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An Analysis of Relationships Among Ratings on Entrance Examinations and Academic Achievement in the College of Engineering, University of New Mexico

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AN ANALYSIS OF RELATIONSHIPS - THURSTON

An Analysis of Relationships among Ratings on Entrance Examinations and Academic Achievement in the College of Engineering, University of New Mexico

By

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A thesis submitted to the Faculty of the Graduate School, University of New Mexico, in partial fulfillment of the requirements for the Degree, Master of Arts in Psychology

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Table of Contents

Chapter I

Introduction

Statement of the problem. The purpose of this study is two-fold:

1. to determine relationships between academic success of students in the College of Engineering, University of New Mexico, and their standing in certain entrance examinations; and

2. to recommend cutting scores on the various tests which might be set as standards for admittance to the College of Engineering.

Significance of the problem. Of recent years, there has been considerable publicity concerning the great need in our country for engineers in all specialties, to perform technical services in our nation's industry and defense, and to assist in the industrial development of the backward nations of the world. The high initial rate of pay for graduate engineers, prospects of choice of good jobs and locations, professional prestige, the fascination of technology to many young Americans, and the publicity devoted to attracting young people into engineering all serve to make this field of study attractive to many students entering college.

At the same time, authorities are generally agreed that in the high schools, the standards of education in the basic sciences necessary to the engineer are widely variable and in many schools deplorably low. Thus many students are presenting themselves to the colleges, desiring entrance to a field of study which is in great demand, but bringing greatly varied proficiencies and background training.

It seems apparent that economic waste, to student and college, of admitting students who will fail, is great. The colleges, faced with

the difficulties of increased enrollment and shortages of qualified teaching personnel, will increasingly need to attempt to select only the students with the best possible chances of success. From the student's standpoint, withdrawal from engineering school because of failure entails not only financial loss and poor use of educational time, but also possibly serious psychological effects and social disability.

Many factors affecting success are very difficult or impossible to measure - factors such as drive, self-discipline, emotional equilibrium, and environmental circumstances. But tests have been designed which are believed to measure some of the aptitudes which make for academic success. This paper attempts to determine the extent to which results of these tests may predict success in engineering college. It is recognized that at best, because of the many other factors which may enter into academic success, the tests give only a rough prediction, but they may still be useful insofar as they predict better than chance selection.

Background of study. All students desiring to enter the University of New Mexico College of Engineering are required to take a battery of tests designed to measure their aptitudes and abilities for this course of study. Exception to this requirement is made in the case of students entering with advanced standing from other accredited engineering schools. The testing program is administered through the Counseling and Testing Service of the University. The test results are used by the Counseling and Testing Service, and also by the faculty of the College of Engineering, to assist students in evaluating their abilities and planning a profitable course of study.

The tests. The tests upon which this study is based are:

1. American Council on Education Psychological Examination for College Freshmen. The test has two parts: Linguistic (yielding the L score) and Quantitative (yielding the Q score). "The L-score is indicative of ability to succeed in those fields which require proficiency with language and facility of expression. The Q-score measures ability to deal with the type of material covered in technical curricula. Separate and composite scores are easily obtainable." (29) The composite score is called the T-score.

2. Pre-Engineering Ability Test of the Educational Testing Service. The test has two parts: Part I, Comprehension of Scientific Materials; Part II, General Mathematical Aptitude. The records of the students' scores on this test are in the form of a composite score for the two parts.

3. University of Nebraska Mathematics Placement Test. This is an achievement test, the results of which show the student to be prepared for more or less advanced mathematics in the curriculum of the University of New Mexico.

Approach to the problem. For the purpose of this study, no correlations were drawn between scores on these entrance examinations and grade point averages for university work. The criterion for validity for these tests in this case was not grade point averages, but simply the "succeed-fail" differential. Since a "C" (1 point) average is required for graduation, this is the point at which the "succeed-fail" cut score was set, averages above this point being counted as "success", and averages below being counted as "fail". The College of Engineering is not primarily interested in predicting the relative standing of the students, but in

differentiating between those who have the ability to succeed in graduating, and those who do not. Therefore the analysis of the data in this study has been restricted to various aspects of measuring ability to succeed by means of these tests. This type of analysis was recommended as early as 1919 by Thurstone, who advised that for purposes of determining critical scores, such as would be useful in determining acceptance or rejection of candidates for specialized training, scattergrams should be used in preference to correlation coefficients. (24) As he said:

> "The correlation methods do not place this emphasis on the individual but state the abstract relation between the several variables and this does not bring home to the psychologist his chances of error in advising about an individual student."

Chapter II

Review of the Literature

In 1952, Dr. A. Wellck, Director of Counseling and Testing Services, University of New Mexico, made a study of relationships between entrance test ratings and academic success during the freshman year, of 99 students who entered the College of Engineering of the University in the fall of 1951 and spring of 1952. Dr. Wellck's findings were presented in a paper read before the annual meeting of the Southwest Section of the American Society for Engineering Education at the University of New Mexico on April 3, 1953. The title of this paper was "The Prediction of Academic Success in the College of Engineering of the University of New Mexico". Some of the principal findings of this study are summarized as follows:

1. Pre-Engineering Ability Test. Of students ranking 6, 7, 8, and 9 (top of the scale), 94% made successful records in the freshman year; of students ranking 1, 2, 3, and 4 (low end of the scale), 35% made satisfactory records.

2. Q-score of the ACE Psychological Test. Of students ranking 6, 7, 8, and 9, 72% made successful records; of students ranking 1, 2, 3, and 4, 37% made satisfactory records.

3. L-score of the ACE Psychological Test. Of students ranking 6, 7, 8, and 9, 80% made successful records; of students ranking 1, 2, 3, and 4, 19% made satisfactory records.

4. T-score of the ACE Psychological Test. Of students ranking

6, 7, 8, and 9, 83% made successful records; of students ranking 1, 2, 3, and 4, 24% made satisfactory records.

It should be emphasized that these results apply only to the freshman class, while the present study is applied to students over a period of 5 years.

An excellent review of literature pertaining to the prediction of success in engineering college is to be found in the bulletin, "Selection and Counseling of Students in Engineering: Papers from a Conference on Counseling of Engineering and Science Students Held at the University of Minnesota in November, 1952." (25) Since this review is available, it is here merely summarized. Over the years, there seem to have been three principal types of studies made on the subject of engineering college success:

1. Studies of the patterns of student progress in engineering, including numbers of students entering engineering schools, intelligence levels, rates of drop-outs, rates of graduation, and subsequent career use of training.

2. Studies of correlations between grade-point averages and various methods of measurement and prediction, including a great variety of individual tests, multiple correlations involving various combinations of test instruments, sometimes combined with such other indicators as high school grades.

3. Studies of relations between engineering entrance, progress, and graduation, and other factors than those which are measured by tests of aptitude and ability. These factors include father's occupation, student's personality, interests, social level, etc.

The bulk of the studies pertain to correlations between single tests

or batteries of tests, and grade point averages, usually for the first term of first school year. The correlation coefficients ranged from about .55 to about .70, while multiple correlations, usually including high school grades, tend to yield somewhat higher coefficients. In general, the highest correlations are with grades on tests of mathematical ability, with high school grades, especially with grades in science and mathematics, and with these two combined.

Some studies not cited in the University of Minnesota bulletin are reviewed here.

Bartlett (2) published in 1943 his findings in a study of 534 students tested with the Yale Battery of Tests of Differential Academic Aptitudes. His studies showed the tests of Quantitative Reasoning, Mathematical Aptitude, Spatial Visualization, and Mechanical Aptitude produced significantly higher scores for engineering students than for non-engineering students, and that the reverse was true of tests of Verbal Comprehension and Artificial Language.

Carrillo and Reichart (4) published in 1952 a study of the effect of applying a "caution factor" to the scores on the ACE Psychological Examination. This "caution factor" was the ratio of the number of correct responses to the number of responses attempted. Multiplying Q, L, and T scores by this factor was found to increase the predictive value of the test for grades in the first year of the engineering curriculum.

Crook, in a Ph.D. thesis at the University of Minnesota (28), reported an attempt to measure the value of personality adjustment inventory items in predicting outcomes of college engineering training. He found a significant correlation between adjustment scale and first term grades,

but less for the second term grades, and no significant correlation for third term grades.

Sessions (21) at the University of Idaho made a study of the predictive value of the Pre-Engineering Ability Test in 1955, using first semester grade averages as criteria. He found that the test's correlation with grades, .60, was not significantly higher than that of the Cooperative General Achievement Mathematics Test, .56, and that "profile patterns as well as scattergrams revealed that even though the ACE test (ACE Psychological Test for College Freshmen) correlated lower than other tests with engineering grades, it served as the best test for determining critical scores". This comparison was between the ACE, the Cooperative Mathematics Test, and the Pre-Engineering Ability Test. Sessions also cites Thurstone as having pointed out "that the critical score techniques was more useful for practical prognostic purposes than the multiple correlation method because of the ease of application and because it differentiated better between those who failed or passed, though it did not predict actual grades". He quotes also Jex (27) and Slaymaker (23) as having independently shown evidence that supported Thurstone's observations.

Jones (11), in 1948 found a correlation of .63 between grade point averages and scores on the Cooperative Mathematics Test, and Cooperative Chemistry or Physics Test, when combined for multiple correlation with high school grades. For the tests alone, he found a correlation of .58.

Drake and Thomas (6) found that a combination of the Pre-Engineering Ability Test and either ACE Psychological or the centile rank in high school separated the high and poor achievers very well, 50% of the high achievers ranking in the top fourth on the tests, and 82% of the poor achievers ranking

in the lowest fourth on the tests.

