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ABSTRACT

This study was conducted to ascertain the factors associated with attrition in engineering programs on all fronts. Academic underpreparedness, psychosocial variables, and their interconnectivity were examined. Subjects included all enrolled University of Alabama students, as of the spring term 2001, who at one time or another were classified as engineering majors. This resulted in the identification of 1,395 current and 536 former majors. Data were obtained from the university's database and Web-based and paper surveys. Findings from the research show that attrition cannot be viewed as a predictable consequence of differing levels of ability. Academic underpreparedness was found to be a substantial determinant in engineering persistence. However, other nonpreparedness variables were found to contribute to attrition as well, Predicting success in the College of Engineering, or any college, is difficult because of the infinite antecedent variables each student brings to higher education. Data seem to indicate that most of the factors associated with attrition from the College of Engineering are precollege attributes, academic underpreparedness, ignorance about engineering, or calculation to leave after a certain time frame. Other factors that need to be considered are the pedagogical methods of gateway and engineering courses and increasing the student's sense of belonging within the college and university. (Contains 16 tables and 35 references.)(SLD)

IMPLEMENTING A RECURSIVE RETENTION ASSESSMENT SYSTEM FOR ENGINEERING PROGRAMS

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Introduction

The Report of the Task Force on the Engineering Student Pipeline (Engineering Deans' Council, 1988) estimated that losses to other majors, and from school altogether, range between 30 percent and 70 percent in four-year engineering schools. This study also found that few engineering schools maintained longitudinal retention data for freshmen persistence in engineering programs. Astin (1993), in his colossal study of nearly 25,000 students at over 300 institutions, found that 43% of first-year engineering students went on to graduate in engineering. Moller-Wong and Eide (1997) found similar results with a probable graduation rate between 40% and 45%. They stated that retention in engineering programs is often argued to be so important that "it should be used as a college outcomes assessment parameter…" and be considered a measure of faculty and professional engineers ability to design programs of study that meet consumer and market expectations (p.7). Further highlighting the importance of the topic, retention rates have also been mentioned as a critical measure of institutional effectiveness (El-Khawas, 1992; Tinto, 1994).

Retention data are very important in planning curricula, facilities, academic intervention programs, and recruiting activities. Studies have shown that it is more expensive to recruit a new student than it is to keep a current one (Ferguson, et al., 1986). Thus, it is imperative to understand what factors contribute to attrition in engineering and other programs. This study's aim is to discover and establish the relative importance of the factors with greatest bearing upon the decisions of undergraduates at the University of Alabama to leave engineering programs.

Research Questions

Question I: What majors did engineering transfers pursue?

Question II: What factors related to academic underpreparedness contributed to student attrition from the College of Engineering?

Question III: What factors related to psychosocial variables contributed to student attrition from the College of Engineering?

Question IV: What can be done to address these factors to reduce attrition from engineering programs?

Question V: How can retention assessment in engineering be made recursive?

Definition of Retention & Attrition

For a study of this nature, it is important to establish exact definitions for retention and attrition. For simplicity, it was decided that retention, i.e., retained students, were all undergraduate student declared majors who remained within the College of Engineering as of Spring 2001. This included students at all class levels (freshmen to senior). Attrition, on the other hand, was limited to those students who had left the College of Engineering and switched to another program at the University. This is often referred to as "leakage" from the engineering pipeline. Students who left the University were not included.

Historical, Theoretical, and/or Conceptual Framework

The problem of attrition, in engineering and all other programs, transcends the individual. Attrition generates social and financial losses for the student. Pascarella and Terenzini (1991) stated,

> Students not only make statistically significant gains in factual knowledge and in a range of general cognitive and intellectual skills, they also change on a broad array of value, attitudinal, psychosocial, and moral dimensions. (p.557).

The institution of higher education is also a loser with attrition. It is a loss of revenue for the institution, especially tuition driven institutions (Tinto, 1993).

But what causes attrition? Attrition is largely the product of risk. Students with higher probabilities of failing to obtain their academic goals, for whatever reason(s), can be described as high-risk and/or at-risk students. Attrition, however, is an outcome. Numerous factors of risk are preliminary to attrition. Thus, rather than focusing only on retention and attrition, colleges and universities should direct programs and strategies toward risk in its multiple forms.

Academic Underpreparedness

While attrition occurs among students of sound academic standing, some argue that the major source of attrition is academic underpreparedness for college (Astin 1975). Academic background and preparation are determinants of academic preparedness. A number of studies have shown that poor academic preparation and academic performance affected retention (Arnold, Mares, and Calkins, 1986; Moline 1987; Nora 1987). Levin and Wyckoff (1988) looked into a predictive model of persistence for engineering students. They determined that math ability was the single best predictor (better than S.A.T., college or high school G.P.A. scores), followed by the choice of their major on the basis of interest in the subject. Additionally, Warburton and Carroll, (2001, p. iii) noted, "The academic rigor of students' high school curriculum was strongly associated with their postsecondary GPA, the amount of remedial coursework they took, and with their rates of persistence and attainment."

Academic background and preparation, however, in part, are socially determined (Reyes and Stanic, 1985). Experiences at primary and secondary schools are key determinants of college preparation.

Academic and related factors are compounded by an assortment of nonacademic factors that enhance risk and attrition. Variables such as numbers of hours worked, nature and number of credits carried, involvement in extracurricular activities, etc., impact risk and ultimately attrition.

Psychosocial Variables

While inherent abilities and other factors beyond the limits of intervention can lead to academic underpreparedness, a number of other variables appear to be of equal or greater importance. Psychosocial variables cannot be viewed as separate from academic underpreparedness. There is a connection between the two, since psychosocial processes can contribute to academic underpreparedness. Pantages and Creedon (1978) documented the role of psychosocial variables, such as clear-cut goals and self-concept. Also, students' educational aspirations are highly correlated with their eventual attainment (Hanson, 1994).

The goals and intentions of students are a considerable factor when addressing retention. "Among entering college students the range of educational or occupational intentions may be quite varied, and not all intentions or goals are clearly held. Also, the goals may not be consistent with degree completion or compatible with the educational goals of the institution" (Folsom, 1996, p. 36).

Astin and Panos (1969), in studying 36,000 college students, found that 75% of their subjects changed career plans after entering college. Uncertainty by students in their career/academic path impacts their persistence, academic performance, and satisfaction with college in general. Also, within this psychosocial realm is the notion of "'fit' as perceived by students or mismatch of students' interests with academic programs offered by the institution" (Li and Killian, 1999, p. 2). Echoing these notions of fit and satisfaction with college Yorke (1999) identified three primary causes of withdrawal among full-time students: a mismatch between students and their choice of field of study, financial difficulties, and poor quality of the student experience (i.e., the quality of teaching, level of support by staff, and organization of the program).

Related to the fit concept are personality characteristics. Brown and Cross (1993, p. 661) state, "It is logical to assume that personality plays a part in selecting and persisting in a major field of study, as interest inventories and career development rely heavily on personality characteristics in their theoretical foundations." A number of studies have shown that personality variables often discriminate between students of differing fields of study. Knott (1978), using the California Psychological Inventory (CPI) and Work Values Inventory, found that personality variables that discriminated significantly between engineering students and non-engineering students included Socialization, Self-Control, Good Impression, Achievement via Conformance, Intellectual Efficiency, and Flexibility. Others, such as Izard (1960), Korn

(1962), and Scott and Sedlacek (1975) also established a difference in the personality traits of engineering students and non-engineering students.

The most established and tested theory of student attrition is Tinto's Student Integration Model (Tinto, 1975, 1987, 1993). This model views student departure as a consequence of the interaction between the individual student and the college or university as an organization. Tinto (1993) claimed the primary roots of departure from higher education can be identified as a student's "intention" and "commitment." One might, similarly, think that a student's departure from a major or program is a consequence of these phenomena as well.

Methods

This section describes the methods used to conduct this study. The subjects of the study are described first, followed by the methods used to answer each of the research questions.

In brief, this study intends to ascertain the factors associated with attrition in engineering programs on all fronts. Academic underpreparedness, psychosocial variables, and their interconnectivity will be examined.

Data Subjects

The subjects for this study included all enrolled University of Alabama students, as of the Spring 2001 term, who at one time or another were classified as engineering majors. This resulted in 1,395 current and 536 former majors being identified. Data were obtained from the UA SIS Database and web-based and paper surveys.

Data Analysis

Methods for Addressing Research Question I

Question I: What majors did engineering switchers pursue?

Former students were categorized by their present major and their new college or school.

Methods for Addressing Research Question II

Question II: What factors related to academic underpreparedness contributed to student attrition from the College of Engineering?

Numerous quantitative variables were examined, including the student's high school, performance (i.e., GPA), ACT entrance examination scores (components and composite), math placement scores, and performance in gateway, engineering, and all college classes.

Independent t-tests were used to compare current and former students for a variety of quantitative variables. Logistic regression and discriminant analysis techniques were employed to ascertain a predictive quantitative model of factors that contribute significantly to attrition in engineering programs. Additionally, cluster analysis was also performed to further see if the two groups could be categorized by similar characteristics.

