A Study of Predictive Factors for Success in Electrical Engineering

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Abstract

Many electrical engineering programs require foundations classes that are a hindrance to students attempting to enter the field of engineering. If we could identify the factors that lead to student success, we would be better able to advise students, or perhaps re-shape the curriculum, in ways that would promote success and ease the path towards graduation.

In this paper we considered numerous candidate predictive factors for academic success in our foundations class, Electrical Engineering Fundamentals. We used the final course grade as the metric of academic success. The candidate factors that we found to be the most predictive are the students' college-level grade point average (GPA), their grades in the pre-requisite courses, their scores on an assessment quiz covering pre-requisite course material, and math readiness as measured by the Math Placement Test taken by incoming freshmen. Other candidate factors that we considered are the amount of time that has elapsed since the pre-requisite courses were taken, students' high-school GPA, Scholastic Aptitude Test (SAT) scores, and whether the students enrolled as freshmen or transfer students. Each candidate factor was compared to the success metric using both linear and rank correlation. Additionally, conditional mean values for the success metric were computed.

I. Introduction

Traditional electrical engineering programs include a lower division circuits course that serves as a foundation for the remainder of the electrical engineering curriculum. The foundations course is often frustrating to students and faculty, with students performing at a level below their own expectations and with faculty decrying the students' apparent lack of preparation, effort, and/or ability. The mismatch between expectations and achievement is so severe that many universities, including our own, devote a considerable amount of time trying to improve student success in the basic circuits course.

In this paper we attempt to identify factors that contribute to students' success or failure in electrical engineering. We analyzed data for students enrolled in the lower division circuits course offered at our university during four consecutive semesters. In Section II we provide a brief description of our program and the data that we collected. We then summarize and interpret the correlation results and the conditional means in Section III. Section IV takes a closer look at how we can utilize our results to improve student success. Finally, in Section V we consider a plan of action for program enhancement based on the results presented in the paper.

II. Background and Data Collection

California State University Northridge (CSUN) is one of the 23 campuses of the California State University system. The California State Universities accept students from the upper one-third of the California high school graduating class. CSUN has an ethnically diverse group of students with over 82% of them being non-white. Forty four percent of our students are enrolled on a part time basis meaning that they are enrolled in less than 12 units per semester, and most of our students are employed on a part or full time basis.

The lower division circuits course, EE 240, Electrical Engineering Fundamentals, studied in this paper is offered by the Department of Electrical and Computer Engineering and is required of all engineering majors in the college. This is a three-unit lecture, one-unit laboratory course that requires both a Physics course in Electricity and Magnetism as a pre-requisite and an applied differential equations course as a co-requisite.

In this study, we collected the records of 229 students who had completed the EE 240 course over the past two academic years. Only the lecture portion of the course was studied, not the laboratory. For each of these students, the following factors were recorded:

- CSUN grade point average
- Overall college grade point average
- Transfer grade point average (if applicable)
- High school grade point average
- Grade in Physics - Electricity and Magnetism
- Grade in third semester (multivariable) calculus
- Grade in differential equations
- Number of semesters since physics was taken
- Number of semesters since differential equations was taken
- Number of semesters since multivariable calculus was taken
- SAT score (total, verbal, analytical)
- First college mathematics course
- Pre-requisite assessment quiz

The pre-requisite assessment quiz is an exam given at the beginning of the semester in each electrical engineering course. The quizzes cover material that is pre-requisite to the course in which they are being tested. The department uses these quizzes as one component of its assessment plan.

II. Summary and Interpretation of Results

Correlation Results

We correlated each of the candidate predictive factors with the final course grade in our foundations class, Electrical Engineering Fundamentals. Table 1 shows the correlation coefficient results, with the first column containing the candidate predictive factors being considered and the next four columns containing the correlation coefficient values computed using our entire database of students. The last two columns of the table contain correlation coefficient values computed using only those students in the database that entered CSUN as freshmen.

Table 1. Correlation Coefficients Between Candidate Predictive Factors and the Final Course Grade in Electrical Engineering Fundamentals

