THE PREDICTION OF ACADEMIC ATTRITION AND SUCCESS THROUGH DISCRIMINATE FUNCTION ANALYSIS

by

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INTRODUCTION

Need for the Study

The prediction of college success was first emphasized in the 1920's, and for a number of years following was a prime target of educational research. Today, with rising costs of education coupled with shortages of both classrooms and qualified teachers, the question arises anew as to the feasibility of some selection procedure for the admittance of students to college and universities. There are those who aver that education of the masses through four years of college is not financially possible. Opponents maintain that in the interests of national survival we can't afford not to educate all to an optimum level for each.

That large numbers of qualified high school graduates do not go on to college has been substantiated by a number of studies, including a local study by the Kansas State Teachers College, Emporia (Daughtry, 7).

Findings published by Emporia State College indicate that only two-thirds of the students from the upper third of their high school classes enrolled in college in the fall following their graduation. In general it could be stated that one-third of the superior students terminated their education at the high school level. These finding concerning the superior students who graduated from Kansas high schools in 1955 are in accordance with those reported by Berdie (2) in a 1950 study in Minnesota.

On the other hand more and more students are presenting themselves at the doors of colleges requesting admission each year. Enrollment figures at the elementary school level indicate that twice as many students will be seeking college admittance in 1970 as will be entering in 1958.

The numerous studies of crowded conditions at many colleges and universities indicate that a need exists for some method where-by those students not capable of succeeding in work at the college level may be screened from college entrance and at the same time those fully capable may be encouraged to attend.

Under present admittance procedures many students are admitted to colleges and universities who will not be able to complete the requirements for graduation. At the same time many students of high ability do not seek a college education. In either case society is the loser. In the first case the loss is represented by tangible costs - which taxes the resources of the college's time, facilities, money, and staff. Also it is a question of whether a favor is being done for those students who come to college and go away failures. Time, money, and emotional upset could also be saved those students. In the second case non-productive talent represents a loss to the individual, the community and the state. This is a cost which, being intangible, may never be fully measured.

It is imperative that if America is to meet the challenge of the Sputnik and the space age that those who are capable and talented must have the opportunity to secure the fullest educational program that is possible.

The question represented here is not a new one, as researchers for a great number of years have attempted to answer the question, "Should I go to college?" Previously the question was primarily an academic one. However, since the beginning of the great influx of students into college, the question has also become one of practicality.

Many of the early studies concerned themselves with the general aspects of predicting academic success in college. During the last few years, there has developed a trend which shifts the emphasis away from general academic prediction and general college success. The predictions of the more recent investigations are aimed at pinpointing specific achievement in certain curricula at specified colleges. Early research investigations included too many complicating factors to make valid predictions for individuals. In addition, many were statistically naive, making interpretations of the results risky. Finally, the wide differences existing among colleges and universities suggests that each educational institution needs to localize their prediction data in order that such data will apply to their particular curricula and students.

Purpose of the Study

The general purposes of this study were to investigate the prediction of academic achievement for engineering students at Kansas State College and to devise a means of identifying those students most likely to fail or succeed.

In developing the major purposes of the study the following subsidary goals were considered:

1. To contribute information of significance regarding the problem of selective admissions.
2. To localize prediction data for students at Kansas State College.
3. To provide information to advisors and counselors of engineering students that would have guidance value.
4. To contribute to methodology by applying a little known, but powerful, statistical tool to a situation representative of a now general problem in higher education.

Limitations of the Study

This study was limited to entering freshman students in the School of Engineering at Kansas State College. The sample included those entering the Fall semesters in September of 1953 and 1954.

As was suggested previously, many of the early studies attempted to predict college achievement in general. Little regard was given to controlling major areas of interest, with the result that variation resulting from this source has been relegated to the category of "error variance."

In summary the present study is limited by an inability to answer the following questions.

1. Only engineers were included in the sample; would results be applicable to other curricula?

2. Only students at Kansas State College were included; would results hold elsewhere?
3. Only a two year sample was used; how far can one generalize?

BACKGROUND AND REVIEW OF LETERATURE

The history of academic prediction has run an ever-changing course over the past 40 years. Studies have ranged from those involving simple reactions to those involving numerous factors and complicated statistical techniques. Most of the criterian used in the past have involved correlations between grades and some other index.

Though one may question the reliability of the grade point average as a measure of academic attainment, no other criterion is as easily accessible or as widely used. The grade point average is widely used by colleges, employers, and others in attempting to asses individual potential and achievement.

Categories of Prediction

Studies in this area may be classified into two broad categories. The first has considered positive factors - factors associated with college success. The second had investigated negative factors; i.e., factors that have led to college failure.

In the first category many factors have been considered. These variables have included scholastic aptitude or intelligence tests, scholastic achievement tests, special aptitude tests (i.e., mechanical aptitude, spatial relations, etc.) high school rank, non-intellectual factors; i.e. personality, or a combination of the above factors as multiple variables.

