

Profile of a Successful Engineering Student at a Private, Liberal Arts University

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Abstract

With shrinking engineering enrollments, programs are looking for ways of predicting and measuring student success. Profiling incoming and graduating students gives some insight as to what student information might be used as a predictor of success. Eventually, these identified qualities of a successful student might be used to prescreen potential students and to counsel high school students interested in an engineering career. A wide variety of factors are available for analysis using already existing University and Department databases. The first factor thought to measure student success is usually cumulative GPA however, that alone is not a sole predictor of success. Other data, such as SAT verbal and math scores, first semester GPA, high school graduation rank, high school extra curricular activities, concurrent employment, internships, math placement exams, socio-economic factors, gender and minority status, may also be indicators of student success. Preliminary data suggest involvement in student professional societies enhances graduation rates. Passing the Fundamentals of Engineering Exam indicates a minimum level of academic success on a national assessment tool. Comparisons are made between incoming freshman data and final graduating student data. Also, a comparison is made between the engineering student profile and that of a typical liberal arts incoming freshman.

Introduction

Having a student enter an engineering program and successfully graduate is the desire of every university. Baylor University is no exception. The engineering program at Baylor is a small presence on the campus. Approximately 14,000 graduate and undergraduate students are enrolled during any given year and the Department of Engineering accounts for approximately 250 of these students or almost 2%. With so few students, every student that enters the program is important. Thus, the goal of an engineering program is for each student to successfully graduate from the program. In 2000, the question was asked about the retention rate of entering freshman at Baylor University and some startling results were uncovered¹. Students graduating with an engineering degree in 1998 and 1999 were approximately 20% of the number that entered for these years. As other researchers have found, the largest attrition occurs during the first year². At Baylor, approximately 50% of the engineering students leave the program during their freshman year. As a result, retention studies were undertaken and positive steps to improve the retention rate were formulated. To date, the retention strategies developed have had only moderate success with the retention rate improving to about 35%. More information is necessary to continue this improvement trend.

The next step proposed by this paper was to profile graduates and see if there were some characteristics that could be used to identify entering freshmen who might have a high probability of success. The antithesis is also true. Knowing characteristics or qualities of success might also lead to the identification of students who are at risk. If a successful graduate could be profiled, then these traits could be used to prescreen freshmen entering the engineering program. Currently, Baylor has an open admissions policy. The open admissions policy means any student that is admitted to the university has the right to enter any major. As a result of this policy, students who are potentially at risk are allowed to begin the engineering program. For instance, students with composite SAT scores lower than 1000, even lower than 900, are currently in the program.

While SAT score alone is not the only indicator of success, it was thought that by studying a number of indicators, additional insight into a student's aptitude for engineering and their probability of success might be discovered. For graduates, several factors were to be considered that were available in existing databases. These factors include: high school GPA, SAT (total, math and verbal), first semester GPA, graduation GPA (overall and engineering), high school quartile, gender, minority status, placement exams (math and language), socio-economic status, concurrent employment, participation in professional societies, and the fundamentals of engineering exam. A number of other studies have also looked at some of these indicators to determine their usefulness for predicting success. An obvious predictor of the potential for graduation success, high school GPA, has been shown to have a positive correlation^{3,4,5,6}. Another obvious indicator is the SAT score; however, it has been shown by some that it is the math SAT score that is more important⁵. Still others conclude that the SAT score coupled with a math performance test is a valid indicator of success^{7,8}. There are many other factors, such as first term probation² and the number of credit hours taken in the first semester⁹ that could also be significant. The goal of this paper was to begin the journey of gathering the information that is already being archived in both the Department and University systems. By beginning this process of organizing the data, the existing information could be used immediately to begin to profile a successful graduate at Baylor. The process of gathering information would also lead to the identification of other topics that might be useful to improve retention.

Gathering Information

The gathering of information has proved very difficult. One might have thought that this type of information would be readily available for analysis in an institution such as Baylor University but this was not the case. The authors were able to identify numerous weaknesses in the information systems presently used. For instance, each student has a file kept in the Department that is used for advisement. A "new and improved" computer product for each student is now in use that has less information available to the faculty advisor than the previous version. The product has a graduation degree audit but does not give any background data such as SAT scores, math placement results, etc. that would allow an advisor to gage a student's potential for success. On the university database level, reluctance of administration offices to support requests for information delayed access to some information. On certain university databases, some information was either entered incorrectly or missing.

