Increasing Engineering Retention Using Only Incoming Data

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Abstract

A four year study of engineering student retention was conducted on the University of Arkansas - Fort Smith campus. The goal of the study was to find which scores (high school grade point average, composite ACT and math ACT) best predicted if a student would be retained in engineering one year after starting the program. The value of such a study is that engineering retention could possibly be increased if we selected a better group of students for admission and scholarships. Results show that high school GPA is the best predictor for engineering retention. The math ACT sub score was the second best predictor and composite ACT was overall the weakest measure in predicting retention. A combination of all three scores suggests that engineering retention of selected groups can be increased significantly through an optimal weighting of each metric.

Introduction

Increasing retention in engineering programs has been a frequent topic in educational research and in engineering programs[1-4]. While efforts to improve the retention of students already on campus are needed, another way to increase retention is to select and scholarship the best students possible. But the definition of the "best" students for engineering in terms of incoming attributes is not well defined. Standardized tests such as the ACT or SAT have long been an excellent guide for institutions looking to select students who show the intellectual ability needed for engineering programs. But these tests often fail to show things like work effort and perseverance, attributes that are also critical for engineering students. Colleges can also look at high school grade point averages, but high school data suffers from variability due to the strength of the school and the strength of the courses taken. Other measures such as interviews, class rankings or other exams may be helpful but are not as widely available or easy to obtain.

The University of Arkansas - Fort Smith engineering faculty has debated over the selection of students for scholarships on a yearly basis. Often these debates focus on which measures (or combination of measures) best predict a successful engineering student. We recently dismissed a formal interview process because the faculty believes (and some limited data supports this assumption) that interviewing students does not efficiently or effectively help the department select good candidates for scholarships. Like most other colleges in our region, we had ACT scores (and sub scores) and high school GPAs for every student who had applied for a scholarship. We have traditionally leaned heavily on the ACT scores since we had many students from high schools that had a poor reputation for academic excellence. We also have many large and small high schools in the area and their standards seem to vary greatly. This paper will focus on three measures: high school GPA, composite ACT, and the math ACT sub score. The math ACT sub score was chosen as an additional variable since math ability is critical to engineering

success. The goal of this work is to explore which measures best predict success in engineering and what combination of measures would produce the maximum number of retained students.

In order to achieve the previously stated goals, incoming data for students registered in our first-semester *Introduction to Engineering* course at the University of Arkansas - Fort Smith was collected from 2004-2007. The retention of each of the 266 students enrolled in fall sections of the course over the four year period was tracked. Retention in this work is defined as a student who is still enrolled and pursing an engineering degree one year after starting the *Introduction to Engineering* course. The overall retention rate was 45.86 percent. While this retention rate may seem low, it is near the typical percentage for an engineering program at a non-selective public university[1]. The percentage has also been rising, with the last two years above 50 percent. This work will begin by examining ACT, math ACT and high school GPA independently. Next, two factors will be combined to predict retention. Finally, all three factors will be formulated into an optimization problem that will lead to the appropriate weightings that will maximize the number of selected students that retain.

Student retention for each measure

Retention rates for high school GPA, math ACT and composite ACT are shown in Table 1. Each measure is broken into quartiles and the absolute scores of each range are given in the plots. The high school GPA and Math ACT retention rates seem to follow a similar pattern through each quartile. The high school GPA has the largest range, with the 1st quartile having a retention rate of 65.7 percent and the 4th quartile having only a 21.2 percent retention rate. A larger difference between each quartile suggests that high school GPA may be the best single statistic (amongst the three considered here) for determining a successful student. The composite ACT has a different distribution, with the 1st quartile having a much larger retention rate than the other three. Quartiles 2 through 4 have a flatter slope which suggests that composite ACT scores on the lower range may not be effective in targeting successful students.

Another way to compare each measure is to calculate the mean and standard deviation of each score for retained and non-retained students. Retained students had a mean high school GPA of 3.62 (0.46 sample standard deviation), a mean math ACT of 26.2 (3.99 standard deviation), and a mean composite ACT 25.0 (3.93 standard deviation). Non-retained students had a mean high school GPA of 3.24 (0.58 standard deviation), a mean math ACT of 23.7 (4.24 standard deviation), and a mean composite ACT of 23.1 (3.83 standard deviation). All three sample means were statistically different ($p < 0.001$) but the high school GPA distributions had the least amount of overlap while the composite ACT had the most overlap. Still another way to look at the data is to calculate the retention rate with students categorized by their weakest score. If each metric was ordered from highest to lowest than each student would have one score (or a tie) that is his or her weakest. Students who scored lowest (relative to the group) in composite ACT had a 56.1 percent retention rate. Students who scored lowest in their math ACT had a 44.4 percent retention rate and students whose weakest score was their high school GPA had a retention rate of 40.2 percent. These results suggest that weak high school grade point averages have the most detrimental effect on retention. The results also suggest that institutions might be wise to accept or scholarship students with weaker composite ACTs if their math ACT and grade point averages are good.