Jones and Case (12) made a validation study of a new aptitude examination for engineering students at UCLA. The test was validated against grade point averages of freshmen and sophomores, and the correlations were found to be not higher than those found with other tests. They stated that it was their conclusion that "prediction of success in Engineering School cannot be improved by further manipulation of aptitude measures. If more of the variance is to be accounted for, it probably will be in terms of interest and personality variables."

Chapter III

Methods and Materials

The students whose records comprise the data for this study entered the College of Engineering in the fall of 1951, spring and fall of 1952, and spring and fall of 1953. The total number of these students is 400. The time elapsed since the entrance of these students is sufficient for them to have completed the normal four-year course of study. Success or failure has been interpreted partly on the basis of completion of the requirements for graduation. In the case of students who transferred out of the College voluntarily, distinction has been drawn between those who left with satisfactory records (a "C" average or better), and those whose records were below the "C" average required for graduation.

In order to determine the relationships between the students' standings on the tests under consideration, and their academic achievement, the records of the Registrar of the University pertaining to these students were consulted. From these records, the students were grouped as follows:

Group I. Graduates. Students who have either graduated from, or are still enrolled in the College of Engineering. In the case of students still enrolled, a satisfactory grade point average was considered presumptive evidence of eventual graduation. There were no students still enrolled who had less than satisfactory averages. Evidently, by this time, any whose work was less than satisfactory have dropped out in one way or another.

Group II. Successful Transfers. Students who withdrew from the College while still in good standing. There were various reasons for these

withdrawals. Some students left college to serve in the armed forces, and did not return. Some transferred to other institutions, and their ultimate achievement is not a matter of record here. Others no doubt withdrew for financial and personal reasons. Some evidently found a greater affinity for other careers, as evidenced by the fact that they transferred into other colleges of this university--especially the Colleges of Education, Business Administration, and Arts and Sciences. There is here a problem as to whether these transfers should be considered to have succeeded in engineering, and whether prediction of success for these students on the basis of these tests can be considered evidence of test validity. However, none of the tests under consideration presumes to be a test of personality factors, interests, or attitudes. The fact that these students did succeed in maintaining a satisfactory grade average until the time of transfer or withdrawal would seem to indicate that their academic potential for engineering was adequate, and it was other factors not measurable by these tests which caused their withdrawal from engineering.

Group III. Unsuccessful Transfers. Students who left the College of Engineering with less than a satisfactory grade point average, but still of their own volition.

Group IV. Suspended. Students who were suspended by action of the College of Engineering.

Since the first two groups are similar in having demonstrated ability to perform adequately in the engineering courses undertaken, these two groups have been combined, for some of the analyses, into a single group termed "Successful". Groups III and IV also being similar in having

demonstrated inability to perform adequately in engineering courses, have been combined, for some purposes, into a single group termed "Unsuccessful". Most of the tables give figures for all four groups, and also for the combined groups.

Standings on entrance tests were categorized as follows:

1. The raw scores of the ACE Psychological Examination and the Pre-Engineering Ability Test were converted to nine scaled scores, called stanines. Stanine is the abbreviated term for "standard nine". A stanine is an interval of one half of a standard deviation, except for the extreme stanines 1 and 9. The middle stanine is 5, and contains the scores from 1/4 S.D. below the mean through 1/4 S.D. above the mean. Stanine 9 contains the scores above 1-3/4 S.D. above the mean score, and stanine 1 contains the scores below 1-3/4 S.D. below the mean. The scores on the ACE Psychological Examination were scaled according to norms established in this University. The scores of the Pre-Engineering Ability Test were also converted to stanines, but in this case the norms used were national norms as announced by the publisher.

2. The raw scores of the University of Nebraska Mathematics Placement Test were scaled in two groups only, according to whether the student did or did not exceed a cut score of 10, and 40, on the two parts of the test. These scores were not recorded separately, the cut score being a combination of the two partial scores. This criterion established the students' placement in their first mathematics courses at the university.

Except in the case of actual graduates, grade point averages were the criterion of success. On the basis of 1 point for a "C", any student whose grade point average was less than his number of credit hours was

considered unsatisfactory. In other words, the student must have maintained at least a "C" average in all work, to be considered as successful.

For most analyses of this study, the raw numbers of students falling within various categories and stanines have been converted into percentages. While this method seemed most practicable for the group as a whole, it should be observed that at the high and low ends of the scale, the raw numbers are very low, to the point that the percentage figured becomes very subject to distortion. Therefore the reader is reminded to bear in mind the possible weakness of the percentage expressions at the ends of the scale.

In this study, the term "cut score" refers to a practical use of test results in the selection of students. The cut score is whatever score is set by college administrators as minimum standard for admittance, or for advising students in favor of their attempting a course of study.

Chapter IV

Presentation and Analysis of the Data

In this chapter data relating to the five test scores (Q score, L score, T score, Pre-Engineering Ability Test score, and Mathematical Placement score) will be presented and analysed. There will also be a presentation of results obtained by combining the three best tests, according to their predictive value, in a battery. The results obtained by grouping the students' scores by stanines, and their academic achievement according to their various success categories are presented in tables and graphs, and discussed.

The Q Scores

Tables 1, 2, 3 and 4 and Figure 1 present the data relating to the Q scores.

Table 2 reveals that the division between stanines 3 and 4 is a point above which a student had a better than even chance of success, and below which he had a 2-to-1 chance of failing. Inspection of Figure 1 also shows a definite break in the curve of successes--a very rapid drop in successes below this point. Analysis of the data of Table 3, using the division between stanine 3 and stanine 4 as a point of analysis, reveals the following facts:

1. Of the Graduates, 97% ranked 4 or better.
2. Of the Successful Transfers, 92% ranked 4 or better.
3. Of the Unsuccessful Transfers, 88% ranked 4 or better.
4. Of the Suspended group, 77% ranked 4 or better.
5. Of the entire 400 students, 91-1/2% ranked 4 or better.

6. Of the combined Successful group, 96% ranked 4 or better.

7. Of the combined Unsuccessful group, 84% ranked 4 or better.

Thus a cut point below stanine 4 would have admitted 96% of the Successful students, and 84% of the Unsuccessful. It would have eliminated 4% of the Successful and 16% of the Unsuccessful students. While this difference is not so great as admissions officers might wish, for their purpose of selection, it is statistically significant. Using the chi square test for the significance of differences, it is found that the groups separated between stanines 3 and 4 are significantly different at the .01 level of confidence, with respect to success in engineering studies.

A cut point between stanines 4 and 5 would have eliminated 15% of the Successful group, and 30% of the Unsuccessful. Thus we see that a cut point below stanine 4 would have eliminated four times as great a percentage of unsuccessful students as successful, while a cut point below stanine 5 would have eliminated only twice as great a percentage of unsuccessful as successful students. Comparison of raw numbers shows that a cut point below stanine 4 would have eliminated 11 successful and 23 unsuccessful students. With a cut point below stanine 5, 39 successful and 44 unsuccessful students would have been eliminated. Thus at stanine 5 we approach the point of eliminating as many successful as unsuccessful students.

Table 3 also shows what percentage of all the students would have been admitted, by establishing cut points below the respective stanine levels. Thus, if the cut point were below stanine 3, 96% would have been admitted. If the cut point were below stanine 5, 79% would have been admitted.

Table 4 shows what percentage of students admitted according to the respective stanine level cut points would have been successful. Thus, if the

cut point for admittance were below stanine 3, 64% of the students admitted would have been successful. If the cut point were below stanine 5, 67% of the students admitted would have been successful. The data show that of all students actually admitted, 63% were successful, according to our present definition of success in relation to these tests, although only 44% actually graduated.

The distribution of successes and failures by stanines is graphically presented in Figure 1.

With a grouping of all scores at or above stanine 4 as High, and all below as Low, the tetrachoric correlation coefficient (r_t) was computed for the relation between High and Low standing on the Q score, and Successful and Unsuccessful groups. The r_t was .25, which is significant.

Table 1

Distribution of Number of Q-Scores on

ACE Psychological Examination for College Freshmen

	Stanines									
Category	9	8	7	6	5	4	3	2	1	Sum
Graduates	13	26	38	52	21	21	4	1	0	176
Successful Transfers	9	9	24	10	10	7	3	2	1	75
Unsuccessful Transfers	3	12	17	22	17	17	7	3	2	100
Suspended	1	1	6	17	9	4	8	3	0	49
Totals	26	48	85	101	57	49	22	9	3	400
Successful	22	35	62	62	31	28	7	3	1	251
Unsuccessful	4	13	23	39	26	21	15	6	2	149
Totals	26	48	85	101	57	49	22	9	3	400

Table 2

Percentages of Q-Scores for Success Categories on

ACE Psychological Examination for College Freshmen

	Stanines								
Category	9	8	7	6	5	4	3	2	1
Graduates	50	54	45	51	37	43	18	11	0
Successful Transfers	35	20	28	10	17	14	14	22	33
Unsuccessful Transfers	11	24	20	22	30	35	32	34	67
Suspended	4	2	7	17	16	8	36	33	0
Totals	100	100	100	100	100	100	100	100	100
Successful	85	74	73	61	54	57	32	33	33
Unsuccessful	15	26	27	39	46	43	68	67	67
Totals	100	100	100	100	100	100	100	100	100

Table 3

Percentages of Q Scores on ACE Psychological Examination for College Freshmen Falling Above Stanine Level Cut Points by Categories of Success

	Stanines*								
Category	9	8	7	6	5	4	3	2	1
Graduates	7	22	44	73	85	97	99	100	100
Successful Transfers	12	24	56	69	83	92	96	99	100
Unsuccessful Transfers	3	15	32	54	71	88	95	98	100
Suspended	2	4	16	51	69	77	93	99	100
Successful	9	23	47	72	85	96	98	99	100
Unsuccessful	3	11	26	50	70	84	94	98	100
Total+	6	18	39	65	79	91	96	98	100

*The scores falling in the given stanines are included in the percentage. That is, the cut point is below the given stanine.