Methods for Addressing Research Question III

Question III: What factors related to psychosocial variables contributed to student attrition from the College of Engineering?

Seymour and Hewitt (1997, p. 33) identified 23 categories raised by participants as factors and concerns possibly leading to attrition in SME (Science, Math, Engineering) majors.

A survey was administered to former students who transferred to other departments or programs outside of the College of Engineering. This survey consisted of a structured component that dealt with 22 of the 23 categories found by Seymour and Hewitt (1997), and other structured sections dealing with their experiences at UA in general. The survey also gave the student the opportunity to express any and all concerns in an open-ended format.

Qualitative analytical techniques were utilized to identify broad themes mentioned by the students. Specific comments were also listed.

Roughly half of the respondents filled out a web-based survey and the other half a paper questionnaire. The forms were identical with regards to the structured responses, but differed slightly with the open-ended questions.

Results

Results for Research Question I

Question I: What majors did engineering switchers pursue?

Former engineering majors were classified in 71 different programs as of Spring 2001. Table 1 shows the distribution by major. Pre-business (PREB) was, by far, the largest choice of major for these students. Following distantly were management information systems (MIS) and finance (FIN). More generally, the College of Commerce and Business Administration received over half of these students (see Table 2). The College of Arts and Sciences received almost a third.

Table 1. Major of Former Engineering Students

Major	N	Major	N	Major	N
Pre-Business	181	General Health Studies	4	Music	1
Mgmt. Info. Systems	29	Environmental Science	4	Music Therapy	1
Finance	28	Consumer Science	4	Performance	1
Marketing	16	Sec. Educ. Mathematics	4	Philosophy	1
Undesignated AS	15	Physics	4	Pre-Law Studies	1
Accounting	15	Nursing	4	Pre-Medical	1
Pre-Major Studies	15	Interior Design	4	Pre-Occup. Therapy	1
Management	14	Journalism	3	Pre-Physical Therapy	1
Criminal Justice	13	Public Relations	3	Pre-Psychology	1
Art	12	Undesignated CM	3	Religious Studies	1
Mathematics	12	Anthropology	3	Sec. Educ. Early Child Handicap	1
Biology	9	CB Upper Division	3	Sec. Educ. Social Studies	1
History	8	Chemistry	3	Spanish	1
Health Care Mgmt. AS	8	Food & Nutrition	3	Urban Planning Geography	1
English	8	Marine Science Biology	2	American Studies	1
Pre-Teacher Education	8	Pre-Major Studies Education	2	Art History	1
Psychology	7	Pre-Pharmacy	2	Asian Studies	1
Computer Science AS	7	Rest, & Hospitality Mgmt.	2	Communication Studies	1
Geology	6	Social Work	2	Economics AS	1
Geography	6	Undesignated CB	2	Human Dev. & Family Studies	1
Advertising	6	Economics	2	Human Performance (Non-Cert.)	1
Political Science	6	Health Care Mgmt. CB	2	HP: Physical Education	1
External Degree	5	HP: Sports/ Fitness Mgmt.	2		
Industrial Management	5	Interdisciplinary	2		
Telecomm. & Film	5	Microbiology	1		

Table 2. Present College or School of Former Engineering Students

	N	Percent
College of Arts & Sciences	168	31.3
College of Commerce and Business Administration	305	56.9
College of Communication and Information Sciences	21	3.9
College of Education	18	3.4
College of Human Environmental Sciences	18	3.4
College of Nursing	4	0.7
School of Social Work	2	0.4

Results for Research Question II

Question II: What factors related to academic underpreparedness contributed to student attrition from the College of Engineering?

Academic underpreparedness, naturally, has a lot to do with the student's high school education. This section sets out to determine what, if any, quantitative differences exist based on entrance exam scores and high school GPA between retained and former engineering students.

Pre-College Comparisons

Quantitative differences between the former students and the current students were analyzed for all of the ACT scores (components and composite), the math placement score, and their high school GPA. Table 3 outlines the averages between the two groups and specifies whether the differences were statistically significant.

The data indicated that the former students scored significantly lower on all ACT components and the composite, as well as the math placement examination. It showed that their performance in high school was significantly poorer as well. Table 4 breaks down the data by race and sex.

Table 3. Comparisons between Current and Former Students

	Former Mean	Former St.Dev.	Current Mean	Current St.Dev.	t	df	Sig. 2-Tail
ACT English	23.66	4.54	24.62	4.90	3.612	1586	.000
ACT Math	24.04	4.56	25.56	4.57	5.993	1586	.000
ACT SS	24.45	5.46	25.37	5.67	2.973	1586	.003
ACT NS	23.78	4.37	24.96	4.50	4.755	1586	.000
ACT Composite	24.13	4.12	25.30	4.30	4.948	1586	.000
Math Placement	35.85	10.00	39.59	9.92	6.829	1580	.000
HS GPA*	3.216	.569	3.482	.503	8.486	733.7	.000

Note: *Unequal variances

Table 4. Comparisons between Current and Former Students by Sex and Race

	Current				Former			
	Male		Female		Male		Female	
	White	AA	White	AA	White	AA	White	AA
ACT English	25.20	21.46	26.92	21.48	23.99	21.27	26.19	20.33
ACT Math	26.65	22.11	26.37	21.38	24.82	21.75	25.59	19.96
ACT SS	26.20	21.64	27.43	21.52	25.10	20.80	26.72	20.98
ACT NS	26.12	21.74	25.44	21.02	24.83	20.81	24.87	19.33
ACT Composite	26.20	21.90	26.76	21.53	24.83	21.31	26.01	20.27
Math Placement	40.49	34.75	42.95	34.10	36.52	32.58	40.29	29.47
HS GPA	3.491	3.236	3.740	3.351	3.209	2.943	3.603	3.100

Figures 1-7 display these comparisons graphically by individual score or GPA. These graphs are useful in identifying possible cut-off scores in order to determine baselines or minimum standard requirements. In every case, with the exception of high school GPA, the graphs reveal a point of consistency at which and below the likelihood of transferring from engineering exceeds the likelihood of remaining. For example, these cut-off scores appear to be

