ABSTRACT OF THESIS

USE OF STANDARDIZED TESTS IN COUNSELING FRESHMEN IN THE ENGINEERING DIVISION, COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

Submitted by

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In partial fulfillment of the requirements

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ABSTRACT

The problem of the student who does not succeed in the Engineering Division of Colorado Agricultural and Mechanical College is of prime importance to the individual and to the college. It is generally recognized that some students fail in college engineering courses because of their lack of ability to succeed in the type of subjects taught in the engineering curriculum. Various psychological testing instruments are used in college counseling programs to assist in discovering and counseling students who will fail if they persist in pursuing a course inappropriate to their abilities.

The efficiency with which prospective failing students at Colorado Agricultural and Mechanical College are discovered and counseled depends largely on the counselor's knowledge of the prognostic value of the data furnished him, and the consistency of the interpretation which he makes of such data.

The problem

The problem, then, is: How can the data available to advisers be used most effectively in the counseling

program of Colorado Agricultural and Mechanical College for the guidance of freshman students in the Division of Engineering?

Analysis of the problem.--1. What is the relationship between grades achieved during the freshman year and graduation in the Engineering Division?

2. What relationship is there between scores achieved by freshman students on various psychological tests and grades achieved during the freshman year in the Engineering Division?

3. What is the relationship between high-school academic achievement expressed in terms of rank in the high-school graduating class and grades achieved during the freshman year in the Engineering Division?

4. What factors or combination of the factors considered are of optimum value in forecasting grade-point average for the freshman year in the Engineering Division?

5. What weights should be assigned to the retained factors to secure optimum prediction of the student's grade-point average during the freshman year in the Engineering Division?

6. How can these data be used by counselors at Colorado Agricultural and Mechanical College in counseling freshman students entering the Engineering Division?

Delimitation.--This study has been limited to the following groups:

1. Students admitted as freshmen the first semester of 1936-37, the Fall and Winter quarters of 1945-46, and the Fall quarter of 1946-47.

2. The American Council on Education Psychological Examination for College Freshmen, 1943 Edition; the Iowa Placement Examination Chemistry Aptitude, Series CA-2, Form M; the American Council on Education Cooperative English Test, Form PM, the Nelson-Denny Reading Test for Colleges and Senior High Schools, Form A.

3. The data obtainable from the credentials and records of students on file in the Registrar's office and the Office of Student Affairs, Colorado Agricultural and Mechanical College

The data were collected from the files of the offices of the college registrar and the dean of student affairs and included the following information:

1. The position of the student in his high-school graduating class.

2. Raw scores made by the students on the Iowa Placement Examination, Series CAI, revised, A, Chemistry Aptitude, to be referred to hereafter as the Chemistry test.

3. Raw scores made by the students on the Cooperative English Test, Form PM, to be referred to hereafter as the English test.

4. Raw scores made by the students on the American Council on Education Psychological Examination for high-school seniors and college freshmen, 1943, Edition, to be referred to hereafter as the A.C.E.

5. Raw scores made by the students on the Nelson-Denny Reading Test for Colleges and Senior High Schools, Form A, to be referred to hereafter as the Reading test.

6. Letter grades achieved in college subjects and the number of quarter credits earned in these subjects by the students.

The grade-point average attained by each student during his freshman year was selected as the criterion of freshman academic success in the engineering division. The files of each student contained the letter grades he achieved in each subject for which he had registered, and the number of quarter credits (semester credits in the September, 1936 and 1937, sample) given for each subject. The freshman grade-point average was computed as follows:

1. Weights were assigned each letter grade, so that an "A" equaled 4, a "B" equaled 3, a "C" equaled 2, a "D" equaled 1, and an "F" equaled 0.

"WF" (withdrawal failure) and "E" (incomplete) were counted as "F." "WP" (withdrawal passing) was disregarded.

2. Grade-points were computed by multiplying the number of credits by the weight assigned the letter grade.

3. The freshman grade-point average for the year was computed by dividing the sum of the total grade points earned during the freshman year by the total number of credits.

Samples studied.--Data from members of the freshman class entering in September, 1936 and 1937, were studied in order to select a critical freshman grade-point average which would be indicative of the lowest grade-point average which a student might acquire and still graduate from the engineering division. The September, 1936 and 1937, samples consisted of 114 engineering freshman students, 40 of whom graduated from the engineering division.

Data from members of the freshman class entering the engineering division in September, 1945, were studied to determine the relationship between data furnished advisers by the office of student affairs and freshman-year grade-point average. Fifty-seven engineering freshmen constituted the September, 1945, sample. Data on each of the variables (high-school rank, the A.C.E., and the English, Chemistry and Reading tests) were available for the following number of members of the sample:

1. English test scores, 43 students.
2. Chemistry test scores, 54 students.
3. Reading test scores, 54 students.
4. A.C.E. test scores, 55 students.
5. High-school rank, 35 students.
6. High-school rank, A.C.E. scores, English test scores, Reading test scores, and Chemistry test scores, 31 students.
7. A.C.E. and English, Reading, and Chemistry test scores, 44 students.

Data on members of the engineering freshman class, September, 1946, were studied to determine the efficiency of a formula derived from the September, 1945, sample study for predicting grade-point averages of succeeding freshman classes. One hundred engineering freshmen were selected for the September, 1946, sample by selecting every third name of students listed in alphabetical order. High-school rank, the A.C.E., and the English, Reading, and Chemistry test scores were all available for every member of this sample.

Statistical methods.--Statistical methods used in studying raw data from the 1945 sample in order to determine the relationship of various variables with first-year grade-point averages involved the following steps:

1. Zero-order correlations were computed to measure the statistical relationship between each of the variables and first-year grade-point averages.

These zero-order correlations were computed by using the Pearson product-moment method.

2. Intercorrelations were calculated between each of the variables and every other variable. This was done to determine the extent to which the various variables measured common factors.

3. Using these data, multiple-correlation coefficients were computed to obtain the relationship between various combinations of variables and grade-point averages.

4. With the most efficient predictive combination of variables, a regression equation was calculated. The regression equation is used as a device for predicting grade-point averages when raw scores of the variables are known.

5. The standard error of estimate ($\sigma_{(est)}$) was used to gauge the accuracy of predicting grade-point averages from the regression equation.

6. The coefficient of "forecasting efficiency" (E) was computed for each multiple coefficient of correlation in order to provide quick estimates of the efficiency of various combinations of variables for predicting grade-point average.

Using the regression equation, predicted grade-point averages were calculated for each member of the 1945 and 1946 samples. Zero-order coefficients of correlation

were calculated in order to determine the relationship between predicted and achieved grades in each of the 1945 and 1946 samples.

To simplify the computation of predicted grade-point averages when raw scores on variables were known, a nomographic predictive chart was derived from the regression equation, and probability scales, giving the chances in 100 that a student would make a grade equal to various grade levels when his predicted grade was known, were calculated by use of the standard error of estimate of the regression equation.

Findings

Raw data consisting of scores made by 44 freshman students entering the engineering division in September, 1945, were collected on five variables, other than marks achieved during the freshman year:

1. Cooperative English test, Form PM (variable 2)
2. Iowa Placement test, Chemistry Aptitude (variable 3)
3. Nelson-Denny Reading test (variable 4)
4. American Council on Education Psychological Examination (variable 5)
5. High-school rank (variable 6)

Zero-order coefficients of correlation were calculated between each of these variables and first-year grade-point average (variable 1) and found to be as follows:

1. $r_{12} = .583$
2. $r_{13} = .652$
3. $r_{14} = .495$
4. $r_{15} = .648$
5. $r_{16} = .359$

Multiple coefficients of correlation were calculated for the five variables in various combinations with one another. The combinations of variables which produced the highest multiple coefficient of correlation were:

1. r1.23456 = .848
2. r1.2345 = .848
3. r1.234 = .846
4. r1.23 = .814

For practical purposes, the combination of the variables, English and Chemistry test scores, was the most economical and practical battery to use in counseling and, therefore, was used in the calculation of the following regression equation:

$$\text{Grade-point average} = .008X_2 + .016X_3 - .16$$

where X_2 = English raw score, and

X_3 = Chemistry raw score.

The standard error of estimate was found to be .45 grade-point average. Using this figure a nomographic predictive chart was constructed to show the probability of attaining grades equal to or greater than various grade levels. This device was designed to assist advisers in using raw scores on a battery of the English and Chemistry

tests for counseling students. A study was made of freshman grades and chances of graduation for 114 students entering the engineering division in the September, 1936, and September, 1937, classes in order to find a critical freshman grade-point average.

This critical score was determined to discover students whose freshman-year grade-point average indicated probable failure in the engineering division. It was found that students who made below a grade-point average of 2.00 had little chance of graduating from the engineering division; therefore, the 2.00 grade-point average was selected as the critical score and was entered on the nomographic predictive chart to assist users in determining students who would probably fail.

The zero-order correlation between predicted first-year grades (from the nomographic chart) and obtained first-quarter grade-point averages of 100 students entering the engineering division in September, 1946, was found to be .657.

Summary and conclusions

The best single predictor of first-year engineering grades among the variables was the Chemistry test, followed by the A.C.E., the English test, and the Reading test. Intercorrelations indicated that the English test, the A.C.E., and the Reading test measure much the same thing and that of the three, the English test is the best

test to combine with the Chemistry test. The low correlation of high-school rank with first-year grades indicated it to be the poorest predictor.

Multiple coefficients of correlations indicated that the Chemistry and English tests were the best and most economical battery for predicting first-year grades. Addition of other variables did not increase the multiple coefficient enough to justify the additional work involved.

The regression equation and standard error of estimate are useful counseling devices which may be graphically represented on a nomographic chart to facilitate their use by advisers. By using the nomographic chart on which a critical score has been designated, advisers should be able to estimate the probability of students' succeeding in the freshman year of engineering and should be able to select students whose chances of graduating from the engineering division are small and who are, therefore, possibly in need of further clinical counseling.

T H E S I S

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Submitted by

Walter R. McClanahan

In partial fulfillment of the requirements
for the Degree of Master of Education
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COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

April 10 1947

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY WALTER R. McCLANAHAN

ENTITLED USE OF STANDARDIZED TESTS IN COUNSELING FRESHMEN IN THE ENGINEERING DIVISION, COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF EDUCATION

MAJORING IN GUIDANCE AND COUNSELING

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TABLE OF CONTENTS

TABLE OF CONTENTS.--Continued

TABLE OF CONTENTS.--Continued

LIST OF TABLES

LIST OF TABLES.--Continued

Chapter I

INTRODUCTION

The problem of the student who does not succeed in the Engineering Division of Colorado Agricultural and Mechanical College is of prime importance to the individual and to the college. Waste of public funds and waste of the economic resources of the student and his parents are involved when students pursue a course of study in which they ultimately will fail. Social waste is involved when a student withdraws from productive pursuits and strives for a goal which he cannot accomplish, and there is a detrimental effect on the personality of the student when he fails in realizing the goal to which he aspires.

