ABSTRACT OF THESIS

THE USE OF THE PRE-ENGINEERING INVENTORY AS AN AID IN COUNSELING PROSPECTIVE ENGINEERING STUDENTS AT COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

Submitted by

Robert H. Eyestone

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ABSTRACT

The problem of discovering at the time of entrance into college the student who will not succeed in the Division of Engineering at Colorado Agricultural and Mechanical College is important, both to the individual, and to the college.

The efficiency with which prospective failing students are discovered and counseled depends upon the counselor's knowledge of the prognostic value of the data available at the time that the counseling takes place.

In 1947, McClanahan made a study that included most of the various testing measures used by the Division of Engineering, Colorado Agricultural and Mechanical College, for counseling prospective engineering students. He determined which combination of variables from this group was best for predicting success in engineering. His study did not include a batter of tests known as the Pre-Engineering Inventory which was developed for the special purpose of selecting students who possessed the abilities necessary to engineering study. Since these test scores are now available to advisers in the Division of Engineering, it becomes important for them to know how much reliance may be placed on these tests when counseling prospective engineering students.

The problem

The problem, then, is, How can the Pre-Engineering Inventory be used for guidance of prospective engineering freshmen at Colorado Agricultural and Mechanical College?

Problem analysis.--In order to solve the above problem, the following questions need to be answered.

1. What is the relationship between the composite score on the Pre-Engineering Inventory and the grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

2. What is the relationship between sub-test scores on the Pre-Engineering Inventory and the grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

3. What is the relationship between various combinations of sub-test scores and grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

4. What score, or combination of scores, on the Pre-Engineering Inventory is of optimum value in predicting grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

5. How do these findings compare with the findings of McClanahan in his thesis entitled, "Use of Standardized Tests in Counseling Freshmen in the Division of Engineering, Colorado Agricultural and Mechanical College?

Delimitation.--This study was limited to the group of students who entered the Division of Engineering, Colorado Agricultural and Mechanical College, in the fall quarter of 1946, and the group who entered the Division of Engineering in the fall quarter of 1947.

The data concerning these groups were collected from the files of the offices of the college Registrar, the Dean of Student Affairs, and the Division of Engineering and included the following information:

1. Scores made by the students of both groups on the Pre-Engineering Inventory.

2. Scores made by the 1947 group on the Iowa Placement Examination Chemistry Aptitude, Series CA-2, Form M; and the American Council on Education Cooperative English test, Form P M.

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

The grade-point average attained by each student during the quarters spent in college was selected as the criterion of academic success in the Division of Engineering. The files in the Registrar's office contained the letter grades he achieved in each subject for which he had registered, and the number of quarter credits given for each subject. The 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 failing) 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 grade-point average was computed by dividing the sum of the total grade points earned by the total number of credits.

Sample studied

Data from members of the class entering engineering study in September, 1946, were studied to determine the relationship between scores on the Pre-Engineering Inventory and the achieved grade-point average. One hundred freshmen constituted this sample and Pre-Engineering Inventory scores were available for every member of the sample.

Data from members of the class entering college in September, 1947, were studied to determine the efficiency of a regression equation derived from the September, 1946, sample study for predicting the grade-point average of succeeding engineering classes, and for comparing the predictive efficiency of this measure with the predictive efficiency of the nomographic chart based on the Iowa Chemistry Aptitude test and the Cooperative English test and developed by McClanahan in his study, "Use of Standardized Tests for Counseling Freshmen in the Division of Engineering, Colorado Agricultural and Mechanical College." Pre-Engineering Inventory test scores, Iowa Chemistry Aptitude test scores, and Cooperative English test scores were available for each member of this sample.

Statistical methods

Statistical methods used in studying data from the 1946 sample of engineering freshmen in order to determine the relationships between various scores of the Pre-Engineering Inventory test and grade-point average involved the following steps:

1. Coefficients of correlation were computed between each score of the Pre-Engineering Inventory and grade-point average.

2. Intercorrelations were calculated between the various scores of the Pre-Engineering Inventory. This was to determine the extent to which the various scores were measures of common factors.

3. Using these data, multiple correlations were computed to obtain the relationships between various combinations of Pre-Engineering Inventory sub-tests scores and grade-point average.

4. With the most efficient predictive combination of variables, a regression equation was calculated

for predicting grade-point averages from the raw scores of the sub-tests used in the regression equation.

5. The standard error of estimate was used to gauge the accuracy of the predictive formula.

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

Using the regression equation, predicted grade-point averages were calculated for each member of the sample of engineering students who entered the college in September, 1947. A zero-order coefficient of correlation was then calculated to determine the relationship between the predicted grades and the grades achieved by members of this group.

For comparative purposes, grades were also predicted for this group from scores achieved by the students on the Iowa Chemistry Aptitude test and the Cooperative English test by means of the nomographic chart developed by McClanahan. The zero-order coefficient of correlation was then calculated between these predicted grades and the achieved grade-point average for this group.

Findings

The raw data used in this study consisted of the grade-point average earned by 100 freshmen who entered the Division of Engineering in September, 1946, and the eight scores achieved on the Pre-Engineering Inventory by these students as follows:

1. Sub-test 1 (General verbal ability)
2. Sub-test 2 (Technical verbal ability)
3. Sub-test 3 (Ability to comprehend scientific materials)
4. Sub-test 4 (Ability to do quantitative thinking)
5. Sub-test 5 (Ability to comprehend mechanical principles)
6. Sub-test 6 (Spatial visualizing ability)
7. Sub-test 7 (Understanding of modern society)
8. Composite

Coefficients of correlation were calculated between each score of the Pre-Engineering Inventory and achieved grade-point average (variable 0) and found to be as follows:

1. r04 = .737	5. r01 = .481
2. r08 = .734	6. r07 = .417
3. r02 = .709	7. r05 = .416
4. r03 = .620	8. r06 = .354

Multiple coefficients of correlation were calculated between various combinations of the seven sub-tests and grade-point average. The combinations which produced the highest multiple coefficients of correlation were:

1. $r_{0.12345} = .787$
2. $r_{0.245} = .784$
3. $r_{0.24} = .779$

For practical purposes, the combination of scores on sub-test 2 and sub-test 4 was the most economical battery to use in counseling, and was used to calculate the following regression equation:

$$\text{Grade-point average} = .028X_2 + .0336X_4 - .315$$

where X_2 = score on sub-test 2

X_4 = score on sub-test 4

Using this regression equation, grades were predicted for a sample consisting of 90 freshmen who entered the Division of Engineering in September, 1947, and a correlation chart was set up to determine the relationship between these predicted grades and the grades achieved by the students of this group during their first two quarters in engineering. The coefficient of correlation was found to be .515. The coefficient of correlation between grades predicted for this group from scores on the English and Chemistry tests by means of McClanahan's nomographic chart and grades achieved by members of the group was found to be .508.