+The total gives the percentage of total applicants that would have been admitted if only those in or above the given stanine had been admitted.

Table 4

Percentage of Successful Students to Total Students

Above Each Stanine Level for Q Scores

	Stanines								
	9	8	7	6	5	4	3	2	1
Percentage	85	77	75	69	67	66	64	63	63

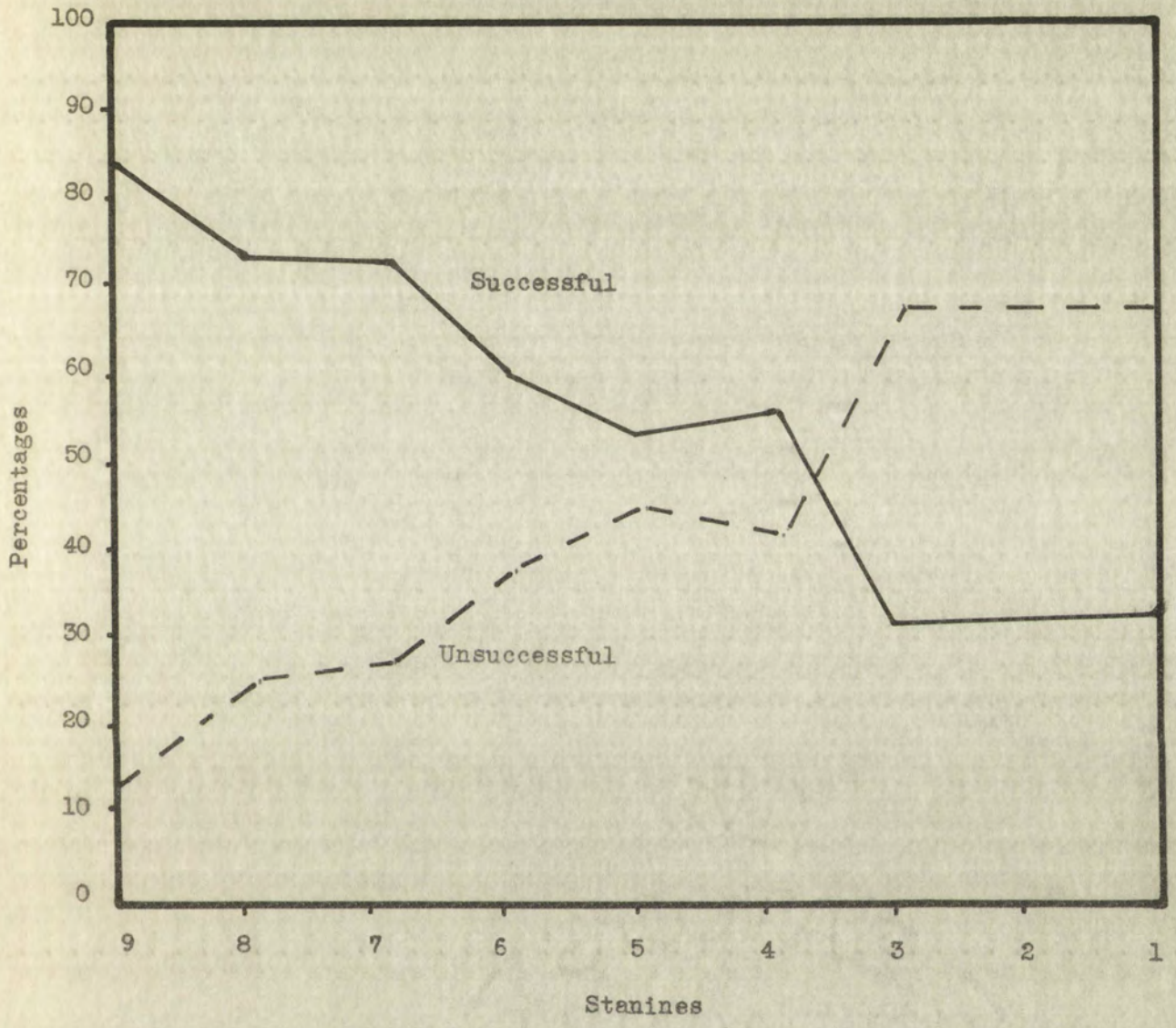
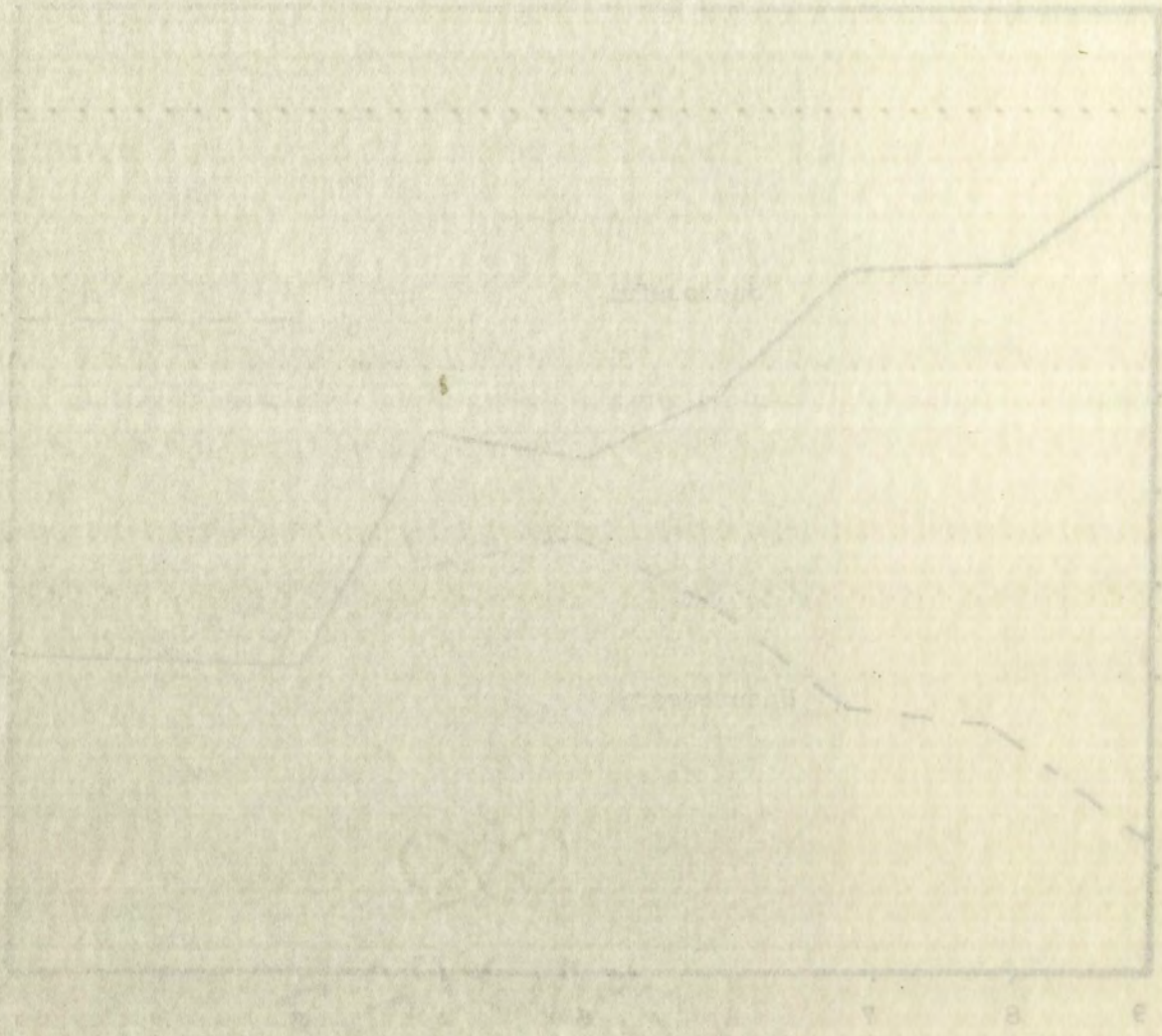


Figure 1. Percentages of Students Who Were Successful and Unsuccessful in Each Stanine of Q Scores on ACE Psychological Examination



The L Score

Tables 5, 6, 7 and 8 and Figure 2 present the data relating to the L score. Figure 2 reveals graphically the lack of any clear-cut relationship between the L score and engineering college success, although in stanines 8, 7, 6, 5 and 4, there is a higher percentage of successful than of unsuccessful students.

Analysis of the data of Table 7, using the division between stanines 3 and 4 as a point of analysis, analagously to the analysis of the Q score data, reveals the following facts:

1. Of the Graduates, 87-1/2% ranked 4 or better.
2. Of the Successful Transfers, 87% ranked 4 or better.
3. Of the Unsuccessful Transfers, 74% ranked 4 or better.
4. Of the Suspended group, 86% ranked 4 or better.
5. Of the total 400 students, 84% ranked 4 or better.
6. Of the combined Successful group, 88% ranked 4 or better.
7. Of the combined Unsuccessful group, 78% ranked 4 or better.

Thus a cut point below stanine 4 would have admitted 87% of the Successful students, and 80% of the Unsuccessful. It is seen that the differentiation here is considerably less than was the case with the Q score. In fact, at some of the high stanine levels, there is here a higher percentage of Suspended students than of Successful. There is also no point of reversal, as there was with the Q scores, of chance of success, except at stanine 1 and, oddly at stanine 9. As has been pointed out, the percentage method of determining relationships is weak at the ends of the scale, because of the low number of scores involved. However, even with

this reservation, the distribution of scores is here not such as to make a clear differentiation between Successful and Unsuccessful students. Application of the chi square test of the significance of difference shows that a separation of two groups at a point between stanines 3 and 4 is not significant. It might be recommended to the College of Engineering that the L score be used only for aid in assessing the students' ability to handle the more general or linguistic courses, but not their ability to succeed in engineering courses.