Figure 1. Percent of Students by ACT English Score and Status

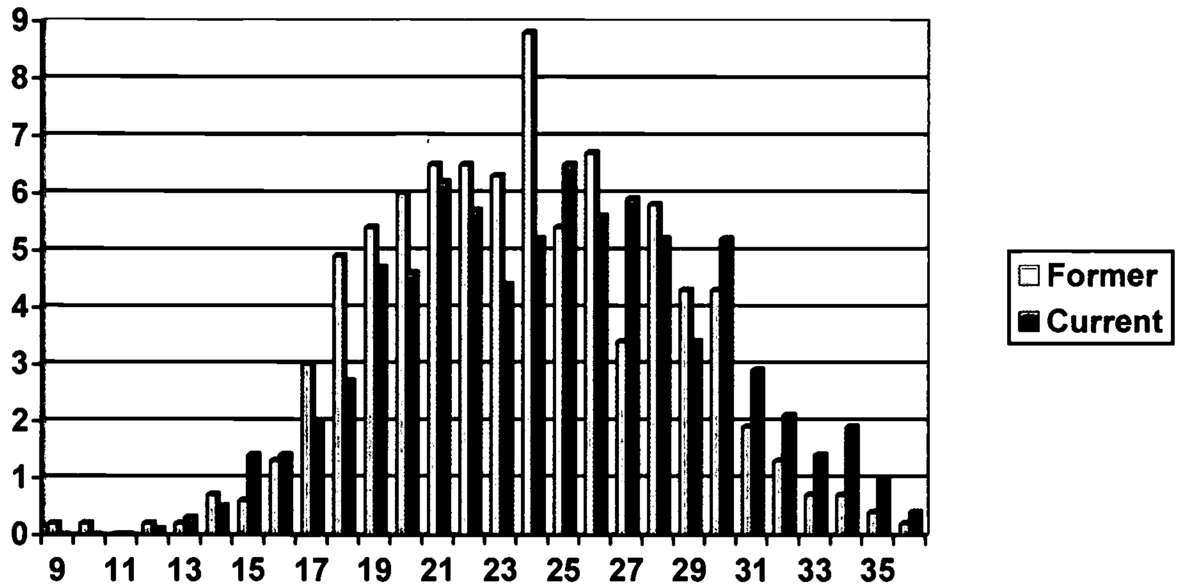

Figure 2. Percent of Students by ACT Math Score and Status

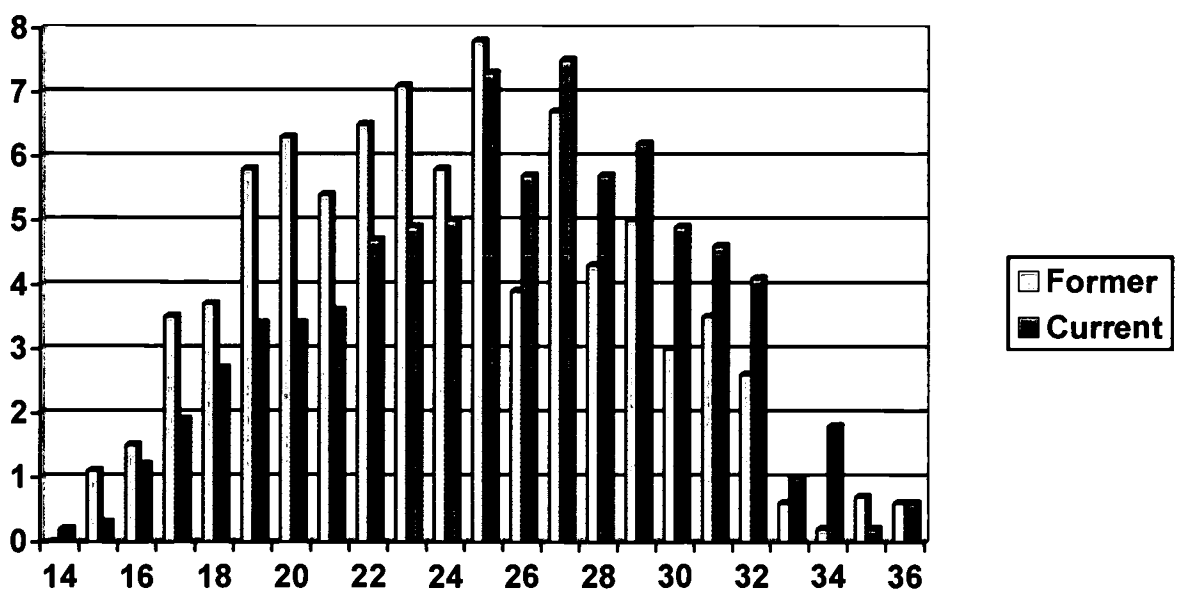

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Figure 3. Percent of Students by ACT Social Studies Score and Status

