010 and 2011 cohorts.

Table 4. shows a lesser drop for Hispanic students, from on average of 24.3% Hispanics in the early cohorts to 19.4% in the cohorts since fall 2006.

Cohort	Status	Hispanic USA students.							N1 (%) in cohort	Average over cohorts
		Retention and Cumulative Graduation rates (% of N1).								
		Start	1-yr	2-yr	3-yr	4-yr	5-yr	6-yr		
Fall 2004 N=327	Enr. + grad.	100.0	72.2	38.9	31.9	25.0	23.6	22.2	72 (22.0%)	78 (24.3%)
	Grad.	0.0	0.0	0.0	0.0	1.4	8.3	13.9		
Fall 2005 N=317	Enr. + grad.	100.0	63.1	41.7	27.4	20.2	20.2	19.0	84 (26.5%)	52 (19.4%)
	Grad.	0.0	0.0	0.0	0.0	0.0	4.8	8.3		
Fall 2006 N=177	Enr. + grad.	100.0	55.0	47.5	37.5	27.5	27.5		40 (22.6%)	52 (19.4%)
	Grad.	0.0	0.0	0.0	0.0	0.0	5.0			
Fall 2007 N=260	Enr. + grad.	100.0	73.1	55.8	48.1	34.6			52 (20.0%)	52 (19.4%)
	Grad.	0.0	0.0	0.0	0.0	3.8				
Fall 2008 N=278	Enr. + grad.	100.0	73.8	52.3	40.0				65 (23.4%)	52 (19.4%)
	Grad.	0.0	0.0	0.0	0.0					
Fall 2009 N=306	Enr. + grad.	100.0	74.6	45.8					59 (19.3%)	52 (19.4%)
	Grad.	0.0	0.0	0.0						
Fall 2010 N=297	Enr. + grad.	100.0	82.7						52 (17.5%)	52 (19.4%)
	Grad.	0.0	0.0							
Fall 2011 N=259	Enr. + grad.	100.0							43 (16.6%)	52 (19.4%)
	Grad.	0.0								

Table 4. Retention and graduation for Hispanic full-time regular Grove School of Engineering freshmen. The shaded cohorts are admitted before the new criterion went into effect.

To compare retention before and after implementation of the new criteria, we considered the retention of Black and Hispanic regular freshmen after the third year (USA citizens / permanent residents only). We chose this point in time because we can then compare cohorts “before” and “after” the new admissions criterion, and because tables 1. and 2. show a fairly consistent 6-year graduation rate about 10% lower than the retention rate after the third year. That makes the retention after the third year into the fourth year a good metric for persistence and expected completion.

Table 5. shows the numbers and percentages of Black and Hispanic students retained after the 3rd year, i.e., at the start of the 4th year, for the cohorts fall 2004 through 2009. The findings show that even though the numbers and percentages of Black and Hispanic students upon entry dropped after implementation of the new admissions criterion, especially for Black students, the numbers returning on average in the fourth year remained almost constant.

Cohort	Retained after the 3 rd year (enrolled at start of 4 th year)					
	Black			Hispanic		
	N cohort	N retained	% retained	N start	N retained	% retained
Fall 2004	67	7	10.4	72	23	31.9
Fall 2005	59	17	28.8	84	23	27.4
Average	63	12	19.0	78	23	29.5
Fall 2006	25	8	32.0	40	15	37.5
Fall 2007	35	17	48.6	52	25	48.1
Fall 2008	33	13	39.4	65	26	40.0
Average	31	13	40.9	52	22	42.0

Table 5. Retention from the third to fourth year of Black and Hispanic full-time regular Grove School of Engineering freshmen. The shaded cohorts are admitted before the new criterion went into effect.

This means two things: 1) a sharp increase in retention and expected graduation rates, especially for Black students, and 2) almost all of the minority students who would not have been admitted in fall 2004 and 2005 if the new criterion had been in effect then, did not return to engineering at the start of the fourth year. In other words, admitting these students did nothing for increasing the number of minority students graduating in engineering.