Table 7 also shows, on the basis of the L score, what percentage of students would have been admitted, with cut scores at the respective stanine levels.

Table 8 shows what percentage of students, admitted according to cut points at the various stanine levels, would have succeeded.

Table 5

Distribution of Number of L Scores on

ACE Psychological Examination

	Stanines									
Category	9	8	7	6	5	4	3	2	1	Sum
Graduates	0	8	21	52	36	37	17	5	0	176
Successful Transfers	1	4	6	22	21	11	5	4	1	75
Unsuccessful Transfers	2	2	10	18	18	24	17	8	1	100
Suspended	1	5	3	12	15	6	4	1	2	49
Totals	4	19	40	104	90	78	43	18	4	400
Successful	1	12	27	74	57	48	22	9	1	251
Unsuccessful	3	7	13	30	33	30	21	9	3	149
Totals	4	19	40	104	90	78	43	18	4	400

Table 6

Percentages of L Scores for Success Categories on

ACE Psychological Examination

	Stanines								
Category	9	8	7	6	5	4	3	2	1
Graduates	0	42	52	50	40	47	40	28	0
Successful Transfers	25	21	15	20	23	14	11	22	25
Unsuccessful Transfers	50	11	25	18	20	31	40	44	25
Suspended	25	26	8	12	17	8	9	6	50
Totals	100	100	100	100	100	100	100	100	100
Successful	25	63	67	70	63	61	51	50	25
Unsuccessful	75	37	33	30	37	39	49	50	75
Totals	100	100	100	100	100	100	100	100	100

Table 7

Percentage of L Scores on ACE Psychological Examination

Falling Above Various Stanine Level Cut Points

by Categories of Success

	Stanines*								
Categories	9	8	7	6	5	4	3	2	1
Graduates	0	4	16	46	66	88	97	99	100
Successful Transfers	1	7	15	44	72	87	93	99	100
Unsuccessful Transfers	2	4	14	32	50	74	91	99	100
Suspended	2	12	18	43	73	86	94	96	100
Successful	1/2	5	16	46	68	88	96	99	100
Unsuccessful	2	7	17	37	59	78	91	97	100
Total+	1	6	16	42	64	85	95	99	100

*The scores falling in the given stanines are included in the percentages. That is, the cut points are below the given stanines.

+The total gives the percentage of total applicants that would have been admitted if only those in or above the respective stanines had been admitted.

Table 8

Percentage of Successful Students to Total Students

Above Each Stanine Level for L Scores

	Stanines								
	9	8	7	6	5	4	3	2	1
Percentages	25	56	63	68	68	65	64	63	63

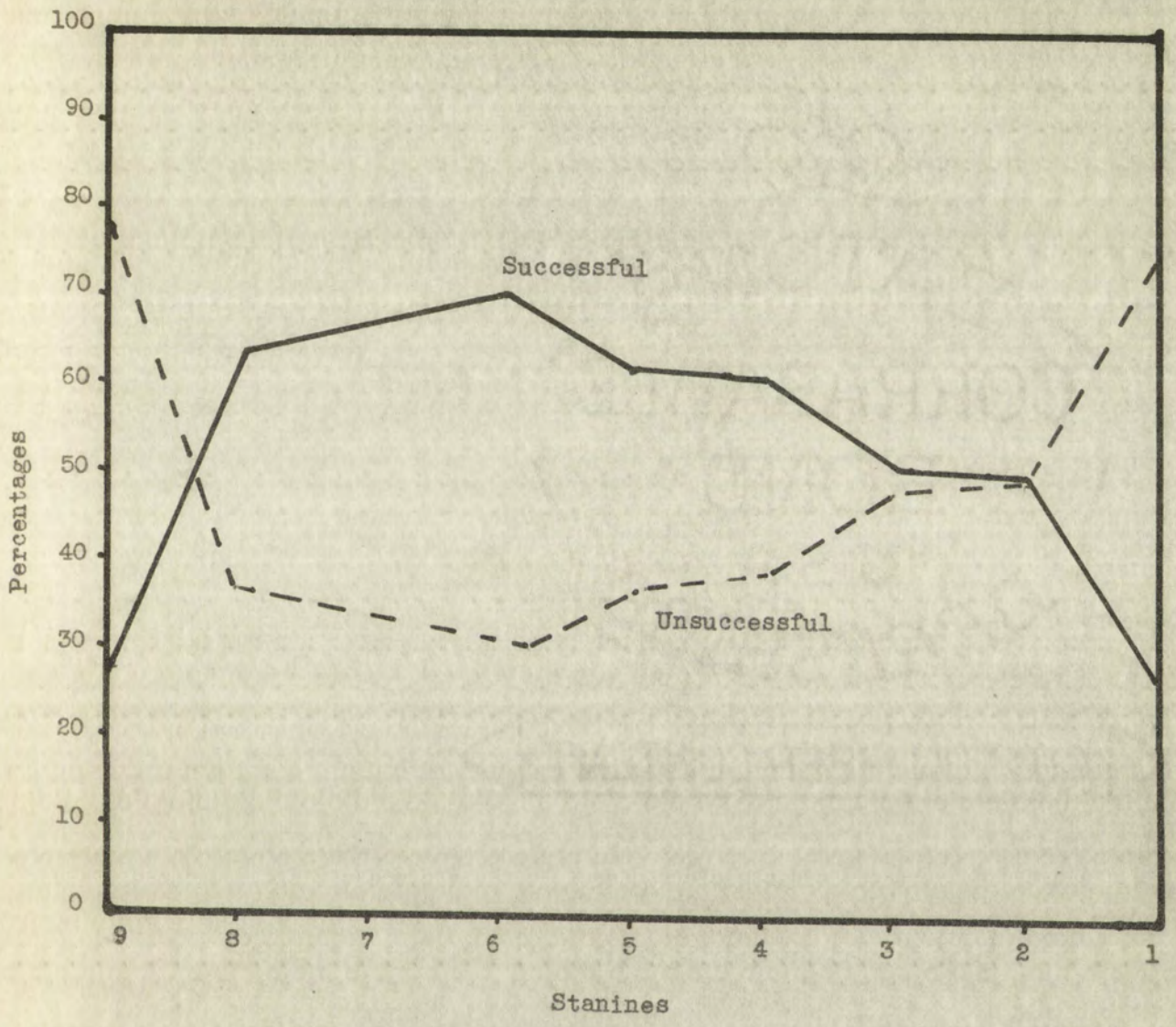
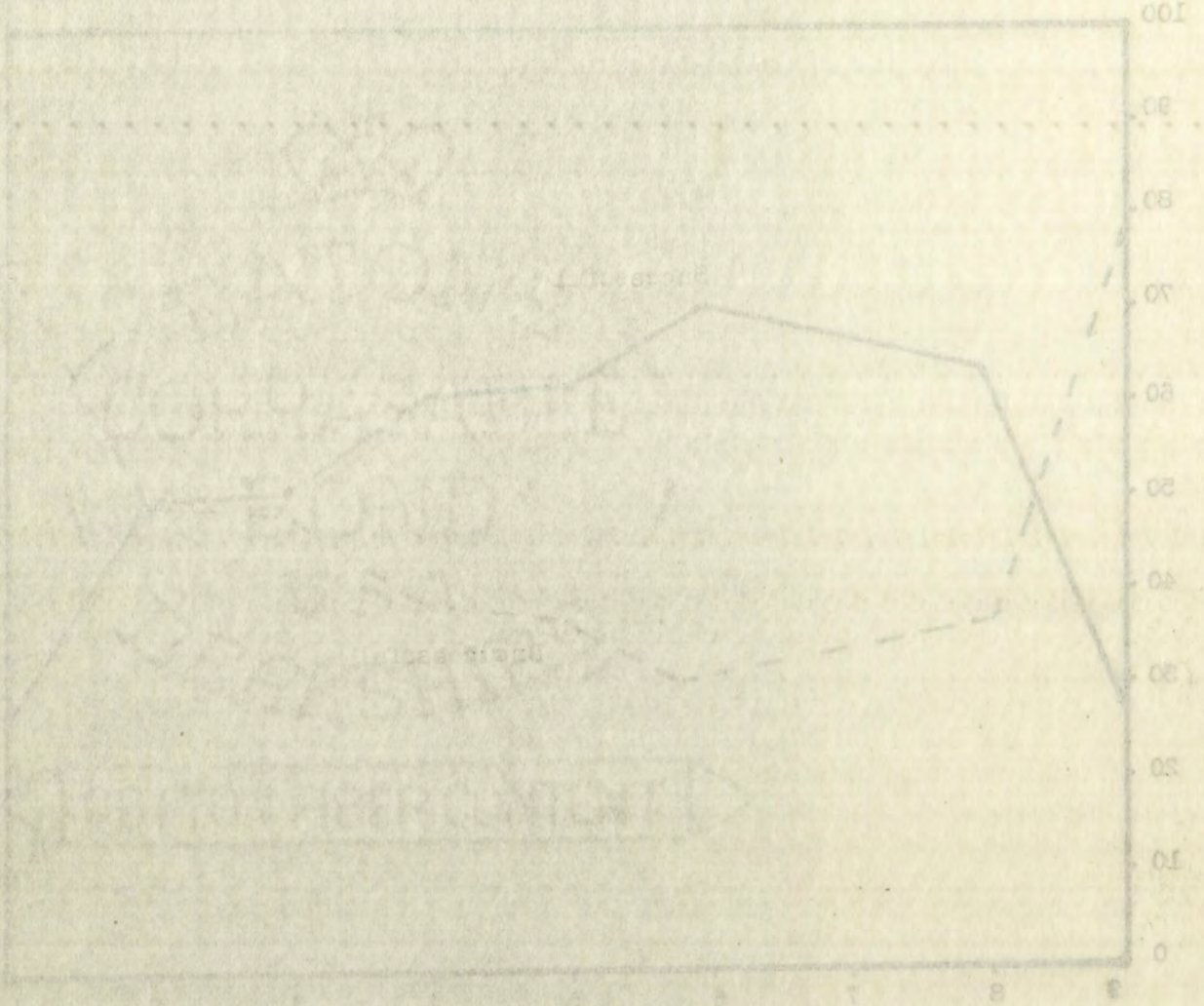