Students without college training are generally admitted to the engineering course of study provided their high-school transcripts indicate sufficient credits in certain prescribed high-school subjects, and they are generally allowed to continue in this course as long as they maintain a certain prescribed average grade. That this practice is not completely adequate is evidenced by the number of students who commence the engineering course and fail to graduate. A system which permits the discovery of prospective failing students and directs them to a counselor for individual attention may reduce student mortality.

It is generally recognized that students experience varying degrees of difficulty with various types of college subjects and that some fail in college engineering courses because of their lack of ability to succeed in the type of subjects taught in the engineering curriculum. Various psychological testing instruments are used in college counseling programs to assist in discovering and counseling students who will fail if they persist in pursuing a course inappropriate to their abilities.

It has been the practice at Colorado Agricultural and Mechanical College to furnish counselors with data which may assist them in estimating the potentialities of entering freshmen. These data consist of the student's relative rank with other students in his high-school graduating class and his relative rank on psychological tests which have been administered to all freshmen admitted to Colorado Agricultural and Mechanical College.

The efficiency with which prospective failing students at Colorado Agricultural and Mechanical College are discovered and counseled depends largely on the counselor's knowledge of the prognostic value of the data furnished him, and the consistency of the interpretation which he makes of such data. The counselor needs to know the validity of the data for estimating success in the particular curriculum for which the student is being considered, and he needs to interpret the data with reliability.

The problem

The problem, then, is: How can the data available to advisers be used most effectively in the counseling program of Colorado Agricultural and Mechanical College for the guidance of freshman students in the Division of Engineering?

Analysis of the problem.--1. What is the relationship between grades achieved during the freshman year and graduation in the Engineering Division, Colorado Agricultural and Mechanical College?

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3. The data obtainable from the credentials and records of students on file in the Registrar's office and the Office of Student Affairs, Colorado Agricultural and Mechanical College.

The study has been restricted to the above limitations for the following reasons:

1. The freshman class entering in the Fall of 1936 was the last class whose members had the opportunity to complete their courses without the interruptions which occurred because of the war emergency, and therefore was possibly more representative of future classes than any other available sample.

2. The freshman classes entering in the Fall and Winter quarters of 1945-46 and the Fall quarter of 1946-47 were the first post-war freshman classes which may have been indicative of future freshman classes entering Colorado Agricultural and Mechanical College.

3. The standardized tests are regularly administered to all entering freshmen at Colorado Agricultural and Mechanical College, and are data used in the individual counseling of students.

Chapter II

REVIEW OF THE LITERATURE

The literature contained many studies investigating the relation of various predictive criteria to college grades. Douglas (8) in 1931, Segel (33) in 1934, Wagner (39) in 1934, Mills (30) in 1936, and Durflinger (12) in 1943, each have published summaries of the findings of numerous investigators of this problem. Some of the later summaries duplicated many of the earlier studies. The summary of Durflinger (12) included the findings of Douglas, Segel, and Wagner, and the results of several studies made during the period 1934 to 1943. These several summaries indicated that measures of high-school achievement and general aptitude tests have most frequently been used as prognostic criteria for college success.

Several studies of the factors related to the success or failure of students in engineering have been made in order to discover means of reducing student mortality in engineering college courses. These studies indicated the predictive value of various measures of high-school achievement, and general aptitude and special aptitude tests.

High-school achievement and college grades

High-school achievement expressed either in terms of grades or relative rank in the high-school graduating class has been found by some writers to be as good a predictor of college scholarship as any other single criterion.

Douglas (8) in his summary in 1931 reported an average correlation between college marks and high-school marks to be .54. Wagner (39) concluded in 1934 from her summary of studies that past achievement was the best indicator of future college achievement. She reported that the vast majority of studies indicated the high-school record to be the best single criterion for scholastic success in college.

Cole (5) in 1940 noted that actual correlations between high-school marks and college achievement grades found in different studies varied from .15 to .65, and concluded:

> The exact amount of agreement in any given case depends presumably upon the extent to which contributing high schools have had a common standard of marking. (5:299).

Cole (5) further stated:

> . . . the great variability in the performance of students (as measured by grades) coming from different (high) schools. . . is not a question of the reliability of marks within each (high) school system. The real trouble is that each teacher tends to assign grades within whatever range of abilities her particular group of pupils may show. (5:297)

and concluded:

> Marks that have been corrected for the variation from school to school still furnish the best single criterion of success in college --that is, the correlations show less variation than those between scholarship tests and college work, and the average coefficient is higher. (5:300).

Durflinger (12) concluded from his summary of previous studies in 1943 that the average correlation between college scholarship and high-school scholarship varied from .50 to .60 with a median of approximately .55. Williamson and Bordin (41) suggested the reason why high-school grades correlated higher with college grades than did various types of tests may have been partly because high-school marks measured in addition to past achievement, "(crude and uncomparable) judgments of motivation and study skills." (41:5)

Rank and high-school marks.--Rank in the high-school graduating class has been found to be a good prognostic criterion by some investigators. Tuttle (36) in a study at the University of Illinois in 1935 found that high-school rank was a good predictor of college success for students who were above the 75th percentile and below the 25th percentile but that it lost some of its value in the middle group. He concluded that there was a definite positive correlation between high-school achievement as indicated in rank in the graduating class and the length of attendance and degrees received.

Cole (5) in 1940 stated:

> . . . high school marks, . . . can be used quite effectively (for predicting college grades) if they are expressed in terms of rank order instead of letter grade or per cents. (5:299-300)

Williamson and Bordin (41) reported in 1942 that high-school percentile rank was the best single predictor in the College of Science, Literature, and the Arts, University of Minnesota.

High-school achievement and college engineering grades.--Seyler (34) in a study at the University of Illinois in 1937 found that high-school rank correlated .59 with engineering freshman scholastic average, and stated that it is possible to predict with considerable accuracy the scholastic success in the freshman year of a group of students whose percentile rank in class falls within certain limits. He found 59 to be the high-school percentile rank at which the most probable average of C was reached. He found 70.97 per cent of those falling at or above this rank made at least a C average, and that 75.07 per cent of those falling below this rank made less than a C average.

Bartlett (2) in 1943 reported extreme differences between the relative value of high school rank in a university engineering school and a smaller state engineering school. In his study of an endowed university engineering school, he found that high-school rank was the poorest single predictor compared with the American Council on Education Psychological Examination and various

Iowa Placement Examinations. In his study of a state college engineering school, he found high-school rank to be the best single predictor compared with the American Council on Education Psychological Examination and the Iowa Placement Examinations. He concluded that this difference was because of the homogeneity of the smaller college group, whose members came from high schools with similar standards located in more restricted geographical areas, while the university contained a hetergeneous group, whose members came from high schools of varying standards located in widely dispersed communities.

High-school achievement examinations and college marks.--Some investigators contended that an achievement examination is as good a criterion of potential scholastic achievement in college as the intelligence test. Condit (6) in 1929 in a study at Colorado State Teachers College found that "reliable achievement tests yield as good results for classification purposes as does a psychological examination." (6:335) and stated that

> The reason for this probably lies in the fact that an achievement test involves both intelligence and application, while the psychological examination measures little more than an abstract type of ability. (6:335)

Condit (6) reported a correlation of .45 between the Thurstone Psychological Examination and average first-year grades, and a correlation of .49 between achievement test scores and average first-year grades.

Williamson and Bordin (41) in a study at

Minnesota in 1938 found that a battery of six Cooperative Achievement Tests (General Mathematics for High Schools, English, Contemporary Affairs, Literary Acquaintance, and General Science) was, in general, superior to any one aptitude test, either the Ohio State University Psychological Test, the American Council on Education Psychological Examination, or the Minnesota College Aptitude Test, and nearly equal to high-school rank in predicting college scholarship. Leaf (27) in 1940 reported a correlation of .63 between the Iowa High School Content Examination and average freshman college grades. Eurich and Cain (14) in 1941 concluded that general achievement tests provided a close second to high-school averages as a single basis for prediction, and stated that correlations ranged from .39 to .64 for College Entrance Examination Board Tests and general college scholarship.

Douglas (8), Segel (33), Wagner (39), and Durflinger (12), in their summaries found that investigators reported many correlations between general achievement examinations and college scholarship. The median correlation between high-school content examinations and college scholarship found in these four summaries ranged from .475 to .56, Table 1 (12:73).

Durflinger (12) suggested that the reason for the lower correlation which he found in his summary of studies may have been because of the small number of studies summarized, or that the students may not have been

Table 1.--SUMMARIES OF CORRELATIONS BETWEEN CONTENT EXAMINATIONS AND COLLEGE SCHOLARSHIPS.

Author	Date	Number of studies	Median
Douglas	1931	67	.55
Segel	1934	13	.545
Wagner	1934	88	.56
Durflinger	1942	20	.475

prepared in one or two parts of the content examinations since high schools have accepted the view that there is no significant correlation between the number of units earned in particular high-school subject-matter fields and scholastic success in college. He concluded that a two-hour achievement test will predict college scholarship as well as the more laborious methods of accumulating the high-school record.

Psychological tests and college grade

One of the most frequently investigated criteria of scholastic success has been the intelligence or general aptitude test. A study made by Langhorne (25) in 1939 at Emory University indicated a significant relationship between the average percentile rank on an American Council on Education Psychological Examination and the length of time students were enrolled. Table 2, reproduced from his study, clearly demonstrates the

association he found between average percentile rank on the American Council on Education Psychological Examination and the number of quarters spent in college. He also reported that candidates for different degrees showed marked differences in average percentile rank on the American Council on Education Psychological Examination, ranging from 30.9 at the beginning of the first quarter to 63.6 at the beginning of the 12th quarter, Table 2.

Table 2.--INTELLIGENCE TEST RESULTS AS RELATED TO LENGTH OF TIME ENROLLED.

Quarters	0	1	2	3	6	9	12	Over 12
Ave. percentile in college	30.9	32.4	42.4	45.9	49.2	58.4	63.6	46.8

Table 3 contains several correlations between various psychological intelligence tests and grades in college reported in the studies summarized by Durflinger (12) in 1943, ranging from .41 to .70.

The median correlation of intelligence scores and college grades reported by Douglas (8), Segel (33), and Wagner (39) were between .40 and .50. Durflinger's summary (12) in 1943 of 47 correlations reported in various studies made from 1934 to 1942 a median correla- of .52 for the period, Table 4.

Williamson (40) in 1935 reported a study made

Table 3.--CORRELATIONS BETWEEN PSYCHOLOGICAL TESTS AND COLLEGE SCHOLARSHIP FROM DURFLINGER (12:70).

Investigator	Institution	Tests	Criterion grades	r
Butsch	Marquette U.	Thurstone	First semester	.46,.47 .49,.49 .52,.53.
Gladfelter	Temple U.	A.C.E.	First year	.52,.57 .59
Hepner	San Diego U.	A.C.E.	First year	.41
Manning	Ursinus U.	Otis S-A	First year	.50,.67
Morris	Albany Jr. College	Ohio State	First semester	.43
Quaid	Phillips U.	Ohio State	First year	.70
Quaid	Phillips U.	A.C.E.	First year	.66

at the University of Minnesota which indicated that the correlation of general aptitude tests and high-school achievement with college grades had decreased over a period of 11 years. He asserted that this was not because of increased homogeneity of the student body but was probably because of changes in educational and administrative procedures, criteria of college grades, or increased efficiency of student personnel guidance.