A comparison between the findings of this study and the findings of McClanahan's study indicated:

1. Three scores on the Pre-Engineering Inventory showed a higher correlation with earned grade-point average than the scores from any single

variable in McClanahan's study, but the multiple coefficients of correlation indicated that the best combination of variables in his study was more reliable as a predictor of grades than the best combination of variables from the Pre-Engineering Inventory.

2. There was no significant difference between the grades predicted from the regression equation in McClanahan's study and the grades predicted from the regression equation developed in this study in terms of correlation when predicting for the same group of students.

3. A study of the correlation charts, however, indicated that the equation developed in McClanahan's study was a better measure than the regression equation developed in this study for selecting the individuals who would fail to succeed in the Division of Engineering, Colorado Agricultural and Mechanical College.

4. A number of other common factors on which the two measures could be compared (such as, time required for administration, cost of tests, and availability of test results) all favored the use of the Iowa Chemistry Aptitude test and the Cooperative English test over the use of the Pre-Engineering Inventory.

Summary and implications

The best single predictor of the Pre-Engineering Inventory was sub-test 4, "Ability to do quantitative thinking."

Multiple coefficients of correlation indicated that sub-test 2 and sub-test 4 were the best and most economical battery to use for predicting grade-point average for freshman engineering students. The addition of other variables did not increase the multiple coefficient enough to justify the additional labor involved.

The nomographic chart, based on the Iowa Placement Examination Chemistry Aptitude, series CA-2, form M; and the American Council on Education Cooperative English test, form P M, was more reliable and more practical for counseling prospective engineering freshmen at Colorado Agricultural and Mechanical College than the best combination of scores from the Pre-Engineering Inventory.

THESIS

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COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

July 8 1948

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY ROBERT H. EYESTONE

ENTITLED THE USE OF THE PRE-ENGINEERING INVENTORY AS AN AID IN COUNSELING PROSPECTIVE ENGINEERING STUDENTS AT 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

CREDITS 4

George G. Comstock
In Charge of Thesis

APPROVED David H. Morgan
Head of Department

Examination Satisfactory

Committee on Final Examination

Herb Heilig — M. Leslie Madison
Charles F. Towne — George G. Comstock
Robert L. Lewis

David H. Morgan
Dean of the Graduate School

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Chapter I

INTRODUCTION

Educators have long recognized that one of their most crucial problems is that of helping the college student to select the area of study for which he is best fitted. One phase of this problem is the determination of those individuals who possess the potentialities necessary for the specialized field of the engineering college.

That the mode of selecting students on the basis of successful performance in certain high school subjects is not the solution to the problem has been evidenced by the number of students who matriculate in college only to drop out before graduation. Educators have tried to lessen the number of students who drop out of college by developing new methods for selecting and guiding students. In this search for better guidance methods, investigators have made many studies attempting to predict the chances for success in college for the individual from material available to the guidance department at the time that the student is matriculating. It has been generally conceded that individuals experience varying degrees of difficulty with different types of college curricula. Some types of curricula require special abilities without which no student can hope to succeed. If it were possible to measure the amount of this special ability that each individual has, it would be reasonable to assume that a counselor could guide the prospective student into a field of learning where he would have a good chance to succeed.

Since the success of any guidance program is dependent upon the accuracy of its predictive devices in forecasting the student achievement, the Office of Student Affairs of Colorado Agricultural and Mechanical College has been desirous of finding out just how well the data furnished by them to the student advisers predict for their particular college. In 1944, Gould (20) made a study of the predictive values of the battery of tests given to each student who entered Colorado Agricultural and Mechanical College. McClanahan (30), in 1947, followed with a study to determine how well the entrance battery predicted for students in the Division of Engineering.

In the fall of 1946, the Division of Engineering added a new battery of tests to the battery already required of entering engineers. This battery, known as the Pre-Engineering Inventory, had been developed for the specific purpose of selecting individuals who possessed the abilities that were presumed to be essential to success in engineering colleges. The Office of Student Affairs is desirous of finding out just how well the battery selects the students who will succeed in engineering studies at Colorado Agricultural and Mechanical College.

The problem

The problem, then, is How may the Pre-Engineering Inventory be used for guidance at Colorado Agricultural and Mechanical College?

Analysis of the problem.--1. What is the relationship between the composite score on the Pre-Engineering Inventory and the grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

2. What is the relationship between sub-test scores on the Pre-Engineering Inventory and the grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

3. What is the relationship of various combinations of sub-test scores and grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

4. What score, or combination of scores, on the Pre-Engineering Inventory is of optimum value in predicting grades in the Division of Engineering, Colorado Agricultural and Mechanical College?

5. How do these findings compare with the findings of McClanahan in his thesis entitled "Use of Standardized Tests in Counseling Freshmen in the Division of Engineering, Colorado Agricultural and Mechanical College"?

<u>Delimitations</u>.--This study will be limited to 100 freshman students who entered the Division of Engineering, Colorado Agricultural and Mechanical College in September, 1946, and 90 freshman students who entered the same school in September, 1947, and took the Pre-Engineering Inventory tests at the time of their entrance into college.

Chapter II

REVIEW OF THE LITERATURE

The literature contained many studies investigating the value of various criteria for predicting college grades. It contained fewer studies predicting the grades for students enrolled in the more specialized fields of engineering.

A review of these studies indicated that measures of intelligence and of high school achievement have often been used as prognostic criteria for college success. Success in the engineering college has frequently been predicted from the same sources, but a new factor--the measure of special aptitude--has sometimes given results that predict with greater reliability for this field than either of the others.

Intelligence and college grades

The intelligence test really came into prominance during World War I when the Army Alpha demonstrated that a paper and pencil test could separate men into homogeneous groups with respect to what the test measured. A number of investigators have used this and similar tests to predict success in college.

Durflinger (12), in 1943, made what is possibly the most extensive survey of the studies of prediction. His summary included the findings of summaries previously made by Douglass, Segel, and Wagner. He also summarized the findings of 47 studies made during the period from 1934 to 1942. He reported a median correlation of .52 between intelligence and scholarship for the studies of that period. Douglass (8) had found a median correlation of .45 for the studies included in his summary to 1931, while Segel (38) and Wagner (47) had reported median correlations of .44 and .45 for their summaries concluded in 1934. Durflinger (12) attributed his increase in correlation for the latter period to new and better tests and possibly better methods of assigning college grades.

In 1944, Gould (20) found the American Council on Education Psychological Examination (1937 edition) the best single predictor for students enrolled at Colorado Agricultural and Mechanical College. He reported a correlation of .67 between this examination and grades at that college.

Intelligence and engineering grades.--Dvorak and Salyer (13), in 1933, reported a correlation of .374 between freshman engineering grades and scores made on the University of Washington Intelligence Test at the University of Washington. Laycock and Hutcheson (26), in 1938, found a correlation of .34 between scores on the American Council of Education Psychological Examination and engineering grades at the University of Saskatchewan. In 1943, Bartlett (2) reported that the scores made on the American Council on Education Psychological Examination correlated .44 with grades at an engineering school.

