Investigating Engineering Retention

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Abstract

Assessment of Engineering programs has become increasingly important as public funding and accreditation both depend upon some form of it. One part of assessment is looking at the retention of one's students. Retention studies provide important information for the evaluation of academic programs. By looking at the success and failure rates of students in our program, we hope to find indicators that will be a good predictor of success in the Electrical Engineering program. Currently, the SAT math score of incoming freshman is used as one such indicator. It is the hope that this study will validate its continued use and suggest other possibly more reliable indicators of success.

Introduction

The purpose of assessment is to improve the effectiveness of instruction and the college curriculum. Part of assessing instruction and curriculum is retention, identifying and helping students who may have trouble succeeding in a demanding engineering program. Nationwide, approximately 50% of students entering an engineering program as freshman are still in an engineering program in their sophomore year [4]. Over the last six entering classes at The Citadel, 60% of freshman Electrical Engineering students returned to the program as sophomores. Retention is especially important since few students switch into engineering from another program of study.

Success in an engineering program depends on many things, some being: mathematical and technical preparation from high school, student and parental expectations, critical thinking skills (problem solving ability), and motivation. Students leave engineering programs for a variety of reasons including: lack of confidence in their mathematics skills, lack of interest in the subject matter, poor performance, and financial reasons. We do not want students to struggle in a major which they are not prepared for; however, there is not the time to do much remedial work in an already compressed engineering curriculum. It is thus very important to have indicators for indentifing students who can be successful in an engineering program.

This research arose from news that engineering programs have had flat or declining enrollment since the early 1980s. “Undergraduate engineering enrollments in the United States reached an all-time high of 406,144 students in 1983. By 1996 this figure had decreased to only 317,772.” [5] Also “undergraduate engineering degrees granted in the U.S. have steadily declined from 77,892 in 1985 to 65,091 in 1997.” [5] This as the workplace increasingly requires more technical expertise. “We heard it from Gary Daniels, senior vice president of Motorola’s Semiconductor Products Sector: we are facing a crisis. Enrollment [in engineering programs] is down 10 percent to 15 percent. Demand for engineers is up 25%.” [3]

In addition, students entering the Electrical Engineering program at The Citadel, increasing enroll in MATH 119, a college algebra and trigonometry course, instead of MATH 131, the first calculus course. Students whose high school background is not appropriate for success in MATH 131 or who score poorly on the Math department’s placement course are required to take MATH 119 before taking MATH 131. Thus, it appears that students entering the Electrical Engineering program at The Citadel are less skilled academically than in previous years.

Other retention studies indicate that students who have more academic skills and better mathematical reasoning ability are more likely to succeed in an engineering program [8] [9] [13]. Good grades at most universities are not achievable without a sufficient level of intelligence, a sufficient level of motivation, a sufficient background, and organizational skills. Approximately 75% of all students who enroll in engineering eventually graduate, but not necessarily in engineering. Those who graduated in engineering had GPAs approximately equal to their first semester GPA. It was concluded that the freshman year was critical to success and that GPA was a good predictor of potential success [8]. Another study [9] reported pre-engineering predicators of success are high school rank and math, science, and English grades. This study also reported that at almost half of all attrition occurs in the freshman year.

In addition, other studies have looked at a wide variety of other possible factors indicating retention such as: student self-perception of ability, high school course work, students impression of engineering, etc. [4] [9] [10]. A survey, given in a study at the University of Pittsburgh [4], indicated that students who left engineering in good standing had a lower opinion of engineering work and were less likely to be interested in mathematical, scientific, and engineering subject matter.

Retention models are of course not 100% accurate. Prediction models developed in several studies have only 20 to 25% of variation accounted to the model variables. Still it is important to understand why students stay in engineering and why students leave. Whether staying in engineering is “best” for a student is another issue. Translating retention models to another institution must be carefully investigated. Generalizations of indicators from one institution to another are not always valid. For instance, at The Citadel, institutional fit is very important whereas at another institution it probably carries less weight. The Citadel is a state military college. Students who do not adapt to the military lifestyle do not succeed at The Citadel and usually withdraw within two semesters of entering.

Goals and Background

Similar to other retention studies [4] [8] [9] [10] this study will encompass: assembling a database for student tracking, identifying model variables, student profiling, and retention analysis. With this study we hope to improve our curriculum, allow earlier intervention for at risk students, and identify indicators of success for the Electrical Engineering program at The Citadel.

This is a preliminary study of Electrical Engineering retention at The Citadel. The Citadel's registrar system does not currently contain some of the detailed high school information used in other retention studies. This study, therefore, will focus on investigating the possible indicators we do have: SAT scores, high school rank, and high school GPA.

The initial study involved the Fall 1994 entering class, the first class of electrical engineering students at The Citadel with which I had contact. The initial sample group was small (38 students). Other retention studies had much larger sample groups (200+ students). Several years of data will be needed before achieving a comparable sample group.

Initially, I hoped to make some general conclusions based on fairly unsophisticated statistical methods. Sophisticated statistical analysis leading to a retention model valid at The Citadel will be done when a suitable sample group has been obtained. This initial work will help to identify potential model variables for this institution and suggest indicators that can be used until a better model is available.