Studies of drop-outs have considered the many factors that may cause the student to leave school, including the variables listed above as well as such matters as financial situation, personal adjustment, study habits, vocational interests, and so forth.

Representative Studies

There have been literally thousands of studies regarding the prediction of academic prediction. It is not practical to review all of them here, but representative studies which illustrate the types of investigations that have been completed, together with major findings, will be reported.

Scholastic Aptitude. This category may include measures of an individual's qualitative or quantitative ability to succeed in academic activities. The most often used predictors have been measures of intelligence (IQ) and so called scholastic aptitude tests, such as, the American Council of Education (ACE) Psychological Examination. Correlations generally ranged between .40 and .60, centering around .50. The correlations obtained varied from school to school and with the various stages of educational development of the individual.

For example: Wallace (39), obtained a correlation of .49

between the ACE and freshmen grades in English. Correlations between the ACE and grades in other courses were lower.

Monroe (24) cited correlations of .44 and .52 between intelligence or scholastic aptitude test scores and college achievement. More accurate predictions were obtained for freshmen grades than for total college work. With the exception of students in the upper or lower ranges of distribution it was hazardous to predict college success with intelligence tests alone. Other studies indicated that indices of differental aptitude may be more useful than the global "intelligence" or "scholastic aptitude" scores.

Held (14) found that of 582 students requested to leave the University of Pittsburg because of low grades, the mean score on the ACE was at the 30th percentile for men and at the 27th percentile for women.

In general the results obtained for the prediction of academic success by scholastic aptitude alone have not been highly successful. Though most studies show positive correlations between aptitude and achievement the correlations have not been high enough to predict with any degree of certainity the marks that an individual would achieve in college.

Achievement. Monroe (24) in reporting studies of achievement and school marks indicates positive correlations of .55 to .71. between previous school work and achieved grades. In studies comparing general achievement tests with college success correlations of .48 and .55 were obtained. The best single predictor was the previous semester's record.

General conclusions indicate that although high school rank has long been considered a major factor in the prediction of college marks, a battery of achievement tests will be almost as predictive as the accumulated high school record. Studies indicate that prediction in specific subjects is less accurate than prediction of general college scholarship. Correlations between specific subjects and specific traits, aptitudes, and achievements were approximately the same as between general intelligence tests and general scholarship, (24). Tests of specific aptitudes and achievements were best for specific subjects, but were not sufficiently high to make accurate predictions for the individual.

Non-intellectual Variables. A group of representative studies reported in the Review of Educational Research (29) indicate that school adjustment is a complex process, whereby individuals react to and are acted on by a number of complex forces and circumstances. School achievement was associated to some degree with such factors as broken homes, home conditions, emotional adjustment, extra class activities, intelligence, irregular attendance, finances, overemphasis on social life, personality traits, school curriculums, study and work habits, vocational plans, interests, place in the family, health, and motivation.

A number of studies have been reported using personality measures as predictors. Most of these studies have yielded negative or inconclusive results. Several investigators have developed specific scales which predict academic achievement but these have not, in general, improved the accuracy of predictions made by high school rank. Most studies reported low correlations (.30 to .44) between personality characteristics and school success.

Findings with respect to interests have been inconclusive. Several investigators have found significant relationships between interest factors and college success. Wilheite (40) found a relationship between level of interests and achievement. Altender (1) found positive relationships between specific Strong keys and college grades. Some studies indicate positive relationship between occupational interest level and achievement at the college level. These positive findings are clouded, however, by the fact that others found no basis for predicting academic success at the college level using interests as predictors.

School achievement, attendance, and retention have been shown to be related and, for a given individual, affected differentially by a complex network of factors. Studies of scholastic aptitude and achievement indicated that college success is a function of more than intellectual factors. But definite patterns of adjustment have eluded research workers.

<u>Multiple Variables</u>. Studies indicated that a combination of several factors was more valuable for prediction than any single factor alone. High school scholarship, general scholastic aptitude tests, and high school achievement provided the best basis for prediction of success in college.

Jones (20) studied Indiana University freshmen who retained and lost scholarships at the end of the first semester. Comparisons were made on high school rank, the ACE, and the COOP English Tests. Results were compared with a non-scholarship group with scores at the same level. Greatest difference on sholarship retention was on high school rank. The ACE was the least reliable index.

Votaw (38) in prediction of college success made use of the ACE, COOP English Test, and a library and study material test, Scores of these three tests were converted into T-scores and substituted into a formula from which an estimate could be made of a student's expected grade point average. The correlation of the actual grade point average with the weighted combined scores of the three tests was found to be .61. This was considerably higher than the zero-order correlation of any of the three tests with grade point average. The library scores were found to be most significant.

The most elaborate and apparently most successful study of prediction of college success yet to date has been conducted at the University of Washington. The study, as outlined by Horst (16), consisted of administering a battery of nineteen tests to the 2,093 entering freshmen of 1949. High school grade point averages were obtained for six different subject areas. Age and sex were recorded, making a total of twenty-seven items to be utilized as predictors.