Some aspects of Baylor's admissions process are targeted at enrollment management, i.e. maintaining a set number of incoming freshman students. As the admissions proceeds, a number of special category students are admitted if targets are not being met. Many of these special category students do not meet at least one of the targeted minimum SAT or high school class rank markers. Many will have graduated below the first quartile line of their high school class or will have SAT scores below 1000. In the fall 2003 semester, six of the 81 first-time engineering majors were provisional admits. This represents 7% of the entering freshman engineering class.

Results

Since Department student files no longer contained quantitative information that could be used for this study, the next step was to turn to the University databases. The Office of Information Management and Testing Services (IMTS) at Baylor University track a number of indicators. The period of time for this study was limited to graduates from fall 2000 to spring 2003. Entering freshmen during this period were also studied for comparison. A total of 128 records were available for graduates and 460 records for freshmen. When looking at the databases, it became obvious that not all information was available for each record. For the graduates, each record was manually checked on one university database to update the original bulk information downloaded from another database. Both databases are normally only available to the administration. For some reason, the university was very reluctant to share information even when this information might help with retention. Information was also gained from two other documents that were discovered to be available to Baylor faculty and staff on the Baylor website. The first document, prepared by IMTS in March 2003 highlights statistics on enrollment and student characteristics¹⁰. The second document profiles entering freshmen¹¹. Baylor has had the foresight to begin profiling entering freshman classes to provide a baseline for entering students to help with recruitment/retention. This document tracks such things as gender, age, minority status, racial/ethnic groups, citizen status, country of citizenship, state of permanent address, religious affiliation, entrance test scores, high school quartile, classification, full-time/part-time status, average credit hour load, program of study, and professional field. Normal distribution of this profile is to university administration, in particular the deans. Pertinent information from these documents is included in Table 1 and 4.

Background Information

Table 1 shows the statistics for engineering. From this table, several things are apparent. First, the entering university freshmen class mirrors the overall university in terms of male and female ratios. These ratios are much different in the engineering department. The percentage of males is almost double that of the university value and the percentage of females is approximately one half to one third of the university value. It is interesting to note that from freshmen year to graduation the percentage of female engineering students increases by 6% and the percentage of males decreases by the same amount. Baylor is obviously doing a better job of retaining women in the engineering program than men. Positive steps taken in the recent past were to hire two female, tenure-track professors which may have contributed to this statistic. Second, the graduation rate, on average, is less than half the university average. Over the last four years, this number has slowly begun to increase from approximately 22% to over 35% but the average is still lower than the Baylor overall average and the national average for STEM graduates. This

shortfall highlights the need for a study such as this at Baylor University¹. Lastly, minority averages in engineering are only slightly below the university average.

Table 1 Demographics/statistics

	Total Records	Male	Female	Minority	Graduation Rate
Graduates	128	76 %	24 %	19.5%	29 %
Entering Freshman	460	82 %	18 %	22.8%	
University (2002 data)	14,159	44 %	56 %	21.9 %	69.4 %
University Freshmen (2002 data)	2,620	40 %	60 %	21.8 %	

Quartile Rankings

One of the original premises prompting this study was the observation by the Associate Dean that most of the students on probation are in the bottom quartile ranking for high school graduation. Table 2 highlights the total quartile percentage for graduates as well as the information for males and females. From the table, the male percentages reflect the university values however; the female percentages are skewed to the top quartile. The average graduating quartile ranking for males was 84% and for females 89%. Coupled with the percentage of students above 90 %, this indicates that the females who enter engineering at Baylor University are much more likely to be successful than their male counterparts. The Baylor entering engineering freshmen data in Table 3, on average, reflect the University averages as do the male percentages. Again, the female percentages reflect a higher percentage in the upper quartile. A comparison of the graduate data with the entering freshmen data shows that while the average percentage for males increases at graduation while female percentages remain approximately the same. The number of students above 90 %, however, increases by 40% indicating that many of the high quartile individuals are retained. Quartile ranking has the potential to be a predictor of success in the program

