Analysis of Men and Women Engineering Students at Ohio State

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Introduction

Engineering mythology describes the dean who greets the entering engineering class by saying: "look to your left and look to your right; only one of the three of you will make it through this program." Whatever the truth of the mythology or whatever the motivation this mythical dean might have in so greeting the class, the story highlights the enormous attrition that engineering programs have.

Another part of the mythology has been, however, that some part of that attrition, perhaps a great deal of it, is due to lack of academic preparedness or to lack of academic qualifications. In that view, the attrition is expected, even desirable, since the attrition is "washing out" those students who don't "have what it takes."

This paper reports on a study of the 1050 students who entered Ohio State in Autumn 1988 intending to major in engineering. We report four conclusions:

1 - Of the 1050 students, 29 quarters later, 34.9% had completed a degree in engineering at Ohio State, 30.8% had completed a degree in some other major at Ohio State, and 34.4% had left Ohio State without completing a degree. Indeed, our mythological professor appears to be still correct.

2 - While academic preparedness seems to account for some of the attrition, our conclusion is that it accounts for remarkably little of the difference in which students end up in which group.

3 - The women students seem to be affected more by each variable: good academic preparedness and weak academic preparedness both make bigger differences in the percent completing in engineering for the women than for the men.

4 - There is some evidence that the women students with strong nonmath skills were less likely to complete in engineering.

We now present evidence in support of each of these conclusions.

1. Overall Attrition

We studied the 1050 students who entered Ohio State in Autumn 1988 intending to major in engineering. (While architecture is part of the College of Engineering at Ohio State, we omitted students intending to major in architecture.) We tracked these students for 29 quarters to Autumn 1995. Of the 1050 students 366 or 34.9% graduated in engineering (ENG group), 323 or 30.8% graduated from OSU in another major (OTHER), and 361 or 34.4% left OSU before receiving a degree (DROP).

We also calculated such results for women and men separately, as shown in Table 1. (All Tables are at the end of the paper). Most tables in the remainder of this paper will have similar column headings and we will use the ENG, OTHER, and DROP labels throughout the rest of the paper. Most tables, like Table 1, will have rows that sum to 100.0 percent. The variables constituting the rows of each table were generally split at the point where the largest decrease in retention occurred. Since we are reporting on the entire population of engineering students in this cohort and not performing statistical inference, we do not report statistical significance.

The average calendar time to graduation was 4.75 years, with little difference between women and men. The quarters enrolled until graduation ranged from 9 to 27, with most students in the range 15 to 18 quarters.

Ohio State's retention in engineering is somewhat lower than other engineering colleges and universities, although each institution has, of course, unique circumstances that affect these results. At Arizona State, "for the class entering in 1989, approximately 47% of the men, but only 31% of the women, remained or had graduated from the College of Engineering and Applied Sciences by 1994" (Blaisdell et al.') At Clemson University approximately 42 percent of incoming students graduate in engineering and approximately an additional 18% get a degree in another major at Clemson (Lasser and Snelsire[4]). Moller-Wong and Eide[5] cite Jakubowski et al.': "In a study of external factors that affect retention of engineers, it was found that approximately 75 percent of all students who start in engineering eventually graduate, but not necessarily in engineering." Moller-Wong and Eide tracked the 925 students who entered engineering at Iowa State in fall semester 1990 and found that, through spring 1995 (5 academic years later), 28% had graduated in engineering, 15% were still in engineering, 18% had graduated from Iowa State in another major, 10% were still at Iowa State in another major, and 29% were gone.

2. Effect of academic preparedness on attrition

We had the following information on the students (some data were missing for some students): ACT composite (which is the average of the students' score on the English, Mathematics, Social studies, and Natural sciences parts of the ACT) ACT math, SAT math, SAT verbal, and Student's rank in high school class (in percentile) We also had information on every course taken by the student at OSU by quarter, with grade.