Figure 2. Percentages of Students Who Were Successful and Unsuccessful in Each Stanine of L Scores on ACE Psychological Examination



The T Score

The T score of the ACE test is a composite score, representing a combination of the L score and Q score. Since there is disparity of predictive value between the L and Q scores, and the T score is a composite of the two, we might expect the latter to prove less valuable than the Q score, but more valuable than the L score. This is indeed the case, as may be seen by examination of Tables 9, 10, 11 and 12, and Figure 3, all pertaining to the T scores. Therefore no analysis will be made of these results, which add nothing of value to this study.

Table 9

Distribution of Number of T-Scores on

ACE Psychological Examination

	Stanines									
Category	9	8	7	6	5	4	3	2	1	Sum
Graduates	0	14	31	48	42	28	11	2	0	176
Successful Transfers	3	6	15	16	16	8	8	2	1	75
Unsuccessful Transfers	2	5	9	22	21	22	14	3	2	100
Suspended	0	0	5	9	14	14	2	4	1	49
Totals	5	25	60	95	93	72	35	11	4	400
Successful	3	20	46	64	58	36	19	4	1	251
Unsuccessful	2	5	14	31	35	36	16	7	2	149
Totals	5	25	60	95	93	72	35	11	4	400

Table 10

Percentagesof T-Scores for Success Categories on

ACE Psychological Examination

	Stanines								
Category	9	8	7	6	5	4	3	2	1
Graduates	0	56	52	50	45	39	31	18	0
Successful Transfers	60	24	25	17	28	10	23	18	25
Unsuccessful Transfers	40	20	15	23	22	31	40	28	50
Suspended	0	0	8	10	15	20	6	36	25
	100	100	100	100	100	100	100	100	100
Successful	60	80	77	67	63	49	54	36	25
Unsuccessful	40	20	23	33	37	51	46	64	75
	100	100	100	100	100	100	100	100	100

Table 11

Percentages of T Scores on ACE Psychological Examination Falling Above Various Stanine Level Cut Points by Categories of Success

	Stanines *								
Category	9	8	7	6	5	4	3	2	1
Graduates	0	8	26	53	77	93	99	100	100
Successful Transfers	4	12	32	53	75	85	96	99	100
Unsuccessful Transfers	2	7	16	38	59	81	95	98	100
Suspended	0	0	10	29	57	86	90	98	100
Successful	1	9	28	53	77	90	98	100	100
Unsuccessful	1	5	14	35	58	82	93	97	100
Total†	1	8	22	46	70	88	96	99	100

* The scores falling in the given stanines are included in the percentages. That is, the cut point is below the given stanine.

† The total gives the percentage of applicants that would have been admitted if only those in or above the respective stanines had been admitted.

Table 12

Percentage of Successful Students to Total Students

Above Each Stanine Level for T Scores

	Stanines								
	9	8	7	6	5	4	3	2	1
Percentage	60	77	77	72	64	65	64	63	63

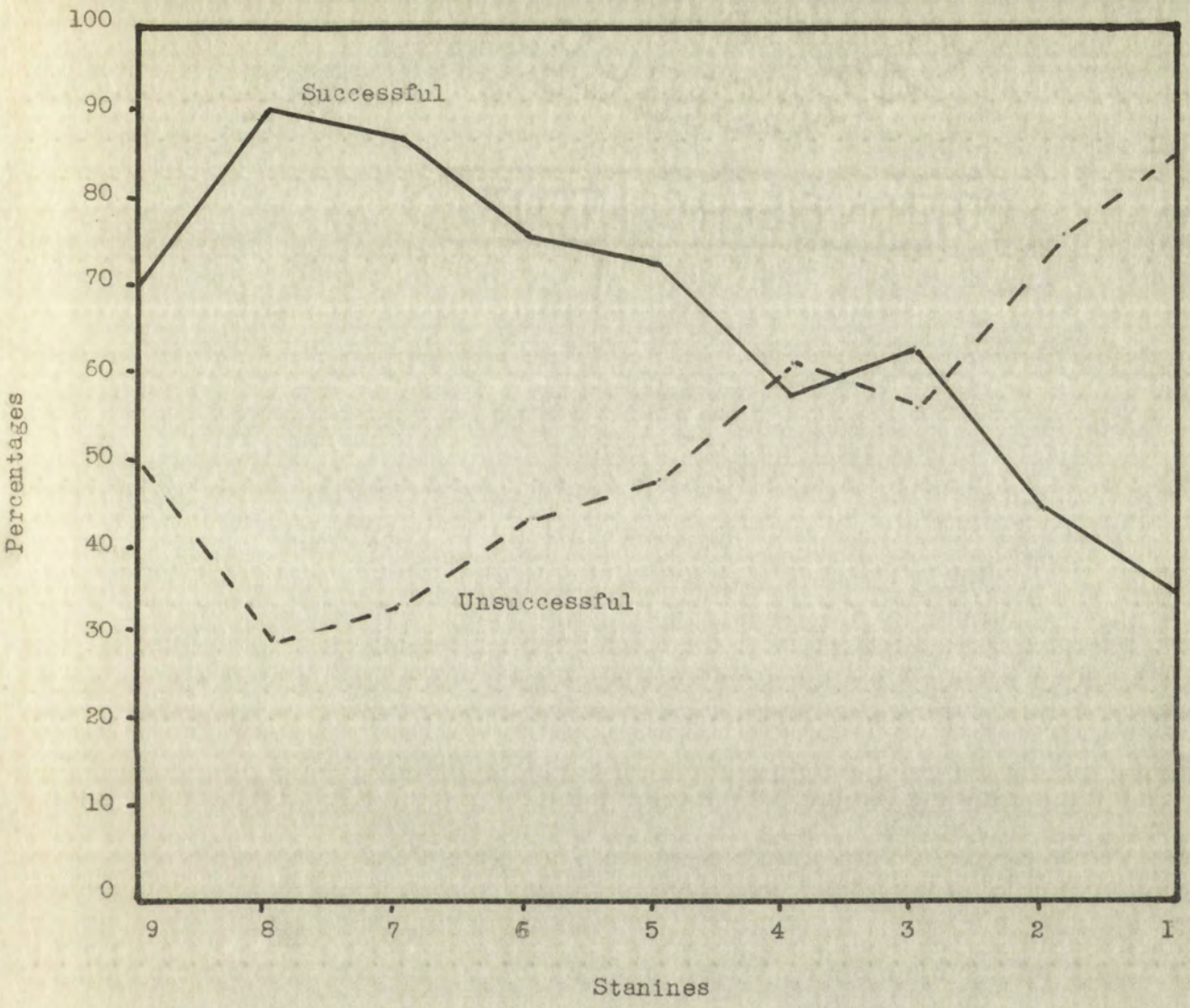


Figure 3. Percentages of Students Who Were Successful and Unsuccessful in Each Stanine of T Scores on ACE Psychological Examination

Pre-Engineering Ability Score

Tables 13, 14, 15 and 16 and Figure 4 present the data pertaining to the Pre-Engineering Ability Test. Note that the total number of scores is, in this case, 330. For some students who were scored on the ACE, there were no scores on record for this test.

Examination of Table 15 and Figure 4 shows that on this test, as on the Q scores, there is a point, within stanine 4, above which there is a rapidly increasing chance of success, and below which there is a rapidly increasing chance of failure, this latter amounting to 2-to-1 at stanine 3, and 4-to-1 at stanine 2.

Analysis of the data of Table 15, using the division between stanines 3 and 4 as the point of analysis, reveals the following facts:

1. Of the Graduates, 94% ranked 4 or better.
2. Of the Successful Transfers, 91% ranked 4 or better.
3. Of the Unsuccessful Transfers, 65% ranked 4 or better.
4. Of the Suspended group, 60% ranked 4 or better.
5. Of all 330 students, 82% ranked 4 or better.
6. Of the combined Successful group, 92% ranked 4 or better.
7. Of the combined Unsuccessful group, 64% ranked 4 or better.

Thus a cut point below stanine 4 would have admitted 92% of the successful students, and 64% of the unsuccessful. It would have eliminated 8% of the successful, and 36% of the unsuccessful. It is seen that this difference is much larger than was the case for any of the previous three scores. At this point, therefore, this test may be said to be more useful for differentiating between successful and unsuccessful students.

Application of the chi square test to this data shows that a cut score below stanine 4 separates two groups of students, Successful and Unsuccessful, far beyond the .01 level of significance.

Table 15 also shows what percentage of students would have been admitted, with cut points at respective stanine levels. Thus, if a cut point were below stanine 3, 95% of the students would have been admitted, and if a cut point were below stanine 5, 61% of the students would have been admitted.

Table 16 shows what percentage of students admitted at the various stanine level cut points would have been successful.