Table 2 Graduate Quartile Rankings (118 records)

Quartile Ranking	Total	Male (76%)	Female (24%)
90<	50.8%	46.2%	66.7%
75-100	76.3%	75.8%	81.5%
50-75	19.5%	20.9%	14.8%
25-50	4.2%	4.4%	3.7%
0-25	0%	0%	0%

Table 3 Entering Freshman Quartile Rankings (435 records)

Quartile Ranking	Total	Male (82%)	Female (18%)	University Freshmen (2002)
90<	35.2%	33%	45%	
75-100	69%	67.6%	80%	67.8 %
50-75	24.6%	25.4%	16.3%	24.2 %
25-50	6.0%	6.5%	3.8%	7.0 %
0-25	0.5%	0.5%	0%	1.0 %

Indicators of Success/Comparison

As many researchers have suggested, information such as high school GPA are important as a possible indicator of success. Baylor University does track high school GPA however; the data entered in the database was unusable. High schools throughout the country use different systems to track GPA. These range from a 4.0 point scale to straight percentage. Either way, the numbers in the database were a mix of these systems as well as other numbers that were unrecognizable. For this reason, high school GPA is not included and future input information must be standardized on the University level. The overall GPA for graduates is 3.19 and their first semester average GPA is 3.32. Entering engineering students take an average load of almost 15 credit hours as compared with the university average 14.5. Taking 15 hours is actually beneficial according to Cummings and Knott⁹. Having a fuller load keeps students occupied and focused on success. SAT scores are often used as predictors. From the data, the entering freshmen reflect the university average but the average for graduates is significantly higher. Female graduate scores were about 2.4% less than male scores. Two indices that are unique to Baylor University are the Math Placement exam and the Academic index.

The SAT score is an instrument that it used in some form by every university. Baylor archives SAT scores from students and combines the highest verbal and math score to get the highest total SAT. A student can take the test as many times as they wish. As can be seen in Table 4, the entering engineering freshman class is not very different from the university freshman class as a whole. What is significant is the average SAT score of those who graduate. The average is 50 points higher, with the female average being slightly lower than the male average. Of the graduates, only seven had an SAT score below 1000. For the entering freshmen, 30 students had SAT scores below 1000.

The Math Placement Exam (MPE) is an exam administered to entering freshmen to determine their appropriate level for entering the math sequence. Students with either a 690 math SAT or a 33 ACT are exempt from taking the test and are allowed to enter Calculus I or higher. Transfer students who already possess credit for Calculus I do not have to take the test. A perfect score on the test is 67. The test has 31 questions, most of which cover subject material from the first two weeks of a pre-calculus course. Each question is worth one point. The remaining points are based on the student's math SAT score with 36 points being awarded for a perfect 800 score. If a student has a MPE score above 52, then the student is placed in honors calculus. A score of 40

or above allows the student to begin Calculus I. Scores between 20 and 39 place a student in pre-calculus and below 20, the student is advised to take a college algebra course. The data for the math placement exam was not very consistent. Only 69 students of the 128 graduates had MPE data. Forty two students who should have taken the test due to low math SAT did not have any data recorded. Still others who clearly had acceptable math SAT scores had a score reported. The overall average of the students with scores was 52.4 (male, female, and total were the same) putting the average graduate in the honors category. Zhang et al. concluded that math SAT correlates positively with graduation rate⁵. Devins and Walker show that a math pre-test is also a good predictor of initial success in an engineering program⁷. Baylor University's MPE might be a good indicator if it is required of all entering freshmen as it combines both instruments.

Another instrument used at Baylor University is the Academic Index. This number is a composite of quartile ranking and total SAT. The exact formula is proprietary but a calculator for Academic Index exists on the admissions website. The academic index is primarily used for scholarship determination. Again, in the database, information is lacking. For the graduates, each record had to be checked individually and even then only 109 out of 128 or 85% had data. The comparison of graduate and entering freshmen data show a 10 point separation (male and female had almost no distinction). No data on the university average was available so no definitive conclusion could be made. This index could be a useful predictor in the future if more is known about the data and the database is more complete.