Needless to say, this amount of data is overwhelming, so we chose to focus on trying to identify factors that distinguish among the three groups: ENG, OTHER, and DROP, with emphasis on two types of factors: (1) data known before the student enters OSU (ACT, SAT, and rank) and (2) data known early in the student's career at OSU. In the latter category we focused on performance in the first math, physics, and english courses.

Table 2 shows how the percent in each group varied with factors known when the student enters OSU. With each factor, the ENG percent increases as the factor improves and the DROP percent decreases, as would be expected. The effect on the OTHER percent depends on the relative size of the increase in the ENG percent and the decrease in the DROP percent.

Table 3 shows the change in the the ENG percent due to moving from the lower category to the higher category for each factor. While academic preparedness (as measured by high school rank, ACT scores, and SAT scores) clearly add some ability to predict which students will graduate in engineering, we still find the ENG percents in Table 2 (49.5, 50.9, 48.8, 40.2, and 41.5) to be very low.

Depending on the student's performance in a placement test, engineering students at Ohio State may start in different math courses'. MA151 is the first course in calculus and is where a student should start to graduate from engineering in 4 years. Ohio State records a failing grade as E. Table 4 (below) shows how the percent in each group varied with performance in the student's first math course.

The first two rows of Table 4 show that readiness to begin calculus is associated with a 32.7 percent increase in the ENG percent (from 19.6 to 52.3). The next 4 rows show that this increase is slightly larger than the increase associated with getting a grade of A, B, or C (compared to D or E) in calculus: a better grade moves the ENG percent from 25.7 to 57.0 for an increase of 31.3 percentage points.

We also studied the students' performance in the first physics and english courses, but found that much attrition has already occurred by the time students reach those courses. At Ohio State, virtually all engineering students take math their first quarter, but not physics and english.

We conclude that although there is some degree of relationship between academic ability and retention in engineering, not all attrition can be explained by lack of academic preparedness or academic talent.

3. Effects on women as differentiated from effects on men

Of the 1050 students we studied, 172 or 16.4% were women, and 878 or 83.6% were men. Table 1 shows that, as compared to men, women had a lower proportion completing in engineering (32.0 compared to 35.5) a higher proportion completing in other majors (35.5 compared to 29.8) and a lower proportion dropping out (32.5 compared to 34.7).

Table 5 is similar to Table 3, but has columns added for women and men. In three of the five rows (high school rank, ACT math, and SAT math), the number in the women's column is greater than the number in the men's column. The impacts of HS rank, ACT math, and SAT math on the probability of completion in engineering are larger for women than for men. Women's completion seems to be affected more strongly than men's completion rates by some of the factors that affect completion.

We found a similar effect even more strongly in the following result. Of the 19 women with high school rank below 70, ACT math below 27, and ACT composite below 27, none completed in engineering. Of the 112 men with similar entering data, 15.2 percent completed in engineering.

4. Effect of strong nonmath skills on women

Table 5 shows that improvement in nonmath scores (ACT composite or SAT verbal) does not improve the ENG percent more for women than for men. In fact, we found evidence that, when the effect of improved math ability is controlled for, improvement in nonmath scores actually *decreases* the percent of women who complete in engineering.

Table 6 shows this effect most clearly, we believe. (19 women students with high school rank less than 70 are omitted from table 6. All 19 also had ACT math and ACT composite less than 27 and none of the 19 completed in engineering.)

Holding ACT math and high school rank constant, increasing the ACT composite actually *decreases* the chance of completion in engineering (in the ENG column, compare line 1 with line 2 and compare line 3 with line 4). Among the more capable women (ACT math 27 or higher), the OTHER percent increased (from 17.6 to 36.4) and the DROP percent decreased (from 17.6 to 12.1) with improved ACT composite score. The number of women in this table are not large, so we must be careful not to read too much from the data.

Also, and perhaps most importantly, such effects are not seen in the similar table for men. No matter what the combination of high school rank and ACT math score, the percentage completing in engineering increases for men with an increase in ACT composite from below 27 to 27 and above.