Samples of the accuracy obtained in some of the areas of grades predicted indicate considerable success. At the end of two years of study 55 per cent of all the college students that had been predicted to obtain a grade of "B" or better had done so. Success in predicting grades of "B" or better ranged from a high of 88 per cent in philosophy to a low of 22 per cent in forestry. Course areas in which more than 75 per cent of the students obtained a predicted grade of "B" or better were anthropology (75 per cent), far eastern (77 per cent), history (81 per cent), music (76 per cent), nursing (75 per cent), philosophy (88 per cent), and sociology (77 per cent). Representative studies cited by Cosand (5) in his review of the literature of multiple variables included the following:

Authority	Criterion	Correlations
Edds and McCall	high school grades + IQ + English grades	.84
Root	high school grades + IQ + English grades	.83
Edds and McCall	high school grades + English grades	.70
Line	high school grades + ACE	.71
Occidental Testing Service	high school grades + ACE	.54
Lonard	high school grades + IQ + study performance	.75
Diederich	ACE + reading + writing	.72

In general studies that have contained several variables for the purpose of prediction of academic success have secured the highest correlations. Whereas single predictive measure tend to produce coefficients centering around .50, multiple variables tend to center around .60, with some studies reporting correlations above .80. This leads one then to the conclusion that research in the area of multiple-variables may hold a valuable key in the solution of the problem of prediction of academic success.

Drop Outs. The study of prediction of academic achievement would not be complete without a review of factors related to withdrawal from school. Studies indicated that leaving school prior to graduation was related to many factors, such as, soci-economic status, lack of participation in extra-class activities, decline in scholarship, decline in rate of attendance from grade to grade, frequent transfer from school to school, lack of interest in school work, lack of social competence, feeling of insecurity or lack of belonging, lure of a job, insufficient knowledge of students by teachers, difficulty in learning, dislike of school, broken homes, and student teacher conflicts.

Kaelsche (22) in a study of student drop outs at Indiana University found that withdrawal resulted from a combination of patterns. It was found that the median attainment on the ACE was the low middle 5th. The median on the English COOP C_2 Examination was in the second quintile. The drop out grade point average was .777; six had a "B" average; 61.7 per cent were below 1.00 (doing unsatisfactory work.)

Newberry (25) in a study of Kansas State College dismissal students reached these conclusions; Low scholastic ability was the primary cause of academic failure. However, 11.2 per cent of those failing ranked above the 75th percentile on placement tests, an indication that other factors were also involved in academic failure. Excessively high or low scores on the emotionality section of the Minnesota Personality Scale were found to be more prevalent among the failing students than normally would be expected. Overdependence on parents was cited as a significant factor in academic failure.

Rose (30) studying drop-outs at Kansas State College found these reasons, given in order of occurance, for dropping from school: To enter military service, change of college, lack of finances, marriage, loss of interest, low scholastic record, other employment, dismissal, family difficulties, health, to enter another type of training.

Studies of the drop-out have indicated that many factors other than academic failure contribute to student mortality at the college level. Many who withdraw from school have the ability to meet the requirements for graduation, but by reason of unforseen circumstances cannot complete their educational plans. It would seem to behoove the researcher seeking to differentiate between persisting and attrition groups to bear these findings in ming. In particular, the importance of differentiating the "withdrawal-failure" from the "withdrawal-some other reason" group should be recognized.

In summary, the literature review highlights several relevant bits of information:

1. Psychological tests of ability and achievement are related to academic success.
2. High school record also forecasts college grades, usually with a higher degree of accuracy than do tests. This may be due, at least in part, to the fact that this variable probably reflects both scholastic ability and motivation to use that ability in academic undertakings.
3. More accurate predictions are made when these variables are used in combination, as in multiple regression studies.

4. Many factors, other than the intellectual ones noted above, are associated with the high attrition rate of college students.

Other than these fairly general findings, results have been inconsistent and inconclusive. This has been true because of certain shortcomings in the studies. Common weaknesses include:

1. Have too few number of cases.
2. Make no differentiation of students in various curricula.
3. Make no differentiation of sex.
4. Use single indicies of prediction.
5. Use questionable or erroneous statistical procedures.
6. Have not cross-validated findings.
7. Have not included motivational factors.

In addition, it may be well to point out a confounding problem in connection with the criterion. While predictions of specific averages may be a useful procedure, the real problem in selective admissions is more qualitative than quantitative. That is, it is more desirable to know if an individual will complete a curriculum or will fail in that effort than it is to know he will earn a B average or a C average. Quantitative prediction has been considerably more accurate than chance, but there is a wide margin for improvement. For purposes of studies like this, prediction of a qualitative criterion would be more meaningful (and less demanding statistically).

PROBLEM

The present study represents an attempt to predict, at the time of enrollment, into which of four groups a student will eventually be placed.