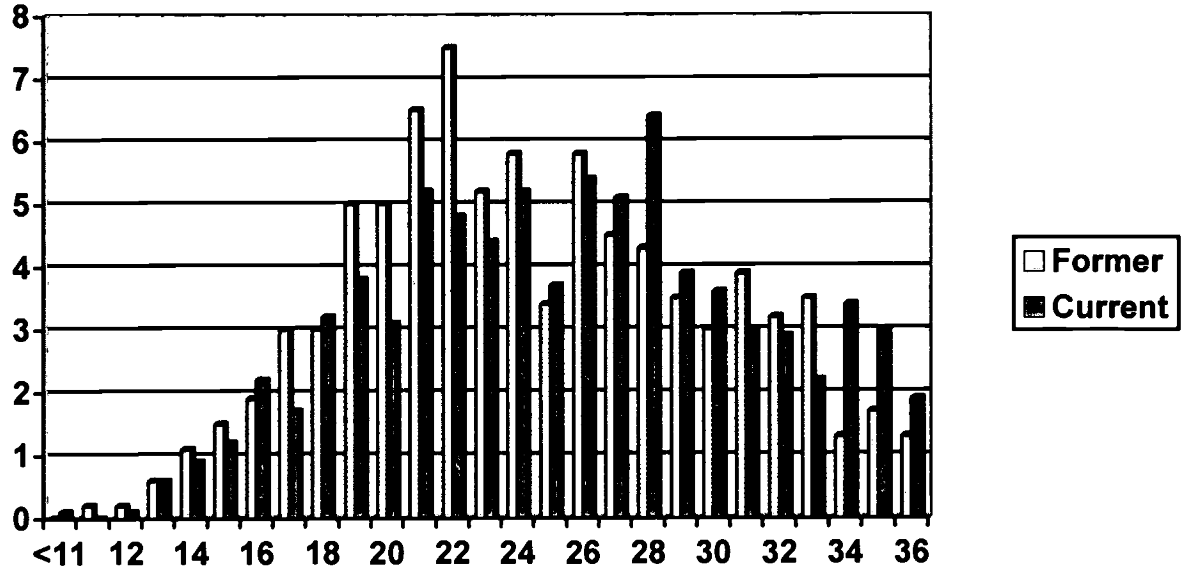


Figure 4. Percent of Students by ACT Natural Sciences Score and Status

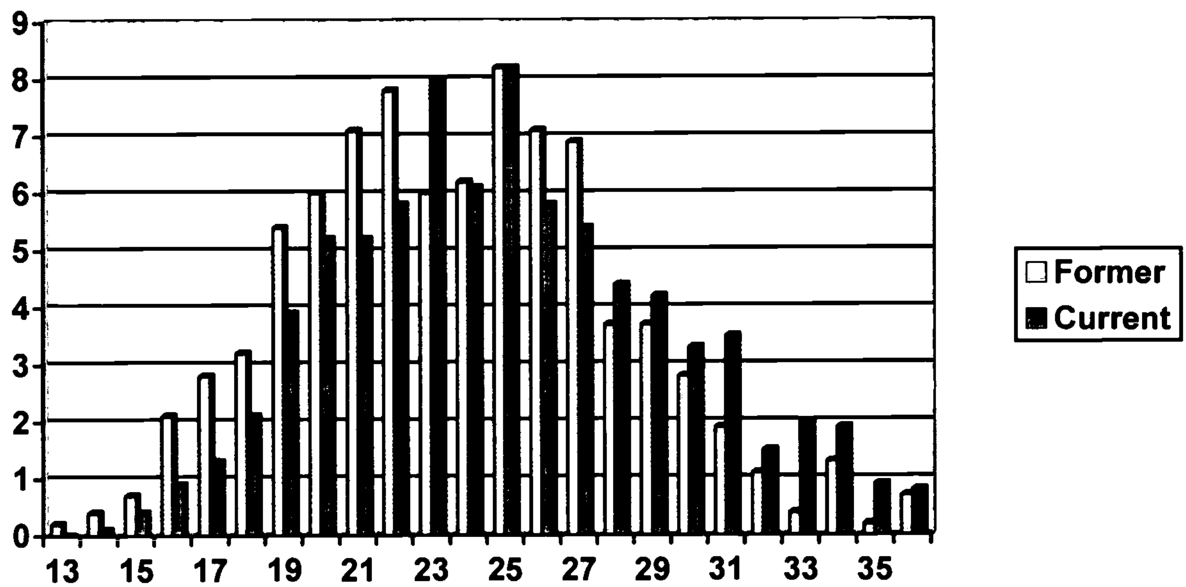


Figure 5. Percent of Students by ACT Composite Score and Status

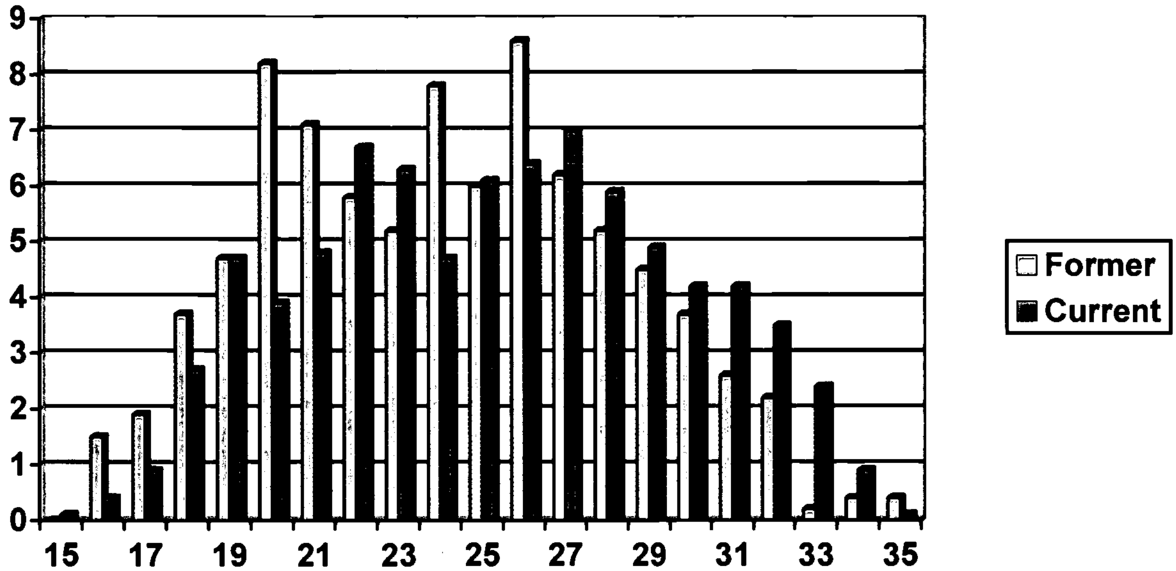


Figure 6. Percent of Students by Math Placement Score and Status

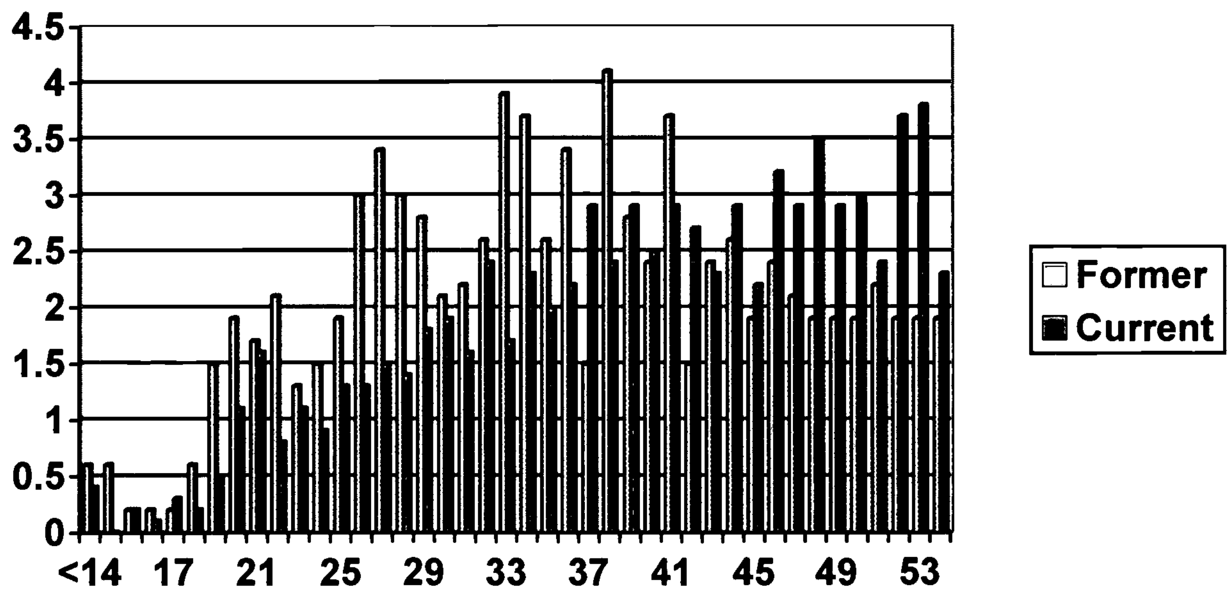
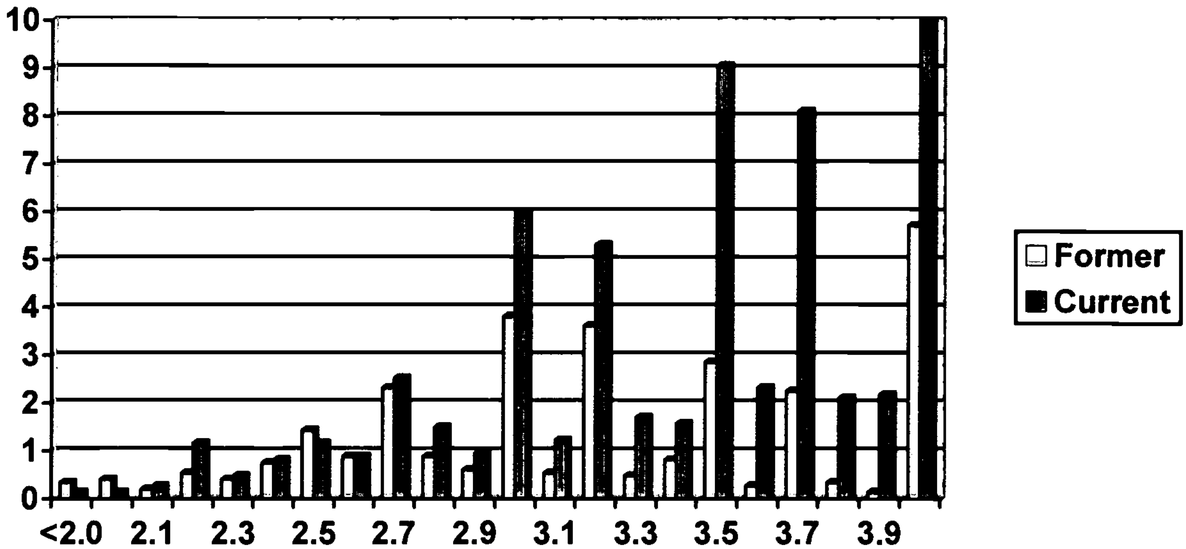


Figure 7. Percent of Students by High School GPA and Status



Note: Current 4.0 = 20.78%

24 for ACT English, 25 for ACT Math, 24 for ACT SS, 22 for ACT NS, 21 for ACT Composite, and 36 for Math Placement. The pattern for high school GPA is less defined. Below a GPA of 2.1 students are much more likely to leave engineering, however, few students with such low GPAs are admitted. There is a marginal area between GPAs of 2.1 to 2.7 where students face an equal chance of continuance or attrition.

Figures 8-10, essentially, combine the data from figures 1-7. These graphs relate the probability of attrition at or below a specific score or GPA. The probability of attrition for the ACT components merges around scores of 26, meaning at and above this score these components do not discriminate. The attrition probabilities gradually and increasingly diverge below 26 indicating discrimination among the tests. The ACT composite and natural sciences component are the best discriminators, with notable increases in attrition with lower scores (see

Figure 8b). The social studies component is the least useful predictor. High school GPA and math placement scores are more consistent with negative linear trends.