Cole (5) in 1940 summarized the reasons for the decline in correlation between general ability level and college achievement as follows:

> First the work of advising students in the high schools has resulted in a narrowing of the distribution of abilities because the poorest students do not go to college but are diverted by guidance into other types of education. The second is that colleges are working much more efficiently with their poorer students who now succeed better in their academic courses. The third is that many special courses have been established for below-average freshmen--courses in which they can receive good grades. (5:297)

Durflinger (12) in 1943 asserted that the higher correlation between intelligence tests and college grades which he found in studies made before 1934 when compared with studies made during the period 1934 to 1943 was probably due to a significant increase of relationship between college grades and intelligence tests. He attributed this increase to the designing of new intelligence tests primarily for college students, the assigning of grades on the basis of intelligence tests, and the possible basing of college marks on course examinations which have a closer relationship to intelligence tests.

Table 4.--SUMMARIES OF CORRELATION BETWEEN INTELLIGENCE AND COLLEGE SCHOLARSHIP FROM DURFLINGER (12:71).

Author	Date	Number	Median
Douglas	1931	160	.45
Segel	1934	100	.44
Wagner	1934	39	.40 to .50 incl.
Durflinger	1942	47	.52

Intelligence tests and engineering freshman grades.--Dvorak and Salyer (13) in 1933, in a study made at the University of Washington Engineering College, reported a correlation of .374 between the university freshman engineering average and the University of Washington Intelligence Test percentile scores. Laycock and Hutcheon (26) in a study at the University of Saskatchewan in 1938 reported that the American Council on Education Psychological Examination correlated .34 with college engineering freshman grades. Bartlett (2) in 1943 found that the American Council on Education Psychological Examination correlated .44 with freshman grades in a university engineering college. He reported this to be lower than the correlation he found between the Iowa Placement Examinations in mathematics, chemistry, and English, and freshman engineering grades.

Other predictive variables

Gladfelter (18) in 1937 reported the Cooperative English test to be as valuable as either high-school rank or the American Council on Education Psychological Examination in predicting scholastic achievement, the correlation being .57. Manning (29) in 1939 reported a correlation of .67 between the American Council on Education Psychological Examination and first-year college grades, and a correlation of .49 between Cooperative English test and first-year grades. He concluded that

because the intercorrelation between the American Council on Education Psychological Examination and the Cooperative English test was .73, they measured much the same thing. Gould (19) at Colorado State College in 1944 reported a correlation of .558 between scores on the Cooperative English test and first-semester grades, but he reported that the American Council on Education Psychological Examination was a better single predictor, the correlation being .63.

The Iowa Placement Examinations have been reported in several studies as having prognostic value for the first-semester college freshman grades. The Iowa Chemistry test was reported by Gould (19) in 1944 to be next to the American Council on Education Psychological Examination in value as a single predictor of first-semester freshman grades at Colorado Agricultural and Mechanical College in 1944, the correlation between these two variables being .605.

Iowa Placement Examinations and engineering grades.--At the Missouri School of Mines, Armsby (1), after an investigation of the prognostic value of the Iowa Placement Examinations, reported in 1932:

> Placement examinations really did separate entering freshmen into three distinct groups--a small group of very superior students at the top; a small inferior group at the bottom; and a large group of not sharply differentiated students between these two extremes. (1:322)

He concluded that the Iowa Placement Examina-

tions, taken as a group, constituted a very effective general aptitude test and enabled personnel workers to pick out with striking accuracy the very good prospective engineering students from the very bad ones.

Feder and Adler (15) asserted in 1939 that the best single achievement or aptitude test to predict first-year engineering grades was the Iowa Mathematics Aptitude test (r=.72). They also reported a relatively high correlation of .69 between the Iowa High School Content Examination and first-year engineering grades, and stated that this test and the Iowa Mathematics Aptitude test was a simple and efficient battery for use in predicting first-year engineering marks. Bartlett (2) found the Iowa Mathematics Examination to be the best single predictor, and Chemistry Aptitude the second best single predictor, of freshman grades in a university engineering school. The Iowa Mathematics Examination correlated .69, and the Iowa Chemistry Examination correlated .57 with freshman engineering grades. He reported that the Iowa English Aptitude test ranked third, with a correlation of .48 with freshman engineering grades.

Lower division college grades and engineering grades.--Some engineering schools have made studies to determine factors which predict the success of students admitted from junior colleges into engineering schools at the end of their sophomore year. Siemens (35) in 1942 reported a study made at the University of California to

determine the relationship between upper division engineering grades and lower division grades of local students and transfer students. This study indicated that little difference existed between the two groups and that the equations developed on the local group were sufficiently accurate to warrant their use on transfer groups. He found that predicted scores made from an equation developed from a study of grade-point averages on various subjects in the lower division and success criteria in the upper division correlated .89 ± .01 with achieved grades of 200 juniors in the upper division.

Engineering aptitude tests and engineering grades.--Several "engineering aptitude" tests have been developed to predict engineering scholastic success. Vaugh (38) in 1944 reported the development of a battery of six tests containing a mathematical test, a test of quantitative reasoning, a test of spatial visualizing, a test of artificial language, a test of mechanical ingenuity, and a test of verbal comprehension. This battery was administered to the freshmen of six engineering colleges, and correlated .58 with freshman grades. The mathematical aptitude test was the best single predictor of the groups and correlated .51 with freshman engineering grades.

The Measurement and Guidance Project in Engineering reported in 1946 by Vaughn (37) was an attempt to develop a group of engineering aptitude tests stand-

ardized on a national scale. This project was approved by the Engineers Council for Professional Development, the Society for the Promotion of Engineering Education, and the Carnegie Foundation for the Advancement of Teaching. The Pre-Engineering Inventory was developed first in 1943, revised for the third time in 1944, and administered to 35,000 individuals in many institutions. At the present time considerable research is being conducted to develop norms on these tests.

Combinations of predictive variables and grades

Various studies have repeatedly demonstrated that a combination of several variables predict academic success more accurately than any single variable alone. Durflinger (12) after a survey of the summaries reported by Segel (33), Douglas (8), and Wagner (39), and various studies during 1934 to 1943, came to the following conclusions:

(1) Multiple correlation coefficients are rarely higher than .80 regardless of the variables used.

(2) An intelligence test, a good achievement test, and high school grade averages together usually bring the highest multiple r's.

(3) The multiple r as found in the summaries is between .60 and .70. (12:77)

Other multiple correlations between various combinations of variables and college grades which have been reported by various investigators varied between .54

and .74, Table 5.

Table 5.--MULTIPLE CORRELATION COEFFICIENTS REPORTED BY DIFFERENT INVESTIGATORS.

Predicted variables		Multiple r	Reporter
High-school rank, intelligence, and High School Content Test		.59	Butsch
Intelligence, high-school rank, college aptitude test, and freshman English		.83	Root
T.C.P.A. intelligence, elementary and English tests	men	.54	Durflinger
	women	.55	
High-school marks, Ohio State University Intelligence Test, and study performance test.		.75	Hartson
College Entrance Board tests, high-school record, intelligence test, and age.		.74	Crawford
American Council on Education Psychological Examination, high-school average, English test		.69	Gladfelter
High-school scholarship, college aptitude test, and achievement test battery		.69	Williamson and Bordin
High-school rank, American Council on Education Psychological Examination, Iowa Chemistry Aptitude test		.74	Gould

Beyond a certain number, additional variables add little to multiple correlations. Segel (33) in 1932 and Manning (29) in 1938 found that the addition of variables beyond the number of three does not increase prediction enough to justify their use. Drake and Henmon (10) in 1937, and Williamson and Bordin (41) in 1942, re-

ported that for practical purposes two variables yielded correlations only slightly less valid than additional variables. Gould (19) in 1944, at Colorado State College, found that high-school rank and the American Council on Education Psychological Examination produced as high a multiple r with first-semester grades as did five variables.

Multiple correlation of variables with engineering grades.--Feder and Adler (15) in 1939 reported a multiple correlation of .74 between the Iowa Content Examination, Iowa Silent Reading test, Iowa Math Aptitude test, and an Iowa English Training test, and first-year grade-point average in engineering.

Bartlett (2) at Yale University in 1943 arrived at a multiple correlation of .75 between freshman grade averages in engineering, and scholastic aptitude, mathematical aptitude, college board subject matter examinations, and adjusted high-school rank.

Sex differential

Many studies offered evidence indicating that the dividing of students into homogeneous groups facilitated better prediction of scholastic success. Rundquist (32) in 1936 found correlations between intelligence and grades to run .10 higher for women than for men. Williamson and Bordin (41) found at the University of Minnesota in 1938 that prediction formulas based on single or

multiple variables differed for both sexes in forecasting college marks in specific subjects and in predicting the general college average. Durflinger (12) concluded in 1943 after reviewing the literature that regression equations set up for a total group of men and women did not predict as accurately as one set up for each sex separately.

Variation of predictive measures

Discrepancies between the predictive values of various criteria in different schools have been noted by several writers. Crawford (7) in 1930 stated as follows:

> Undergraduates differ greatly as to point of view, motivation, scholastic training, social and economic status, and other factors significant for academic achievement. College populations also vary in proportionate representation of groups from different schools and localities. (7:126)

He went on to state that every institution must study its own student body and the college work as a whole in arriving at predictive formulas.

Segel (33) in 1934 found in his summary that correlations based on high-school achievement were more variable than those based on intelligence tests. He reported rs to vary from .29 to .77. He attributed this to variability between the meaning of marks from school to school. Tuttle (36) stated in 1937:

> The percentage of true performance between high school rank and freshman university record vary considerably between different colleges of the same university. (36:117)

Freeman and Johnson (16) in a study at Minnesota in 1942 found that predictive criteria varied so much in value from one division to another that it was necessary to make separate predictive investigations for different divisions in the same college in order to obtain satisfactory results. Butsch (4) in his study at Marquette University in 1939 found that the variation of correlations between college grades and various predictive measures in the different schools of the college was so remarkable that each school had to study the tests in its own particular situation.

Relationship of first-semester grades to college success

Cole (5) in 1940 stated that the first-semester grades of college students are indicative of those they will continue to get. Eurich and Cain (14) in 1941 reported that college grades achieved by students during the first semester correlated sufficiently high to base college graduation on success achieved during the first semester.