Currently Used Indicators of Success

I have initially shied away from using freshman surveys to gather information since I have had poor results with them in the past in both freshman and junior classes at The Citadel. This limits attitude and motivational assess-

ment, and may need to be retried in the future. Two previous studies in 1977 and 1995 by Professor James Scoggin have indicated that the SAT math score is a good indicator of success at The Citadel.

The following is a brief summary of those two reports and the recommendations made. In Table 1 the Number of students indicates how many students graduated from The Citadel with a degree in Electrical Engineering over the given range of years. The second, third, and fourth columns, give the average SAT math score, the lowest SAT math score, and the standard deviation of SAT math scores for the students graduating with Electrical Engineering degrees in those years.

Years of Graduation	Number of Students	SAT math average	SAT math low score	Standard Deviation
1970 - 1977	82	580	460	50
1978 - 1982	84	558	400	73
1989 - 1994	67	598	450	70

Table 1

Note: 1994 (entering classes of 1989 and 1990) was the last year graduation statistics were compiled by Professor Scoggin and that his study does not include students who entered the program and did not graduate with an Electrical Engineering degree. Also, if the SAT was taken more than once by a student, the scores were averaged.

In 1977 the recommendation made was:

> "A cadet having a valid* SAT-M score below 500 is unlikely to graduate in electrical engineering at The Citadel unless he is highly motivated and/or adapts very readily to the cadet environment. If he does graduate, he is likely to rank in the bottom 25% of his class." [11]
>
> "The data justify a caution to new cadets with SAT-M scores below 500. The data justify a stronger caution to new cadets with a SAT-M score below 460." [11]

In 1995 the recommendation made was for a student to have a minimum total SAT of 1000 and a SAT math score of 540, realizing that some would be lower. Along with the recommendation was a note:

> "It is important to recognize that there are many individual cases of student performance greatly out-of-line with the SAT math score." [12]

For example: in the 1978 - 1982 period there was a cadet with a SAT math score of 430 and a graduation GPR of 3.07. In the 1989 - 1994 period there was a cadet with a SAT math score of 450 and a graduation GPR of 2.209, and in the 1989 - 1994 period there was a cadet with a SAT math score of 640 and a graduation GPR of 2.265.

These two previous studies led me to believe that the SAT math score would continue to be a good indicator of potential success in the Electrical Engineering program. The current recommendation is for entering students to have a SAT score approaching 1150 (re-centered) with the expectation that between 50% and 60% of these students will be retained (make it the sophomore year).

More recent average SAT scores for the Citadel's entering class as well as average SAT scores for students entering

the Electrical Engineering program have been tracked by Dr. Harold Askins, Electrical Engineering Department head for assessment purposes. These are summarized in Table 2 below.

Entering Class	Average SAT Score for Entering Freshman Class	Average SAT score for Students Entering EE Program
Fall 1990	986	1021
Fall 1991	982	1041
Fall 1992	979	1078
Fall 1993	973	1039
Fall 1994	967	1012
Fall 1995	973	1008
Fall 1996	1067 (re-centered)	1153 (re-centered)
Fall 1997	1063	1105

Table 2

The declining trend in SAT scores of entering freshman for the Electrical Engineering program is cause for concern, we believe it is hurting retention.

Analysis of Current Data

Baker [2] suggests that engineering students who transfer to other programs of study should not be considered a failure, but viewed as positive self-development by the student. In this study, success is defined to mean graduation from The Citadel with an Electrical Engineering degree, partial success to be graduation with degree other than Electrical Engineering, and failure to be leaving school with no degree. Students who have left the school in their freshman year in good standing have been dropped from the study. This usually indicates they have left for lack of institutional fit.

Current data is from student transcripts of the Fall 1994 entering class. The data was obtained from The Citadel's System and Computer Technology 2000 online system (SIS), a database of student records. Subsequent data will be added as each additional entering class since then graduates. Thirty-eight students entered the program in the Fall of 1994. Of those, four were dropped from this study. Two students never completed the first semester; i.e. they did not fit into the military life at The Citadel and withdrew before completing one semester. In addition, two students left at the end of one semester with good grades, GPRs of 3.17 and 3.55. It was assumed, that they left because of the military aspect as they were still enrolled in the Electrical Engineering program at the time of departure. This left 34 students for analysis.

Nine students, 26.47%, graduated with an Electrical Engineering degree on time (within 4 years). Six additional

students, 17.65%, are still enrolled in the Electrical Engineering program and are expected to graduate within 5 years. Five students, 14.71%, graduated on time with degrees other than Electrical Engineering and six students, 17.65% are expected to graduate over the next two years with degrees other than Electrical Engineering. The remaining eight students, 23.53%, were discharged for predominantly academic reasons.

For the Fall 1994 entering class 44% have graduated or are expected to graduate with a degree in Electrical Engineering, 32% have graduated or are expected to graduate with a degree other than Electrical Engineering, and 24% did not graduate. In other words 44% of entering freshmen succeeded in the Electrical Engineering program and 32% achieved partial success. The 76% graduation rate coincides with graduation statistics from other retention studies. A breakdown of attrition by semester follows in Table 3.