McClanahan (30), in 1947, found the American Council on Education Psychological Examination test scores second to the Iowa Chemistry Aptitude Test scores as the best single predictor of engineering grades at Colorado Agricultural and Mechanical College. He obtained a correlation of .648 between scores on that examination and grades achieved by freshman engineers at that college.

<u>High school achievement and college grades</u>

Many investigators have reported that high school achievement, expressed in terms of grade, rank, or achievement test scores, is a valuable criterion for predicting college grades. Dressel (10) in a study of 810 students at Michigan State College, 1934-1937, found that high school grade average correlated .52 with college grade average. Quaid (35), in 1938, reported that high school grades would predict college success as effectively as Ohio State University Psychological Examination test scores. In 1933, Edds and McCall (14) obtained a correlation of .65 between high school marks and college grades earned by 85 college freshmen at Milligan College. Read (36), in 1939, found a correlation of .63 between high school grade average and first semester grades at Wichita University. Cole (6), in 1940, reported a range in correlation of from .15 to .65 between high school marks and college grades. She assumed that this difference in correlation was due to a lack of common grading system in various high schools. Durflinger (12), in 1943, found a median correlation of .55 between college grades and high school grades from the studies summarized by Douglass, Segel, Wagner, and himself.

High school rank and college grades.--Rank in the high school graduating class was used by many investigators instead of high school grade-point average for the purpose of predicting college grades. Rank was found by some to be a good criterion for predicting success or failure in college. Condit (7), in 1928, reported that a study of 559 students at Colorado State College of Education showed a correlation of .49 between high school rank and college grades. He stated that high school rank would predict as well as scores from the Thurstone Psychological Examination. Drake and Henmon (9), in 1937, found high school rank to be a better predictor of college grades for the University of Wisconsin than the centile rank on the American Council on Education Psychological Examination, Henmon-Nelson Test of Mental Ability, or the Cooperative English Test. Gould (20), in 1944, reported that high school rank was second only to the American Council on Education Psychological Examination as a single predictor of college grades at

Colorado Agricultural and Mechanical College. He found a correlation of .605 for these two factors. McClanahan (30), in 1947, found high school rank to be the poorest of five variables which he studied to predict grades for engineering students at Colorado Agricultural and Mechanical College. He obtained a correlation of .359 between this measure and engineering grades.

High school achievement test scores and college grades.--Some investigators have indicated that scores on high school achievement tests are valid as criteria for predicting college success. Douglass (8), in 1931, reported a median correlation of .55 between achievement test scores and college grades for the 67 studies which he summarized. Segel (38), in 1934, found a correlation of .545 between high school content examination and grades earned in college for 13 studies which he summarized. Wagner (47) reported a correlation of .56 between these two factors for 88 studies summarized in 1934. Durflinger (12) found a correlation of .475 for 20 studies of the period between 1934 and 1942. He felt that an achievement examination was as valuable a predictor of college success as was the high school average.

High school achievement and engineering grades.--Boardman and Finch (3), in 1934, found that some high school courses contributed to the achievement in the college of engineering at the University of Minnesota. They reported that the amount of credit in science, mathematics, and manual training showed a slight relationship to grades earned in engineering. The number of high school credits in these subjects showed a correlation of .194 with total credits earned in college. They found the least relationship between engineering grades and the amount of social studies taken in high school.

Seyler (39), in 1937, discovered that 70 per cent of the students who stood above the 59th percentile rank in high school made a grade of C or better in the College of Engineering at the University of Illinois, and that 75 per cent of those who ranked below the 59th percentile in high school made less than a C in college.

Bartlett (2), in 1943, found that high school rank was a good predictor for a small engineering college that enrolled students from a relatively small number of high schools in the same vicinity as the college, but was a poor predictor for a large college which drew students from a wide geographical area.

Special aptitudes and college grades

Some investigators have found that tests of special aptitudes sometimes yield scores that are indicative of college success. Gladfelter (19), in 1937, reported a correlation of .57 between scores on the Cooperative English Test and college grades. Manning (29), in 1939, found that scores on the Cooperative English Test correlated .49 with freshman college grades. Bartlett (2) found correlations of .69 for Mathematics Aptitude, .57 for Chemistry Aptitude, and .48 for English Aptitude with college grades. Gould (20), in 1944, obtained a .589 correlation between Chemistry Aptitude test scores and first-year college grades, .558 correlation between English Test scores and first-year grades, and .525 correlation between Mathematics Aptitude test scores and college grades. In a study conducted by McGough (31), in 1945, it was found that two tests taken together from the battery of American Council on Education Psychological Examination, Cooperative English Test, and the Cooperative General Mathematics Test could be used as indices of college achievement in these subjects but correlated too low to predict college grades for an individual.

Special aptitudes and engineering grades.--The few studies available on engineering grades seemed to indicate that measures of special aptitudes play an important role in predicting for the engineering student.

Armsby (1), in 1932, found the Iowa Placement Examinations test scores separated the entering freshmen into three distinct groups--a small group of superior students at the top, a large group of not sharply differentiated students in the middle, and a small group of inferior students at the bottom. He reported that the Iowa Placement Examinations taken as a group could be used to select the very good or the very bad students.

Feder and Adler (16) reported in 1939 that they found a correlation of .72 between scores made on the Iowa Mathematics Aptitude Test and engineering grades. They also reported a correlation of .69 between engineering grades and scores on the Iowa High School Content Examination. Bartlett (2), in 1943, found the Iowa Mathematics Aptitude Test to be the best single predictor of freshman grades in a university engineering school. The Mathematics Test scores correlated .69 with earned point average. He rated the Iowa Chemistry Aptitude Test second with a correlation of .57, and the Iowa English Training Test scores third with a correlation of .48 with engineering grades.

McClanahan (30), in a study completed in 1947, reported that the Chemistry Aptitude test was the best single predictor of freshman grades for the Divisioh of Engineering of Colorado Agricultural and Mechanical College. He found a correlation of .652 between Chemistry test scores and grade-point average in that division. He also found that English and Reading correlated .583 and .495 respectively with grades in the Division of Engineering.

Pre-Engineering Inventory

According to Vaughn (44), in 1944, the Measurement and Guidance Project in Engineering Education was organized as the result of an appeal from the Society for the

Promotion of Engineering Education and the Engineers' Council for Professional Development to the Carnegie Foundation for financial aid and assistance in the conduct of research to discover and apply suitable guidance methods for high school students who intend to take engineering.

The request was granted and in July of that year the Measurement and Guidance Project in Engineering under the joint sponsorship of the Society for the Promotion of Engineering Education, the Engineers' Council for Professional Development, and the Carnegie Foundation for the Advancement of Teaching set out to develop a series of objective tests expressly designed to discover in the background of individual students at the time they are beginning engineering study certain abilities prerequisite to success in the engineering curriculum.