These four groups were defined as:

1. Failures - students whose grades did not meet graduation standards. Most of these voluntarily or nonvoluntarily terminate their enrollment at Kansas State College. (<.70)
2. Non-engineering success - students who transfered to another school at Kansas State College and maintained satisfactory grades. (>.70)
3. Withdrew passing - students who did not become Kansas State College graduates but whose grade records were satisfactory. (>.70)
4. Engineering success - students who persisted in engineering with satisfactory grades. (>.70)

METHODS AND PROCEDURES

The samples used as the basis for this study were selected from the school of Engineering and Architecture at Kansas State College. Two samples were used. These samples were termed (1) original and (2) cross-falidation. For the original sample names of the freshmen entering the School of Engineering and Architecture in 1953 and 1954 were obtained from the Registrar's office. By utilizing honor books (records of credit hours and grade point earned) and student directories, the student sample was classified into one of four groups into which they belonged as of September, 1957. These sub-samples were: (1) failures; this group included all students having less than a .70 grade point average regardless of whether they had withdrawn from school or were still persisting; (2) non-engineering persistors; these were students that had changed from engineering to some other curriculium and were making grades above the graduation requirement of .70; (3) withdrawn from school - passing; students no longer enrolled but who, at the time of withdrawal, had satisfactory grades (greater than .70 average); (4) persisters; students continuing in engineering studies with satisfactory grades, ($>$.70) average.

The cross-validation sample consisted of the 1955 entering freshman. The same information was secured about each subject as for the original sample. The subjects were classified into one of the four previously defined criterion groups as of September, 1957.

Seven different predictor variables were used. These variables represented quantified information about the student which was normally available at the time of his first registration. Three scores are obtained from the American Council on Education (ACE) Psychological Examination, 1951, College Form. The linquistic (L) and quantitative (Q) sections each were scored separately. The sum of the two produced the total (T) score.

Three additional test scores were obtained from the freshman orientation test battery. These were tests of achievement in two "crucial" subject matter areas; i.e., English and reading taken from The Cooperative English Test, 1951, by the Education Testing Service. One was the Mechanics of Expression Test (Mech). This test concerns matters of correct usage in grammer, puncuation, capitalization, and spelling. The other was the Reading Test, which included scores on both Vocabulary (VOC) and Speed of Comprehension (RS).

The final variable included was the high school rank (HSR). Rankings of the students from their high school graduating class were secured from the Registrar's office. This information was available on 267 of the 428 students included in the sample. The rankings of these 267 students were converted into percentiles. These percentiles were in turn converted into standard scores. The standard scores were determined according to "Tables of Normal Probability" as found in Edwards (9,pp, 396-405). Table 7, in the appendix, gives the conversion of HSR to standard score.

Because the data regarding high school rank were not available for all subjects, it was decided to perform two experiments. Experiment I included all students for whom psychometric data were available. Experiment II included those students from Experiment I for whom high school ranks were also available.

The essential statistical tool was the discriminate function (Rao, 28). An analysis was performed first on the original (1953-1954 freshmen) sample. In this analysis, weighted numerical values were determined for each of the predictor variables in Experiment I and Experiment II separately. A different set of weights was developed for each of the four criterion groups (failures, persisters, etc.). These weights were used to develop four equations - one for each of the four groups - for both Experiment I and Experiment II. By fitting a given student's scores into each of these equations, it was possible to obtain four scores for him. The largest of these scores presumably is indicative of the group to which he most likely will belong.

After the equations had been developed from the original sample, scores of the cross validation sample were fitted into them. By this process, statistical predictions were made as to which of the four groups each student in the cross-validation sample would be placed.

Comparisons were then made between his actual placement and the group into which he was predicted to belong.

RESULTS AND DISCUSSION

Initial inspection of the variables for each of the four groups indicate a definite pattern of means. These means are shown in Table 1.

Mean scores for each of the groups, one through four, were progressively higher. Failures, Group 1, scored at the lowest mean level, while engineering successes, Group 4, achieved the highest mean scores.

The same pattern of means was true for both Experiment I and Experiment II with the exception of HSR. In Experiment II the mean HSR was higher for non-engineering successes, Group 2, than for the withdrew passing, Group 3. Perhaps there is a hint here of the role of motivation in college persistence. But the small number of cases involved makes any interpretation highly speculative.

The general conclusion reached by study of the mean scores is that the higher one scores on the test sample the higher one's potential for successful achievement in engineering.

Table 1. The means and standard deviations of the predictor variables for each of the four criterion groups.