	← All Students →				First-time Freshmen	
Candidate Predictive Factor	Pearson Corr. Coeff.	% Conf. to Reject H_0	Spearman Rank Correl. Coeff.	% Conf. to Reject H_0	Pearson Correl. Coeff.	% Conf. to Reject H_0
CSUN GPA	0.718	> 99.9	0.738	> 99.9	0.630	> 99.9
College GPA	0.661	> 99.9	0.674	> 99.9	0.615	> 99.9
Physics/Diff. Eq. Grade	0.560	> 99.9	0.550	> 99.9	0.515	> 99.9
3rd Sem. Calc. Grade	0.265	> 99	0.503	> 99.9	0.411	> 99.9
Physics Grade	0.478	> 99.9	0.450	> 99.9	0.474	> 99.9
Transfer GPA	0.421	> 99.9	0.463	> 99.9	NA	NA
Diff. Eq. Grade	0.429	> 99.9	0.447	> 99.9	0.354	> 99
Pre-req. Quiz Score	0.370	> 99	0.413	> 99.9	0.399	> 98
1st Fresh Math Course	0.232	> 96	0.278	> 99	0.222	> 96
SAT Math Score	0.147		0.179		0.182	
SAT Total Score	0.135		0.153		0.093	
SAT English Score	0.086		0.109		-0.003	
High School GPA	0.125		0.154		0.223	> 96
Time Since Physics	0.007		0.094		-0.056	
Time Since Calculus	-0.041		-0.087		-0.180	
Time Since Diff. Eq.	-0.056		-0.103		-0.187	

First consider the correlation coefficients computed using our entire data base of students. For each candidate predictive factor, we computed the Pearson correlation coefficient [1] as given in the second column. We then formulated a null hypothesis (that the respective factor or variable is independent of the final course grade in the foundations class for the entire population), and computed the student's t-test statistic for the correlation for each candidate predictive factor. Confidence levels [1] for rejecting the null hypothesis are given in the third column for each correlation that is significant at the 5% level.[1]

[1] Throughout this paper, correlation is considered significant at the 5% level.

Examining the results in the second column, we noted that the highest Pearson correlation coefficients with the success metric occurred for the students' CSUN GPA and their over-all college-level GPA. This was not surprising, and it seemed to reflect the fact that if students are finding success in college in general, they will also find success in electrical engineering. Unfortunately, it is somewhat of a misnomer to call these two candidate factors "predictive." Students' success in pre-requisite courses (calculus, physics, and differential equations) also showed significant correlation with success in electrical engineering, as did their scores on the pre-requisite assessment quizzes and their math readiness as measured by the Math Placement Test taken by incoming freshmen.

The most surprising result from the second column was the lack of significant correlation between the students' performance in electrical engineering and their quantitative SAT scores. However, since insignificant Pearson correlation only reflects an absence of linear dependence, we hypothesized that performance in electrical engineering could still be dependent on quantitative SAT scores, but in a non-linear way. As a test of this hypothesis, we computed the Spearman rank correlation [2] for each of the candidate predictive factors, as given in the fourth column of Table 1. Again we formulated a null hypothesis (that the respective factor or variable is independent of the final course grade in the foundations class for the entire population), and computed the Student's t-test statistic for the correlation for each predictive factor. Confidence levels [3] for rejecting the null hypothesis are given in the fifth column for each correlation that is significant.

Comparing the rank correlation coefficients in the fourth column to the linear correlation coefficients in the second column, we note that they are very similar with the exception of those for the calculus grade. In fact, the factors that are determined to have significant correlation with success in electrical engineering are identical whether we use linear or rank correlation. As before, quantitative SAT scores do not appear to be significantly correlated with success in electrical engineering at our school.

We also considered the possibility that certain candidate predictive factors may show different levels of correlation with success in electrical engineering depending upon whether the student came to us as a transfer student or a freshman. Correlation coefficients for factors such as high school GPA and SAT scores, for example, could be increased or decreased by a junior college experience. To test this hypothesis, we computed the Pearson correlation coefficients [1] for all the candidate predictive factors using only the students who came to us as first-time freshmen, obtaining the results as shown in the sixth column of Table 1. Confidence levels for rejecting the null hypothesis (that the candidate factor is independent of the success in engineering for the entire population) based on the test statistic [1] are given in the last column of Table 1 for each correlation that is significant.

Comparing the Pearson correlation coefficients obtained using our entire data base of students (column two) to those obtained using first-time freshmen only (column six), we note that there are substantial differences for the candidate factors of grades in both calculus and differential equations. However, both of these factors are significantly correlated to success in electrical engineering for both of the subsets of students under consideration. We also note that the high school GPA turned out to be significantly correlated with success if we considered first-time freshmen only, while it was not significantly correlated if we considered both first-time freshmen and transfer students.

Conditional Means

In this section we compare the average grade earned in Electrical Engineering Fundamentals by students who began school at CSUN as first-time freshmen to that earned by transfer students. The results are shown in Table 2. If we consider the null hypothesis that the population means for the two subsets of students are in fact equal, the test statistic computed from this data is insufficient to reject the null hypothesis. [1] For all practical purposes, the first-time freshmen performed about as well as the transfer students in the foundations classes.