A battery of seven tests, known as the Pre-Engineering Inventory, was the result. This battery was adopted after it had been administered to some 6,000 students in 11 universities and colleges in the fall of 1943 and refined through a year of careful study and research.

The tests as adopted were described as follows:

1. General verbal ability--The ability to comprehend the meaning of words in the vocabulary of general reading.

2. Technical verbal ability--The ability to comprehend the meaning of important words in the vocabulary of high-school science and mathematics.

3. Ability to comprehend scientific materials--The ability to comprehend reading materials similar to those encountered in college science, engineering and mathematics.

4. Ability to do quantitative thinking--The ability to solve problems ranging in difficulty from arithmetic to the elements of analytical geometry; to comprehend passages involving quantitative concepts; to interpret graphs and tables; and to apply mathematical thinking to the solution of new type problems.

5. Ability to comprehend mechanical principles.--The ability to comprehend and apply physical principles and to solve problems involving direction of motion, mechanical advantage, forces, ratio, and other mechanical principles.

6. Spatial visualizing ability--The ability to visualize form and detail from plane figures.

7. Understanding of modern society--An understanding of social science terms and concepts and the ability to comprehend reading materials in the social sciences. (44:6)

Vaughn (43) wrote of this battery that tests two, three, and four are highly predictive of engineering grades. He stated that test one was not highly predictive of grades, but that a student who scores low on the test will probably run into trouble because his abilities are largely nonverbal in nature. Concerning the validity of the battery Vaughn (43) said:

> Coefficients of validity are a direct measure of the dependence which can be placed in the test results for predicting the student's chances of success. (43:167)

He reported that tests two and three correlated .69 with the grade-point average of students enrolled at University A. The American Council on Education Psychological Examination correlated .43 with the grades of the same group. According to Vaughn, the Pre-Engineering Inventory was designed to "pull out" the student with special engineering ability from the general group of students. He offered a comparison between the Pre-Engineering Inventory and the American Council on Education Psychological Examination and the Cooperative General Achievement Tests as given to 1,175 freshman students enrolled in four different curricula as an indication of how well the first three tests of the inventory separated the engineers from the other college groups. These tests were administered to 428 students enrolled in engineering, 167 in science, 162 in liberal arts, and 418 in the school of business.

A study of the four curricular groups indicated that the engineering, science, and liberal arts groups had approximately the same verbal ability as measured by the L scores on the American Council on Education Psychological Examination and test one scores of the Pre-Engineering Inventory. The liberal arts group scored slightly higher in this ability as shown by median scores on Tables 1 and 3.

The engineering group achieved a higher median score on each of the three tests of the Cooperative General Achievement Tests than the other curricular groups, but the standard deviation of the scores and the slight difference between the median scores for the various groups indicated that there was considerable overlapping of the accomplishments of the groups, Table 2.

The Q score and the total score of the American Council on Education Psychological Examination, as presented in Table 1 and tests two and three of the Pre-Engineering Inventory, as presented in Table 3, indicated that they measured a factor peculiar to the engineering group. The median test scores on the Pre-Engineering Inventory showed a greater difference between the four curricular groups than was shown by the median scores on the American Council on Education Examination, but the greater standard deviation exhibited by the scores of the Pre-Engineering Inventory indicated that the overlap of scores earned by the science group and the engineering group might be approximately the same on both tests. The greatest difference between the median scores of the four curricular groups was shown by the Pre-Engineering Inventory. Test two showed a difference of 28 points between the median score earned by the business group and the median score earned by the engineering group. Test three showed the next greatest difference of 23.87 points for the same groups, as compared with a greater difference of 10 points by the other tests. The Pre-Engineering Inventory showed a difference of 18.35 points between the median score of the liberal arts group and the median score of the engineering group as compared with a difference of 6.24 shown by the Cooperative General Achievement test.

Table 1.--MEANS AND STANDARD DEVIATIONS OF SCORES ON THE AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION FOR FOUR CURRICULAR GROUPS AT UNIVERSITY A. From Vaughn (43:171)

Group	"L"		"Q"		Total	
	M	S.D.	M	S.D.	M	S.D.
Engineering	70.38	13.91	47.18	8.61	117.56	19.31
Science	70.67	14.01	45.33	9.02	116.00	19.85
Liberal Arts	71.73	14.42	42.35	10.23	114.08	21.38
Business	63.43	13.13	39.91	9.74	103.34	20.07

Table 2.--MEANS AND STANDARD DEVIATIONS OF SCORES ON THE COOPERATIVE GENERAL ACHIEVEMENT TEST FOR FOUR CURRICULAR GROUPS AT UNIVERSITY A. From Vaughn (43:171)

Group	1		2		3	
	M	S.D.	M	S.D.	M	S.D.
Engineering	73.37	9.88	68.81	6.77	69.78	6.68
Science	72.57	10.22	67.32	6.52	67.47	6.61
Liberal arts	71.79	10.38	62.57	6.48	63.55	7.25
Business	65.77	9.36	58.28	5.71	59.88	6.44

1. A test of general proficiency in the field of social studies.
2. A test of general proficiency in the field of natural sciences.
3. A test of general proficiency in the field of mathematics.

Table 3.--MEANS AND STANDARD DEVIATIONS OF SCORES ON THE PRE-ENGINNERING INVENTORY TESTS FOR FOUR GROUPS AT UNIVERSITY A. From Vaughn (43:171)

Group	1		2		3	
	M	S.D.	M	S.D.	M	S.D.
Engineering	39.46	16.22	47.89	16.29	47.97	15.31
Science	41.43	16.02	43.14	15.48	42.96	15.14
Liberal arts	42.94	15.91	29.54	16.93	31.75	16.16
Business	33.20	15.46	19.00	11.47	24.10	12.84

1. A test of general verbal ability.
2. A test of technical verbal ability
3. A test of ability to comprehend scientific materials.

From his study which included 3,858 students, Vaughn (43) found the typical engineer attending college in 1944 was a male, 17 years of age at his last birthday, from a public high school with an enrollment of 500, or over, located in a city of 5,000 population. He had taken two years of algebra, one year of plane geometry, one semester of solid geometry or one semester of trigonometry, one year of science and one year of either chemistry of physics in high school.

Other's findings on the Pre-Engineering Inventory. --Person 1/, in 1947, reported that he found the Pre-Engineering Inventory to be a reliable test battery for predicting success or failure at the University of Wyoming, but that the use of the test was given up because of the time involved in administering the test and the time lapse of approximately three weeks, after the test had been administered, until the results were available.

In the "Statistical summary of the testing program" (5), at the University of California, since 1944, it is reported that the Pre-Engineering Inventory was found to be only a fair means of predicting success of applicants in engineering. The summary showed the following correlations between the Pre-Engineering Inventory scores and two years of work in college of engineering, 1945-47.