7. Level of Math in the first semester, retention and graduation and ethnicity.

To illustrate the influence of math preparedness on retention and graduation, we calculated retention and graduation rates separately for freshmen starting in pre-calculus, calculus 1 or higher, and college algebra or lower for cohort fall 2004, or “Gateway” students for cohort fall 2008. A small number of freshmen took no math in their first semester and they were included in the “college algebra or Gateway” group, respectively.

The graphs in figures 1. and 2. visualize how “math readiness” influences retention and graduation in engineering. They underscore the importance of a solid basis in Math for students hoping to graduate in engineering. The other cohorts exhibit a very similar pattern. Students in the fall 2004 cohort were still admitted if they fulfilled the “index”, even if they were not eligible to start in pre-calculus.

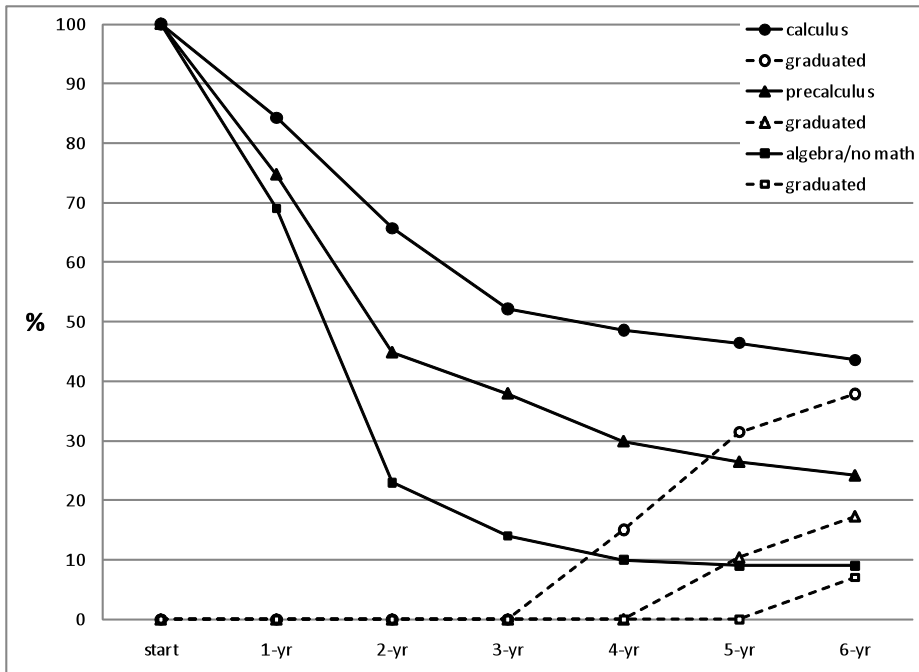


Figure 1. Retention + graduation for freshmen cohort fall 2004 by math in 1st semester. Solid lines show the percentage of the original cohort enrolled plus graduated previously after the first and subsequent years. Dotted lines show the percentage graduated.

