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Engineering Program Matriculation: Timing and Graduation

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Introduction

Graduation rates in engineering remaining stubbornly low[1], and numerous researchers have studied the problem from several different vantage points[2]. At the same time, there is an increasing number of students desiring to enroll in engineering programs[3], placing strain on programs. Matriculation into a degree granting engineering program is an important step in the graduation process, and administrators approach the matriculation question differently.

Some institutions have processes that admit students directly into a degree granting program; while at other institutions, students are admitted to degree engineering programs after completing a common first-year curriculum that would normally focus on core math and science classes[4]. In situations where students complete a common first-year and then seek admission to a degree granting engineering program, admission is typically competitive. Moreover, these engineering programs may face capacity concerns, and these types of meritocracy-based programs are used as a means of managing program growth and enrollment.

Given the importance of matriculation to engineering degree completion, we examine if timing of matriculation into a degree granting program is related to engineering degree completion. In this working paper, we use data from a single institution that has a meritocracy-based matriculation program. Using hierarchical linear modeling, we consider a student's probability of graduating within six-years to be a function of matriculating into a degree granting engineering program in one of four possible entry points, while controlling for academic achievement in key math and science classes.

Matriculation Process

Students at the study site are admitted directly into the College of Engineering as first-year engineering (FYE) students, where students are not yet committed to specific engineering disciplines. All FYE students complete a curriculum that, among other classes, requires a grade of "C or better" in the first two calculus courses, the first of two engineering physics courses, and chemistry with lab. Once an FYE student completes these math and science courses, they are eligible to apply for matriculation into one of the many engineering and computer science degree options in the college.

Matriculation into the engineering programs is competitive, and students are evaluated on grade performance in the math and science courses and their overall GPA. For students with AP or IB credit in the required math and science courses, a set of concordance tables are used for awarding grades and weighting for the purpose of the matriculation process. For transfer credit earned at other postsecondary institutions, the grade awarded by the transferring institution is used. Students apply to the matriculation process at the end of each semester, where demand and capacity are matched in each cycle.

All FYE students are guaranteed a seat in one of the engineering or computer science programs in the college if the math and science courses are successfully completed within four semesters with a grade of "C or better." For students who have not matriculated at the conclusion of the fourth semester, they are assisted in transferring into another degree program at the university. In some extenuating circumstances students may petition for an extension beyond four semesters.

Methods

The 2013-2016 fall engineering first-year cohorts are the sample for this study. We selected students from these entering cohorts because they have all reached the 6-year timeframe for degree attainment (i.e., 6-year graduation rates available). We started the analysis process with a careful consideration of inclusion criteria.

Given that we were interested in understanding if timing into a degree granting engineering program influences the probability of graduating with an engineering degree within six-years, we first excluded any student who did not matriculate into an engineering program. Next, we evaluated the number of times a student applied for matriculation to an engineering program and noted the application as being approved or denied. While students can transfer between engineering programs, we focused on the timing of the students first approved matriculation application. We did not consider a student's subsequent attempts to move between engineering programs. As noted earlier, students are provided up to four semesters to matriculate into an engineering program, and matriculation decisions are based on factors as described previously.

The problem under investigation is consistent with a repeated measures design. Repeated measures designs involve a subject being measured across the same variable multiple times[5]. In our case, the repeated measure is the student's application for matriculation. Complicating our data, though, is that not all students applied for matriculation multiple times. Most students are admitted the first time they apply (time 1) and would thus have missing data for any subsequent application cycles. To deal with the proceeding issue, we used hierarchical linear modeling (HLM).

HLM (or multilevel modeling) is an advanced regression type technique where data are conceived as having a nested structure. In some instances, researchers may conceive of data as being nested in schools or classrooms, and in others, as in the case of the current study, researchers conceive of data as being nested in individuals (i.e., repeated measures)[6.]

The use of HLM with repeated measures has several advantages. One such advantage is a more accurately estimated standard error. Since clusters tend to produce homogenous data, it is not uncommon to expect shrunk standard errors. However, a natural biproduct of HLM is an exploded standard error resulting in a more accurately estimated type I error rates. Second, and of importance to our study, HLM does not require that a case have a valid value for each time[6]. Standard univariate repeated measures approaches are incapable of handling missing data. In a standard repeated measures analysis of variance, cases with missing data would be excluded in a listwise fashion, thereby removing any student who did not have a valid value for each time point. The proceeding would make it impossible for us to answer our research question. In addition to matriculation attempts, we also considered a student's average performance in math and science, cumulative GPA, gender, and race/ethnicity, comparing students based on if they are or are not an underrepresented minority. Graduating within six-years is a dichotomous variable, and we used the binomial logistic regression function, consequently.