Using the findings of predictive investigations

Regression equations derived from statistical treatment of combinations of tests and other variables predictive of college grades have been used frequently to predict college grades of individuals. Williamson and

Bordin (41) in 1942 suggested the following explanations for limitations in such a practice:

1. Grades are not perfectly reliable or valid criteria of success.

2. Even the most reliable and valid criteria would not yield coefficients of unity because

> Success in college comes not only from the possession of requisite aptitudes, but perhaps to an equal extent from skillful and persistent use of aptitudes in the appropriate type and level of academic competition. (41:3)

3. Too frequently the results of studies made on groups operating under heterogeneous conditions of motivations and related factors are applied to one person with little recognition of what are often significant differences between the individual and the group. (41:4)

Williamson and Bordin (41) further stated:

> Generalized regression equations do not make proper allowances for individual factors except by means of the factor of group probability. . . some method of particularization of regression equations must be developed if one would obtain significantly higher (validity) coefficients. . . group statistics are indispensable and yield a more reliable and valid criterion than anecdotal instances of chance association, the fact that a regression equation is inapplicable to large numbers of students seems to indicate the omission of certain significant variables. At the present time such factors can be identified, if at all, only by clinical diagnosis and can be given weighing only by crude judgments. (41:4)

Douglas and Maaske (9) in 1942 stated:

> Regression equations using certain variables as applied to one group can be used in predicting the degree of scholastic success

> for a new group only if the hypothesis that the two groups are similar in general ability and preparation is well founded. (9:34)

Douglas and Maaske (9) in a study conducted over a period of three years found the entering college groups studied to be statistically homogeneous and concluded:

> Barring radical changes in the total number of annual entrants, or in student selection policies, or unforseen circumstances, the group entering each succeeding year can apparently be considered as a homogeneous sample from the same population group with respect to general aptitude or scholastic achievement. (9:35)

Freeman and Johnson (16) in 1942 concluded:

> In a fairly large majority of cases predictions (in individual cases) based on these measures (correlations based on groups of students) will be reasonably accurate. The remainder will fail in various degrees to afford a true picture of subsequent performance. This is especially important in the middle ranks of the prediction distribution, for predictions of complete failure or signal success are comparatively more dependable. (16:35)

Summary

A review of literature gave evidence to support the following conclusions:

1. General aptitude tests, measures of high-school achievement, and various special aptitude tests each tend to correlate positively with college freshman grades.

2. Combinations of the above variables tend to correlate higher with college freshman grades than these variables taken singly.

3. The above variables tend to differ in their predictive value from one college to another and from one division to another in the same college to such a degree that each college and each division needs to study these variables in its own particular situation.

4. Regression equations may be used by counselors for transferring achieved scores on a combination of several variables into a predicted grade which may be interpreted in terms of theoretical probability.

5. A predictive formula derived from a study of present groups of college freshmen can be used in counseling freshmen of succeeding years, provided no radical changes occur in the college administrative policies or total number of annual entrants.

6. Individual predictions based on tests are comparatively more dependable for indicating failures or signal successes than for indicating subsequent performance in the middle ranks of the prediction distribution.

Chapter III

METHODS AND MATERIALS

In order to determine the relationship between various predictive data and grades in the engineering division, data on members of the four freshman engineering classes entering in September, 1936, September, 1937, September, 1945, and September, 1946, were studied. The data were collected from the files of the offices of the college registrar and the dean of student affairs. The office of the college registrar provided a scholastic record of each engineering student who entered in September, 1936, and September, 1937. The files in the office of student affairs yielded data on engineering students who entered in September, 1945, and September, 1946. These data collected from the office of student affairs had been furnished to advisers for use in counseling engineering students and included the following information:

1. The position of the student in his high-school graduating class.

2. Raw scores made by the students on the Iowa Placement Examination, Series CAI, revised, A, Chemistry Aptitude, to be referred to hereafter as the Chemistry test.

3. Raw scores made by the students on the Cooperative English Test, Form PM, to be referred to hereafter as the English test.

4. Raw scores made by the students on the American Council on Education Psychological Examination for High-School Seniors and College Freshmen, 1943, Edition, to be referred to hereafter as the A.C.E.

5. Raw scores made by the students on the Nelson-Denny Reading Test for Colleges and Senior High Schools, Form A, to be referred to hereafter as the Reading test.

6. Letter grades achieved in college subjects, and the number of quarter credits earned in these subjects by the students.

The high-school rank of each student was recorded in his file either as a statement of the student's relative position from the top of his graduating class and the number in his graduating class (the high-school rank of a student who was ranked as sixth from the top of a graduating class of 18 students was recorded as six in a class of 18), or in terms of the quartile in which he stood in his high-school graduating class.

The high-school rank of each student was translated into a percentage rank as follows:

1. The relative standing of the student from the bottom of his graduating class was found

by subtracting the number of his position from the top of his class from the number of students in his graduating class. In the example above, for instance, the position of the student from the bottom of his class would be 18 minus six, or 12.

2. The relative standing of the student from the bottom of his graduating class was divided by the number of students in his graduating class, and the resulting quotient multiplied by 100.

In the example cited above the percentage high-school rank of the student would be 12 divided by 18 and multiplied by 100, which would equal 66.6 per cent. Students who were ranked according to the quartile in which they stood in their high-school graduating class were assigned a percentage rank equal to the midpoint of their assigned quartile rank.

The grade-point average attained by each student during his freshman year was selected as the criterion of freshman academic success in the engineering division. The files of each student contained the letter grades he achieved in each subject for which he had registered, and the number of quarter credits (semester credits in the September, 1936 and 1937 sample) given for each subject. The freshman grade-point average was computed as follows:

1. Weights were assigned each letter grade, so that an "A" equaled 4, a "B" equaled 3, a "C" equaled 2, a "D" equaled 1, and an "F" equaled 0. "WF" (withdrawal failure) and "E" (incomplete) were counted as "F." "WP" (withdrawal passing) was disregarded.

2. Grade-points were computed by multiplying the number of credits by weight assigned the letter grade.

3. The freshman grade-point average for the year was computed by dividing the sum of the total grade points earned during the freshman year by the total number of credits.

Table 6 contains an example of the computation involved in determining the grade-point average of a student.

Table 6.--CALCULATIONS INVOLVED IN TRANSPOSING LETTER GRADES AND CREDITS TO GRADE-POINT AVERAGE.

(A) Letter Grades	(B) No. of hours for which registered	(C) Weights for each letter grade	(D) (B X C)
A	5	4	20
B	5	3	15
C	10	2	20
D	5	1	5
F	5	0	0
TOTAL CREDIT HRS.	30	TOTAL GRADE POINTS	60

60 ÷ 30 = 2.00 Grade-Point Average

A student must maintain a grade-point average of 2.00 in order to be successful in this college.

Sample studied

Data from members of the freshman class entering in September, 1936 and 1937, were studied in order to select a critical freshman grade-point average which would be indicative of the lowest grade-point average which a student might acquire and still graduate from the engineering division. The freshman classes entering in September, 1936 and 1937, were selected for this study because they were the last classes whose members had the opportunity to complete the four-year engineering course without the interruptions which occurred when mobilization for war took place.

The September, 1936 and 1937, sample consisted of 114 engineering freshman students, 40 of whom graduated from the engineering division 1/ (31 students graduated in four years, one student graduated in less than four years, and eight students remained in college longer than four years before they graduated).

Data from members of the freshman class entering the engineering division in September, 1945, were studied to determine the relationship between data furnished advisers by the office of student affairs and freshman-year grade-point average. Fifty-seven engineering

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1/ See Appendix A.

freshmen constituted the September, 1945, sample. Data on each of the variables and high-school rank, the A.C.E., and the English, Chemistry, and Reading tests, were available for the following number of members of the sample 2/:

1. English test scores, 43 students.
2. Chemistry test scores, 54 students.
3. Reading test scores, 54 students.
4. A.C.E. scores, 55 students.
5. High-school rank, 35 students.
6. High-school rank, A.C.E. scores, and English, Reading, and Chemistry test scores, 31 students.
7. A.C.E. and English, Reading and Chemistry test scores, 44 students.

Data on members of the engineering freshman class, September, 1946, were studied to determine the efficiency of a formula derived from the September, 1945, sample study for predicting grade-point averages of succeeding freshman classes. One hundred engineering freshmen were selected for the September, 1946, sample by selecting every third name of students listed in alphabetical order. High-school rank, A.C.E., and English, Reading, and Chemistry test scores were all available for every member of this sample 3/.

2/ See Appendix B.

3/ See Appendix C.

Chapter IV

ANALYSIS OF DATA

Raw data for the problem, How can the data available to advisers be used most effectively in the counseling program of Colorado Agricultural and Mechanical College for the guidance of freshman students in the Division of Engineering?, were gathered from the student files of the offices of student affairs and the registrar, Colorado Agricultural and Mechanical College. These data consisted of the raw scores achieved by freshman students who took the college entrance examinations (the A.C.E., and the English, Chemistry, and Reading tests), credits and letter grades earned by all students, and, for some students, rank of the student in his high-school graduating class.

Raw data were collected for four separate groups of students entering the engineering division during each of the four years: 1936, 1937, 1945, and 1946. The samples of the 1936 and 1937 engineering freshman classes were collected for study to determine a critical freshman grade-point average for students graduating from the engineering division. Data on the 1945 sample of engineering freshmen were collected for the purpose of determining the relationship of first-year

grades with other data contained in the student files. The 1946 sample of engineering freshmen was collected to test the predictive efficiency of a regression equation based on the 1945 sample when used on the entering freshmen of a succeeding year.

The raw data used in this study were analyzed by statistical methods in order to determine their relationship to the criterion of success, grade-point averages, and to derive a regression equation from which predicted grade-point averages could be calculated when the raw scores on variables were known. By statistical methods the standard error of the regression equation was computed in order to determine the probability that achieved grades would be equal to predicted grades derived by use of the regression equation.

Statistical methods

Statistical methods used in studying raw data from the 1945 sample in order to determine the relationship of various variables with first-year grade-point averages involved the following steps:

1. Zero-order correlations were computed to measure the statistical relationship between each of the variables and first-year grade-point averages. These zero-order correlations were computed by using the Pearson product-moment method (17:265-71).

2. Intercorrelations were calculated between each of the variables and every other variable. This was done to determine the extent to which the various variables measured common factors.

3. Using these data, multiple-correlation coefficients were computed to obtain the relationship between various combinations of variables and grade-point averages. Multiple-correlation coefficients were calculated by the Doolittle method described by Griffin (20). The worksheet outlined in Dunlap (11:68-9) was used to facilitate the computation of multiple correlations.

4. With the most efficient predictive combination of variables, a regression equation was calculated by the method contained in Dunlap (11:69). The regression equation is used as a device for predicting grade-point averages when raw scores of the variables are known.

5. The standard error of estimate ($\sigma_{(est)}$) was used to gauge the accuracy of predicting grade-point averages from the regression equation (17:300-1).

6. The coefficient of "forecasting efficiency" (E) was computed for each multiple coefficient of correlation in order to provide

quick estimates of the efficiency of various combinations of variables for predicting grade-point average. (17:345-6)

Using the regression equation, predicted grade-point averages were calculated for each member of the 1945 and 1946 samples. Zero-order coefficients of correlation were calculated in order to determine the relationship between predicted and achieved grades in each of the 1945 and 1946 samples.

To simplify the computation of predicted grade-point averages when raw scores on variables were known, a nomographic predictive chart was derived from the regression equation, and probability scales, giving the chances in 100 that a student would make a grade equal to various grade levels when his predicted grade was known, were calculated by use of the standard error of estimate of the regression equation.