Figure 4 presents graphically the distribution of Successful and Unsuccessful students at the various stanine levels. The apparent reversal of trend at stanine 9 must be interpreted in light of the fact that there were only 3 cases at this point, which is not sufficient for accurate percentage representation.

With a grouping of all scores at stanine 4 or above as High, and of all below as Low, the tetrachoric correlation coefficient (r_t) was computed for the relation between High and Low standing in the test, and Successful and Unsuccessful groups. The r_t was .63, which is highly significant.

Table 13

Distribution of Number of Scores on

Pre-Engineering Ability Test

	Stanines									
Category	9	8	7	6	5	4	3	2	1	Sum
Graduates	1	5	24	41	38	25	10	0	0	144
Successful Transfers	1	2	13	15	19	7	4	3	0	64
Unsuccessful Transfers	0	0	5	9	12	27	20	8	0	81
Suspended	1	0	1	6	7	10	11	5	0	41
Totals	3	7	43	71	76	69	45	16	0	330
Successful	2	7	37	56	57	32	14	3	0	208
Unsuccessful	1	0	6	15	19	37	31	13	0	122
Totals	3	7	43	71	76	69	45	16	0	330

Table 14

Percentages of Scores for Success Categories on

Pre-Engineering Ability Test

	Stanines								
Categories	9	8	7	6	5	4	3	2	1
Graduates	33	71	56	58	50	35	22	0	0
Successful Transfers	33	29	30	21	25	10	9	19	0
Unsuccessful Transfers	0	0	12	13	16	41	44	50	0
Suspended	33	0	2	8	9	14	25	31	0
Totals	99	100	100	100	100	100	100	100	0
Successful	67	100	86	79	75	46	31	19	0
Unsuccessful	33	0	14	21	25	54	69	81	0
Totals	100	100	100	100	100	100	100	100	0

Table 15

Percentages of Pre-Engineering Ability Test Scores

Above Various Stanine Level Cut-Points

by Categories of Success

	Stanines *								
Category	9	8	7	6	5	4	3	2	1
Graduates	1	4	21	50	76	94	100	100	100
Successful Transfers	2	5	26	50	80	91	98	100	100
Unsuccessful Transfers	0	0	6	17	32	65	90	100	100
Suspended	2	2	5	19	36	60	87	100	100
Successful	1	5	22	49	76	92	99	100	100
Unsuccessful	1	1	2	18	33	64	89	100	100
Total +	1	3	16	38	61	82	95	100	100

* The scores falling in a given stanine are included in the percentages. That is, the cut point is below the given stanine.

+ The total gives the percentage of total applicants that would have been admitted if only those in or above the respective stanines had been admitted.

Table 16

Percentage of Successful Students to Total Students Above Stanine Levels for Pre-Engineering Ability Test

	Stanines								
	9	8	7	6	5	4	3	2	1
Percentages	66*	90	87	82	80	71	65	63	63

*Note that this percentage is a distortion, due to the fact that there were only three cases at this level.

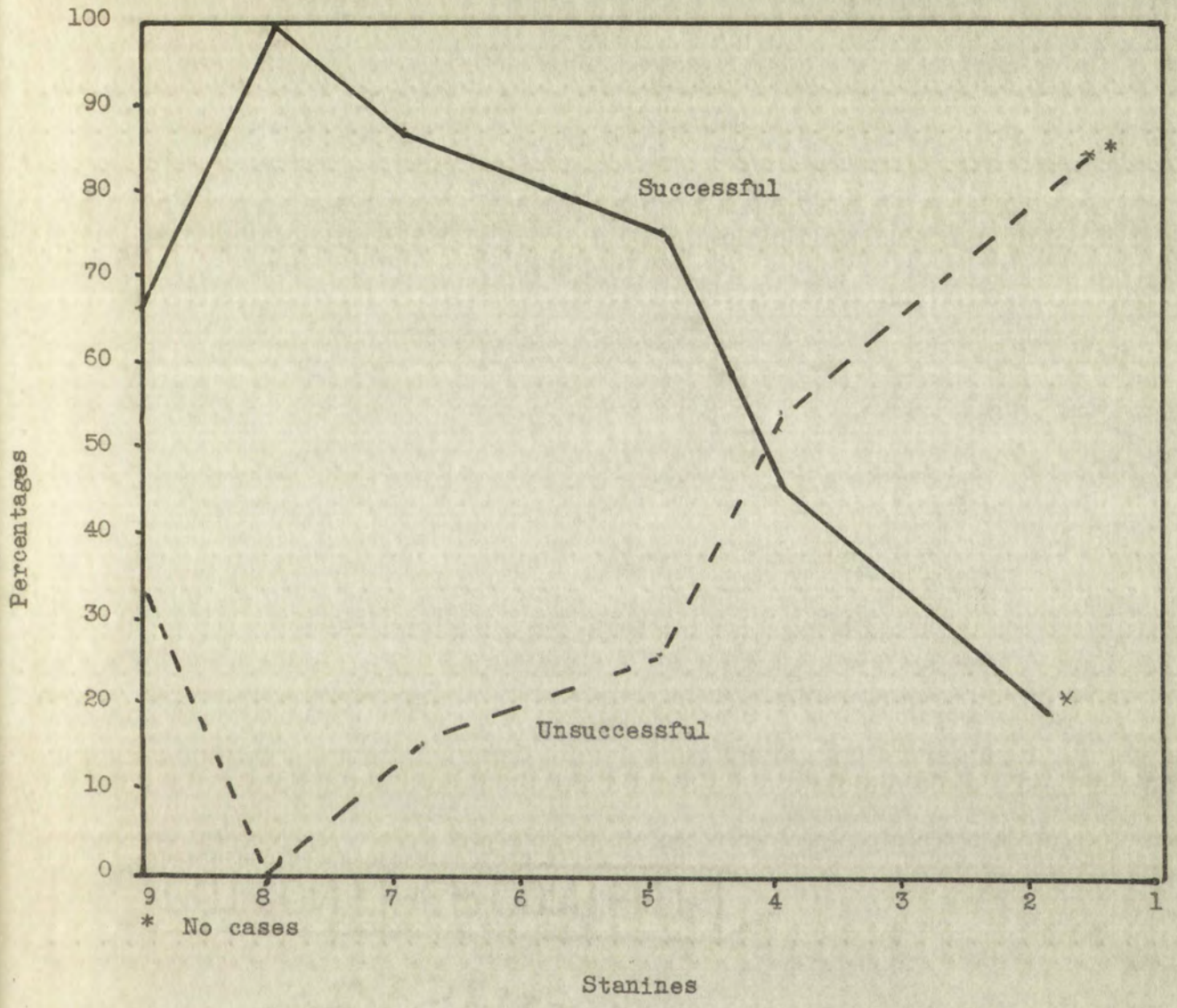
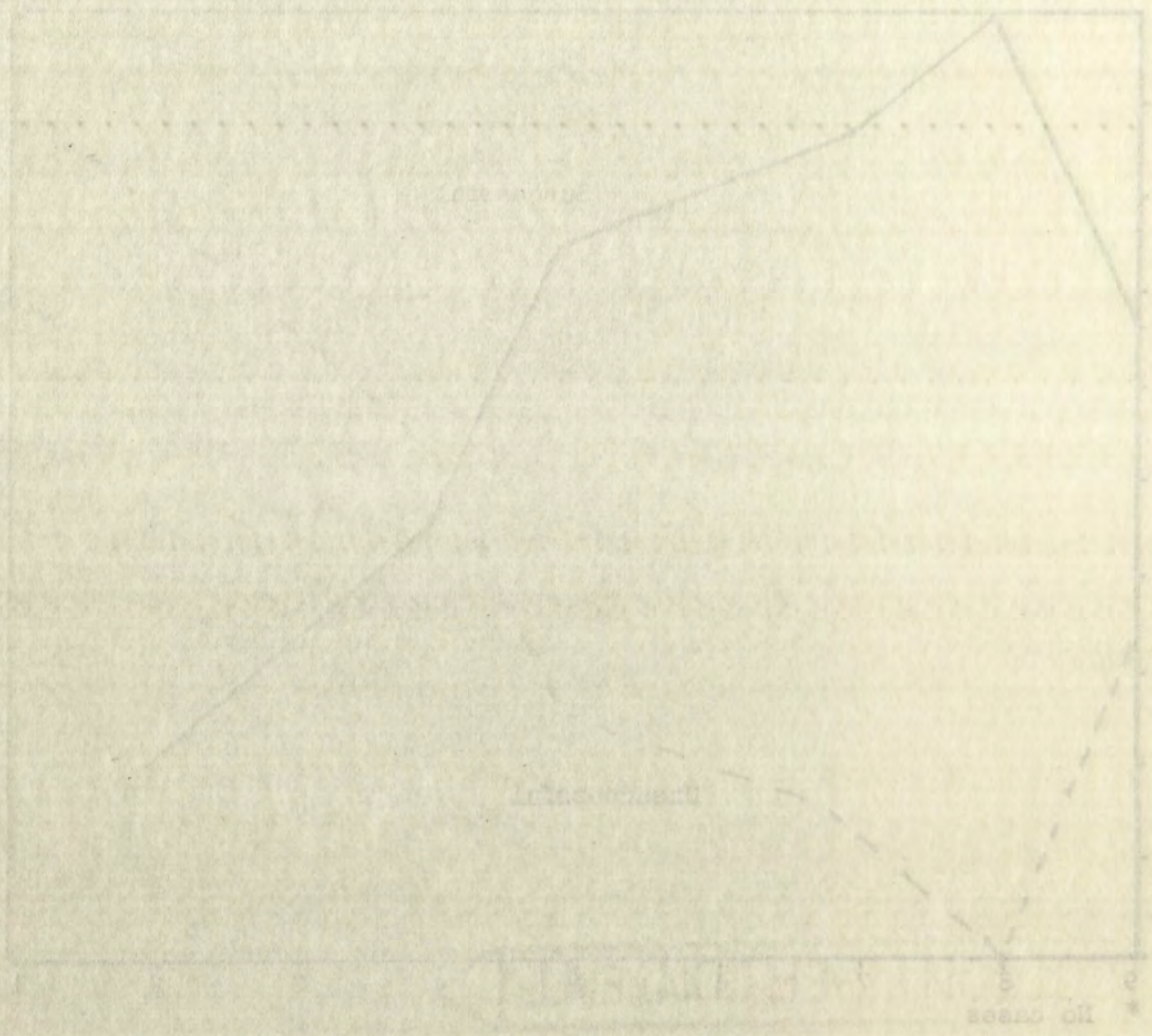


Figure 4. Percentages of Students Who Were Successful and Unsuccessful in Each Stanine of Pre-Engineering Ability Test Scores



University of Nebraska Mathematics Placement Test

The scores of this test were scaled into only two groups, those which exceeded a cut score which was a combination of the scores on two parts of the test (scores of 10 and 40 respectively), and those which did not exceed this cut score. For the purpose of this study, the first group is here designated "High", and the second "Low".