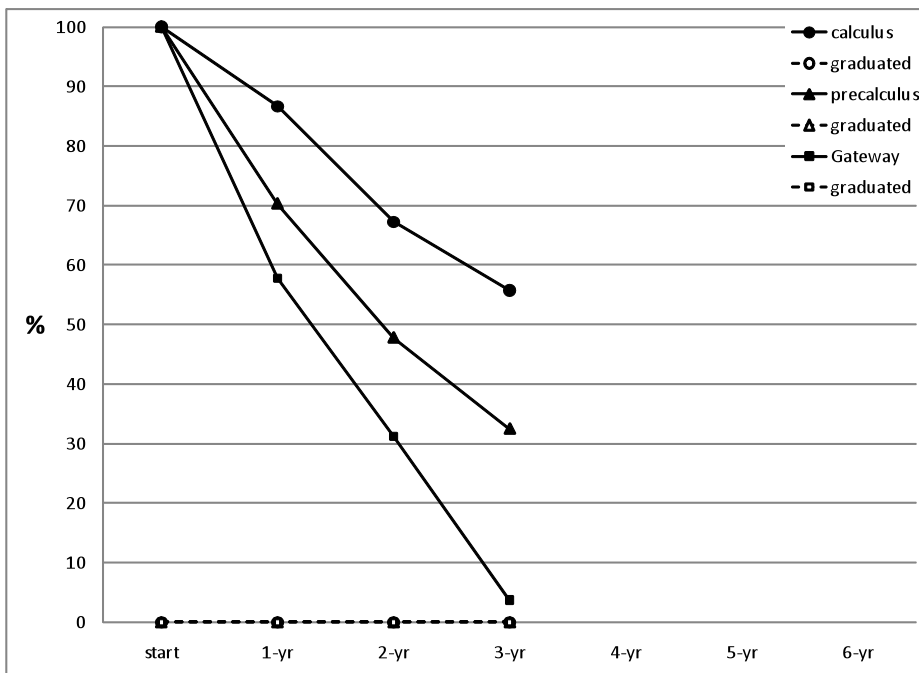


Figure 2. Retention + graduation for freshmen cohort fall 2008 by math in 1st semester.

Nine out of ten of these students had dropped out of engineering by the fourth year. The pattern is even stronger for the fall 2008 cohort, when students who could not start in at least pre-calculus were not admitted to engineering, but referred to Gateway instead. Almost none of them were retained by the start of their 4th year, either within Gateway or engineering.

Although at present the math requirement is readiness to start in pre-calculus, one could argue based on the retention and graduation rates shown, that eligibility to start in Calculus 1 would be the preferable criterion for admission.

To estimate the effect on ethnic composition of raising the required level of Math to eligibility to start in calculus I, we considered the ethnic distribution within each level of math and the total cohort.

Table 6. estimates that averaged over the cohorts since fall 2006, the percentage of Black students would drop slightly, from 11.9% to 10.9%, if calculus I eligibility would have been the criterion, and the percentage of Hispanic students would drop by 3.8%, to 17.4% from 21.2%.

Cohort	Math Eligibility	N	% of N			
			Black	Hispanic	Other	All students
Fall 2006-2010	precalculus	99	13.7	26.2	60.2	100.0
	calculus	145	10.9	17.4	71.7	100.0
	Total	244	11.9	21.2	66.9	100.0

Table 6. Ethnic composition within each “math eligibility” group and the total cohort. Notes. We took averages over the cohorts 2006 through 2010, to smooth out variations and arrive at a better prediction for impact of “calculus admissions requirement” on ethnic composition. The shaded areas compare ethnic composition between calculus-only eligibility and the entire cohort. “Other” are Asian, White and Foreign students. Foreign students may be Black or Hispanic.

8. Summary and Conclusions.

We have shown that the new admissions criterion of eligibility to place in at minimum pre-calculus led to a drop in the number and percentages of entering minority freshmen. However, the new admissions criterion did not lead to a drop in the number of minority students returning in the fourth year. Almost all students who were not eligible to start in at least pre-calculus, dropped out of engineering or Gateway before the fourth year. Retention and expected

graduation rates of minority students, especially Black students, increased considerably under the new admissions criterion.

If we adopted eligibility to start in calculus I as admissions criterion, numbers overall would drop for every group, minority and non-minority, but the percentage of Black students would remain almost the same and the percentage of Hispanic students would drop by an estimated 3.8%. This does not mean we should not be concerned about the decrease in the number of minority students, but low admissions standards do not appear to be the answer to ensure minority participation in engineering. An alternative could be found in strengthening the long-standing STEM institute at the Grove School of Engineering, which gives students the opportunity to take Math courses during the summer before their first fall semester, so they are ready to take calculus I and have refreshed their math knowledge and skills at the start of their study in engineering.

Further studies will explore the interactions between SAT, high school GPA and Math placement at entry and ethnicity, gender and field of study. The impact of specific interventions (e.g., STEM institute, joint dual degree programs for transfers from Community Colleges) will also be taken into account.

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