1/ Letter from H. T. Person, Head, Civil Engineering Department, University of Wyoming, to Dean Stinson, Director of Testing, Colorado Agricultural and Mechanical College, dated November 18, 1947.

	r
Total PEI scores	.46
Composite scores	.49
Test I - General verbal ability	.23
Test II - Technical verbal ability	.32
Test III - Comprehension of scientific materials	.47
Test IV - General mathematical ability	.53
Test V - Comprehension of mechanical principles	.43
Test VI - Spatial visualizing ability	.38
Test VII - Understanding of modern society	.37

Other predictive criteria

A few investigators have studied things other than test scores and high school achievement attempting to discover just how much bearing they might have on the grades which college students achieve.

Young (48) reported that he found three fifths of the class of Colgate University who were dropped for failure in 1928 were extroverts. The extroverts were selected on the basis of results on two Colgate Mental Hygiene tests. Read (38), in a study made in 1938, found that first semester grades correlated .719 with second semester grades at the University of Wichita. Hartson (22), in 1941, reported that college graduation could be predicted from first semester averages. Votaw (42), in 1946, found that a test on the use of library materials would give results that would predict college grades more accurately than scores on either the American Council on Education Psychological Examination or the Cooperative

English Test.

In a study completed in 1947 McClanahan (30) found that students who made a grade-point average of less than 2.00 during the freshman year had little chance of graduating from the Division of Engineering at Colorado Agricultural and Mechanical College. Only two from a sample of 114 graduating engineers made less than a 2.00 average during their freshman year in the Division of Engineering. He found that a student who maintained a grade-point average of 3.00 during his freshman year had 78 chances in 100 of graduating, while one who maintained an average of 2.50 had 66 chances in 100 of graduating, and one who maintained an average of 2.00 had 30 chances in 100 of graduating. The student who made a grade-point average of less than 1.79 had only one chance in 100 of graduating, and if the average was less than 1.75, no chances in 100 of graduating, from the Engineering Division.

Siemens (40) found the grades earned in lower division engineering classes at the University of California correlated .89 with the grades earned in the upper division grades. He concluded that grades earned in the lower classes could be used to predict the grades that would be earned later in college.

Multiple correlations between various factors

A number of the investigators in the field of prediction of college success have worked out correlations using a combination of several variables for predicting this success. Several investigators have reported correlations between the grade-point average earned in college and a combination of high school achievement and intelligence test scores. Douglass (8) found this multiple correlation to be .63; Drake and Henmon (9) reported a variation of .69 to .71 for 618 studies and 455 studies. Finch and Nemzek (17) reported .78 for 118 studies; Hepner (24), .56 for 382 studies; Quaid (35), .49 for 140 studies; and Read (36), .643 for 415 studies of the same factors.

Other investigators have reported multiple correlations involving other factors. These show a multiple correlation ranging from .55 as reported by Durflinger (12) to .83 as shown by Root (37).

In planning a multiple correlation, Read (36) found that the addition of more than two variables to the multiple did not add much to the predictive efficiency of the equation. Segel (38) reported that the addition of variables beyond the number of three did not increase the predictive efficiency of the multiple correlation sufficiently to warrant their use. Gould (20) in 1944 found a multiple correlation of three variables to be the best combination for prediction of college success.

Multiple correlations and engineering grades.--Feder and Adler (16) reported a multiple correlation of .74 between engineering grade-point average and the Iowa Content Examination, Iowa Mathematics Aptitude test, Iowa Silent Reading Test, and the Iowa English Training test. Bartlett (2) at Yale University, in 1943, found that freshman engineering grade-point average correlated .75 with scholastic aptitude, college board subject matter examinations, adjusted high school rank, and mathematics aptitude. McClanahan (30), in 1947, arrived at an .81 correlation between scores on the Cooperative English test and the Iowa Chemistry Aptitude test and grade-point average in the Division of Engineering, Colorado Agricultural and Mechanical College.

Limitations to prediction of college success.--Regression equations have been derived by statistical treatment of tests, combinations of tests, and other variables in order that findings might be used to predict college grades. That such procedure will predict for a group of students the percentage which is apt to succeed, there is little question. Predicting for the individual is another matter.

Wagner (47) found that test scores were not valid or reliable criteria of success for the individual. Manning (29) felt that too much dependence should not be placed on predictions from tests when advising individuals, for every individual has factors which tests do not measure. Condit (7) reported that he found students drop out of school regardless of scores on tests or of scholastic standing. Vaughn (43) in describing the Pre-Engineering Inventory found that students least apt to succeed could be separated from the group but said,

> The most important generalization as it applies to your measurement program is that it is not possible to say to an applicant that he has no chance whatsoever of succeeding in the college of engineering, however low his test scores may be. (43:169)

Gould (20), in 1944, worked out a table showing the percentage of students who would likely succeed, or fail, providing the student attained a certain predicted score using his equation for obtaining the predicted score. McClanahan (30), in 1947, using a regression equation based on data from the September, 1945, group of freshmen entering the Division of Engineering at Colorado Agricultural and Mechanical College, developed a nomographic chart for counseling prospective engineering students in that college. This chart was constructed to show the probability of a student's achieving various grade-point levels by using the raw scores made by the student on the Chemistry and English tests at the time of entrance into the college. Using this nomographic chart, he was able to predict grades of 100 freshmen entering the Division of Engineering in September, 1946, that correlated .657 with their earned-point average.

Conclusions

The review of literature has led to the following conclusions:

1. There is a positive correlation between test scores and earned college grades.

2. Combinations of variables show closer relationship to grades than the variables taken singly.

3. There is a positive correlation between past performance in school and college grades.

4. Tests of special aptitudes are important in predicting for specialized fields of college work.

5. Parts of the Pre-Engineering Inventory are predictive of engineering grades.

6. Factors other than test scores of past performance are important in predicting college grades.

7. Predictions may be made from a combination of achieved scores on several variables by using a regression equation to change the achieved scores into predicted grades.

8. Predicting for an individual is hazardous, but the individual can be informed of the relative chance that he has for succeeding in a particular college field.

Chapter III

METHODS AND MATERIALS

In order to determine the relationship between various scores on the Pre-Engineering Inventory and grades in the Division of Engineering, Colorado Agricultural and Mechanical College, data on the freshman engineering classes entering the college in September, 1946, and September, 1947, were studied. These data were collected from the files in the offices of the college Registrar, the Dean of Student Affairs, and the Division of Engineering. The files of the college Registrar provided the scholastic record of each engineering student who entered the Division of Engineering in September, 1946, and September, 1947. The files of the Office of Student Affairs yielded the Pre-Engineering Inventory test scores made by the class entering in September, 1946. The files of the Division of Engineering of the college produced the Pre-Engineering Inventory test scores made by the class entering in September, 1947.

The scholastic averages made by the students of the classes entering the Division of Engineering in September, 1946 and 1947, were selected as the criterion of success in the Division. The files contained the letter grade each student achieved in each subject and the number of quarter hours of credit given for each subject. The 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 failing) 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 each letter grade.