Table 2. Conditional Means for Success Metric (First-time Freshmen vs. Transfer Students)

	Average Grade in EE Fundamentals
First-time Freshmen	1.947
Transfer Students	2.045

IV. Using the Results to Promote Student Success

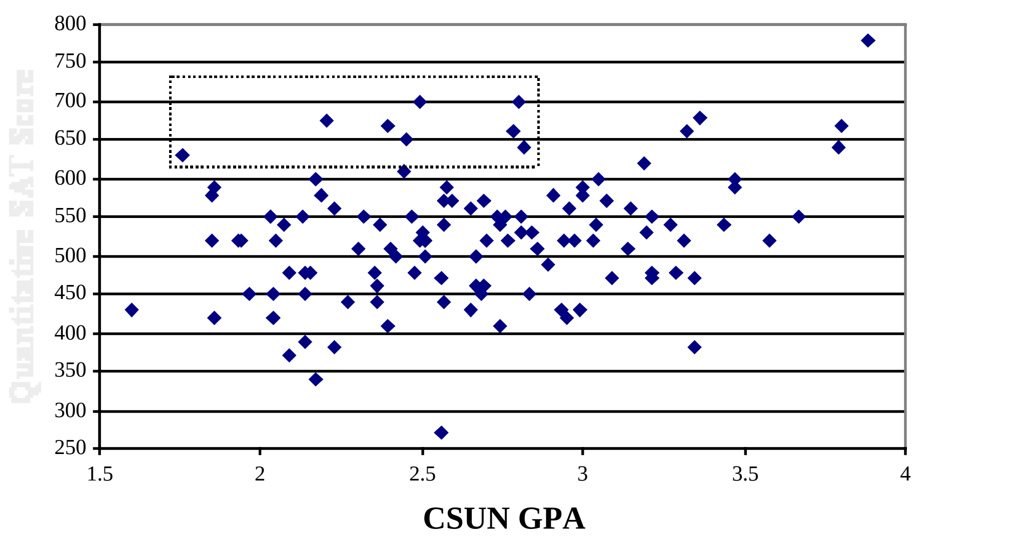
The initial results of this study are not surprising. It is well known that students who do well in mathematics and physics have a higher chance of succeeding in an engineering program. Based on this data we intend to make a stronger commitment to emphasizing the importance of math and physics to our students early in the program. We were pleased to note the correlation between the pre-requisite quizzes that we have developed and course performance. This indicates that the quizzes are an effective tool in assessing student learning.

However, what is surprising is the lack of correlation that we observe between the students' success in engineering and their SAT scores (overall, verbal, or quantitative). We would have expected that at least the quantitative SAT score would be a good predictor of success in our program. In an attempt to understand this lack of correlation, we looked closely at the records of some of the students in our study.

Figure 1 shows a plot of the quantitative SAT score versus CSUN GPA for the students in our study who had taken the SAT. Of particular interest are those students who came to CSUN with high quantitative SAT scores but have not performed as well as we would have expected. Recent data obtained on students admitted to the CSUN engineering program show that the average quantitative SAT score is 500. If ranked based on the quantitative SAT score, the upper 10% of our incoming class has a score of 630 or higher. We took a closer look at eight students who fall into this upper 10% but have a CSUN GPA of less than 3.0. They are indicated in the enclosed area on figure 1.

These eight students have a CSUN GPA ranging from 1.76 to 2.8. In an attempt to understand the lack of correlation between their performance at CSUN and their incoming SAT scores we reviewed their records carefully. This included transcripts, background information and detailed class performance. It was interesting to note that factors such as long work hours, family responsibilities, or economics did not account for the performance of these students. Based on some preliminary interviews and anecdotal information that we have as their instructors, it may be that these students with high potential lack the proper motivation to perform at a higher level.

Figure 1. Quantitative SAT Scores versus CSUN GPA



V. Conclusions and Plan of Action

In summary, we have presented the results of a study involving 229 engineering students at California State University, Northridge. In this study, we have attempted to correlate a number of factors with the final course grade in our foundations class, Electrical Engineering Fundamentals. The results of the study show that student performance in this course is correlated with their performance in pre-requisite mathematics and physics courses. It also shows that the departmental assessment quizzes are effective tools for predicting student performance.

In this study, we found that the performance in the engineering program was not well correlated with the student's SAT score. The nature of the students at CSUN may be different from those at other institutions. However, based on this study we have decided to focus some attention on the group of students who come to our university with high SAT scores and do not realize their potential. Since the typical factors such as long work hours, family responsibilities, or economics do not seem to account for the low achievement of those in our study group, we plan to further study students in this category. The objective of this further study would be to determine how to motivate this group of students with high potential.

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