Tables 17, 18, and 19 present the data pertaining to the grouping of scores and categories of students, according to the results of this test. Note that the number of students for whom this data was available was 374.

Examination of the tables shows a strong positive correlation between mathematics placement level, as established by this test, and chance of success in engineering courses. Application of the chi square test shows that the differentiation of Successful and Unsuccessful students on the basis of High and Low scores on this test is valid at the .01 level of confidence.

Table 18 shows the percentage of each category of students who scored High and Low. Particularly striking is the fact that of the actual Graduates, 92% scored High. Also noteworthy is the fact that the 25% of the entire group who scored Low accounted for 45% of the Unsuccessful records, while the 75% who scored High accounted for 88% of the Successful records.

Table 19 shows that of the Low group, only 31% succeeded, while of the High group, 73% succeeded.

A tetrachoric correlation coefficient (r_t) was computed for the relation between High and Low scores and Successful and Unsuccessful groups. A r_t of .61 was found, which is highly significant statistically.

The fact that this test is an achievement test must enter into the interpretation of these results, since achievement tests reflect more of

specific school opportunity than do aptitude tests. The results here may be interpreted to indicate that the more adequate foundation in mathematics greatly enhances the chances of success in engineering college. They may also mean that those students who have shown interest in and ability for mathematics in high school have demonstrated to a high degree the requisites for success in engineering college. In any case, the results here shown would seem to indicate that success in mathematical training prior to undertaking an engineering course may make the difference between a student's having a greatly preponderant chance of success, or a strong chance of failure.

Inequalities of scientific education among widely scattered school systems, and even at times within the same school system, are admitted facts. It appears possible that among students who present themselves for entrance to engineering college, some may have aptitude, as evidenced by good scores on the Pre-Engineering Ability Test and the Q score on the ACE, but have deficient preparation in mathematics, as reflected by poor scores on the Mathematics Placement Test. Proper attention to improving this preparation, prior to admittance to engineering courses, might result in the avoidance of failure by such students. With 92% of Graduates scoring High on this test, it might seem advisable to make a High score a prerequisite to admittance to engineering courses. However, in the interest of keeping all potentially successful students in engineering, it would also be important to ascertain the reasons for Low placement on this test. For some it might be lack of ability, for others possibly lack of stimulation, low standard of local requirements, or lack of available advanced high school mathematics courses in the home community. For a few, there might have been a late awakening

in the adolescent of interest in engineering, at a time too late for him to complete an adequate preparation in mathematics. Thus some preliminary college mathematics courses might serve to differentiate between students who lack ability for engineering and those whose deficiency is in preparation.

It must be observed, however, that of the Unsuccessful group, a higher percentage scored High on this than scored Low. Therefore a High score on this test is not of itself sufficient indication of probable success. In view of the many factors that may influence a student's performance on this test, it would seem wise that it be used only in conjunction with other tests, in assessing the student's potentiality for success.

Table 17

Number of High and Low Scores by Categories on

University of Nebraska Mathematics Placement Test

Category	Low	High	Totals
Graduates	14	151	165
Successful Transfers	15	53	68
Unsuccessful Transfers	39	57	96
Suspended	25	20	45
Totals	93	281	374
Successful	29	204	233
Unsuccessful	64	77	141
Totals	93	281	374

Table 18

Percentage of Low and High Scores by Categories on University of Nebraska Mathematics Placement Test

Category	Low	High	Totals
Graduates	8	92	100
Successful Transfers	22	78	100
Unsuccessful Transfers	41	59	100
Suspended	56	44	100
Successful	25	75	100
Unsuccessful	45	55	100
Total Group	25	75	100

Table 19

Percentage of Successful and Unsuccessful Students in Scoring Groups

University of Nebraska Mathematics Placement Test

	Low	High
Successful	31%	73%
Unsuccessful	69%	27%
Totals	100%	100%

A Suggested Battery

After the foregoing analyses had been made of the scores of the individual tests in relation to academic success, a study was made of the relations between a combination of the scores of the three tests which had proved most valuable, and success in engineering studies. This combination of tests, hereafter called the "Battery", consisted of the ACE Q section, the Pre-Engineering Ability Test, and the University of Nebraska Mathematics Placement Test. Preliminary findings had established that a point between stanines 3 and 4 made valid and practical separation between Successful and Unsuccessful students, on the basis of the Q scores and Pre-Engineering Ability Test. Therefore, for comparison with results of the Mathematics Placement Test and the Battery, all students who ranked in stanine 4 or higher in these scores, were grouped as High, and all students below stanine 4 were grouped as Low. For the Battery, all students who ranked High on all three tests, were grouped as High, and all students who ranked Low on any one or more of the three tests, were grouped as Low.

Data pertaining to the Battery are shown in Tables 20, 21 and 22. From Table 22, it may be seen that the Battery makes a very good differentiation between Successful and Unsuccessful students, the High group including 85% of the Successful and only 40% of the Unsuccessful, while the Low group includes only 15% of the Successful and 60% of the Unsuccessful students. This Battery would be especially valuable for eliminating Unsuccessful students, of whom 60% did not make the High group. However, a requirement of High rank on the Battery would also have eliminated 15% of the Successful students. It may also be noted here, that of the 72 Unsuccessful students

who ranked Low on the Battery, 31, or 43%, ranked High on both aptitude tests, and Low only on the Mathematics Placement Test. As was pointed out in discussion of the Mathematics Placement scores, some special preparation in mathematics might affect their ultimate success considerably. However, it was also found that of the 32 Successful students who ranked Low on the Battery, 16, or 50%, ranked High on the aptitude tests, and Low only on the Mathematics Placement Test. This would seem to indicate that the low mathematics preparation can be overcome by some good students with good aptitude. The difference between these Successful students with Low rank on the Battery, and the Unsuccessful who also were Low, may be to a large extent the factors of drive, determination, and self-discipline which these tests cannot measure.

A Comparison of Results

Table 23 summarizes for comparison the percentages of students, Successful and Unsuccessful, who placed High on the individual tests and on the Battery, and the tetrachoric correlation coefficients, for the tests and for the Battery, of Successful and Unsuccessful groups and High and Low test rank. It may be seen that the test results show varying proportions of Successful and Unsuccessful students to have ranked above and below the suggested cut points for the respective tests. It is also shown that some of the test measures discriminate much more clearly than others between the Successful and Unsuccessful groups, with the Battery discriminating far better than any single test.

Table 20

Number of Successful and Unsuccessful Students

Who Ranked High and Low on Battery

Category	Low	High	Total
Successful	32	178	210
Unsuccessful	72	48	120
	104	226	330

Table 21

Percentage of Students Low and High on Battery

Who Were Successful and Unsuccessful

Rank	% Successful	% Unsuccessful	Total
Low	31	69	100
High	79	21	100

Table 22

Percentage of Successful and Unsuccessful Students

Who Ranked High and Low on Battery

	Low	High	Total
Successful	15%	85%	100%
Unsuccessful	60%	40%	100%

Table 23

Comparison of Individual Tests and Battery

	Tests			
	ACE-Q	Pre-Eng.	Math. Pl.	Batt.
1. % of Students, Successful and Unsuccessful, in High Group				
Successful	96	92	88	85
Unsuccessful	84	64	55	40
2. % of Students, in High and Low Groups, Who Were Successful				
High	66	71	73	79
Low	34	29	27	21
3. Tetrachoric Correlation Coefficients				
	.25	.63	.61	.69

Chapter V

Discussion and Conclusions

This chapter is concerned with some considerations which should be borne in mind in interpreting and evaluating the preceding material, and with conclusions.

In the review of the literature, it was seen that most of the studies of the predictive value of tests have been concerned with correlations between test scores and grade point averages for the first year, or at most for the first two years. There is therefore an important difference between the present study, in which the four or five year record of the students has been studied, and the previous studies cited. From one standpoint, this might seem to make the present study more definitive, since it allows for the ultimate criterion of success, graduation. However, insofar as this is a study of the validity of tests for prediction, rather than of the careers of the students, the time element may have contributed little to its value. Perhaps students show as well in their first year, as in four or five, the extent to which these tests have measured their abilities for academic success. An interesting and perhaps instructive study would be a comparison of the long-term predictive value of these tests, as indicated in this study, with their short term value for prediction of first year success of the same group of students.