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

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

Sample studied

Data on members of the freshman engineering class of 1946 were studied to determine the relationship between raw scores made on the Pre-Engineering Inventory and grade-point average in the Division of Engineering. One hundred engineering students were obtained for the sample by selecting every third name of the students listed in alphabetical order. The Pre-Engineering Inventory test scores were available for every member of this sample 1/.

Data on members of the freshman engineering class entering school in September, 1947, were studied to determine the efficiency of a formula derived from the 1946 sample study for predicting grade-point average of succeeding freshman classes. Ninety engineering freshmen were selected for this sample by taking the name of every other student listed in alphabetical order. The Pre-Engineering Inventory test scores were available for every member of this sample 2/. In order to make a comparison between the efficiency of the regression equation, derived from the Pre-Engineering Inventory, and the nomographic chart developed by McClanahan (30), the data on the September, 1947, class were also used to predict grade-point averages for that group using the nomographic chart to make the predictions 3/.

1/ See Appendix A.

2/ See Appendix B.

3/ *Ibid.*

Chapter IV

ANALYSIS OF DATA

Raw data for the problem, How may the Pre-Engineering Inventory be used for guidance at Colorado Agricultural and Mechanical College?, were gathered from the files of the college Registrar, the Office of Student Affairs, and the Division of Engineering at Colorado Agricultural and Mechanical College. These data consisted of credits and letter grades earned by students in the college and scores achieved by students on tests taken prior to entering study in the college.

These data were analyzed by statistical methods in order to determine the relationship that existed between Pre-Engineering Inventory test scores and grade-point average and to derive a regression equation from which grade-point average could be calculated when certain scores on the Pre-Engineering Inventory were known. The standard error of the regression equation was computed in order to determine the probability that achieved grades would be equal to the predicted grades derived from the regression equation.

Statistical methods

Statistical methods were used in studying the data from the 100 students who entered the Division of Engineering, Colorado Agricultural and Mechanical College in September, 1946, to determine the relationship between the various scores achieved on the Pre-Engineering Inventory and the grade-point average earned by these students. The study involved the following steps:

1. Zero-order correlations were computed to measure the statistical relationship between earned grade-point average and the composite score and between grade-point average and the score on each of the seven sub-tests of the Pre-Engineering Inventory. These zero-order correlations were computed by using the Pearson product-moment method (18:265-71)

2. In order to determine the common factors measured by each test, intercorrelations were calculated between each test score and every other test score.

3. From the data thus assembled, multiple-correlation coefficients were computed to determine the relationships between combinations of various sub-test scores and grade-point average. These multiple-correlation coefficients were found by using a scheme devised by Cureton for use with an electrical calculating machine and described by Dunlap (11:63-7)

4. With the most efficient predictive combination of variables, a regression equation was calculated by the method described by Otis (35: 243-4). The regression equation is used to assign weights to the variables in the equation in such a way as to obtain the maximum efficiency in predicting grades when raw scores of the variables are known.

5. The standard error of estimate (σ_{est}) was used to determine the extent to which an earned grade was likely to deviate from the predicted grade.

6. The coefficient of "forecasting efficiency" (E) was computed for each multiple-correlation coefficient to provide an estimate of the value of various combinations of sub-test scores for predicting grade-point average (18:345-6).

By using the regression equation, predicted grade-point averages were calculated for each member of the group of engineering students who entered the college in September, 1947. Zero-order coefficients of correlation were then calculated between the predicted grade-point averages and the earned grade-point averages, and zero-order coefficients were calculated between the grades predicted from McClanahan's nomographic chart and the earned grade-point averages of these students.

Zero-order coefficients of correlation

Coefficients of correlation were computed to determine the relationship between each score on the Pre-Engineering Inventory and grade-point average and between the variables themselves.

Sub-test 4, "Ability to do quantitative thinking," correlated .737 with grade-point average, making it the best single predictor of grade-point average, Table 4. This test was followed closely in value by the composite score (r = .734) and sub-test 2, "Technical verbal ability," (r = .709). Sub-test 3, "Ability to comprehend scientific materials," was fourth in order with a correlation of .620. The relationships between the other sub-tests and scholastic success were considerably lower, varying from .481 for sub-test 1, "General verbal ability," to .354 for sub-test 6, "Spatial visualizing ability."

The correlations between the composite score and various sub-test scores were all high, ranging from a low of .564 with sub-test 6 to a high of .925 with sub-test 3, Table 4. High coefficients of intercorrelation between the sub-test scores indicated that the sub-tests all measure common factors to a great extent. Sub-tests 6 and 7 showed the least relationship with a correlation of .380. Four other combinations showed inter rs of less than .50 with all other combinations ranging from .512 through .795.

Table 4.--ZERO-ORDER COEFFICIENTS OF CORRELATION BETWEEN SCORES ON VARIOUS SUB-TESTS OF THE PRE-ENGINEERING INVENTORY AND BETWEEN GRADE-POINT AVERAGE AND PRE-ENGINEERING SCORES.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0	.481	.709	.620	.737	.416	.354	.417	.734
1		.686	.678	.611	.465	.547	.736	.737
2			.744	.728	.512	.470	.550	.892
3				.795	.682	.572	.675	.925
4					.630	.487	.526	.906
5						.503	.423	.683
6							.380	.564
7								.645

(0) grade-point average

(1) sub-test 1 (General verbal ability)

(2) sub-test 2 (Technical verbal ability)

(3) sub-test 3 (Ability to comprehend scientific materials)

(4) sub-test 4 (Ability to do quantitative thinking)

(5) sub-test 5 (Ability to comprehend mechanical principles)

(6) sub-test 6 (Spatial visualizing ability)

(7) sub-test 7 (Understanding of modern society)

(8) composite

Multiple correlations

Sub-test 2, "Technical verbal ability," combined with sub-test 4, "Ability to do quantitative thinking," gave a multiple r of .779, Table 5. This was nearly as good for predictive purposes as the .787 obtained when the

Table 5.--MULTIPLE COEFFICIENTS OF CORRELATION BETWEEN VARIOUS COMBINATIONS OF SUB-TEST SCORES OF THE PRE-ENGINEERING INVENTORY AND GRADE-POINT AVERAGE.