Group	N		Mech	ACE-T	ACE-Q	ACE-L	RS	VOC	HSR
				Experiment I					
1	189	m:	76.07	98.81	42.40	56.34	18.28	21.71	
		sd:	(24.31)	(20.45)	(10.20)	(13.52)	(11.24)	(12.76)	
2	111	m:	89.32	110.72	46.15	64.37	24.26	25.85	
		sd:	(26.10)	(21.15)	(9.58)	(14.34)	(12.37)	(11.54)	
3	92	m:	94.59	115.88	47.99	68.11	26.99	28.47	
		sd:	(23.21)	(19.17)	(8.16)	(13.85)	(11.81)	(10.58)	
4	214	m:	95.56	118.48	49.83	69.79	28.16	30.42	
		sd:	(24.47)	(20.94)	(9.41)	(14.18)	(13.46)	(11.73)	
				Experiment II					
1	132	m:	78.92	102.15	44.87	57.28	19.33	22.89	49.73
		sd:	(25.01)	(19.40)	(8.71)	(13.49)	(11.19)	(13.61)	(7.02)
2	74	m:	90.55	110.22	45.86	64.24	24.58	26.76	55.95
		sd:	(25.43)	(21.34)	(9.74)	(14.65)	(12.64)	(11.36)	(7.29)
3	59	m:	97.15	118.41	49.22	69.36	26.95	28.81	53.88
		sd:	(21.65)	(14.87)	(8.10)	(9.68)	(10.32)	(10.01)	(8.15)
4	144	m:	97.88	119.84	50.68	70.59	29.08	30.40	59.21
		sd:	(25.37)	(21.72)	(9.62)	(14.61)	(14.00)	(11.83)	(7.96)

No significant conclusions were obtained from study of standard deviations. In each case, as illustrated in Table 1, there was little variation of standard deviations from group to group.

Table 2 summarizes the intercorrelations for all groups in Experiment I and Experiment II. It was assumed that no great differences for intercorrelation existed between the criterion groups.

Table 2. Table of intercorrelations * for the seven predictors variables.

	X_1**	X_2	X_3	X_4	X_5	X_6	X_7
X_1	___	.65	.46	.65	.63	.56	
X_2	.61	___	.77	.86	.69	.61	
X_3	.44	.76	___	.49	.42	.32	
X_4	.61	.84	.48	___	.73	.71	
X_5	.61	.69	.43	.72	___	.69	
X_6	.53	.58	.30	.69	.68	___	
X_7	.25	.28	.25	.23	.21	.14	___

* Correlations above the diagonal are for subjects in Experiment I; those below the diagonal are for subjects in Experiment II.

** X_1 - Mechanics of Expression
X_2 - ACE-T
X_3 - ACE-Q
X_4 - ACE-L
X_5 - Reading Speed
X_6 - Vocabulary
X_7 - High School Rank

Intercorrelations existing between some of the variables are quite high. For example, the intercorrelations for the Q and L with the T score of the ACE range from .77 to .86 on Experiment I and .76 to .84 on Experiment II. These intercorrelations substantiate findings of previous studies. Despite these high intercorrelations, the Q and L scores were both used in this study because of its exploratory nature. It was felt that there may be significance in these variables for the prediction of engineering as opposed to non-engineering, success.

High intercorrelations between the majority of the variables used in this study indicate that additional factors need to be designed in order that more accurate predictions for engineering success can be made. With the exception of HSR, the scores seemed to overlap to the point where it is doubtful that they could make independent contribution to prediction.

From the tables of intercorrelations and means, various weights were evolved for each of the variables. These weights were indicative of the degree of positive or negative prediction that each of the variables contributed to the total predictive value arrived at by solution of the equations. The weights as developed for each group are given in Table 3.

Table 3. Comparison of weighted values for mechanics of expression, ACE-T, ACE-Q, ACE-L, reading speed, vocabulary, HSR.

Variable	Group 1	Group 2	Group 3	Group 4
		Experiment I		
Mech of Exp	l_1=69.7686	87.8805	90.7256	81.4702
ACE-T	l_2=242.2222	263.1591	253.1591	220.3251
ACE-Q	l_3=339.6835	332.9444	355.4705	452.2691
ACE-L	l_4=375.4965	407.6479	434.9997	462.3750
Reading Speed	l_5=506.1747	492.5475	490.0454	493.0130
Vocabulary	l_6=117.1989	146.4525	138.8504	108.6261
	A*=26501.0323	31428.5709	33725.9978	35081.0343
		Experiment II		
Mech of Exp	l_1=41.0141	61.4412	73.6059	50.1688
ACE-T	l_2=253.6196	267.6724	286.4530	210.0593
ACE-Q	l_3=573.0411	449.0182	522.4232	608.6983
ACE-L	l_4=625.7192	700.2946	761.5388	797.8708
Reading Speed	l_5=827.4492	804.2305	846.1770	793.0108
Vocabulary	l_6=158.1971	205.8126	220.0298	209.5078
HSR	l_7=1822.9499	2076.5599	1935.3422	2179.3333
	A*=80868.5994	95736.2123	97368.2115	108431.5459

*A = Constant term for linear discriminate measurement.

From the above weighted values formulas were developed. These formulas were for the purpose of securing a total value which would indicate into which one of the four criterion groups a subject could be expected to belong. These formulas are given below.