We specified the model at level 1 as:

$$\eta_{ti} = \pi_{0i} + \pi_{1i}(attempt_t) + e_{ti}$$

And at level 2:

$$\pi_{0i} = \beta_{00} + \beta_{01}(MathSci\_GPA) + \beta_{02}(CUM\_GPA) + \beta_{03}(Gender) + \beta_{04}(URM) + r_{0i},$$

and

$$\pi_{1i} = \beta_{10} + \beta_{11}(MathSci\_GPA) + \beta_{12}(CUM\_GPA) + \beta_{13}(Gender) + \beta_{14}(URM) + r_{1i},$$

where η_{ti} equals the probability of matriculating at attempt *t* for person *i* graduating with an engineering degree within six-years

Descriptive Statistics

Descriptive statistics for math and science classes and cumulative GPA are listed below. Predictably, mean academic achievement scores are higher in earlier attempts than in subsequent attempts.

Table 1: Mean Math/Science GPA and Cumulative GPA by Attempt

	N	Math/Science GPA	Cumulative GPA
Attempt 1	3525	3.53 (0.42)	3.50 (0.44)
Attempt 2	564	3.32 (0.46)	3.17 (0.49)
Attempt 3	124	3.21 (0.44)	2.99 (0.49)
Attempt 4	38	3.08 (0.43)	2.87 (0.44)
Attempt 5	12	2.97 (0.28)	2.72 (0.27)

Frequencies based on gender and race/ethnicity at each attempt are listed in table 2. The percentage of women as a total number of applications decreases as attempts increase. However, the percentage of URM students increases as attempts increase.

Table 2: Gender and Race/Ethnicity by Attempt

	Gender		Race/Ethnicity	
	Female	Male	Non-URM	URM
Attempt 1	878 (24.9%)	2647 (75.1%)	3296 (93.5%)	229 (6.5%)
Attempt 2	116 (20.6%)	448 (79.4%)	512 (90.8%)	52 (9.2%)
Attempt 3	18 (14.5%)	106 (85.5%)	110 (88.7%)	14 (11.3%)
Attempt 4	2 (5.3%)	36 (94.7%)	32 (84.2%)	6 (15.8%)
Attempt 5	0 (0.0%)	12 (100.0%)	8 (66.7%)	4 (33.2%)

Results

The overall model results are presented in Table 4. The coefficient presented is a logodd, which can be converted to odds using e^{logodd}. Odds can be converted to probabilities, $\frac{odds}{1+odds}$. At level 1, where matriculation attempts are evaluated, none of the variables were statistically significant, indicating that variability in probability of graduating with an engineering degree within six-years does not vary based on timing of matriculation. Meanwhile, the level 2 results do show that cumulative GPA is significant. A one-point increase in cumulative GPA results in a 74.4% increase in probability to graduate within six-years, unsurprisingly. Gender and race/ethnicity were not significant predictors at level 2.

Table 3: Results – HLM

	Coefficient	*SE*	*t*	*df*	*p*-value
For π_0					
Intercept	-2.97	1.55	-1.91	3488	.06
Math/Science	0.24	0.42	0.58	3488	.06
Cumulative GPA	1.07	0.46	2.33	3488	.02
Gender	0.21	0.41	0.51	3488	.61
vs Male					
URM	-0.43	0.50	-0.88	3488	.38
vs Underrepresented					
For Matriculation Attempt π_1					
Intercept	-1.55	1.59	-0.97	257	0.33
Math/Science	-0.16	0.44	-0.37	257	0.71
Cumulative GPA	0.73	0.47	1.53	257	0.13
Gender	-0.19	0.42	-0.46	257	0.64
vs Male					
URM	0.11	0.52	0.22	257	0.82
vs Underrepresented					

Discussion

The results of this study indicate that timing of matriculation is not tied to likelihood to graduate in six-years, and we view this as a positive and important finding. Regardless of when a student was admitted to a program, the likelihood of graduating in six-years did not change. This indicates that college administrators might be able to use programs like the one described in this paper to help manage college enrollments without impacting graduation rates. Moreover, there was no ill-effect noted based on URM status or gender. Researchers could scale up a similar type of study and investigate program matriculation timing across numerous institutions to see if a similar type of pattern is observed.

References

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