Figure 8a. Probability of Attrition at or below each ACT Score

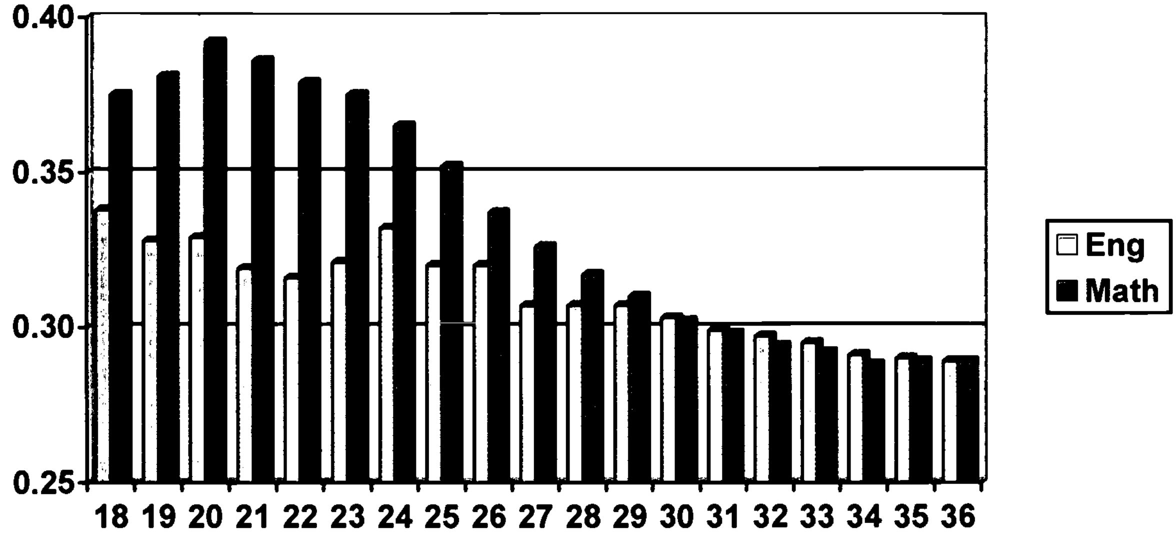


Figure 8b. Probability of Attrition at or below each ACT Score

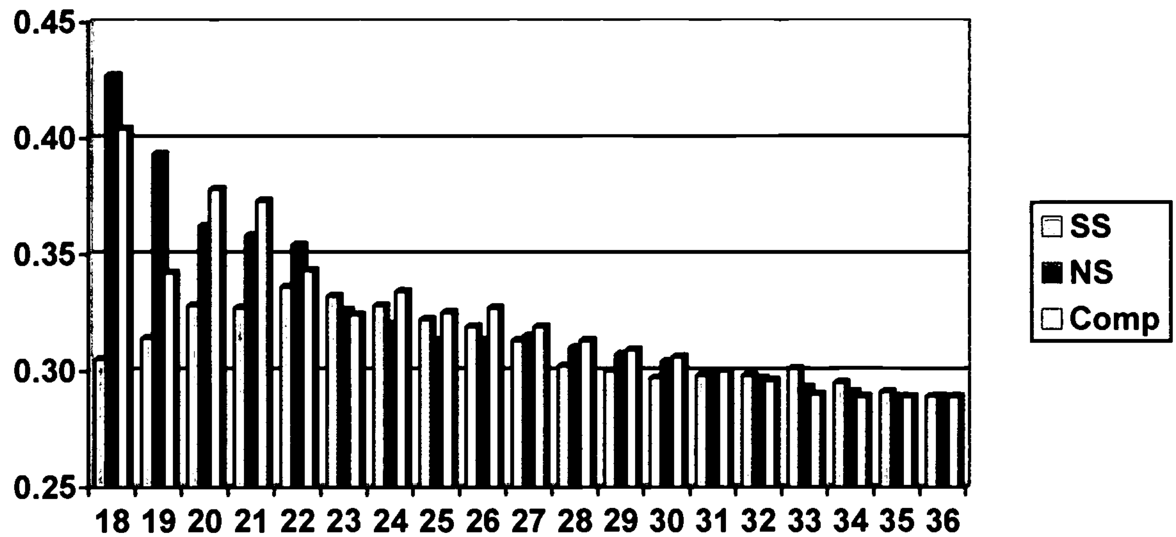


Figure 9. Probability of Attrition at or Below each High School GPA

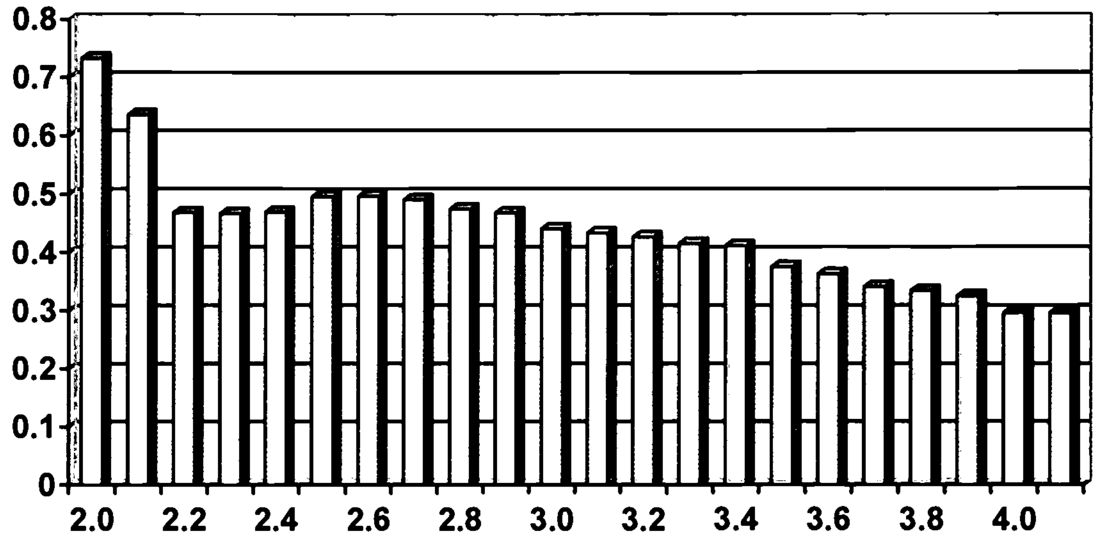
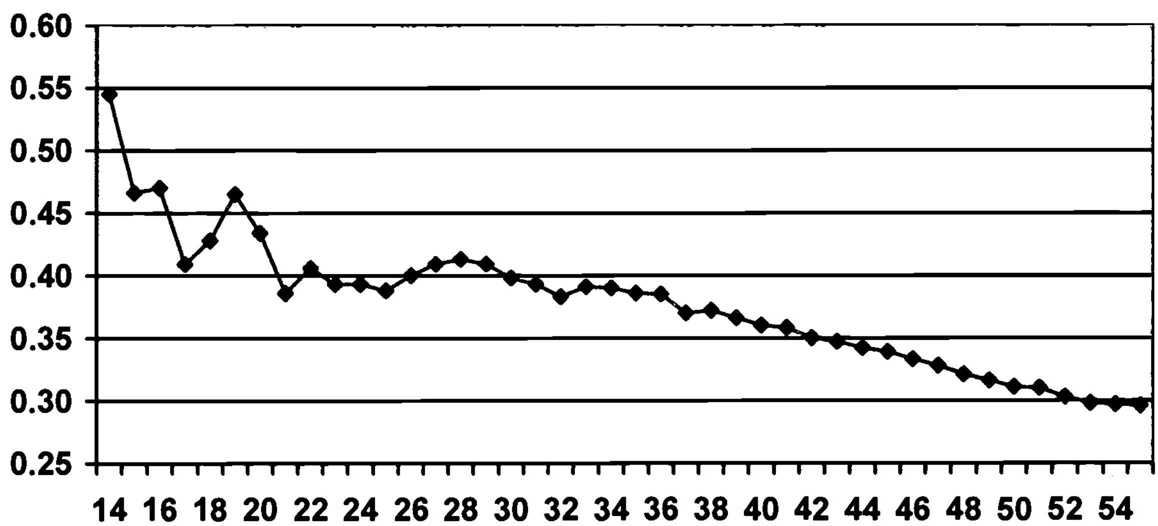


Figure 10. Probability of Attrition at or Below each Math Placement Score



College Performance

This section looks at how the current and former student's performed in college at various levels: individual courses, within the college of engineering, and overall.

Performance in Gateway Courses

All engineering programs have a number of "gateway" courses. These are courses that successful completion is required of the student in order to continue in the program. Gatekeeper courses frequently block students from progressing into degree programs, thus eliminating students who are judged as lacking the analytical ability to become competent scientists and engineers. "'Weed-out' is a long established tradition in a number of academic disciplines, but is dominant in all SME (Science, Math, Engineering) majors. It has a semi-legitimate, legendary status and is part of what gives SME majors their image of hardness (Seymour & Hewitt, 1997, p. 122)."

The question then arises, are these courses a barrier or a filter? At the University of Alabama these required prerequisite courses include general chemistry (CH 101, 102, 131, 132), calculus (MATH 125, 126, 131, 132), and general physics (PH 105, 106, 131, 132).

Table 5 lists the performance breakdown by status for each of these classes. In every case the current students outperformed the former students. Also, note the substantial attrition from each course to its successor. For example, former students took 33.2% of the CH 101 classes, but only 22.8% of the CH 102 classes.

Table 5. Gateway Course GPA Comparison by Status

Status	N (Classes)	Credits Attempted	Credits Earned	Quality Points	GPA
CH 101: General Chemistry I					
Current	512	2048	1604	3950.8	1.929
Former	255	1020	688	1512.1	1.482
CH 102: General Chemistry II					
Current	292	1168	1048	2721.1	2.330
Former	86	344	240	546.6	1.589
CH 131: General Chemistry for Engineering I					
Current	450	1797	1337	3560.5	1.981
Former	98	390	262	603.4	1.547
CH 132: General Chemistry for Engineering II					
Current	150	597	581	1499.1	2.511
Former	17	67	59	147.0	2.194
MATH 125: Calculus I					
Current	444	1776	1292	3742.1	2.107
Former	128	512	288	749.5	1.464
MATH 126: Calculus II					
Current	528	2112	1680	4411.6	2.089
Former	68	272	144	409.4	1.505
MATH 131: Calculus I, Integrated Curriculum					
Current	252	1008	948	2982.7	2.959
Former	20	80	68	192.0	2.400
MATH 132: Calculus II, Integrated Curriculum					
Current	177	708	684	2140.3	3.023
Former	8	32	32	96	3.000
PH 105: General Physics with Calculus I					
Current	609	2286	1984	5460.2	2.389
Former	125	421	267	648.6	1.541
PH 106: General Physics with Calculus II					
Current	532	2061	1869	4993.6	2.423
Former	44	155	115	282.4	1.822
PH 131: Physics I, Integrated Curriculum					
Current	235	940	884	2389.6	2.542
Former	19	76	56	160.0	2.105
PH 132: Physics II, Integrated Curriculum					
Current	66	263	251	701.4	2.667
Former	7	28	24	61.3	2.189

Note: Grades of I, W, WP, and N were not included.

Performance in Engineering

Some former students made it through the gateway classes and began their engineering coursework. However, the pattern remained the same in that former students performed more poorly than current students (see Table 6).

Table 6. Overall Engineering Course GPA Comparison by Status

Status	N (Classes)	Credits Attempted	Credits Earned	Quality Points	GPA
Current	12607	35369	32429	100404.5	2.839
Former	2369	6429	5211	15187.7	2.362

Looking at specific courses and programs it is apparent that almost all of the former students who started their engineering program did not make it past the 200 level courses. Introductory courses with a sizable number of former students were selected for comparison. Of the classes shown in Table 7, the former students performed much more poorly than the current students in all cases. The former students' GPA was from .3 to 1.1 points lower than the current students'. No statistical comparison was made due to some students repeating courses.