Experiment I

Group 1 $L^{*} = 69.7686X_1 + 242.2222X_2 + 339.6835X_3 + 375.4965X_4 - 506.1747X_5 - 117.1989X_6 - 28436.4755.$

Group 2 $L = 87.8805X_1 \; 263.1591X_2 + 332.9444X_3 + 407.6479X_4 - 492.5475X_5 - 146.4525X_6 - 34248.0736.$

Group 3 $L = 90.7256X_1 + 253.3897X_2 + 355.4705X_3 + 434.9997X_4 - 490.0454X_5 - 138.8504X_6 - 36857.3260.$

Group 4 $L = 81.4702X_1 + 220.3251X_2 + 452.2691X_3 + 462.3750X_4 - 493.0130X_5 - 108.6261X_6 - 36810.0886.$

Experiment II

Group 1 $L = 41.0141X_1 + 253.6196X_2 + 573.0411X_3 + 652.7192X_4 - 827.4492X_5 - 158.1971X_6 + 1822.9499X_7 - 83660.9653.$

Group 2 $L = 61.4412X_1 + 267.6724X_2 + 449.0182X_3 + 700.2946X_4 - 804.2305X_5 - 205.8126X_6 + 2076.5599X_7 - 99957.5579.$

Group 3 $L = 73.6059X_1 + 286.4530X_2 + 522.4232X_3 + 761.5388X_4 - 846.1770X_5 - 220.0298X_6 + 1935.3422X_7 - 102148.9704.$

Group 4 $L = 50.1688X_1 + 210.0593X_2 + 608.6983X_3 + 797.8708X_4 - 793.0108X_5 - 209.5078X_6 + 2179.3333X_7 - 111009.0686.$

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*L = Summation.

Some of the values (X_5 and X_6) are negative values. This is an indication of the importance of the over-all pattern of scores of the individual in making an academic prediction. More importance was given to the pattern than to the fact that differ-test results carry varying weights.

In determining prediction of classification for a particular subject into one of the criterion groups, the test raw score for each student was multiplied by the weighted predictive value for the particular test in that group. Each of the weighted values obtained for each test score was inserted into the formula. Addition or substraction was performed as indicated until a final numerical value was determined.

These calculations were performed for each subject in the cross-validation sample four times in both Experiment I and Experiment II. Results of these cross-validation calculations are shown in Table 4.

Table 4. Accuracy of group predictions.

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	Predicted Group				
			Experiment I		
Actual Group	1	2	3	4	Total
1	97	2	2	56	157
2	21	3	0	23	47
3	14	0	0	32	46
4	53	1	1	123	178
Total	185	6	3	234	428
			Experiment II		
N-267					
1	65	1	0	32	98
2	18	3	0	11	32
3	18	0	1	16	35
4	40	0	0	62	102
Total	141	4	1	121	267

In Experiment I, 97 subjects who had been predicted as failures were actually failures. There were 3 correct predictions for Group 2 and 123 correct predictions for Group 4. None were predicted correctly for Group 3. In Experiment II there were 65 correct predictions for Group 1, 3 for Group 2, 1 for Group 3, and 62 predicted correctly for Group 4. For Group 1, the per cent of correct predictions for Experiment I and Experiment II respectively was 65 per cent and 69 per cent. For Group 4 the per cents were 66 per cent and 61 per cent for Experiment I and Experiment II respectively. No similar percentages were obtained for either of the other groups.

Clearly, predictions for Groups 2 and 3 were unsuccessful. The equations developed simply failed to predict placement in these groups for a significant proportion of the sample, even though 93 of the 428 cases were so categorized.

There may be several reasons for this failure. First, there may be no real differences between these groups and Groups I and 4. This seems like a particularly plausible hypothesis with respect to Group 3 (withdrew passing), who differed from Group 4 only with respect to the fact that they were not enrolled at Kansas State College in September, 1957. Their last registration was in Engineering, and their grades had been at least satisfactory. Group 2 might also be considered similar to Group 1. It is common for Engineering students to find the science and mathematics demands so heavy that persisting would lead to failure; such students often change to curricula which are less demanding in quantitative abilities, thus avoiding the Group 1 (failure) classification.

With this consideration in mind, a new grouping was made. Groups 1 and 2 were combined into an "Engineering - non-success" group; and Groups 3 and 4 were similarly combined into an "Engineering - non-failure" group. Results of this combination are shown in Table 5.

Table 5. Accuracy of prediction for gross classification.

Actual Group	Predicted Group: 1 or 2	3 or 4	Total
	Experiment I		
1 or 2	123	81	204
3 or 4	68	156	224
Total	191	237	428
	Experiment II		
1 or 2	87	43	130
3 or 4	58	79	137
Total	145	122	267

Chi-square values were computed from the data in Table 5. These values, 38.813 and 16.648 for Experiments I and II respectively, were significant well beyond the .001 level. In other words, using the gross classifications of Table 5, there is little doubt that predictions considerably better than chance were made.