Zero-order coefficients of correlation

The Pearson product-moment method (17:265-79) was used to compute zero-order coefficients of correlation between first-year grade-point average and each variable, and between each of the variables with every other variable, Table 7.

The Chemistry test was the best single predictor, the coefficient of correlation with grade-point average being .652. This was only slightly higher than

the A.C.E. which correlated .648 with grade-point average. The English test with r = .583 was third; the Reading test with r = .495 was fourth; and high-school rank with r = .359 was the lowest single predictor of grade-point average.

Intercorrelations between the variables indicated that the A.C.E. and the English and Reading tests measured common factors to a considerable extent and, therefore, should add little to the predictive efficiency of a combination of tests when used together in a battery. The Chemistry test, the best single predictor, had a relatively low intercorrelation with all other variables and, therefore, should add to the predictive efficiency of a battery of other tests when combined with them.

Table 7.--ZERO-ORDER COEFFICIENTS OF CORRELATION BETWEEN EACH VARIABLE AND VARIOUS SINGLE VARIABLES.

Measuring device	(2)	(3)	(4)	(5)	(6)
(1)	.583	.652	.495	.648	.359
(2)		.157	.708	.777	.487
(3)			.496	.543	.173
(4)				.807	.308
(5)					.297

(1) First-year grade-point average
(2) The English test
(3) The Chemistry test
(4) The Reading test
(5) The A.C.E.
(6) High-school rank

Multiple coefficients of correlation

The Doolittle method (20) of computing multiple correlations between variables was used to calculate multiple coefficients of correlation between all possible combinations of the variables (the A.C.E. and the Reading, English, and Chemistry tests, and high-school rank) with first-year grade-point average.

The multiple coefficient of correlation between a combination of the English and Chemistry test scores and grade-point average, r1.23, was found to be .814, which was considerably higher than the next highest multiple correlation of .708 between grade-point average and a combination of the Chemistry test and the A.C.E. A combination of the scores on the Chemistry and English tests has a greater efficiency for predicting grade-point average than does a combination of any two of the other variables: the A.C.E., the Reading test, the Chemistry test, the English test, and high-school rank, Table 8.

Table 8.--MULTIPLE CORRELATION OF A COMBINATION OF TWO VARIABLES WITH GRADE-POINT AVERAGE.

Combined variables	3	4	5	6
r1.2x	.814	.594	.660	.588
r1.3x	X	.681	.708	.686
r1.4x	X	X	.650	.540
r1.5x	X	X	X	.670

For example, r1.45 may be found from the row r1.4x and the column 5. This value is .650

1. Grade-point average
2. The English test
3. The Chemistry test
4. The Reading test
5. The A.C.E.
6. High-school rank

Multiple coefficients of correlation computed between various combinations of three variables and grade-point average indicated the English, Chemistry, and Reading tests formed the best combination of any three of the variables for predicting grade-point averages, the multiple correlation being .846; and that either the A.C.E. or high-school rank combined with the English and Chemistry tests provided batteries of three tests which predicted grades with slightly lower efficiency, the multiple correlation of both being .814, Table 9.

Table 9.--MULTIPLE CORRELATIONS FOR A COMBINATION OF THREE VARIABLES WITH GRADE-POINT AVERAGE.

Combined variables	4	5	6
r1.23x	.846	.814	.814
r1.24x	X	.665	.662
r1.34x	X	.722	.711
r1.25x	X	X	.675
r1.35x	X	X	.758

For example, r1.345 may be found from the row r1.34x and the column 5. This value is .722.

1. Grade-point average
2. The English test
3. The Chemistry test
4. The Reading test
5. The A.C.E.
6. High-school rank

The correlation between combinations of four variables and grade-point average was found to be highest between a combination of the English, Chemistry, and Reading tests, the A.C.E., and grade-point average, the multiple coefficient of correlation being .848. The next best multiple coefficient of correlation found between a combination of four variables and grade-point average was .846, the multiple coefficient of correlation of a combination of the English test, the Chemistry test, the Reading test, and high-school rank, with grade-point average, Table 10.

Table 10.--MULTIPLE CORRELATIONS FOR A COMBINATION OF FOUR VARIABLES WITH GRADE-POINT AVERAGE.

Combination of four variables	5	6
r1.234x	.848	.846
r1.235x	X	.816
r1.245x	X	.677

For example, r1.2345 may be found from the row r1.234x and the column 5. This value is .848.

1. Grade-point average
2. The English test
3. The Chemistry test
4. The Reading test
5. The A.C.E.
6. High-school rank

The addition of high-school rank to a battery consisting of the English test, the Chemistry test, the Reading test, and the A.C.E. was found to add nothing to the multiple coefficient of correlation, the multiple correlation being .848.

"Coefficient of Forecasting Efficiency"

The formula, $E = 1 - \sqrt{1 - r^2}$ (17:345) (E is the "coefficient of forecasting efficiency," r is the coefficient of correlation between the variable or combination of variables and the criterion, grade-point average) was used to estimate the relative predictive efficiency of various combinations of variables for predicting grade-point averages, Table 11.

A combination of the English, Reading, and Chemistry tests predicted grade-point averages about as efficiently as a combination of any four or more of the variables studied. The forecasting efficiency of the battery of the English, Reading, and Chemistry tests in predicting grade-point average was 46.7 per cent, and the forecasting efficiency of the combination of all five of the variables in predicting grade-point average was 47.5 per cent. Because of the greater economy of time and labor in predicting grades from three variables rather than from five variables, the difference of eight-tenths in forecasting efficiency can be disregarded when selecting batteries of variables for predicting grades for

counseling purposes.

A combination of the Chemistry test and the English test predicted grades with an efficiency of 41.9 per cent, which was five and six-tenths less than the efficiency of predicting grades from a combination of all five variables, and four and eight-tenths less than the efficiency of predictions made from the best combination of three variables, the Chemistry, English, and Reading tests. These increases in forecasting efficiency hardly compensate for the greater time and labor required to collect data and compute predicted grades from three or more variables. Because of the greater economy in time and labor, the English test and Chemistry test battery is most practical for use in counseling.

Table 11.--THE COEFFICIENT OF "FORECASTING EFFICIENCY," E, FOR COMBINATIONS OF VARIABLES HAVING THE HIGHEST MULTIPLE COEFFICIENTS OF CORRELATION, r, WITH GRADE-POINT AVERAGE.

Variables	r	E
1, 2, and 3	.814	.419
1, 2, 3, and 6	.814	.419
1, 2, 3, and 5	.816	.422
1, 2, 3, and 4	.846	.467
1, 2, 3, 4, and 5	.848	.475
1, 2, 3, 4, 5, and 6	.848	.475

1. Grade-point average
2. The English test
3. The Chemistry test
4. The Reading test
5. The A.C.E.
6. High-school rank

The regression equation

The regression equation based on the data for the September, 1945, group of freshmen in the Division of Engineering was as follows:

$$W = .008X_2 + .016X_3 - .16$$

In this equation, the two independent variables, X_2 (score on the English test) and X_3 (score on the Chemistry test), were used to predict the first-year grade-point average, W.

The standard error of estimate

The grade-point averages "predicted" from the regression equation may be considered as the "most probable" values accompanying given scores on the tests on which the regression equation was based. In order to find the probability of the predicted grade-point averages equaling various achieved grades when scores on test variables are known, the standard errors of estimate for the predicted grade-point averages were calculated by the following formula:

$$\sigma_{(est)} = \sigma_1 \sqrt{1 - r^2_{1.23}}$$

$\sigma_{(est)}$ = the standard error of estimate

σ_1 = the standard deviation of achieved grade-point average distribution of the 1945 sample

$r_{1.23}$ = the multiple coefficient of correlation between the Chemistry and English tests and achieved grade-point average.

The standard error of estimate was found to be .45.

From the regression equation a "predicted" grade-point average was obtained. The probability that the true grade-point average falls within the limits minus and plus .45 from the predicted grade-point average is 68 in 100 chances (17:300-1). It is almost certain that the achieved grade-point average will fall within the limits predicted grade-point average plus and minus 3 times .45 from the predicted grade-point average.

Predictive efficiency of regression equation for succeeding groups

The coefficient of correlation between predicted first-year grade-point averages calculated from the regression equation and achieved first-quarter grade-point averages of individuals of the September, 1946, sample was .657. This was slightly lower than the coefficient of correlation of .676 calculated between predicted first-year grade-point averages, using the regression equation, and the achieved first-year grade-point averages of the September, 1945, sample. Closer agreement between the coefficients of correlation should be expected if first-year achieved grades instead of first-quarter achieved grades were correlated with predicted first-year grades in the 1946 sample; however, the agreement between the coefficients of correlation of

predicted with achieved grades in each of the 1945 and 1946 samples, was close enough to warrant the assumption that the regression equation computed from the 1945 sample can be used to predict grades in the 1946 sample.

In order to check the efficiency of the regression equation for predicting the achieved grade-point averages of a succeeding freshman class, a comparison was made between the theoretical probability of students in the 1946 sample achieving grades equal to or greater than grades "predicted" by use of the regression equation, and the empirical probability of students in the 1946 sample of obtaining grades equal to or greater than grades "predicted" from the regression equation.

Theoretical probability was computed by use of the standard error of estimate of predicted grades, and empirical probability was found by computing the percentages of students in the 1946 sample who achieved first-quarter grades equal to or greater than their predicted first-year grades. Table 12, prepared by the method described by Freeman and Johnson (16:61-5), shows the empirical probability of a student in the 1946 sample with a predicted first-year grade-point average equal to or better than 2.00 as having 40 in 100 chances of obtaining a first-quarter grade equal to or greater than a first-year grade-point average of 2.00. The theoretical probability of a student's achieving a first-year grade-point average equal to or greater than a predicted first-

year grade-point average of 2.00 is 50 in 100 chances.

Table 12.--EMPIRICAL PROBABILITY TABLE GIVING THE CHANCES IN 100 THAT A FRESHMAN IN THE DIVISION OF ENGINEERING WITH A PARTICULAR PREDICTED SCORE (W) WILL EARN A GRADE EQUAL TO OR ABOVE DIFFERENT SPECIFIED GRADE LEVELS.

Predicted grade-point average (W)	Chances in 100 of earning a grade equal to or above		
	(1.00) D	(2.00) C	(3.00) B
3.50 and above	99	96	95
3.25 to 3.49	99	96	95
3.00 to 3.24	95	94	85
2.75 to 2.99	90	88	80
2.50 to 2.74	82	76	50
2.25 to 2.49	70	60	35
2.00 to 2.24	51	40	20
1.75 to 1.99	31	13	0
1.50 to 1.74	16	5	0
1.25 to 1.49	10	2	0
1.00 to 1.24	2	0	0
.75 to .99	2	0	0
.50 to .74	0	0	0
below .50	0	0	0

There was considerable discrepancy between the empirical and theoretical probabilities of achieved grades equaling or excelling predicted grades. This discrepancy was greatest at the extreme grade levels and was

least for grades about the 2.00 grade-point average level. The number of cases falling in the extreme grade intervals of the limited group of 100 students in the 1946 sample was few, and any empirical probability based on percentages of those achieving grades equal to or above the grade intervals containing such few cases should be expected to deviate considerably from the theoretical probability.