Table 7. Engineering Course GPA Comparison by Status

Status	N (Classes)	Credits Attempted	Credits Earned	Quality Points	GPA
AE 125: Intro Aerospace Engineering					
Current	69	138	120	385.3	2.792
Former	18	35	25	68.7	1.963
CE 260: Elementary Surveying					
Current	145	435	426	1470.1	3.380
Former	24	72	72	223.0	3.097
DR 125: Engineering Graphics					
Current	449	1347	1185	3497.5	2.597
Former	151	453	348	864.2	1.908
ESM 201: Statics					
Current	459	1377	1080	2914.6	2.117
Former	35	105	66	139.1	1.325
GES 126: Intro Engineer Computing					
Current	506	1518	1326	3949.4	2.602
Former	132	396	270	639.0	1.614
IE 203: Engineering Economics					
Current	424	1272	1092	3263.6	2.566
Former	83	249	141	364.0	1.462
ME 110:					
Current	129	228	224	723.5	3.173
Former	45	76	68	198.7	2.614

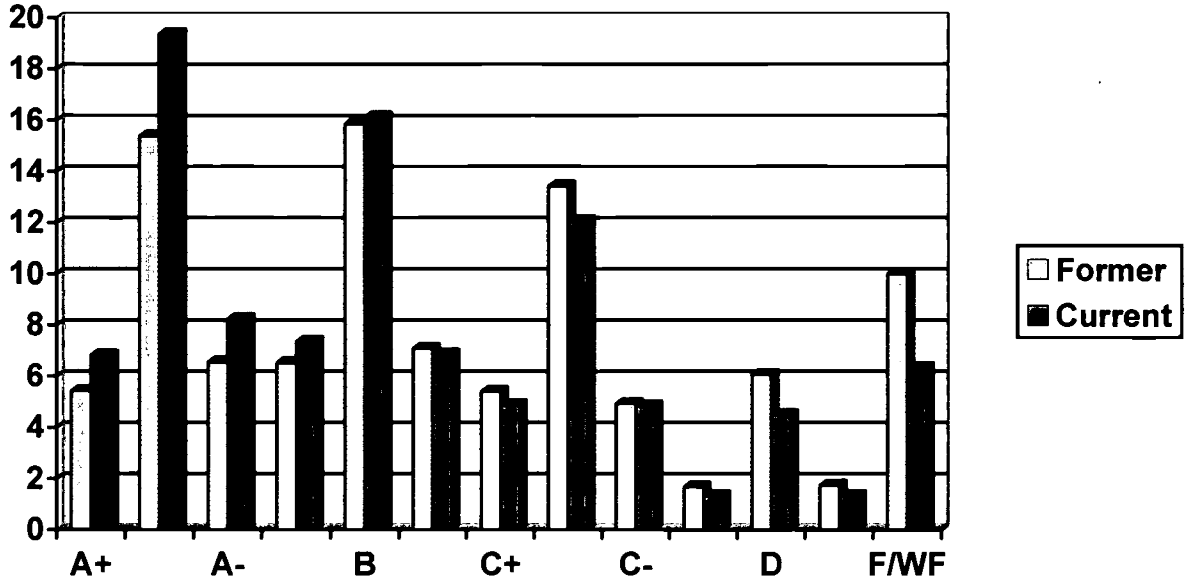
Performance Overall

Overall grade point averages were calculated for all classes taken at the University of Alabama for both current and former students. The former students performed substantially more poorly than the current students (see Table 8). No statistical comparison was made due to the disparate nature of credit hours completed/taken and curriculum difficulty, and also the repeating of classes among the students.

Table 8. Overall College GPA Comparison by Status

Status	N (Classes)	Credits Attempted	Credits Earned	Quality Points	GPA
Current	30654	93183.5	83519.5	250901.8	2.693
Former	16398	48990.0	41755.0	120170.6	2.453

Figure 11. Percent of College Grades by Status



Looking at the distribution of grades (Figure 11) shows how retained students are more likely to earn from an A+ to a B. Former students are more likely to earn a B- and below. Perhaps the most striking characteristic of this data is that former students are nearly 60% more likely to obtain an F or WF than current students (9.99% vs. 6.33%).

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Logistic Regression Model

A logistic regression model was calculated for the following nine independent variables (SEX, RACE, ACTENG, ACTMAT, ACTSS, ACTNS, ACTCOM, MATHPL, GPAHS), with STATUS as the dependent variable. STATUS was coded as 1 = Current, 0 = Former. SEX was coded as 1 = Males and 2 = Females. RACE was coded similarly with 1 = Whites and 2 = African-Americans. Other racial groups were excluded due to their small size. The remaining independent variables (ACTENG, ACTMAT, ACTSS, ACTNS, ACTCOM, MATHPL, GPAHS) used their actual scores. (see Tables 9 and 10) Logistic regression is useful for situations where you want to predict the presence or absence of a characteristic, event, or outcome based on a set of predictor variables. Logistic regression is similar to linear regression but is suited to models with a dichotomous dependent variable.

The forward stepwise (likelihood ratio) procedure indicated GPAHS, MATHPL, and RACE, was the best model. The ideal cut value was changed from .50 to .55. This increased the overall error slightly, but reduced greatly the error in predicting former students. However, while the overall percent correctly predicted at 69.6 seems good, consider that blindly estimating retention based on the most frequent category would yield a correct percentage of 72.2. Thus, the model actually does worse than our blind estimation.

Table 9. Attrition Logistic Regression Models

Model/Step		Coefficients B	Std. Error	Sig.
1	(Constant)	-2.280	.392	.000
	GPAHS	.915	.116	.000
2	(Constant)	-2.535	.403	.000
	GPAHS	.748	.128	.000
	MATHPL	.021	.007	.002
3	(Constant)	-2.527	.405	.000
	GPAHS	.788	.129	.000
	MATHPL	.025	.007	.000
	RACE	-.382	.153	.013

Table 10. Logistic Regression Models' Predicted Classification

Model		Status Former	Current	Pct. Correct
1	Former	90	308	22.6
	Current	87	804	90.2
	Overall			69.4
2	Former	79	319	19.8
	Current	76	815	91.5
	Overall			69.4
3	Former	89 (52)	309 (346)	22.4 (13.1)
	Current	83 (41)	808 (850)	90.7 (95.4)
	Overall			69.6 (70.0)

The cut value is .550

Note: Values in parentheses are for a cut value of .500

Discriminant Analysis Model

Discriminant analysis was performed on the same nine independent variables (SEX, RACE, ACTENG, ACTMAT, ACTSS, ACTNS, ACTCOM, MATHPL, GPAHS), with STATUS as the dependent variable. Like logistic regression, discriminant analysis is a technique used to build a predictive model of group membership based on observed characteristics of each case.

The stepwise procedure indicated GPAHS, MATHPL, and RACE was the best model, the same as the logistic regression. (see Table 11) Table 12 shows the predictive utility of the model. Unfortunately, it, like the logistic regression prognosis, does not match the blind estimate (62.1% vs. 72.2%). Interestingly, the discriminate analysis did a much better job in predicting the former students than the logistic regression, but worse at predicting the current students.

Table 11. Discriminant Analysis Models

Model/Step		Tolerance	F to Remove	Wilks' Lambda
1	GPAHS	1.000	68.945	
2	GPAHS	.817	36.821	.969
	MATHPL	.817	9.273	.949
3	GPAHS	.803	40.279	.967
	MATHPL	.778	12.513	.947
	RACE	.899	6.810	.942

Table 12. Discriminant Analysis Model's Predicted Classification

Status		Predicted Group Membership		Total
		Former	Current	
Count	Former	245	173	418
	Current	346	605	951
%	Former	58.6	41.4	100.0
	Current	36.4	63.6	100.0

62.1% of original grouped cases correctly classified.

K-Means Cluster Analysis

This technique attempts to identify relatively homogeneous groups of cases based on predetermined characteristics. The procedure, however, requires the number of clusters to be specified.

Clusters of two and three groups were specified using all nine independent variables and for only high school GPA, since it was determined earlier to be the single best predictor. Table 13 outlines the results of these combinations.

Table 13. Cluster Membership

Two Clusters: All Independent Variables							
Predicted Group	Cluster Centers	Current	Former	Total	Percent Current	Percent Former	Percent Total
Low (Former)	*	376	228	604	42.2	57.3	46.9
High (Current)	*	515	170	685	57.8	42.7	53.1
		891	398	1289	Correct = 57.6%		
Two Clusters: High School GPA							
Low (Former)	2.857	356	253	609	34.5	58.2	41.5
High (Current)	3.791	677	182	859	65.5	41.8	58.5
		1033	435	1468	Correct = 63.4%		
Three Clusters: All Independent Variables							
Low (Former)	**	214	148	362	24.0	37.2	28.1
Middle (Current)	**	322	152	474	36.1	38.2	36.8
High (Current)	**	355	98	453	39.8	24.6	35.1
		891	398	1289	Correct = 64.0%		
Three Clusters: High School GPA							
Low (Former)	2.513	133	120	253	12.9	27.6	17.2
Middle (Current)	3.243	379	187	566	36.7	43.0	38.6
High (Current)	3.890	532	128	649	51.5	29.4	44.2
		1033	435	1468	Correct = 70.2%		

*Cluster Centers Low:
ACTENG 21, ACTMAT 22, ACTSS 22, ACTNS 22, ACTCOM 22, MATHPL 31, GPAHS 3.154, SEX 1, RACE 1
*Cluster Centers High:
ACTENG 28, ACTMAT 29, ACTSS 29, ACTNS 28, ACTCOM 28, MATHPL 46, GPAHS 3.646, SEX 1, RACE 1
**Cluster Centers Low:
ACTENG 20, ACTMAT 20, ACTSS 21, ACTNS 21, ACTCOM 21, MATHPL 27, GPAHS 3.069, SEX 1, RACE 1
**Cluster Centers Middle:
ACTENG 24, ACTMAT 25, ACTSS 24, ACTNS 24, ACTCOM 24, MATHPL 39, GPAHS 3.387 SEX 1, RACE 1
**Cluster Centers High:
ACTENG 29, ACTMAT 30, ACTSS 30, ACTNS 29, ACTCOM 30, MATHPL 48, GPAHS 3.723, SEX 1, RACE 1

Equating the lowest performance group to the former students and the other group(s) (i.e., High or High and Middle) to the current students we can compare how well the model distinguishes the actual breakdown. The analyses using all nine independent variables, in both two and three-cluster cases, did not classify group membership as accurately as the sole variable of high school GPA (Two: 57.6% vs. 63.4%, Three: 64.0% vs. 70.2%).

