Motivation and Success in Engineering

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Abstract

Declining enrollments in engineering programs, pressure from state legislatures, and accreditation have made student retention a major issue. Community building, mentoring and learning style models are some of the approaches used to improve retention. Retention studies have shown that high school grades and admission tests (SAT scores) are two of the more reliable pre-college indicators of success in engineering, although, there are exceptions. Some students with marginal math and science aptitude succeed against the odds, while others with more than adequate aptitude fail. We will explore, in this paper, the role of motivation as an ingredient of success at both ends of the spectrum of student ability. We will make suggestions on ways to discern and increase student motivation, thereby retaining those students at risk of failure.

Introduction

Typically, one-third to one-half of the entering engineering students will leave the major in the first two years due, primarily, to academic failure [1]. Many papers have been written on strategies for retaining students in the major. Some of these approaches depend on team building and socialization [2], some on adapting teaching to student learning styles [3] and some on student advising [4]. The underlying goal of these approaches is to retain students, who are at risk of academic failure, by improving their grades. We have observed that the three most important factors in predicting a student's success in engineering are: aptitude, motivation (work ethic and interest) and preparation.

Retention studies [1] [5] [6] [7] [8] show that admission exams (SAT-M (Math)) are a good pre-college statistical indicator of aptitude in engineering. However, there are students whose scores indicate a high likelihood of success, who do not graduate with an engineering degree or any degree. There are also students whose scores indicate a low likelihood of success, who do graduate with an engineering degree. This paper focuses on motivation, one of the two factors not investigated in [1]. We will explore some indicators of motivation in an electrical engineering program. We will also offer some approaches that we have used to enhance the motivation of at-risk students with the goal of improving retention.

Aptitude Indicators

Retention studies usually focus on aptitude indicators such as high school grades and admission tests. Studies have looked at other factors such as interest, background, race, gender, etc. but they are not as

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reliable an indicator of college success. In a previous paper [1], it was determined that a SAT-M score of 540 or higher was a good pre-college indicator of aptitude and thus success in an engineering program. However, it was noticed that certain students succeeded even though their aptitude scores were lower or in some cases much lower than expected of an engineering student. This led the authors to believe that other traits, such as motivation, would allow students to overcome a lack of aptitude or preparation. The effect of learning styles on success was also considered, but a study done by The Citadel Writing Center showed no correlation between learning style and success.

A comparison of aptitude and motivation versus success in The Citadel's electrical and computer engineering program was done for the Fall 1996 and Fall 1997 entering classes of electrical and computer engineering students. Motivation was assessed by surveying faculty impressions of students that they had in classes or had advised. Students were rated on a 1 – 3 scale, one being not motivated, two being of average motivation, and three being motivated when compared to their peer group. Motivation scores were rounded up to and truncated down to 2 if there was disagreement in the faculty ratings.

Table I and II below show the comparison of aptitude (SAT-M) and motivation versus success for 74 students entering the electrical and computer engineering program at The Citadel in the Fall of 1996 and 1997. Several students were omitted due to lack of SAT-M scores. Success was broken up into categories of Left FY, Left SY, Left JY, and Expec Grad. Left FY, SY, JY refers to leaving the electrical and computer engineering program during their freshman, sophomore or junior year, respectively. Expec Grad refers to students expected to graduate within five years. One student (noted with a ? in Table I), may leave the program due to academic deficiencies in the junior year.

Table I

Motivation and Success for High Aptitude

SAT-M	Motivation	Left FY	Left SY	Left JY	Expec Grad
>540	3	1	2	0	6
>540	2	8	3	1	12
>540	1	3	3	1?	2
totals		12	8	2	20

Table I shows that students with high aptitude and high motivation (SAT-M > 540 and motivation = 2 or 3) had a high probability of success (55%). This percentage would have been higher had several students in this category not been lost due to a lack of institutional fit. These students left The Citadel in good standing and transferred to other universities.

Table II illustrates that students lacking both aptitude and motivation (SAT-M < 540 and motivation = 1) have a very low probability of success (0%) in an engineering program. Students lacking aptitude, but with

higher levels of motivation (SAT-M < 540 and motivation = 2 or 3) can succeed in an engineering program (50%). This is close to national averages for graduating with an engineering degree. It can be inferred that motivation can make up for a lack of aptitude. There are, of course, exceptions. Students with a high enough aptitude may succeed in an engineering program despite a lack of motivation. Two students with high aptitude and low motivation will probably graduate in five years with GPAs close to a 2.0.

Table II

Motivation and Success for Low Aptitude

SAT-M	Motivation	Left FY	Left SY	Left JY	Expec Grad
<540	3	1	0	0	1
<540	2	3	1	0	4
<540	1	8	2	0	0
Totals		12	3	0	5

In general, higher levels of motivation corresponded to higher GPAs. This was not surprising. Few students are capable of performing well in courses such as circuits, electronics, systems, and digital logic without hard work. The high success rate for students with low aptitude (SAT-M < 540) and high motivation suggests motivation is very important for success. Motivation appears to be a more important component for success than was originally thought.

Motivation Indicators

A student's level of motivation is difficult to measure. We have not found an instrument (test) that attempts to measure motivation as it applies to engineering. Such an instrument could be administered to incoming engineering students, and along with SAT-M scores, would be a powerful pre-college predictor of student success or failure. Lacking such an instrument, we have relied on subjective measures of motivation: membership in an engineering society, willingness to seek tutoring, and willingness to do extra credit work (puntos).