Table 4 Graduate/Freshman Comparison

	Grad GPA	Math Placement Exam	1 st Sem GPA	Academic Index	Total SAT	Verbal SAT	Math SAT	Average Credit Hour Load
Graduates	3.19	52.4	3.32	164	1246	591	655	
Freshman				154	1195	575	620	14.9
University Freshmen (2002 data)					1180	580	600	14.6

First Term Probation as an Indicator

As other researchers have found, the largest attrition occurs during the first year². Scalise et al. have developed a retention model to determine if first term probation status could be predicated for entering freshman engineering students⁴. To gauge the possible impact of first-term probation on attrition at Baylor, the probation status of the 2003 entering class was reviewed. The University database indicated 82 declared majors. The number of students enrolling in the first engineering course (EGR-1301) during the fall 2003 semester was 72. Each of these students had passed the math qualifying exam and was enrolled in or had credit for Calculus I. Of these students, 8.3% had a first semester GPA < 2.0 and were placed on probation at the end

of the fall term. At least 21 entering engineering students did not qualify for EGR-1301 and had to enroll in pre-calculus math during their first semester to qualify for enrollment in EGR-1301 in the spring semester. Of the 21 students enrolled, 5 were on probation as result of first term grades, i.e. a GPA < 2.0.

A surprising one-fifth (21.7%) of the students in the spring introductory engineering class were on academic probation. This is nearly 3 times the rate for students that qualify for introductory engineering during their first enrollment semester. Enrollment qualification was based on a combination of SAT score and the results of a math placement exam (MPE) administered by the Mathematics Department. The magnitude of the difference indicates that SAT and MPE scores may be significant predictors for student success. However, if one assumes that all first-term probation students will eventually leave engineering, the impact would only account for one-fifth of the 65% attrition rate at Baylor thus, more research is needed.

Professional Societies

Van Treuren et al.¹ and Fry and Allgood¹² have done some preliminary research that the involvement of students in professional societies increases the probability of graduation. ASME involvement increases graduation rates of those involved to 65%. Work with the SWE chapter also shows the same trends. Involvement in professional societies should be encouraged early in an academic career.

Fundamentals of Engineering Exam

Another indicator of success is the taking and passing of the Fundamentals of Engineering Exam. Not all students at Baylor University take this exam though all students are encouraged to do so. Baylor has the highest passing rate of students in Texas who take the exam. Students who take the exam and successfully pass the exam have graduated from the program.

Future Considerations

This study has begun to focus on the important data, already being collected at Baylor, which might help predict success of the incoming students. Factors to consider in the future might be the number of years a student takes to graduate, as some marginal students might be successful over extended periods of time. The issue of course load in the first semester should be investigated. An observation after reviewing graduate data indicates that very few students that take pre-calculus finish the program. This should be investigated further. Success in the two introductory engineering classes should be correlated to see if successful completion of both courses with a minimum grade is an indicator of success. Perhaps the Calculus I grade is a better indicator. Clearly the study is investigating the proper instruments with the Baylor MPE and possibly the Academic Index. More could be done to validate these tools. First term probation and first term GPA also continue to show promise as indicators of success. Incomplete databases hinder progress and more must be done to help the university system track the data important to the engineering program. At present, the system is not as useful as it needs to be and the administration must be more receptive to these kinds of inquiries. It would also help to track

individual records to see, for a given entering class, who is successful and draw some conclusions.

Conclusions

A successful engineering student at Baylor University enters in the top quartile of their class, would have above a 1246 SAT, have a first term GPA of around 3.32, score a 52 or above on the MPE, be involved in professional societies, pass the Fundamentals of Engineering Exam, and not be on probation after the first semester. These statistics have begun some thought of minimum entrance requirements to the engineering program to admit students who have a high probability of success. For a student to struggle through five years or more of engineering education might not be an effective use of the student's time or talents. By identifying at risk students earlier in the program, this might help more students be successful in an academic endeavor at the university. Students with a marginal chance for success in engineering should not be allowed to enter the program and should be encouraged to explore other opportunities.

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