Combined variables	Multiple coefficients
0.1234567	.787
0.123456	.787
0.12345	.787
0.1234	.783
0.123	.715
0.12	.709
0.24	.779
0.34	.739
0.46	.737
0.23	.514
0.245	.784
0.234	.739

(0) grade-point average

(1) sub-test 1 (General verbal ability)

(2) sub-test 2 (Technical verbal ability)

(3) sub-test 3 (Ability to comprehend scientific materials)

(4) sub-test 4 (Ability to do quantitative thinking)

(5) sub-test 5 (Ability to comprehend mechanical principles)

(6) sub-test 6 (Spatial visualizing ability)

(7) sub-test 7 (Understanding of modern society)

seven sub-tests were all included in the combination. Sub-test 1 when combined with sub-test 2 did not add to the predictive efficiency of sub-test 2 for the multiple *r* for this combination was .709, the same as the correlation between sub-test 2 and grade-point average. The addition of sub-test 3 to this combination increased the multiple *r* only .006 of a unit, but the addition of sub-test 4 increased the multiple correlation to .783 which was nearly as high as the coefficient of multiple correlation of .787 obtained when the other sub-tests were added. Sub-test 2 combined with sub-test 3 showed a multiple *r* of .514; and combinations of sub-test 4, with 6 a multiple *r* of .737; and 4 with 3, the multiple *r* of .739. The addition of sub-test 3 to the 2-4 combination produced a slight increase from .779 to .780, and the addition of sub-test 5 provided an increase from the original .779 to .784.

Coefficient of forecasting efficiency

The coefficient of forecasting efficiency (E) was computed from the formula: $E = 1 - \sqrt{1 - r^2}$ (18:345) to make a comparison between the various combinations of variables. The forecasting efficiency of sub-test 2 in combination with sub-test 4 was found to be 37.3 per cent better than chance. This was nine-tenths of one per cent less than the forecasting efficiency of 38.2 found when all of the sub-test scores were used. For counseling purposes this difference is not significant and the amount of work involved in finding the correlation of the larger number of variables makes the combination of sub-test 2 and sub-test 4 much more usable. The increase in forecasting efficiency gained by adding other variables to the combination of sub-tests 2 and 4 was not sufficiently great in any instance to compensate for the additional labor required to obtain the increase, and all other combinations of two variables were less efficient as predictors of grade-point average.

Regression equation

A regression equation based on the data for the group of engineering students who entered school in September, 1946, was found to be:

$$Xc = .028X_2 + .0336X_4 - .325$$

In the equation Xc was used to indicate the predicted grade-point average, X_2 was the raw score on sub-test 2 and X_4, the raw score on sub-test 4.

Standard error of estimate

The standard error of estimate is the measure of tendency of actual scores to group themselves around an estimated score obtained from a regression equation. The formula for finding the standard error of estimate is

$$\sigma_{est} = \sigma_0 \sqrt{1 - r^2_{0.24}} \quad (18:300)$$

σ_{est} = standard error of estimate

σ_0 = standard deviation of the achieved grade-point average distribution of the 1946 sample

$r^2_{0.24}$ = the multiple coefficient correlation between achieved grade-point average and raw scores achieved on sub-tests 2 and 4.

The standard error of estimate was found to be .55. The chances are better than 99 in 100 that the actual grade will lie within the limits of three times the standard error of estimate above, or below, the predicted score, and 68 times out of 100 the actual score will lie within one standard error of estimate above, or below, the predicted score. (18:300-1)

<u>Efficiency of predicting devices on succeeding classes</u>

Zero-order correlations were run between grades predicted for the 90 students of the 1947 sample (using the regression equation based on the data of the 1946 group) and the grade-point average achieved by this group during their first two quarters in school. The coefficient of correlation was found to be .515 which gave a forecasting efficiency 14.3 per cent better than chance. A correlation chart was also set up to determine the relationship between the grades earned by this group and grades predicted from the nomographic chart developed by McClanahan (30) in his 1947 study.

The correlation between the earned grade-point average of the 90 students which constituted the 1947 sample and the grades predicted from the nomographic chart was found to be .508. The difference of seven thousandths between the correlations of the two predictive devices and grade-point average was not great enough to select either one as the better predictor when considering the results for the group as awhole.

When the correlation charts were studied to determine how well they selected the students who were apt to fail to make a passing grade there was found a marked difference between them. Out of 41 predicted to make a grade-point average of less than 2.00, 32, or 78 per cent, failed to make that score, and only nine made a passing grade, Table 6. The correlation chart based on tests 2 and 4 of the Pre-Engineering Inventory showed that 44, or 61 per cent, of the 72 predicted to make a grade-point average of less than 2.00 made a failing average, Table 7. Three out of five predicted to make a grade of less than D by the English-Chemistry test combination made less than a D, and the other two made a grade of less than C. Out of 26 predicted to make less than a D by tests 2 and 4 of the Pre-Engineering Inventory, 12 earned grades below D, 10 earned grades between D and C, and four earned grades of better than C. On the upper end of the charts, two of the eight predicted to make a B or better by the English-Chemistry test score earned grades between B and A, five between C and B, and one between D and C; while no student pre-

Table 6.--RELATIONSHIP BETWEEN EARNED GRADE-POINT AVERAGE AND ESTIMATED GRADE-POINT AVERAGE (BASED ON ENGLISH AND CHEMISTRY TEST SCORES) OF 90 STUDENTS WHO ENTERED THE DIVISION OF ENGINEERING, COLORADO AGRICULTURAL AND MECHANICAL COLLEGE IN SEPTEMBER, 1947.

Achieved grade-point average	Estimated grade-point average .25- .49	.50- .74	.75- .99	1.00-1.24	1.25-1.49	1.50-1.74	1.75-1.99	2.00-2.24	2.25-2.49	2.50-2.74	2.75-2.99	3.00-3.24	3.25-3.49	3.50-3.74	3.75-3.99	Frequency
3.75-3.99																
3.50-3.74						1										1
3.25-3.49												1	1			2
3.00-3.24								2								2
2.75-2.99								1		1	1	1		2		6
2.50-2.74						1	1		3	2	1				1	9
2.25-2.49				1			1	2	3		2					9
2.00-2.24					1	1	2	5		1		1				11
1.75-1.99				1		3		2		2				1		9
1.50-1.74			1	2	1		3	1	1	3	2					14
1.25-1.49						4			1	2						7
1.00-1.24			1				3									4
.75- .99			3	1	2	2			1							9
.50- .74				1	2	1	1									5
.25- .49								1								1
.00- .24									1							1
Frequency			5	6	6	13	11	14	10	11	6	3	1	3	1	

Table 7.--RELATIONSHIP BETWEEN EARNED GRADE-POINT AVERAGE AND ESTIMATED GRADE-POINT AVERAGE (BASED ON SCORES MADE ON TESTS 2 AND 4 OF THE PRE-ENGINEERING INVENTORY) OF 90 STUDENTS WHO ENTERED THE DIVISION OF ENGINEERING, COLORADO AGRICULTURAL AND MECHANICAL COLLEGE IN SEPTEMBER, 1947.

