Work in Progress - The GPA Trajectories of Engineering Students

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WIP: Analysis of GPA Trajectories of Engineering Students

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This Work in Progress (WIP) paper focuses on engineering students who graduated and the relationships between their third semester GPA and their cumulative graduating GPA. The use of grades and GPA as a proxy for academic success have been used widely in a large number of studies, and this study focuses on documenting how students' grades fluctuate with time and the role this play in students' persistence. We apply Ordinary Least Squares and Ordinal Logistic regressions to a longitudinal database to identify the characteristics of that population. This population is a subset of the database and included 52,946 engineering students from 14 U.S. universities.

In the United States there has been an urge to improve the number of engineering graduates in preparedness and numbers for over a decade [1] [2] [3]. Furthermore, the Bureau of Labor statistics projected increase in need for some engineering in 2024 disciplines is estimated to be as high as 20% [4]. Lowell et al. [6], note that the engineering programs ineffectiveness in keeping and retaining high achieving students may serve as the key reason in producing a gap between the number of engineering graduates and what the workforce needs.

Some scholars consider academic GPA as a proxy to academic success [5] and that high school GPA is a strong predictor to it [7] [8]. On the other hand, Sawyer [9] has noted that for high achieving students, high school GPA loses its statistical power. The institutions that administer the SAT and ACT standardized tests acknowledges that high school GPA should carry more weight when predicting students' graduating college GPA [10] [11]. Zhang et al. [12] have found that GPA was inconsistent in predicting female students' graduation. On the other hand, earlier studies had more difficulty determining the impact of ethnicity due to the sheer number of groups to be included [13]. In an earlier study Min et al. [14] created a regression analysis using the subset of the current data set to interpret students' risk of dropping out of college. The study used a statistical method called survival analysis or failure time analysis. Through this study, the authors suggested that on average the most likely time undergraduate engineering students to leave engineering is after the third academic term. Furthermore, it indicated that both White and women students tend to leave engineering programs at an earlier time as compared to other demographics.

This paper focuses on looking at students' academic performance from the point where they are most likely to drop out of college and identify their GPA trajectories as measures to persistence and motivation. The paper navigates academic paths to graduation not only across time but also through majors. It provides a pathway to future studies with emphasis on establishing a proxy for student motivation and its relationship with academic performance.

Data

The Multiple Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) is database that includes 227,450 students who have ever declared engineering as their major has been used for this study. This database includes student data from

14 academic institutions for the last thirty years. For this study, the data is filtered to account for engineering students who enrolled directly to an engineering major and managed to graduate in any major within 6 years of matriculation. We only include U.S. citizens and first-time-in-college (non-transfer) students. These criteria reduced the dataset sample size to 52,946 students from thirteen institutions.

The variables that we use in this study includes: students' third semester cumulative GPA, students' graduation cumulative GPA, and the number of major switches students experience during their academic years. We calculated a variable which we call delta; delta is equal to the difference between student's graduation cumulative GPA and their third semester cumulative GPA. That means that the greater the delta value, the greater increase in GPA a student has from their third semester to graduation. A negative delta value means that the student had a drop in their GPA from their third semester to graduation.

Based on the quartile distribution of delta, we divide students into three delta categories:

- Students with a delta GPA less than or equal to -0.11 (1st quartile).
- Students with a delta GPA greater than -0.11 or less than 0.29 (2nd and 3rd quartiles).
- Students with a delta GPA greater than or equal to 0.29 (4th quartile).

Methods

The purpose of this work in progress study is to develop a research that investigates engineering undergraduate students' trajectory, focusing on the trajectory from their third semester to graduation. In this paper we navigate the following research questions: how is the number of credits, number of major switches, and the number of semesters students spent in a university related to undergraduates' GPA trajectory? and how is a students' third-semester GPA related to their GPA trajectory? To address these research question, we apply two regression models to our data. We first apply ordinary least squares linear regression (OLS) to investigate the influence of academic records on students' GPA trajectory. We then apply an ordinal logistic regression (OLR) on the data to investigate how these variables affect different student clusters.