Semester	Percentage of students (Fall 1994 entrants) retained at end of semester
Fall 1994	65% (22/34)
Spring 1995	60% (20/34)
Fall 1996	50% (17/34)
Spring 1996	50% (17/34)
Fall 1997	47% (16/34)
Spring 1997	47% (16/34)
Fall 1998	44% (15/34)
Spring 1998	44% (15/34)

Table 3

The largest attrition occurred in the first and third semester, which is consistent with other retention studies. This should mean that there are courses in the first semester freshman year and first semester sophomore year that are good indicators of potential success.

Potential Indicators of Success

Students graduating on time with an Electrical Engineering degree had an average SAT math score of 619, an average high school rank of the 85th percentile, and an average high school GPA of 3.46. These students graduate with a cumulative GPR of 3.09. Students who are expected to graduate this year with a degree in Electrical Engineering had an average SAT math score of 585, an average high school rank of the 71st percentile, and an average high school GPA of 3.10. These students have a current cumulative GPR of 2.44.

Students graduating on time with other majors had an average SAT math score of 500, an average high school rank of the 77th percentile, and an average high school GPA of 3.02. These students graduated with a cumulative GPR of 2.54. Students expected to graduate with other degrees had an average SAT math score of 597, an average

high school rank of the 58th percentile, and an average high school GPA of 2.78. These students have a current cumulative GPR of 2.36.

Students not graduating had an average SAT math score of 583, an average high school rank of the 65th percentile, and an average high school GPA of 2.85. Their average GPR upon dismissal was 1.54.

Those graduating or expected to graduate with an Electrical Engineering degree had an average SAT math score of 608 with a standard deviation of 74. Those graduating or expected to graduate with a degree other than Electrical Engineering had an average SAT math score of 542 with a standard deviation of 71. Those students failing to graduate had an average SAT math score of 583. It is somewhat disturbing, that those who failed to graduate have on average higher SAT math scores, higher high school GPAs, and higher high school class rank.

Prior work by Professor Scoggin and current data support a recommendation that a SAT math score in excess of 540, a high school GPA of 3.0+, and a high school class rank of 70% or higher is needed to have a good probability of success in the Electrical Engineering program at The Citadel.

Preliminary Verification of Indicators

Using the criteria of SAT math score in excess of 540, a high school GPA of 3.0+, and a high school class rank of 70% or higher it was then investigated how well this measure would predict the performance of the Fall 1995 entering class. The Fall 1995 data is still preliminary; these students are not expected to graduate until this spring (1999). The success rates will most likely be somewhat lower than is currently indicated.

There were 36 students who entered the Electrical Engineering program in the Fall of 1995. One person was eliminated from the data set; he withdrew from school in the first semester. The remaining 35 students had the following entering statistics and the expected success rate is given (HSR stands for high school rank, and HSPGA stands for high school GPA). If a student met either the HSGPA or HSR criteria and had no reported data for the other, it was assumed that they met both.

Criterion Met	Students meeting the criterion	# of Successes	# of Partial Successes	# of Failures
All	13	9	3	1
SAT math only	8	6	2	0
HSR and HSPGA	5	1	3	1
HSGPA	2	2	0	0
None	5	1	2	2
No data	2	2	0	0

Table 4

Some additional comments. The two students for which we had no SAT or high school data are both foreign nation-

als and very good students. Three students currently classified as successes and two currently classified as partial successes have low college GPAs and their status may change.

Conclusions

Students meeting all three criteria had a success rate of 69% and a combined success and partial success rate of 92%. This is to be expected. Students meeting only the SAT math criteria had a success rate of 75% and a combined success and partial success rate of 100%. Students meeting one or both of high school rank and high school GPA but not SAT math had a success rate of 33% and a combined success and partial success rate of 75%. This suggests that the SAT math score is a good predictor of success and that high school rank and high school GPA are less reliable indicators of success.

Since the largest attrition occurred in the first and third semester, there should be courses normally taken in these semesters which would be good indicators of potential success. This will need to be investigated, but it may be too late for intervention at that point. A few students with very strong entering academic credentials did not succeed, indicators which better measure motivation and organization skills are needed to address this.

Future Additions to this Work

Each year as more data is collected from the graduating class, the indicators of success will be reevaluated. Once the data set becomes sufficiently large, more sophisticated statistical analysis will be used to analyze and verify results. In addition, specific courses (math, science, and engineering) in each semester will be investigated as additional possible indicators of success.

The Mathematics department at The Citadel has been giving a math placement test to entering engineering students. Students entering engineering majors whose high school background is not appropriate for success in the first calculus course (MATH 131) are instead enrolled in a college algebra and trigonometry course (MATH 119). It is then hoped they will have better success with calculus. Next years graduating class will be the first I have math placement test scores for, and this will also be investigated as a possible indicator of potential success.

Motivation, which is very important, is the hardest element to assess. The use of a critical thinking or personnel test may aid in this assessment. Both tests require the attention and effort of the test taker. Unmotivated students, unless extremely bright, do not generally do well on such tests. This test would be administered early in the fall semester of the freshman year.

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