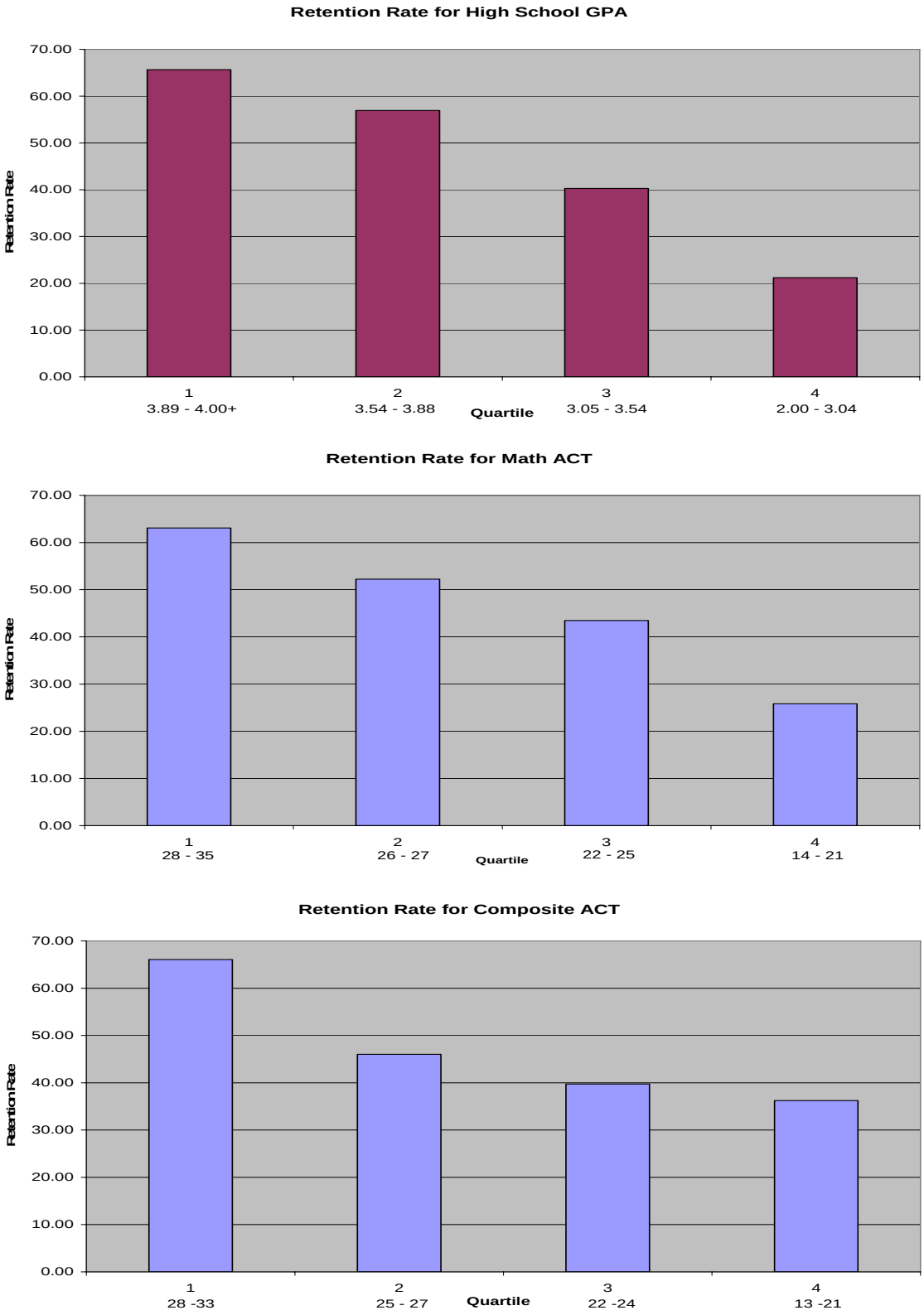

Table 1: Retention Rates for High School GPA, Math ACT, and Composite ACT.