In evaluating these results, it should be borne in mind that the students involved were to some extent a pre-selected group. It seems logical to assume that most of the students who would attempt an engineering course would have had some previous evidence of aptitude or special

interest in it. Thus, the relationships between test results and academic success should be less clear-cut than would be the case if the students involved were a general college population. The attempt here is to differentiate among an already restricted group of students. In view of this fact, the results obtained with these tests are more significant than might seem apparent.

The choice of tests to be used in the selection of students would seem to be a matter of the primary objective of the College of Engineering. If the primary aim is to admit a very large proportion of potentially successful students, the Q score of the ACE might be used as criterion, with knowledge that this would also involve admitting a large proportion of potentially unsuccessful students. On the other hand, if the primary objective is to weed out a large proportion of the potentially unsuccessful students, the criterion of High rank on the Battery, involving High rank on all three of the best tests, might be chosen, with knowledge that this would also involve eliminating a fair proportion of potentially successful students. Between these two extremes, there are the Pre-Engineering Ability Test and the Mathematics Placement Test, which could be used in conjunction with each other, to assess two aspects of student potential, aptitude and preparation. Thus we see that each of the four test measures can be successful in its own way, or in conjunction with the others. It is recommended that the College of Engineering study the results obtained with the various measures, to determine which best suit its purposes.

Summary and Recommendations

The findings and recommendations of this study may be summarized as follows:

1. Three of the test scores showed significant relationship with student success in the College of Engineering. These were the scores of the Q section of the ACE Psychological Examination for College Freshmen, the Pre-Engineering Ability Test, and the University of Nebraska Mathematics Placement Test. The relationships for the latter two were highly significant, with tetrachoric correlation coefficients for the relation between High and Low test rank and Successful and Unsuccessful student grouping of .63 and .61 respectively.

2. A cut point which is statistically valid and also practically useful for admissions purposes was found to exist, for the ACE Q scores and the Pre-Engineering Ability Test scores, at a division between stanines 3 and 4 of the stanine scale.

3. Students who ranked above the cut point on these two scores, and also above the Mathematics Placement Test cut point already established by the University for placement in mathematics courses, were found to be widely differentiated, in favor of success, from students who placed below the cut point on any of the three test measures. The use of the three scores as a battery is recommended for the purpose of making the best differentiation between potentially Successful and Unsuccessful students. A requirement of High standing on all three tests would, however, have eliminated 15% of the ultimately Successful students.

4. Special mathematics preparation is recommended, as pre-requisite to admission to engineering courses, for students who rank above the

cut point on the two aptitude tests (the ACE Q test and the Pre-Engineering Ability Test), but below the cut point on the Mathematics Placement Test.

5. It is recommended that a study be made, comparing these results concerning the long-range predictive value of the tests, with results of a similar study of the same student group and the same test scores, on a short-range basis, using success in the first year of engineering college as criterion. This might indicate whether there is any particular value in a long-range study, such as this one, in establishing the validity of the tests concerned.

6. It is recommended that a study similar to this one be made, after a period of a few years, to determine whether the findings of this study can be considered valid on a long term basis, for practical selection of, or advising of students.

References

Books

1. Guilford, J. P. Statistics in Psychology and Education. New York: McGraw Hill, 1942.

Periodical Literature

2. Bartlett, Russell S. Guidance and Placement of Engineering Students. J. Eng. Ed., 1943, 33, 535-551.

3. Berdie, R. T. & Sutter, Nancy A. Predicting Success in Engineering Students. J. Educ. Psychol., 1950, 41, 184-190.

4. Carrillo, Lawrence W. J. & Reichart, Robert R. Use of a Caution Factor to Increase Predictive Value of the ACE Examination for Students of Engineering. J. Educ. Research, 1952, 45, 361-368.

5. Coleman, W. An Economical Test Battery for Predicting Freshman Engineering Course Grades. J. Appl. Psychol., 1953, 37, 465-467.

6. Drake, L. E. & Thomas, W. T. Forecasting Academic Achievement in the College of Engineering. J. Eng. Ed., 1954, 44, 275-276.

7. Gregg, George W. An Investigation of the Reliability and Validity of the Engineering and Physical Science Aptitude Test. J. Educ. Research, 1951, 45, 299-305.

8. Harris, D. Factors Affecting College Grades: A Review of the Literature. Psychol. Bull., 1940, 37, 125-166.

9. Johnson, A. P. College Board Mathematical Test and the Pre-Engineering Inventory Predict Scholastic Success in Colleges of Engineering. Amer. Psychologist, 1950, 5, 353.

10. Johnson, A. P. Tests and Testing Programs of Interest to Engineering Educators. J. Eng. Ed., 1951, 41, 277-283.

11. Jones, Vernon. Prediction of Student Success in an Engineering College. Amer. Psychologist, 1948, 3, 295.

12. Jones, Margaret, & Case, H. H. The Validation of a New Aptitude Examination for Engineering Students. Educ. Psychol. Measmt., 1955, 15, 502-508.

13. Kalin, E. S. Selection of Entering Students by Colleges of Engineering. J. Eng. Ed., 1957, 47, 553-555.

14. Laycock, S. R. & Hutcheon, N. B. A Preliminary Investigation into the Problem of Measuring Engineering Aptitude. J. Educ. Psychol., 1939, 30, 280-288.

15. Lord, T. & Cowles, J. T. & Cynamon, M. The Pre-Engineering Inventory as a Predictor of Success in Engineering Colleges. J. Appl. Psychol., 1950, 34, 30-39.

16. Malloy, John P., Wysocki, Boleslaw, & Graham, Leo T. Predicting Attrition-Survival in First Year Engineering. J. Educ. Psychol., 1955, 46, 217-221.

17. McLanahan, W. R. & Morgan, D. H. Use of Tests in Counseling Engineering Students in College. J. Educ. Psychol., 1948, 39, 491.

18. Moore, J. E. A Decade of Attempts to Predict Scholastic Success in Engineering Schools. Occupations, 1949, 27, 92-96.

19. Moore, Roland C. A Note on the Validity of the Pre-Engineering Ability Test. J. Eng. Ed., 1952, 42, 512.

20. Porter, J. M., Jr. Prediction of Success in an Engineering Curriculum. Amer. Psychologist, 1946, 1, 278.

21. Sessions, T. Q. An Analysis of the Predictive Value of the Pre-Engineering Ability Test. J. Appl. Psychol., 1955, 39, 119-123.

22. Siemens, Cornelius H. Forecasting the Academic Achievement of Engineering Students. J. Eng. Ed., 1942, 32, 617-621.

23. Slaymaker, R. R. Admission Test Procedure. J. Eng. Ed., 1946, 7, 37, 402-413.

24. Thurstone, L. L. Mental Tests for College Entrance. J. Educ. Psychol., 1919, 10, 129-142.

Bulletins

25. Layton, Wilbur L. (Ed.) Selection and Counseling of Students in Engineering: Minn. Studies on Student Personnel Work, No. 4. Minneapolis: U. of Minn. Press, 1954.

Unpublished Materials

26. Wellck, A. A. The Prediction of Academic Success in the College of Engineering of the University of New Mexico. A paper read before the annual meeting of the Southwest Section of the American Society for Engineering Education at the University of New Mexico, April 3, 1953.

27. Jex, F. B. The Predictive Value of the Pre-Engineering Inventory. Unpublished Master's Thesis, U. of Utah, 1947.

Dissertation Abstracts

28. Crook, William Ramaden. The Value of Personality Questionnaire Items in the Prediction of Outcomes in College Engineer Training. Ph.D. Thesis, U. of Minn., 1952. Dissertation Abstracts, 1953, 13, 255-256. Psychological Abstracts #3282, 28, 294.

Catalog

29. Cooperative Tests Programs Service, 1957 Catalog, Educational Testing Service, Princeton, N. J. Description of Psychological Examination for College Freshmen.

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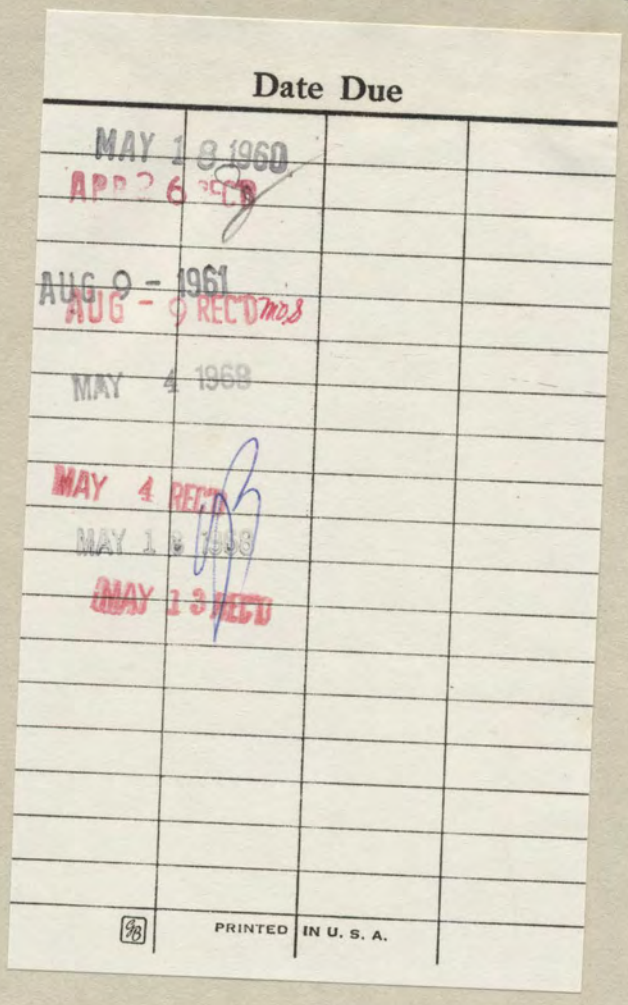

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