Critical freshman predicted grade-point average

In order to select a minimum standard--a lower critical predicted grade-point average--at a point below which experience has shown first-year grade-point averages to be indicative of probable failure in the engineering division, the samples of 1936 and 1937 freshman students were studied, A bivariate frequency distribution showing the period spent in college by students making various grade-point averages and the number of graduates who had achieved various freshman grade-point averages indicated that more students achieving high grades during their freshman year tended to graduate than did those who made only a passing grade-point average of 2.00 during their freshman year, and that students who made less than a passing grade-point average of 2.00 during their freshman year tended to have very little chance of graduating, Table 13.

Table 13.--RELATIONSHIP OF GRADES ACHIEVED DURING THE FRESHMAN YEAR IN THE DIVISION OF ENGINEERING, COLORADO AGRICULTURAL AND MECHANICAL COLLEGE, BY STUDENTS ENTERING IN SEPTEMBER, 1936 and 1937, TO TIME SPENT IN COLLEGE.

Number of years completed	Freshman year grade-point average						
	.50-.99	1.00-1.49	1.50-1.99	2.00-2.49	2.50-2.99	3.00 up	Total
Above 4 years			3(2)	2(2)	3 (3)	1 (1)	9 (8)
4 years		1		7(6)	13(13)	12(12)	34(31)
3 years but not 4 years			1	1		1 (1)	3 (1)
2 years but not 3 years	2	5	4	10	4	2	27
1 year but not 2 years	4	7	8	5	1	1	26
Less than 1 year	2	4	4	1	3	1	15
TOTAL	8	17	20(2)	26(8)	24(16)	18(14)	114(40)

(Figures in parentheses indicate number of students graduating)

The following percentages of students who made indicated grade-point averages their freshman year graduated from engineering: 78 per cent of those who achieved a 3.00 or higher; 66 per cent of those who made 2.50 to 2.99; 30 per cent of those who made 2.00 to 2.49; one per cent of those who made 1.75 to 1.99; and none who made less than 1.75.

Generally, a freshman grade-point average of 2.00 tends to be the lower grade limit which a student may receive and still have a chance of graduating from the engineering course. Only two students who made less than a 2.00 grade-point average in their freshman year graduated from engineering, and these two students received their degrees after spending five years in college.

Chapter V

DISCUSSION

The problem, How can data available to advisers be used most effectively in the counseling program of Colorado Agricultural and Mechanical College for the guidance of freshmen in the Division of Engineering?, was resolved into the following parts:

1. Relationship between freshman engineering grades and graduation from the engineering division.

2. Relationship between data furnished advisers and first-year freshman grades.

3. Factors which, when taken singly or in various combinations with one another, are of optimum value in forecasting freshman grades.

4. Weights assigned to retained factors in order to secure optimum prediction of first-year freshman grades.

5. Means by which data furnished counselors can be used in counseling students in the Division of Engineering.

Freshman grades and graduation

Freshman-year grades achieved by freshman

engineering students entering in September, 1936 and 1937, were found to be indicative of graduation from the engineering division. This finding agreed with those reported by Cole (5) in 1940, who stated that first-semester grades of college students are indicative of those they continue to achieve, and Eurich and Cain (14) in 1941, who reported that college grades achieved during the first semester correlated sufficiently high to base college graduation on them.

Disregarding all other factors which influenced "drop outs" before graduation, it was found in this study that a very small percentage of students who attained below a 2.00 grade-point average graduated, and the proportion of graduating students to failing students became increasingly higher as the freshman-year grade-point average increased. Among students who ranked below a 2.00 grade-point average, the proportion of graduating students was so small that a grade-point average of 2.00 may properly be interpreted as a critical freshman grade below which students have little chance of graduating from the engineering division. Fifty-six per cent of the students who made a 2.00 grade-point average or better during their freshman year graduated, and 44 per cent failed to graduate.

Data furnished advisers and freshman grades.--The relationship found between the variables considered in this study have been discussed below under the headings

of each variable and the intercorrelation between variables.

Chemistry test and grades.--The coefficient of correlation .652 found in this study between the Chemistry test and first-year grades was somewhat higher than that reported by Bartlett (2) who reported r = .57 between the Chemistry test and freshman grades in an engineering school. Bartlett found that the Chemistry test was a better predictor of first-year engineering grades than was the A.C.E.

The A.C.E. and grades.--The correlation between the A.C.E. and first-year grades was found to be .648 in this study. This indicates the A.C.E. to be only slightly less efficient than the Chemistry test as a predictor of first-year grades in engineering. This correlation between the A.C.E. and first-year engineering grades in considerably higher than that reported by Laycock and Hutchen (26) in 1938, r = .34, and Bartlett (2) in 1943, r = .44, but was in close agreement with the correlation between the A.C.E. and general college grades, r = .63, reported by Gould (19) at Colorado State College in 1944.

English test and grades.--The correlation of .583 between the English test and first-year grades found in this study was only slightly above that reported by Gould (19) in 1944, who found r = .558, between the English test and first-semester general college grades. Bartlett (2) in 1943 did not find as high a

correlation between the Iowa English Aptitude Test and freshman engineering grades, r = .48, but reported that next to the Iowa Placement tests of Mathematics and Chemistry, the English test was the best single predictor of first-year grades in a university engineering school.

Reading test and grades.--The Reading test was found to rank fourth highest in efficiency as a predictor of first-year grade-point average, with r = .495. This agrees with the findings of Feder and Adler (15) who reported a coefficient of correlation of .495 between reading ability measured by the Iowa Silent Reading Test and first-year grade-point average in an engineering school.

High-school rank and grades.--High-school rank was found in this study to correlate lowest with first-year grades, r = .359. These findings do not agree very closely with those of Seyler (34) who found a correlation of .59 between high-school rank and engineering freshman scholastic average. They do, however, agree closely with the findings of Bartlett (2) in 1943 who reported that high-school rank correlated .39 with first-year engineering grades in an endowed university engineering school. He found that high-school rank was the poorest single predictor compared with the A.C.E. and the Iowa placement tests--Chemistry aptitude and English aptitude. This agrees with the findings of this study.

Intercorrelations between variables.--Intercorrelations between the various variables in this study indicated that the A.C.E. and the English and Reading tests measured common factors to a considerable extent, and that of these three variables the English test had the lowest intercorrelation with the Chemistry test, $r = .157$. This, coupled with high relative correlation with grades, warranted the conclusion that a combination of the Chemistry test and the English test was the best battery of any two of the variables, the A.C.E. and the Chemistry, Reading, and English tests. The findings of Gladfelter (18) reported the coefficient of intercorrelation between the A.C.E. and the English test was .73. This does not differ widely from $r = .777$ between the A.C.E. and the English test reported in this study.

Combinations of variables and grades

A combination of the five variables, the A.C.E. and the Chemistry, English, and Reading tests, and high-school rank, yielded a multiple coefficient of correlation of .848. This was higher than the multiple coefficient of correlation commonly found between combinations of various variables and freshman grades, but approximated the findings of Root (31), who reported a multiple $r = .83$ between a combination of an intelligence test, high-school rank, a college aptitude test, and freshman English grades and college freshman grades.

Both Bartlett (2), who found a multiple r = .75 between freshman engineering grades and a combination of four variables, and Feder and Adler (15), who found a multiple r = .74 between freshman engineering grades and four variables, reported similar multiple coefficients of correlation, which are lower than the findings of Root (31) and those of this study.

The multiple coefficient of correlation of a combination of the two variables, Chemistry and English test and first-year grades, was found to be .814. This is very near the multiple coefficient of correlation of .80 which was reported by Wagner (39) as the upper limit above which multiple correlation coefficients between combinations of variables and freshman grades are rarely found, regardless of the variables used. (11:77)

Assigning weights to retained factors.--The combination of the Chemistry test and the English test, with a multiple r = .814 with first-year grades, was found to be only slightly less efficient than the combination of all variables, with a multiple r = .848, with first-year grades. A zero-order correlation of .672 was found between predicted grades, computed from a regression equation based on a combination of the English and Chemistry tests, and achieved grades of 44 freshmen entering in September, 1945. This was only slightly lower than the zero-order coefficient of correlation of .692 found between predicted grades, computed from a

regression equation based on a combination of all five variables used in the study, and obtained grades of the same freshman group. These findings are in agreement with the findings of Williamson and Bordin (41) who concluded that for practical purposes two variables yield correlations only slightly less valid than do additional variables.

The coefficient of forecasting efficiency for a coefficient of correlation of .814 between the battery of the Chemistry and English tests and grade-point average enables one to predict on the basis of the Chemistry and English test scores, the value of grade-point averages with an accuracy that is 41.9 per cent better than chance. By "predicting" grades on the basis of the relationship found between all five variables and grade-point average, the value of grade-point averages may be found with an accuracy 47.5 per cent better than chance.

For purposes of counseling students the combination of the English and Chemistry tests was more practical than was the combination of all five variables. The increase in predictive efficiency gained by adding additional variables to the English and Chemistry tests battery does not justify the additional work and time involved in collecting and correlating the scores on additional variables.

Use of data in counseling

By use of the regression equation a grade-point average may be "predicted" for a student when his raw scores on the English and Chemistry tests are known. The student's grade, predicted from the regression equation, may be referred to as his "most probable" grade-point average. The true grade-point average of the student may, of course, vary from this most probable grade-point average, computed from the regression equation. The probable amount of this variation is indicated by the standard error of estimate, which was found to be .45 when calculated from the regression equation based on the correlation of a battery of the Chemistry and English tests with first-year grade-point averages.

The standard error of estimate, equal to .45 grade-point average, indicates that the chances are approximately 68 in 100 that a student will achieve a grade-point average not less than .45 grade-point average lower, or more than .45 grade-point average higher, than his predicted grade-point average.

An adviser could estimate the chances in 100 that a student with given raw scores on the Chemistry and English tests has of obtaining any selected grade-point average, by determining the number of units of standard deviation that the selected grade-point average is from the most probable grade-point average, calculated from

the regression equation, and translating the number of units of standard deviation into percentages by use of a table indicating the area under the normal probability curve corresponding to the distances on the baseline between the mean and various units of standard deviation (17:467).

The units of standard deviation of any selected grade-point average from the most probable grade-point average, calculated from the regression equation, are found by finding the difference between the selected grade-point average and the most probable grade-point average, and dividing this difference by the standard error of estimate 1/.

The computation involved in calculating the most probable grade-point average from a regression equation and calculating the probability of obtaining any selected grade-point average by the use of the standard error of measurement discourages many advisers from using the regression equation and standard error of measurement in estimating the chances a student has of obtaining a certain grade-point average.