But how practical is this finding? In Experiment I, 56 of 157 students had been predicted to be engineering successes but actually were failures; 53 of 178 subjects had been predicted to fail in engineering but had achieved success.

These success and failure reversals total 109 of 335 cases. This represents 30 per cent of the prediction which must be considered as complete misses.

Results of Experiment II indicated the same trend. Forty of the 98 failures had been predicted to succeed and 32 of 102 engineering successes had been predicted to be failures. This represents 72 of 200 cases or 36 per cent as complete misses.

Clearly, a sizeable number of erroneous judgments would be made if students were selected for admission to the School of Engineering and Architecture at Kansas State College if the formulas developed in this study had been employed. In both Experiment I and Experiment II, 28 per cent of those who would have been denied admission (were predicted to be in Group 1) were actually classified in Group 4. To make an error of this size would seem grossly unfair to both the individual and to the society which needs trained engineers.

What suggestions might be made to improve upon this situation? It seems likely that improvements might be brought about with proper attention to both the criterion groups and the predictor variables.

In connection with the former, the present study appears weak in several respects. First of all, the definition of Group 2 seems too arbitrary. A student who successfully transferred to a physics, chemistry, or mathematics major was classified in

Group 2; so was the successful agriculture, business administration, or education transfer. It would be more sensible to treat the science and mathematics majors as Group 4 cases.

Students included in Group 3 undoubtedly were a heterogenous group. Some probably transferred to other schools, perhaps as engineering or science majors. Others may have temporarily postponed college for financial, health, or personel reasons. Still others may have simply been "fed up" with school, and have no intention of returning. Without some knowledge of why the student was no longer enrolled, or what his future plans were, a Group 3 classification would seem quite meaningless. Future research should attempt to define a more homogeneous group.

If the 28 per cent error in Group 1 classification is to be reduced substantially, it is probable that that group will have to be redefined also. In particular, it will probably be necessary to be more restrictive in the definition of failure. Rather than call any student with less than a .70 a failure, it may be necessary to change that figure to .50 or even .30. While such a procedure will increase the number of false positives (i.e., more predicted successes will fail), it should substantially decrease the odds that a student denied admission would actually have succeeded.

In terms of the predictor variables, several suggestions can be made. First, the inclusion of aptitude and achievement tests particularly relevant to engineering success would be desireable. Such tests as the Educational Testing Services <u>Pre-Engineering</u>

Ability Test, the Differential Aptitude Tests of Space Relations and Mechanical Reasoning, and an achievement test in mathematics would probably produce better predictions than tests in the present battery.

Second, a prediction battery should recognize that scholastic attainment is a function of non-intellectual, as well as intellectual processess. The inclusion of certain of the scales from the Edwards Personal Preference Schedule or the California Psychological Inventory, for example, might well get at some of these non-intellectual (motivational) elements, (Gebhart, Hoyt, and Gough, cf., 12, 13). Measures of attitude toward school, intellectual activities, work and self might also contribute to more adequate prediction.

Finally, a measure of interest in science and engineering might well be considered. While interest scores seldom correlate high with degree of achievement, they have been shown to be indicative of curriculum enrollment, curriculum change, and future occupation. Such measures might well contribute to the identification of parts of the Group 2 and Group 3 subjects.

SUMMARY

The major purpose of this study was to devise a means of identifying, at the time of enrollment, students entering engineering who would either pass or fail. There were four subsidary goals:

1. To contribute information regarding the problem of selective admissions.

2. To localize prediction data for engineering students at Kansas State College.
3. To provide information of guidance value to advisors and counselors.
4. To contribute to methodology, by applying a little known statistical tool to a situation representative of a now general problem in education.

A total of 1,035 freshman males at Kansas State College in the School of Engineering were considered in this study. Subjects were divided into four groups on the basis of school placement as of September 1957.

The four groups were:

1. Failures - students whose grades did not meet graduation requirements. (gpa $< .70$)
2. Non-engineering success - students who transferred to another school at Kansas State College. (gpa $> .70$)
3. Withdrew passing - students who did not become Kansas State College graduates but whose grades were satisfactory. (gpa $> .70$)
4. Engineering success - students, who persisted in engineering with satisfactory grades. (gpa $> .70$)

Data from orientation tests taken at the time of enrollment were used as variables for prediction. These variables included the Q, L, and T scores of the American Council on Education Psychological Examination and the Mechanics of Expression, Vocabular, and Reading Speed scores of the Cooperative English Expression Test. The study was divided into two experiments. Experiment I used the above variables for prediction. Experiment II included the above variables and the high school rank as a basis for prediction.