The three-cluster high school GPA model nearly equaled the predictive utility of our blind estimate. More importantly, students classified in the lowest cluster had nearly a 50% departure rate, which would indicate they are highly at-risk students.

Results for Research Question III

Question III: What factors related to psychosocial variables contributed to student attrition from the College of Engineering?

A synopsis of the responses to the survey of the former students is provided below. Survey items are reproduced in the write-up. Percentages of structured responses are reported in tables. Open-ended questions have a brief summary of the comments in italics that categorizes the themes of the specific remarks. This summary is followed by a list of all of the students' remarks. An ID number is provided each student to allow comparisons and context among their open-ended responses. The number in parentheses in the summary of opinions refers to how many references were made to a specific concern. If no number is given that remark was mentioned once. The number of respondents (N) for each structured item and those providing open-ended comments is given as well.

College of Engineering Survey for Former Majors

02. Why did you first choose an engineering program when entering UA? N = 85

Summary of opinions

Having an interest in engineering or wanting to be an engineer was mentioned most often with 30 references. Interest in computer science/technology also was a large factor being mentioned 18 times. Having a family member be an engineer, or pressure from one's family, was referenced 15 times. Academic interests in math (10), science (7), chemistry (2), or physics (1) were all mentioned. Seven students noted money, while career considerations were stated by five students. The reputation of the program was mentioned five times. Participation in the SITE program or an internship was mentioned by four students. Scholarships were referenced twice, as was working previously with an engineering firm. Resources offered, the co-op program, relatedness to architecture, advisor recommended, and prestige were all mentioned once.

03. Was your engineering program what you expected? If not, how did it differ from your expectations? N = 84

Summary of opinions

Twenty-six students indicated yes, while 40 students indicated no. Three students did not know. Of those that answered no, many stated that the curriculum or workload was too hard (12). Other concerns mentioned were too much math (4), uncaring or bad faculty/advising (4), boring (3), more hands-on activity (2), and unkind people (2). A host of other issues were mentioned once.

04. What did you like best about your engineering program, i.e., what were its strengths? N = 34

Summary of opinions

The respondents mentioned faculty (7), small class size (5), and good classes (4) most often. Five respondents said the program was challenging or strong, while three said they didn't like anything. Hands-on, easy getting help, one-on-one advising, TIDE program, physical applications, scholarship, labs, tutors, engineering center, available advisors, co-op program, technical aspect, and familiarity with faculty were all mentioned once.

05. What did you like least about your engineering program, i.e., what were its weaknesses? N = 35

Summary of opinions

Advising and the math requirements led all concerns here with five references each. Numerous issues were mentioned once.

Among the following list of issues please identify factors that led to your leaving engineering.

06a. Table 14.

		Percent of Responses		
	N	Strong Factor	Weak Factor	Not a Factor
Non-engineering major more interesting	87	66.7	19.5	13.8
Non-engineering career option more appealing	88	61.4	21.6	17.0
Switched as a means to career goal	87	52.9	16.1	31.0
Lack of/Loss of interest in engineering	88	50.0	27.3	22.7
Curriculum overload, fast pace	88	42.0	31.8	26.1
Discouraged by poor grades	88	42.0	26.1	31.8
Discovered an aptitude for a non-engineering subject	88	39.8	29.5	30.7
Inadequate advising or help with academic problems	87	34.5	24.1	41.4
Language difficulties with foreign faculty or TA's	88	34.1	27.3	38.6
Prefer teaching approach in non-engineering courses	88	34.1	26.1	39.8
Conceptual difficulties with subject matter	88	30.7	28.4	40.9
Inadequate high school preparation	88	26.1	22.7	51.1
Non-engineering major offers better education	88	20.5	25.0	54.5
Poor teaching by faculty	87	19.5	39.1	41.4
Lack of peer group support	88	17.0	22.7	60.2
Unexpected length of engineering degree	88	14.8	25.0	60.2
Career options not worth effort to get degree	88	13.6	23.9	62.5
Rejection of engineering career and lifestyle	88	12.5	31.8	55.7
Morale undermined by competition	88	11.4	13.6	75.0
Problems related to class size	87	6.9	13.8	79.3
Poor lab/computer facilities	87	5.7	18.4	75.9
Financial problems	88	3.4	11.4	85.2

06b. Please identify any other factors you feel led to you leaving engineering. N = 37

Summary of opinions

No interest in, or not liking, engineering was mentioned by seven respondents. The reputation of CBA, and better facilities in CBA were noted. Also, a racial accusation, improper treatment, unattainable TA's, and same people in classes were all mentioned once. Note: any of the issues mentioned below that were addressed in the structured question above were not included in this synopsis.

The following items pertain to your overall evaluation of your experiences at UA.

In general, how satisfied are you with each of the following? (VS=Very Satisfied, S=Satisfied, D=Dissatisfied, VD=Very Dissatisfied, N/A=Not Applicable).

07a. Table 15

		Percent of Responses				
	N	VS	S	D	VD	N/A
Academic experiences (courses, professors).	85	11.8	71.8	10.6	4.7	1.2
Academic performance (GPA, honors).	85	7.1	44.7	32.9	12.9	2.4
Social experiences.	86	27.9	44.2	9.3	5.8	12.8
Recreational experiences (SRC, Intramurals).	86	31.4	40.7	2.3	2.3	23.3
Cultural experience.	85	21.2	44.7	11.8	3.5	18.8
Overall undergraduate experience.	86	31.4	53.5	9.3	4.7	1.2
Professional development.	86	22.1	52.3	14.0	3.5	8.1

07b. Please identify the nature of any of your concerns regarding your overall experiences at UA. If you have any suggestions for improvement, please include them. N = 13

Summary of opinions

Newer facilities, more human interaction in engineering, more social opportunities for older students, stop lights in city, too warm in EE building, disjoined culturally, better advisors, more adept teaching, racism on campus, improve teachers, lack of teacher understanding, and developing a stress program were all mentioned once.

Please select the response that corresponds to your opinion about each item.

08. With how many faculty members in engineering did you develop a close professional relationship, such that you could ask them for a letter of recommendation? N = 87

Percent of Responses

[65.5] None
[25.3] One
[5.7] Two
[3.4] Three or more

09. All things considered, how would you characterize the intellectual environment at UA?
N = 87

Percent of Responses

[12.6] Very Strong
[43.7] Strong
[36.8] Average
[5.7] Weak
[1.1] Very Weak

10. If you had to do it again, would you choose to attend UA? N = 87

Percent of Responses

[52.9] Definitely
[35.6] Probably
[11.5] Probably not
[0.0] Definitely not

11. What advice would you give for improving enrollment and persistence in UA engineering programs? N = 28

Summary of opinions

Overwhelmingly, issues pertaining to the faculty were mentioned. Ten students recommended having better teachers or better teaching, with four additional references pertaining to the English competency of some faculty. Obtaining better facilities was mentioned by three students, while having smaller classes was stated by two. A plethora of issues were mentioned once.

Scholarships

Commitment and intent, when it comes to accepting scholarships from the college, needs to be examined. The college is making a financial investment in the student, which is lost should they transfer. The concern centers on students accepting the funding with the premeditation of leaving their engineering program at a later date.

Scholarship information was gathered from the college for the 1999-2000 and 2000-2001 academic years. For those two years 519 students were offered at least one scholarship for at least one academic year. Of those students 41, or 7.9%, transferred to other programs. This is a small percentage, but is misleading because it represents students who have been at the University a short amount of time (i.e., less than one or two years). Most of those 41 students received their scholarship during the 1999-2000 year. Thus, it is likely that number will rise substantially in the upcoming year as more scholarship-receiving students from the 2000-2001 year transfer.

Most of the scholarships are based on academic performance. Hence, it is not surprising that the 41 transfers, overall, did much better when it came to academic preparedness. Table 16

Table 16. Comparison of All Former and Former Scholarship Students

	Former Mean: All	Former Mean: Scholarship
ACT English	23.66	28.73
ACT Math	24.04	28.40
ACT SS	24.45	29.15
ACT NS	23.78	28.28
ACT Composite	24.13	28.78
Math Placement	35.85	44.24
HS GPA	3.216	3.708

compares these scholarship students to all former students. Several references were made in the survey with regards to scholarships as a factor in entering an engineering program.

Discussion

Discussion for Research Question IV

Question IV: What can be done to address these factors to reduce attrition from engineering programs?