In order to facilitate the use by advisers of raw data on the Chemistry and English tests, a nomographic predictive chart, Table 14, was constructed by the method

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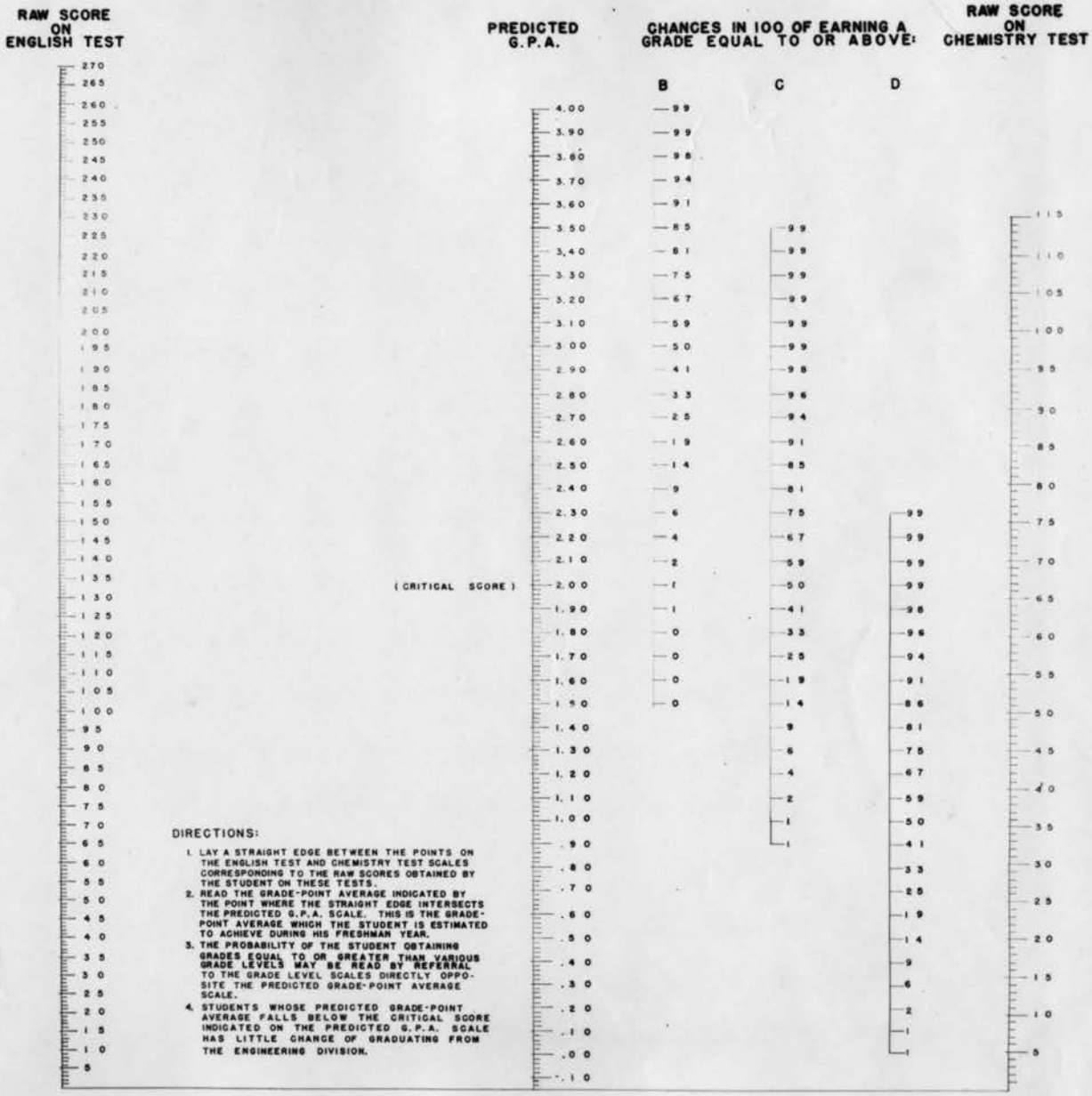
1/ Edward B. Greene, Measurement of Human Behavior. New York. Odyssey Press. 1941, p. 75.

Table 14.--NOMOGRAPHIC PREDICTIVE CHART FOR ESTIMATING FRESHMAN GRADES OF ENGINEERING STUDENTS.



described by Lipka 2/. By use of this chart, which is designed for use in counseling freshman students in the Division of Engineering at Colorado Agricultural and Mechanical College, it is possible to read the predicted grade-point averages when raw scores on the English and Chemistry tests are known.

Probability scales for assisting users in interpreting the predicted grade-point average indicated by the Chemistry and English test scores of an individual were drafted on the predictive chart. The predicted grade-point averages, 1.00, 2.00, and 3.00, were each selected as the mean grade-point average of the three separate scales. The probability of a student's achieving a grade-point average equal to any specific predicted grade-point average on these scales was computed by changing the predicted grade-point average scores into units of standard deviation 3/ and reading from a table the area under the normal probability curve corresponding to distances along the baseline between the mean and various units of standard deviation (17:467).

Advisers should find the nomographic chart a practical device to determine, at a glance, the theoretical chances a student has of obtaining a grade-point

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2/ Joseph Lipka, Graphical and Mechanical Computation. New York. John Wiley and Sons, Inc., 1918, pp. 45-46.

3/ Edward B. Greene, op. cit., p. 59.

average equal to a "C," a "B," or an "A" during his freshman year. In using this device in counseling an individual, advisers should recognize that they are applying to an individual the results of a study made on a group operating under heterogeneous conditions of motivation and other related factors, and that certain significant variables present in the individual under consideration may have been omitted. Williamson and Bordin (41) stated that "At the present time such factors can be identified, if at all, only by clinical diagnosis and can be given weighing only by crude judgments." (41:4)

Advisers using the nomographic predictive chart may question whether the results of this study should be used in "predicting" the grade-point averages of students who enter the engineering division during a succeeding year. The coefficient of correlation of .657 found between the achieved and predicted first-quarter grade-point averages (calculated from the nomographic predictive chart) of 100 students entering the engineering division in September, 1946, warrants the assumption that the group entering each succeeding year can be considered as a homogeneous sample from the same population as the sample from which the regression equation was derived; therefore, advisers may use the regression equation for counseling members of succeeding groups entering the Division of Engineering provided radical changes in the total number of annual entrants, college administrative

policies, or other unforeseen circumstances do not occur.

Advisers are often undecided as to whether they should encourage an aspirant to the engineering course to matriculate in the engineering division during the freshman year. By use of the test scores on the Chemistry and English tests and the predictive chart, the adviser may determine the probability of the student's obtaining during his freshman year a grade-point average equal to or greater than any specific grade level. Where the student's predicted grade-point average falls below the critical grade-point average of 2.00, his chances of graduating from the engineering division are against him, and it may be advisable to refer him to the office of student affairs for diagnosis and vocational counseling before he undertakes any definite course of action. Such a procedure, if adopted by advisers, should reduce mortality among freshman engineering students without preventing qualified aspirants from trying out in the engineering course.

If faculty advisers are provided with a copy of the nomographic predictive chart, they should find it helpful in the following respects:

1. To determine those students who might be advised to take a limited program.

2. To recommend to the office of student affairs for clinical counseling cases of serious discrepancy between achievement and ability.

3. To recommend to the office of student affairs for clinical counseling those students whose measured abilities indicate possible lack of capacity to succeed in the engineering division.

Recommendations for further study

The regression equation developed on the engineering freshman class of September, 1945, seems to be useful in estimating the probability of success for students entering the engineering division. It is possible that other combinations of tests might be worked out for the Divisions of Agriculture, Forestry, Home Economics, Science and Arts, and Veterinary Medicine.

Further studies might be made to determine other factors which, when combined with the Chemistry and English tests, might increase predictive efficiency.

A study to determine the manner in which entrance tests may be used in counseling sophomore, junior, and senior students in the engineering division should be helpful to advisers.

A study of entering engineering freshmen and their academic success made over a period of several years, to determine a critical score below which students have little chance of graduating from the engineering course, and to determine the implications of entrance test scores in regard to "predicting" this critical score

for aspiring freshman engineering students should furnish data valuable for use in counseling students.

Chapter VI

SUMMARY

The engineering division faculty advisers of Colorado Agricultural and Mechanical College are provided by the office of student affairs with data on the college entrance tests--the A.C.E. and the English, Chemistry, and Reading tests--and rank in the high-school graduating class for each student entering the engineering division. If some device, which facilitated the evaluation of these variables in terms of future academic success, could be furnished the adviser of freshman engineering students, better guidance might be provided the students entering the engineering division. The present study was undertaken for this purpose.

Raw data consisting of scores made by 44 freshman students entering the engineering division in September, 1945, were collected on five variables other than marks achieved during the freshman year:

1. Cooperative English test, Form P M (variable 2)
2. Iowa Placement test, Chemistry Aptitude (variable 3)
3. Nelson-Denny Reading test (variable 4)
4. American Council on Education Psychological Examination (variable 5)

5. High-school rank (variable 6)

Zero-order coefficients of correlation were calculated between each of these variables and first-year grade-point average (variable 1) and found to be as follows:

1. $r_{12} = .583$
2. $r_{13} = .652$
3. $r_{14} = .495$
4. $r_{15} = .648$
5. $r_{16} = .359$

Multiple coefficients of correlation were calculated for the five variables in various combinations with one another. The combinations of variables which produced the highest multiple coefficient of correlation were as follows:

1. r1.23456 = .848
2. r1.2345 = .848
3. r1.234 = .846
4. r1.23 = .814

For practical purposes, the combination of variables, the English and Chemistry tests, was the most economical and practical battery to use in counseling, and, therefore, was used in the calculation of the following regression equation:

Grade-point average = $.008X_2 + .016X_3 - .16$

where X_2 = English raw score, and

X_3 = Chemistry raw score.

The standard error of estimate was found to be .45 grade-point average. Using this figure a nomographic predictive chart was constructed to show the probability of attaining grades equal to or greater than various grade levels. This device was designed to assist advisers in using raw scores on a battery of the English and Chemistry tests for counseling students. A study was made of freshman grades and chances of graduating of 114 students entering the engineering division in the September, 1936, and September, 1937, classes in order to find a critical freshman grade-point average.

This critical score was determined to indicate students whose freshman-year grade-point average indicated probable failure in the engineering division. It was found that students who made below a grade-point average of 2.00 had little chance of graduating from the engineering division; therefore, the 2.00 grade-point average was selected as the critical score and was entered on the nomographic predictive chart to assist users in determining students who would probably fail in the engineering course.

The zero-order correlation between predicted first-year grades (from the nomographic chart) and obtained first-quarter grade-point averages of 100 students entering the engineering division in September, 1946, was found to be .657.

Summary and conclusions

The best single predictor of first-year engineering grades among the variables was the Chemistry test, followed by the A.C.E., the English test, and the Reading test. Intercorrelations indicated that the English test, the A.C.E., and the Reading test measure much the same thing and that of the three, the English test is the best test to combine with the Chemistry test. The low correlation of high-school rank with first-year grades indicated it to be the poorest predictor.

Multiple coefficients of correlations indicated that the Chemistry and English tests were the best and most economical battery for predicting first-year grades. Addition of other variables did not increase the multiple coefficient enough to justify the additional work involved.