Using the 1953 and 1954 entering freshmen, weighted values were derived by a discriminate function analysis. Four values were determined for each of the variables, one for each of the four groups. These weighted values were used to develop four formulas - one for each of the four criterion groups. On the basis of these formulas, predictions were made regarding the most likely eventual classification of members of the cross-validation group (1955 engineering freshmen). The accuracy of these predictions was checked by comparing them with the actual status of the students as of September, 1957.

Within the limits of the samples used and with reseveration regarding the appropriateness of the statistical treatment the following conclusions appear warranted:

1. Results of the major hypothesis must be considered negative.
2. There was some indication that gross prediction, pass or fail, may be feasible.
3. There was no great assurance that an individual specifically designated pass or fail would fall into that category.
4. In Experiment I, 109 of 335 cases or 30 per cent must be considered as reversable between prediction for Group 1 and Group 4 and actual placement.
5. In Experiment II, 72 of 200 cases (367 total) were

complete reversals.

6. No pattern of the potential drop-out could be identified using the presently identified variables.
7. No pattern could be developed for the student apt to drop engineering yet succeed in another curriculum.
8. The addition of high school rank did not improve prediction for the sample used in Experiment II.
9. Mean scores on the variables tended to be successively higher as one proceeded from Group 1 through Group 4.
10. In only 12 cases was any group other than one or four predicted.
11. High intercorrelations indicate that additional variables need to be identified for a basis of prediction.

Several suggestions for future research were made. First, the criterion groups should be more adequately defined, so that these groups are more homogeneous, with respect to their behavior and plans. Secondly, the prediction battery should be revised drastically.

Such factors as perception, motivation, other personality factors, interests, and mathematical or engineering aptitude were suggested as variables to be included in future research. Attention was called to the fact that other curriculums should be investigated. Much more data need to be collected before the question, "Should I go to college", can be answered with any degree of certainty.

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APPENDIX

Table 6. Linear discriminate scores for criterion groups.

Gp:	Ni:	Ni/ Ni:	log. Ni/ Ni	: 2.302585 x log Ni/ Ni	: Multiplied by 10^6
			Experiment I		
1.	189	.31188	(9.4939875-10)--.5060125	-1.1651367923	-1165136.7923
2.	111	.18317	(9.2628543-10)--.7371457	-1.6973406316	-1697340.6316
3.	92	.15182	(9.1813290-10)--.3186710	-1.88505595645	-1885059.5645
4.	214	.35314	(9.5479469-10)--.4520531	-1.0408906873	-1040890.6873
Tot.	606				/602
					-1935.4432
					-2819.5027
					-3131.3282
					-1729.0543
			Experiment II		
1.	132	.32274	(9.5088528-10)--.4911472	-1.1309081755	-1130908.1755
2.	74	.18093	(9.2575106-10)--.7424894	-1.7096449551	-1709644.9551
3.	59	.14425	(9.1591158-10)--.8408842	-1.9362073457	-1936207.3457
4.	144	.35208	(9.5466414-10)--.4533586	-1.0438967120	-1043896.7120
Tot.	409				/404
					-2792.3659
					-4221.3456
					-4780.7589
					-2577.5227

Table 7. Conversion of high school percentile rank to standard score.

%-ile Standard Score	%-ile Standard Score	%-ile Standard Score	%-ile Standard Score
99 - 73	74 - 56	49 - 50	24 - 43
98 - 71	73 - 56	48 - 49	23 - 43
97 - 69	72 - 56	47 - 49	22 - 42
96 - 69	71 - 56	46 - 49	21 - 42
95 - 68	70 - 55	45 - 49	20 - 42
94 - 66	69 - 55	44 - 48	19 - 41
93 - 65	68 - 55	43 - 48	18 - 41
92 - 64	67 - 54	42 - 48	17 - 40
91 - 63	66 - 54	41 - 48	16 - 40
90 - 63	65 - 54	40 - 47	15 - 40
89 - 62	64 - 54	39 - 47	14 - 39
88 - 62	63 - 53	38 - 47	13 - 39
87 - 61	62 - 53	37 - 47	12 - 38
86 - 61	61 - 53	36 - 46	11 - 38
85 - 60	60 - 53	35 - 46	10 - 37
84 - 60	59 - 52	34 - 46	9 - 37
83 - 60	58 - 52	33 - 46	8 - 36
82 - 59	57 - 52	32 - 45	7 - 35
81 - 59	56 - 52	31 - 45	6 - 34
80 - 58	55 - 51	30 - 45	5 - 32
79 - 58	54 - 51	29 - 44	4 - 31
78 - 58	53 - 51	28 - 44	3 - 31
77 - 57	52 - 51	27 - 44	2 - 29
76 - 57	51 - 50	26 - 44	1 - 27
75 - 57	50 - 50	25 - 43	

THE PREDICTION OF ACADEMIC
ATTRITION AND SUCCESS THROUGH DISCRIMINATE FUNCTION ANALYSIS

by

BOYD GAYLE TALLEY

A. B. OTTAWA UNIVERSITY, 1949

AN ABSTRACT OF A THESIS

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