The outcome of the model will be the difference between graduation cumulative GPA and third semester cumulative GPA. Throughout this paper we will call this difference as our delta variable. The intention for choosing this variable is to identify students' GPA trajectories post the semester where they For the OLS regression, students' delta GPA will be used as the outcome (dependent variable). We then divided the students into three categories based on delta's quartiles. We divide the students into three delta categories: We used the delta categorical ordered variable as the outcome for the OLR model.

The independent variables we use in both models include: students' third semester cumulative GPA, number of semesters that the student is enrolled, number of major switches students have through their academic pathway, and the number of credit hours at graduation.

Results and Discussion

The results for the linear regression are illustrated in Table 1. As shown, all the variables have an influence on the delta variable (difference between the cumulative GPA at graduation and third semester cumulative GPA). The results show that, on average with every ten credit hours students take, delta decreases by 0.0025 points. A likely explanation of this result is that students earn their best grades in foundational courses, particularly those courses that repeat some of what students learned in pre-college settings. On average, with every major switch, students tend to have an increase of 0.009 GPA points. While this might be explained as students changing majors to one where they will be more successful, earlier studies found out this may not always be the case. Main et al. [15] found that "students with a GPA lower than 3.0 in introductory courses are less likely to stay in their intended major where they are expected to have earned the highest GPA" (p. 1472). That is, when students with lower GPAs in introductory courses change majors, it does not tend to improve their GPA compared to what would be expected if they remained in their original major. Among the variables used in the OLS model, third semester GPA has the most influence on delta. The model's result show that on average with every 1.0 GPA increase in students third semester cumulative GPA, the graduation GPA decreases by 0.35 GPA points. Meaning that students with higher GPA in their first three semesters tend to have a higher drop in their graduation GPA.

Table 1: Linear Regression

Variables	Regression Coefficient (Std. Error)
Total Number of Credit Hours	**-0.00257*** **
	(7.67e-05)
Number of Semesters	**-0.00919*** **
	(0.000368)
Number Major Switch	**0.00915*** **
	(0.00153)
Third Semester's Cumulative GPA	**-0.347*** **
	(0.00202)
Constant	**1.529*** **
	(0.0124)
Observations	**52,946**
R-squared	**0.374**

*** p<0.01, ** p<0.05, * p<0.1

Table 2 shows the results for our ordinal linear regression. For a one unit increase in the credit hours, we expect a 0.017 increase in the log odds of being in a higher level of delta categories, given all of the other variables in the model are held constant. For a one unit increase in the number of semesters students spend in college this we expect a 0.06 increase. This is good news, because it indicates that students who spend longer times enrolled do so with increasing chances of graduation. Earlier findings using a subset of the current data showed that this has not always been the case at all institutions [16]. This study identified one institution at which only half of those enrolled in engineering for eight semesters actually graduated within six years. Similar to our linear model, with every major switch the log odds of being in a higher delta category increases by 0.009, given that all of the other variables in the model are held constant. For a one unit increase in students' third semester cumulative GPA, we would expect a 2.088 decrease in the log odds of being in a higher level of delta category, given that all of the other variables in the model are held constant.

Table.2 Ordinal Linear Regression

VARIABLES	Coefficient (St Error)
Total Number of Credit Hours	**-0.0166*** **
	(0.000594)
Number of Semesters	**-0.0601*** **
	(0.00279)
Number Major Switch	**0.0603*** **
	(0.0116)
Third Semester's Cumulative GPA	**2.088*** **
	(0.0179)
/cut1	**7.472*** **
	(0.101)
/cut2	**10.26*** **
	(0.107)
Observations	**52,946**

*** p<0.01, ** p<0.05, * p<0.1

Predicted Probability of delta categories

Based on the analysis of the study it was found that for engineering students who graduated, there was minimal difference in graduating GPA between those who took additional semesters or switch majors. There was little evidence that students "learn to be students," but rather student GPAs seemed to simply regress toward the mean GPA of 3.0.

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