Students who identify themselves as future members of an engineering profession are more apt to complete the program successfully [9]. Therefore, student membership in a professional engineering society, such as IEEE, indicates motivation. Conversely, those students, having little or no interest in engineering, will not likely join their professional society.

The willingness to seek learning skills or tutoring to overcome academic difficulty is another measure of motivation. For example, the Writing Center at The Citadel offers a series of short courses on learning skills, such as time management, note taking, etc. The math department at The Citadel offers a voluntary Math Lab to students seeking help with college algebra and calculus. From both sources, we can obtain the names of the students who are taking advantage of this extra help. We can infer from this, that these students are motivated to be successful in our program.

"Puntos" (Spanish for points) [10] and other incentives can be used to identify students with high motivation. Puntos are awarded for an activity related to learning or engineering. Students are awarded puntos for attending the short courses on learning skills. Puntos are awarded to students who participate in a Career Fair on campus and visit the booths of companies recruiting engineering graduates. Puntos could also be awarded for attending presentations of guest speakers or attending school and IEEE sponsored plant visits. Puntos are offered for reworking exam problems to correct errors. For example, in the Engineering Fundamentals courses one point was added to the final grade for each learning skills course attended. Often, it is the best students in the class, the motivated students, who take advantage of the opportunities to gain puntos.

Observations

Once guidelines were established for success based on aptitude and motivation, students from current entering classes were chosen to illustrate the use of the SAT-M scores and the motivation indicators for predicting the success of students in engineering. We present three first year engineering students in the class of 2002, entering class of Fall 1998. Table III contains the SAT-M scores, the motivation indicators and the GPA of the three students at the end of their first year.

Table III

Three Student Examples

	SAT-M	IEEE	Punto's	Tutoring	GPA
Student A	450	YES	30	YES	2.50
Student B	590	YES	0	NO	2.35
Student C	500	NO	0	NO	1.08

Student A is an example of a student with marginal aptitude (SAT-M of 450) but one who is highly motivated. Student A shows the importance of motivation by achieving a better than average GPA in his class at the end of the first year. Freshman electrical and computer engineering majors at The Citadel usually have a GPA in the 2.0 range.

Student B, on the other hand, has better than average aptitude (SAT-M of 590), but low motivation. Student B also completed the first year with an above average GPA, but is not performing to the level of students with similar aptitude scores and higher motivation.

Student C is an example of a student with marginal aptitude (SAT-M of 480) and low motivation. Student C completed the first year with a low GPA. This is in contrast to Student A, who had a similar SAT-M score but a much higher level of motivation. There are also students with high aptitude (SAT-M greater than 600) and high motivation who are performing very well in our program (GPA greater than 3.0) as expected.

Enhancing Motivation

Our attempts to enhance motivation have had mixed results. Our success in motivating students that are not self-motivated started with intensive advising. Showing interest and offering encouragement is sometimes all that is needed to motivate an uninspired student. By getting to know students personally, we may find the spark that will make them excited about engineering.

Understanding and identifying with the engineering profession can also be a strong motivator. Our students are made aware of the job opportunities and the salaries that are waiting for them when they graduate with an engineering degree. Students are strongly encouraged to become student members of the IEEE. The monthly publication, the Spectrum, is included in the IEEE membership fee and contains articles that cover leading edge technology. The Spectrum also contains ads for major companies that employ electrical engineers. The articles and ads broaden the horizons for engineering students regarding engineering work. Students are also encouraged to attend guest presentations and IEEE sponsored company visits. Not only is attendance of these presentations and visits an indicator of motivation, it also appears to enhance it. We have noticed that students who attend these events get excited about engineering and the applications of engineering that they observe.

We have found that introductory lab projects motivate some students. They like the hands-on aspect of building something and making it work. Lab projects also help them to make the connection between a circuit that they can see and touch and the theory they learn in class.

There will always be students that can not be motivated and have no interest in the engineering profession, in spite of our best efforts. We can do them and the profession a favor by encouraging them to change to a major that excites them. Many times, students failing in engineering transfer to another major and do very well. This, at least, retains the student in the college and the student graduates rather than continuing on the road to failure in engineering. We count this as a success.

Conclusions

In our experience, the majority of students getting good grades in engineering do not transfer to another major. Aptitude, measured by SAT-M scores, is a reliable predictor of success. A motivation indicator, however, is lacking for incoming students. Therefore, motivation has not been used as a pre-college predictor of success even though it is also important for success. Students with above average aptitude who lack motivation generally do poorly in engineering and are at risk of failure. On the other hand, students with high motivation can make up for marginal aptitude and succeed in engineering. We have not found a statistically significant instrument for measuring motivation as it applies to engineering. However, the motivation to do well in engineering can be observed. Motivated students see themselves as future members of the profession, they seek help in order to understand and to learn, and they take advantage of opportunities to improve their grades.

Attempts to enhance the motivation of the students that are unmotivated have met with limited success. Most of the successes started with intensive advising that produced excitement about engineering and the engineering profession. It may be the professional aspects of engineering or the practical, hands-on lab projects that provide the appeal and generates excitement. Whichever it is, it will be unique for every student. We have suggested a few ways to enhance motivation that have worked for us. Enhanced motivation results in increased retention and students that are eager to learn.

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