Student retention with two measures combined

Combining multiple measures offers the possibility of greatly improving the prediction accuracy of the data. The previous section examined each factor individually with three different perspectives. Table 2 shows high school GPA combined with math ACT for different quartiles. For example, students who were in both the 1st quartile of high school GPA and math ACT had a retention rate of 71.4 percent. The relative effect of each measure can be observed by comparing to the main diagonal. A lowering of high school GPA quartile typically produces a greater drop in retention than lowering the math ACT score. All groups but the lowest math ACT quartile had relatively good retention rates when the high school GPA was in the first two quartiles. But poor high school grades resulted in lower retention rates regardless of their math ACT scores.

		High School GPA Quartiles			
Math ACT Quartiles		**1**	**2**	**3**	**4**
	1	71.4	72.2	*14.3*	*40.0*
	2	65.0	59.1	33.3	*42.9*
	3	66.7	50.0	54.5	15.0
	4	*0.0*	*28.6*	44.4	17.6

Table 2: Retention rates for high school and math ACT quartiles combined. Percentages in italics are from less than 10 students.

		High School GPA Quartiles			
Composite ACT Quartiles		**1**	**2**	**3**	**4**
	1	78.6	68.8	*33.3*	*33.3*
	2	57.7	58.3	35.3	*12.5*
	3	*55.6*	48.1	31.8	30.0
	4	*50.0*	54.5	57.9	17.1

Table 3: Retention rates for high school and composite ACT quartiles combined. Percentages in italics are from less than 10 students.

Table 3 shows the retention rates for high school GPA combined with composite ACT. As in Table 2, the retention rates of 1st and 2nd quartile high school GPA students remained relatively high regardless of ACT score. On both tables there seemed to be an interesting trend in the 3rd quartile of high school GPA. The retention rates trended slightly upward with decreasing ACT and math ACT scores. A possible explanation for this is that student with better ACT scores but lower high school GPAs lack the work effort necessary for success in engineering. Students with lower ACT scores may have shown a greater amount of work effort but lacked the ability to gain better scores. It seems like this type of student stands a better chance of succeeding in engineering.

Maximizing student retention with all three factors

A weighted score can be used to produce an optimal combination of all three measures discussed in this paper:

$$\text{Score} = 10\alpha(HSgpa) + \beta(Math\ ACT) + \delta(Composite\ ACT)$$

The weights are calculated by optimizing the number of retained students in the top 50 percent of the weighted score. The percentage should be similar to the percentage of students selected for admission or scholarships. At UA Fort Smith about 50 percent of our incoming students got a university funded scholarship over this time period, and 55 percent of them were retained. Thus, we want a scoring system that will optimize the number of retained students that we would scholarship. Since we also offer a larger scholarship to the top 25 percent of students, we were also interested in developing a score to maximize retention for this group as well. The high school GPA was multiplied by ten so that scores were the same order of magnitude. This is similar the academic preparedness index that was proposed by Lackey et al[3]. The previous data was fed into a MATLAB program that manipulated the weightings such that they maximized retention of the given percentage. The weights were constrained to sum to one and be non-negative to simplify the analysis. Table 4 shows the calculated weightings:

	α (HS GPA)	β (Math ACT)	δ (Comp. ACT)	Retention Rate
Top 25%	0.47	0.43	0.10	74.6
Top 50%	0.56	0.00	0.44	62.4

Table 4: Weighting for each metric to optimized retention rate in given set.

The results show some similar trends for both percentages. Maximizing the retention of both groups is a score that is approximately half of the high school GPA and half of an ACT score. The maximization of the top 25% of students came from about half high school GPA and forty percent math ACT while the maximization of the top half of the group had about half high school GPA and half composite ACT. The results agree with previous analysis that shows that high school GPA is the most important factor in prediction of retention. These results also suggest that optimizing retention for scholarship selection of top students can come from a combination of high school GPA and math ACT, with just a small weighting on composite ACT. For a larger group of students, high school GPA and composite ACT are more important towards the prediction of retention. The new formula will result in five additional students each year who are retained on university scholarships. This should increase retention since many students drop out due to lack of funds and not academic difficulties.

Conclusion

A four year study of University of Arkansas - Fort Smith engineering students has shown that high school grade point average is the most important factor in predicting retention. Math and composite ACT are also good predictors of engineering retention in certain cases. When these three scores are combined, retention is maximized by weighting high school GPA and one standardized score equally. Results also suggest that math ACT is a slightly better factor for predicting retention than composite ACT, especially for selecting top students.

References

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