Pre-College Psychosocial

One needs to begin with the preconceptions a potential college student has with regards to engineering as a field of study and a career option. Many potential students do not understand the demands of engineering in higher education or comprehend the breadth and depth of the field as a career. A student, even one who is considered academically prepared, who falls into this trap is at-risk. Substantial evidence of this is found within the survey responses of the former students for this study. The top four structured responses cited as strong factors leading to the student leaving engineering dealt with realizations of a more interesting major or a more desirable career path outside of the discipline. Also, numerous respondents indicated they chose engineering initially because of a family member, mainly a parent. Brown and Cross (1993, p. 669) say it best in stating, "If the personality of students entering engineering differs significantly from that of prior students and engineers in the field, then the expectations and activities that were effective with prior students will not be effective with current students."

A retention analysis completed for the COE by ACT using the ACT Interest Inventory (Hovland, 2001) similarly found occupational/academic major interests to be a significant predictor of attrition. They determined this by using the Hexagon Congruence Index (HCI), which compares an individual's pattern of interests across six UNIACT-R Basic Interest Scales with the interest pattern of the Engineering Cluster.

One means of addressing this is by offering a "pre-college primer course" to introduce students to the subject matter, and possibly foster interest in the field. Ayorinde & Gibson (1995) claimed success in offering a pre-college primer course in composites engineering for six weekends. This course could be offered at the high school level or during college orientation. Another option would be having the college of engineering require an engineering orientation, complete with class lectures about the various programs and their particular demands, with mentoring and counseling by engineering faculty and upperclassmen providing a more interpersonal experience.

Pre-College Academic Underpreparedness

Next, academic underpreparedness needs to be addressed. All of the quantitative data provided for research questions II and III indicate that the former students were less prepared academically, in all aspects, than the current students. Performance in high school, prerequisite gateway courses, engineering courses, and all courses were poorer for the transfer students than the continuing students. The survey revealed that between one-quarter and one-half of former student survey respondents indicated that curriculum overload, poor grades, or inadequate high school preparation were strong factors leading to their departure (see Table 14). Plus, nearly one-half of the survey respondents said they were either dissatisfied or strongly dissatisfied with their academic performance at the University (see Table 15).

The logistic regression and discriminant analysis models outlined previously indicated that *high school GPA*, followed by *math placement score* and *race* were significant contributors to attrition from the College of Engineering at UA. While race was determined to be a significant factor there were multicollinearity concerns with sizable correlations between it and high school GPA ($r = -.213$, Sig. .000), and math placement score ($r = -.271$, Sig. .000). African-American students, for a variety of economic and social reasons, suffer academically, which is evidenced by the low scores in Table 4 as compared to White students. Thus, eliminating race, a student's overall high school performance with an emphasis in their math competency should be our focus dealing with academic underpreparedness. The cluster analysis provided further evidence that academic underpreparedness was a substantial determinant of attrition.

The ACT study (Hovland, 2001), likewise, found that math proficiency and high school performance were significant factors. While this study determined a students' math placement score and overall high school GPA to be significant predictors, the ACT study concluded that the ACT Math component and high school GPA were relevant predictors of attrition in engineering.

Tackling these variables at the high school level is no easy task. Raising GPA's and math competency levels have been goals of the education community in perpetuity, but many students still fall short. One possible solution could be bridging higher education with secondary education and creating a communication pipeline that fosters better high school preparation for college. Problem high schools could be identified and targeted for help.

Another solution dealing with academic underpreparedness would be to raise admission standards. Figures 8, 9, and 10 show the proclivity of students to transfer from engineering based on their high school GPA, ACT scores, and math placement score. While no minimum score can assure the college a student will be successful the data in those charts do provide insight as to relationship between academic underpreparedness and engineering continuance.

It should be emphasized that even though high school GPA, and math competency were found to be significant indicators of attrition, based on the predictive models, they should not be viewed exclusively as a solution. It was noted that both the logistic regression and discriminant analysis models could not predict attrition with sufficient accuracy to warrant their exclusive use. This is because other variables that contribute to attrition, namely psychosocial aspects, were missing from the equation.

College Gateway Courses

Once a student is in higher education further steps can be taken to deal with risk factors. One area that needs to be looked at are the specific gateway courses. The crucial point here is what is a reasonable amount of time for a gateway course to prepare a student for further study within engineering. The ICE^2 model (Indicies of Course Efficiency and Effectiveness), which was constructed by the University of Texas at El Paso, deals with this matter. This model recommends 24 months, i.e., four semesters. "Any longer period suggests that the gateway course is serving as a barrier rather than a springboard into the major or degree program" (Andrade, 2001, p. 5).

College Psychosocial Variables

Another area of concern is the sense of identity or community the student has with the institution. This is often mentioned as a factor associated with retention. Students are most vulnerable in their freshmen year. Thus, intervention needs to take place immediately. One avenue to build a relationship between the student and the institution is through Freshmen Interest Groups (FIG). FIG's are clusters of first-year students who elect to live near one another in the residence halls, co-enroll in courses, and take a seminar together. Each FIG is organized around a fairly broad theme, such as Science or Arts or Politics. (AIR, Indiana University Report)

The University of Alabama has a similar forum for first-year students in engineering called the TIDE (Teamwork, Curriculum, Integration and Design in Engineering) Freshmen Program. The TIDE Program was initiated in the Fall of 1999, and has met with considerable success thus far. Consideration should be given to expanding this program.

The notion of students deceptively taking engineering scholarships needs to be addressed as well. The easiest solution is to make multi-year scholarships contingent upon continuation in engineering programs. It's a bit more problematic when dealing with single, or one-year scholarships. The option of restitution exists, either partial or in-full. Student notification about the expectations and consequences associated with their funding should reduce attrition through this outlet.

A sizeable number of students in the survey indicated some problem with regards to pedagogical methods. Roughly a third of the respondents indicated that the teaching approach in non-engineering courses was a strong factor leading to their departure, while another quarter said it was a weak factor. Similarly, a third of the respondents noted language difficulty with foreign faculty or TA's as a strong factor. This is not unusual. There is evidence that pedagogy in engineering has an affect on retention. Felder, et al. (1998) looked at instruction techniques with regards to student performance and retention in chemical engineering. They concluded that course instruction using more active and cooperative learning in conjunction with other techniques designed for a broad spectrum of learning styles led to a higher retention and graduation rate.

Also related to this, there is some evidence that there is a negative correlation between first- to second-semester retention and courses taught by part-time faculty (Study: Part-Time Instruction Hampers First-Year Retention, 2002). However, it was found that students taking more courses from part-time faculty were more likely to be male, have lower entrance examination scores, and earn lower GPAs than other students. Thus, one needs to be cautious of the actual causes of lower retention- the part-time faculty or the increased at-risk factors these students bring to the classroom.

Discussion for Research Question V

Question V: How can retention assessment in engineering be made recursive?

1) The college has to make a commitment to assessment.
2) The college needs to track students and attrition-related factors. Tracking such factors for a large number of students requires enormous planning and effort, because the targets being tracked are constantly changing. A longitudinal database needs to be implemented and maintained on all prospective, incoming, current, and former students. This database needs to be comprehensive and incorporate scores of quantitative and qualitative variables.
3) The college should do a more thorough job of understanding its prospective students. Recruiters should counsel and/or query the recruits to ascertain or assess if the prospective student is psychologically and academically prepared for study in the college.
4) The college needs to advance more one-on-one interaction between prospective and admitted students and faculty, advisors, and upperclassmen.

5) The college needs to work with other related disciplines (i.e., Math, Chemistry, Physics) to ensure effective, high-quality teaching is offered in prerequisite freshmen courses. A greater percentage of at-risk students gravitate towards classes taught by part-time faculty. Make sure that all faculty members, in particular adjuncts, have the skills necessary to identify these students.

6) The college should implement annual or semester assessments of all engineering students. These could be administered during advising or with course evaluations. Students deemed "at-risk" should be counseled periodically until they are no longer considered susceptible to loss. Counseling could be carried out twice or three times a semester. Data from these assessments would be input into the longitudinal database.

7) Monitor retention efforts. "Students' goals, preparedness, and a variety of other factors will deviate from year to year, therefore, efforts to monitor the effectiveness of retention activities must be rigorous and continuous" (Moller-Wong & Eide, 1997, p. 8).

Conclusions

The implications of this research are clear: attrition cannot be viewed as a predictable consequence of differential levels of ability. Academic underpreparedness was found to be a substantial determinant in engineering persistence. However, other non-preparedness variables were found to contribute to attrition as well. Predicting success in the College of Engineering, or any college, is difficult due to the infinite antecedent variables each student brings to higher education. No model can be perfect, so the results presented here must be taken for what they are, our best estimate.

The data in this research seem to indicate that most of the factors associated with attrition from the College of Engineering are pre-college attributes, i.e., academic underpreparedness, ignorance about engineering, or calculation to leave after a certain timeframe. However, other factors specific to higher education need to be considered as well. These include assessing pedagogical methods in gateway and engineering courses, and increasing the student's sense of belonging within the college and the University through greater interaction with faculty, advisors, and other students.

One can never totally eliminate attrition. It, however, can be limited with a comprehensive effort to address its many aspects.

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