The regression equation and standard error of estimate were useful counseling devices which may be graphically represented on a nomographic chart to facilitate their use by advisers. By using the nomographic chart on which a critical score has been designated, advisers should be able to estimate the probability of students' succeeding in the freshman year of engineering and should be able to select students whose chances of graduating from the engineering division are small, and who are, therefore, possibly in need of further clinical counseling.

A P P E N D I X

APPENDIX TABLE OF CONTENTS

Appendix A.--VARIATES USED IN THE STUDY OF THE 1936 AND 1937 SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case Number	First-year grade-point average	Four-year grade-point average	Time in college (years)
1	2.00		2
2	2.76		½
3	2.38		2½
4	2.55	2.16	5 (grad.)
5	2.57	2.55	4 (grad.)
6	1.47		1
7	3.20	3.39	4 (grad.)
8	2.37		3
9	2.59	2.66	5 (grad.)
10	1.63		1
11	1.36		1½
12	1.66		1
13	2.32		2
14	1.72		1½
15	3.59	2.92	4 (grad.)
16	.56		2½
17	3.32	3.11	4 (grad.)
18	.72		2
19	1.70		1½
20	2.33		2
21	2.16		1
22	1.55		½
23	2.14	2.32	4 (grad.)

Appendix A.--VARIATES USED IN THE STUDY OF THE 1936 AND 1937 SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	Four-year grade-point average	Time in college (years)
24	2.76		2
25	2.76		½
26	3.77		2
27	1.63		1
28	3.19	3.43	3½ & 1 summer session (grad.)
29	1.16		1
30	3.00	3.01	4½ (grad.)
31	1.38		2
32	1.53		1
33	2.51		1
35	1.51		½
36	1.24		½
37	3.37	2.71	4 (grad.)
38	3.61	3.12	4 (grad.)
39	2.74	2.04	4 (grad.)
40	1.76	1.95	4½ (grad.)
41	2.55		2
42	3.42	3.21	4 (grad.)
43	1.66		1
44	.45		½
45	2.69	2.77	4 (grad.)

Appendix A.--VARIATES USED IN THE STUDY OF THE 1936 AND 1937 SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	Four-year grade-point average	Time in college (years)
46	2.57		½
47	2.22		1
48	3.03		1
49	2.42		1
50	1.85		2
51	2.50	2.38	4½(grad.)
52	2.54	2.45	4 (grad.)
53	1.75		3+
54	1.21		½
55	3.00	2.98	4 (grad.)
56	.82		1
57	2.19	2.49	5 (grad.)
58	1.22		1
59	2.07	2.34	4½(grad.)
60	1.57		½
61	2.86		2
62	2.00		2
63	2.66	2.43	4 (grad.)
64	3.72	3.68	4 (grad.)
65	2.40		2
66	2.30	2.17	4 (grad.)
67	2.32		2

Appendix A.--VARIATES USED IN THE STUDY OF THE 1936 AND 1937 SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	Four-year grade-point average	Time in college (years)
68	.82		1
69	2.28	2.06	4 (grad.)
70	2.08		2
71	1.36		1
72	2.33	2.57	4 (grad.)
73	2.10		1
74	2.60	2.27	5 (grad.)
75	2.10		2
76	1.69		2
77	3.45		$\frac{1}{2}$
78	1.48		1
79	2.85		$\frac{1}{2}$
80	1.66		2
81	2.79	2.28	4 (grad.)
82	1.47		4
83	1.63		$1\frac{1}{2}$
84	2.41	2.18	4 (grad.)
85	3.26	3.53	4 (grad.)
86	2.39		$\frac{1}{2}$
87	1.16		2
88	2.30	2.61	4 (grad.)
89	1.48		2

Appendix A.--VARIATES USED IN THE STUDY OF THE 1936 AND 1937 SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	Four-year grade-point average	Time in college (years)
90	3.10	2.56	2
91	1.28		½
92	2.38		3
93	3.13	2.86	4 (grad.)
94	1.35		½
95	3.89	3.61	4 (grad.)
96	2.42		2
97	.66		1
98	3.52	3.58	4 (grad.)
99	1.69		2½
100	.57		½
101	2.53	2.84	4 (grad.)
102	2.55	2.17	4 (grad.)
103	2.55	2.21	4 (grad.)
104	2.16		1½
105	2.90	3.25	4 (grad.)
106	1.16		1
107	.83		1
108	2.76	2.94	4 (grad.)
109	1.11		2½
110	1.09		2
111	2.87	2.61	4 (grad.)

Appendix A.--VARIATES USED IN THE STUDY OF THE 1936 AND 1937 SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	Four-year grade-point average	Time in college (years)
112	2.82		$2\frac{1}{2}$
113	1.75	1.97	5 (grad.)
114	1.40		$4\frac{1}{2}$
115	2.14	1.48	4

Appendix B.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1945, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case Number	High-School Rank	A.C.E. raw score	Chemistry raw score	English raw score	Reading raw score	1st year grade-point average in all subjects
1		45	52	77	40	1.62
2	.5	99	62	121	55	1.84
3	.88	81	2		43	1.42
4		101	67	168	78	2.31
5	.59	89	57		55	1.15
6		159	112		112	3.47
7		112	47	146	67	1.60
8		136	82	118	110	2.00
9		137	106	198	83	2.74
10	.89	146	105	208	115	3.77
11	.89	128	105	185	114	3.28
12		84	41	163		1.52
13	.44	117	51		77	2.19
14	.80	98	70	142	57	2.68
15	.26	136	85	164	82	2.18
16	.83	122	54	187	93	2.75
17	.48	108	94	121	87	2.24
18	.31	108	91	132	94	1.54
19	.87	144	44	272	111	2.60
20		115	78	114	95	1.15
21	.87	102	106	161	73	3.09

Appendix B.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1945, SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	High-school rank	A.C.E. raw score	Chemistry raw score	English raw score	Reading raw score	1st year grade-point average in all subjects
22		92	56	136	78	1.78
23	.84	97	55	142	82	1.55
24	.86	146	102	198	84	2.48
25	.92	98	72	146	55	2.54
26	.46	115	85	130	68	2.22
27	.95	101	63	108	59	1.61
28	.92	88	39	114	72	2.43
29	.23	88	70	100	44	1.50
30	.44	93	79	98	36	2.87
31	.33	140	99	191	94	2.02
32	.89	110	77	164	78	2.52
33		112	44	175	74	2.17
34		168	23	63	50	.69
35	.85	106	88	171	82	2.79
36	.49	90	88	93	64	1.63
37	.87	157	115	272	144	3.10
38		149	46	236	122	2.10
39		129	98	189	113	2.36
40	.62	42	34	184	45	.95
41	.37	92		124	107	1.46
42		78	92	119	71	.96

Appendix B.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1945, SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	High-school rank	A.C.E. raw score	Chemistry raw score	English raw score	Reading raw score	1st year grade-point average in all subjects
43	.26	88	10	185	61	1.57
44	.87	123	115		104	3.36
45		147	105		122	2.67
46		72	36		50	.17
47		121	29		75	1.43
48		141	91	193	90	3.55
49		159	85		152	2.57
50		86	36		66	1.09
51	.20	105	42		70	1.54
52	.75	112	44	175	74	2.42
53	.87	137	77	245	97	3.76
54	.66	79	41	120	45	1.29
55	.94	126	55	176	106	2.13
56	.68	133	50	210	118	2.12
57	.60	110	79	129	81	2.26

Appendix C.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case Number	First-year grade-point average	A.C.E.	English	Chemistry	Reading
1	2.6	52	54	9	26
2	2.7	95	91	93	99
3	2.4	68	71	78	18
4	1.9	49	57	54	22
5	2.4	68	35	56	50
6	3.8	99	90	97	99
7	2.4	52	37	78	20
8	3.2	98	75	88	97
9	2.7	93	84	97	76
10	2.2	86	44	85	47
11	2.5	71	67	16	70
12	2.1	94	86	84	97
13	.9	37	16	13	10
14	2.3	66	11	69	38
15	1.8	59	44	71	60
16	1.8	11	12	13	20
17	3.0	65	54	71	67
18	3.5	99	92	82	86
19	3.0	26	67	27	38
20	3.8	99	99	85	99
21	2.1	37	23	96	22
22	1.3	61	25	21	52
23	.9	89	45	6	50

Appendix C.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	A.C.E.	English	Chemistry	Reading
24	3.8	82	58	88	54
25	2.3	62	65	77	42
26	3.9	99	98	99	97
27	.5	71	57	89	19
28	.6	67	46	52	53
29	1.9	25	27	35	33
30	2.3	62	82	21	56
31	2.2	82	85	98	92
32	1.9	45	65	56	33
33	2.0	96	54	50	99
34	3.1	86	77	56	75
35	3.2	83	65	87	77
36	1.3	40	12	31	6
37	2.2	49	48	45	16
38	2.2	71	28	56	45
39	1.2	26	24	49	6
40	2.4	98	86	47	97
41	2.8	97	86	65	65
42	3.5	99	84	97	92
43	2.1	56	39	5	20
44	2.6	71	68	38	88
45	3.2	86	54	91	19

Appendix C.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	A.C.E.	English	Chemistry	Reading
46	2.5	33	21	77	44
47	.6	63	32	23	63
48	1.2	10	5	5	4
49	2.3	63	44	96	54
50	.5	16	34	1	1
51	2.3	70	52	21	25
52	.5	62	20	55	18
53	2.4	73	86	39	68
54	.3	7	7	1	5
55	.5	87	34	6	25
56	.4	1	3	1	1
57	2.1	70	24	82	10
58	1.7	84	77	23	97
59	2.8	78	32	55	42
60	2.6	35	49	79	19
61	2.8	68	37	45	33
62	2.0	66	77	84	85
63	3.7	80	72	99	68
64	2.2	88	77	60	24
65	2.2	52	69	48	31
66	1.8	66	28	69	64
67	3.0	61	61	68	38

Appendix C.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	A.C.E.	English	Chemistry	Reading
68	2.8	99	90	94	99
69	3.0	61	68	25	76
70	2.4	73	62	38	47
71	2.4	89	86	55	97
72	1.0	80	77	30	74
73	1.4	65	47	5	48
74	2.9	35	37	79	17
75	2.8	66	78	65	67
76	2.5	65	51	39	77
77	1.3	42	51	3	81
78	1.6	16	39	7	25
79	1.6	27	20	41	30
80	2.1	61	48	41	65
81	2.5	66	57	71	65
82	2.4	52	20	88	20
83	1.1	91	61	52	65
84	1.1	30	12	14	31
85	1.8	25	20	96	5
86	3.6	99	60	97	53
87	1.1	27	9	4	22
88	2.5	39	67	85	39
89	2.5	66	34	41	29

Appendix C.--VARIATES USED IN THE STUDY OF THE SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS. --Continued.

Case Number	First-year grade-point average	A.C.E.	English	Chemistry	Reading
90	1.0	56	44	20	31
91	2.6	56	50	75	26
92	2.5	66	39	52	29
93	3.8	61	86	94	45
94	.7	23	9	39	31
95	3.0	70	80	89	61
96	2.8	80	63	93	38
97	1.2	37	81	13	65
98	3.4	79	75	96	83
99	2.8	61	90	69	76
100	1.9	21	19	25	52

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