Conclusions

In a review of the literature seeking to explain attrition by college students, we found the model by Tinto[6] to be most appealing. His model postulates that family background, individual attributes, and pre-college schooling interact to create the goal commitment of the student and the institutional commitment of the student. These in turn affect and interact with grade performance and intellectual development in the academic system and to peer-group interaction and faculty interaction in the social system. Through academic integration and social integration, these have effect on the goal and institutional commitments of the student, leading to decision whether to drop out.

Clearly, our study has examined only a fraction of the variables that would make up such a complete model. We believe our study has, however, provided some evidence against a contrary and much simpler model that only the outcomes of pre-college schooling (as measured by high school rank, ACT scores, and ACT scores) matter in whether a student will complete engineering. We believe that some engineering professors implicitly hold such a model.

On page 2 of his book, Studying Engineering,[3] Ray Landis recalls the one-out-of-three greeting we cited at the beginning of our paper. He then writes:

“When I meet with freshman engineering students, I convey a very different message. My message to them and to you is that: Each and every one of you can be successful in graduating with your bachelor of science degree in engineering.”

We believe our study confirmed this result. In almost every category of student, we found that some students completed an engineering degree. Dean Landis believes that the difference between those who complete and those who don't is: determination, effort, and approach. We believe our study supports those like Dean Landis who seek to help students find such determination. However, we believe our study also shows that we need to make even more efforts to help our women students find such determination (using Landis's word) or commitment (using Tinto's word).

Table 1	N	ENG	OTHER	DROP
All	1050	34.9	30.8	34.4
Women	172	32.0	35.5	32.5
Men	878	35.5	29.8	34.7

Table 2	N	ENG	OTHER	DROP
All (n=984):				
HS rank 90 or less	606	26.9	31,7	41.4
HS rank 91-100	378	49.5	29.1	21.4
All (n=917):				
ACT math below 27	524	23.7	35.9	40.5
ACT math 27 and up	393	50.9	24.4	24.7
All (n=917):				
ACT comp below 27	587	27.8	33.6	38.7
ACT comp 27 and up	330	48.8	26.4	24.8
All (n=633):				
SAT math below 500	122	17.2	39.3	43.4
SAT math 500-800	511	40.2	32.1	27.2
All (n=633):				
SAT verb below 500	380	32.6	33.9	33.4
SAT verb 500-800	253	41.5	32.8	25.7

Table 3	change in ENG %
HS rank 90 or less	
to HS rank 91-100	22.6
ACT math below 27	
to ACT math 27 and up	27.2
ACT comp below 27	
to ACT comp 27 and up	21.0
SAT math below 500	
to SAT math 500-800	23.0
SAT verb below 50	
to SAT verb 500-800	8.9

Table 4	***N***	ENG	OTHER	DROP
All (n=1027):				
below MA151	530	19.6	35.1	45.8
MA151 and up	497	52.3	25.4	22.3
All (n=1027):				
below MA151, DE	117	4.3	23.1	72.6
below MA151, ABC	413	23.4	38.5	38.3
MA151 and up, DE	74	25.7	32.4	41.9
MA151 and up, ABC	423	57.0	24.1	18.9

Table 5	change in ENG %	change for women	change for men
HS rank 90 or less			
to HS rank 91-100	22.6	34.7	21.7
ACT math below 27			
to ACT math 27 and up	27.2	32.5	26.3
ACT camp below 27			
to ACT comp 27 and up	21.0	13.6	22.3
SAT math below 500			
to SAT math 500-800	23.0	27.9	22.3
SAT verb below 50			
to SAT verb 500-800	8.9	2.5	8.6

Table 6	N	ENG	OTHER	DROP	
Women (n=128):					
ACTmath<27, ACTcomp<27	70	28.6	41.4	30.0	line 1
ACTmath<27, ACTcomp>27	8	12.5	37.5	50.0	line 2
ACTmath>27, ACTcomp<27	17	64.8	17.6	17.6	line 3
ACTmath>27, ACTcomp>27	33	51.5	36.4	12.1	line 4

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