	Estimated grade-point average																	
Achieved grade-point average	.25- .49	.50- .74	.75- .99	1.00-1.24	1.25-1.49	1.50-1.74	1.75-1.99	2.00-2.24	2.25-2.49	2.50-2.74	2.75-2.99	3.00-3.24	3.25-3.49	3.50-3.74	3.75-3.99	4.00-4.24	4.25-4.49	Frequency
3.75-3.99																		
3.50-3.74						1												1
3.25-3.49									1		1							2
3.00-3.24					1		1											2
2.75-2.99							1	2			2					1		6
2.50-2.74			1		1	3	1		1		1						1	9
2.25-2.49		1	1			1	4		2									9
2.00-2.24		1		3	4	3												11
1.75-1.99	1		2	2		1	1		1				1					9
1.50-1.74			4	1	3	2	2		1	1								14
1.25-1.49			2	2	1		1			1								7
1.00-1.24	1			1		1		1										4
.75- .99	3	1	2		1		2											9
.50- .74	2	2	1															5
.25- .49						1												1
.00- .24			1															1
Frequency	7	5	14	9	11	13	13	3	6	2	4	0	1	0	0	1	1	

dicted to make a grade of B by the tests of the Pre-Engineering Inventory earned that grade. Two of the three selected to earn Bs made grades between C and B, and the third placed between D and C.

Chapter V
DISCUSSION

In order to simplify the search for a solution to the problem, How may the Pre-Engineering Inventory be used for guidance at Colorado Agricultural and Mechanical College?, this study was divided into five parts, as follows:

1. Relationship between the composite score and freshman grades in engineering.

2. Relationships between the various sub-test scores and engineering grades.

3. Relationships between various combinations of sub-test scores and grades.

4. Method of using the best combination of sub-tests for predicting grade-point average.

5. A comparison between the findings of this study and the findings of McClanahan (30) in his study, "Use of standardized tests in counseling freshmen in the Division of Engineering, Colorado Agricultural and Mechanical College."

Since the Pre-Engineering Inventory furnished eight different scores for the advisers in the Division of Engineering, it seemed desirable to determine, if possible, just how valuable each score might be in predicting grades for students enrolled in the Division of Engineering.

Composite score and grades

The composite score was found to be a relatively good single predictor of earned grades for a group of college students who enrolled in Colorado Agricultural and Mechanical College in September, 1946. The coefficient of correlation of .734 between these two variables was considerably higher than the .49 reported in the "Statistical Summary of the Testing Program," at the University of California (5). It agreed more closely, however, with the coefficients of correlation of .69 and .72 between engineering grades and Iowa Mathematics Aptitude test scores reported by Bartlett (2), in 1943, and Feder and Adler (16), in 1939.

When compared with findings of others who had used several variables to predict grade-point average, the composite score correlation with engineering grade-point average was found to be nearly as high as the $\underline{r}$ of .74 reported by Feder and Adler (16) using four variables, but was lower than the multiple coefficient of correlation of .81 found by McClanahan (30) for a combination of two variables that included scores achieved on the Iowa Chemistry Aptitude test and the Cooperative English test.

In spite of the fact that the composite score showed a relatively high relationship with earned grade-point average, it was not the best single score obtainable for the various tests included in the Pre-Engineering Inventory for predicting grades in engineering. It was found to rank second to sub-test 4, "Ability to do quantitative thinking," as a single predictor of grades for the group studied. This finding was substantiated by the "Statistical Summary of the Testing Program" at the University of California(5) which also showed the composite score ranking second to sub-test 4 as a predictor of engineering grades.

Sub-test scores and grades

As has already been stated above, sub-test 4 was the best single predictor of the eight scores obtained from the Pre-Engineering Inventory battery of tests. The coefficient of correlation of .737 between sub-test 4 and grades was considerably higher than the coefficient of .53 reported by the University of California, but was in accord with the findings of the University in that both studies found sub-test 4 outranked the other variables of Inventory as a single predictor of engineering grades. This coefficient of correlation approximates closely the r=.69 and r=.72 between engineering grades and the Iowa Mathematics Aptitude test scores reported by Bartlett (2) and Feder and Adler (16) and the r of .65 reported by McClanahan (30) for the association between engineering grades and the Iowa Chemistry Aptitude test.

Sub-test 2, "Technical Verbal Ability," which correlated .709 with earned grades in the Division of Engineering ranked second among the sub-tests as a predictor of engineering grades. This compared favorably with a coefficient of correlation of .65 between scores on the American Council on Education Psychological Examination and engineering grades reported by McClanahan (30) in 1947. There was considerable difference between the *r* found in this study and the *r* of .32 reported for this sub-test in the "Statistical Summary of the Testing Program," at the University of California (5). The summary also showed that for the group studied in California sub-test 3 was the sixth best predictor of grades instead of second as found in this study.

Sub-test 3 with a coefficient of correlation of .62 between test scores and engineering grades was the only one of the remaining five tests which showed a reasonably close relationship to grades. The scores on the other tests ranged from a high coefficient of correlation of .481 between sub-test 1, "General verbal ability," to a low correlation of .354 between scores on sub-test 6, "Spatial visualizing ability," and grades.

Combinations of sub-tests and grades

A combination that included all of the sub-tests was found to predict engineering grades with but very little more efficiency than the combination that included only sub-tests 2 and 4. The coefficient of multiple correlation for the combination which included the test scores from all seven sub-tests was found to be .787 which was only .008 higher than multiple r of .779 for the combination which included only the above two variables.

The addition of sub-test 3, the only remaining test which showed a relatively high correlation with grade-point average, to the combination which included tests 2 and 4 raised the multiple r to only .780. The increase of .001 gained by this addition was not sufficiently great to compensate for the additional labor required to compute a multiple correlation which included three variables instead of two. The addition of other variables to the combination which included sub-tests 2 and 4 failed to raise the efficiency of the predictive combination sufficiently to warrant the extra labor involved. Since the combination that included sub-test 2 and sub-test 4 showed a closer relationship to earned grades than any other combination which included only two variables, this combination was selected as the most practical from the Pre-Engineering Inventory for counselors.

Use of best combination

In order to use this combination of sub-tests to the best advantage, weights were assigned to each score through the use of a regression equation based on the findings of this study of the sample of 100 students who entered the college in September, 1946. This regression equation was then used to predict grades for 90 students of the succeeding class who enrolled at Colorado Agricultural and Mechanical College in September, 1947, and were given the Pre-Engineering Inventory at that time. Grades were also predicted for this same sample of students who had also taken the Iowa Chemistry Aptitude test and the Cooperative English test at the time of enrolling in the college. These predictions were made from the nomographic chart developed by McClanahan (30), in 1947.

Coefficients of correlation were then computed between the predicted scores based on each of the two predictive devices described above and the grade-point average earned by these students during the first two quarters of work in college.

Comparison of findings
of this study and McClanahan's

This study found that three scores obtained from the Pre-Engineering Inventory showed a closer relationship to earned grade-point average than the scores from any one of the variables used in McClanahan's study (30). The scores of sub-test 4 were found to correlate .737 with achieved grades in comparison with a coefficient of correlation of .65 reported by McClanahan between scores on the Iowa Chemistry Aptitude test and grades when both measures were considered as single predictors of grade-point average. McClanahan (30), however, reported a multiple coefficient of correlation of .814 between a combination that included scores from the Chemistry test and the Cooperative English test and the grade-point average achieved by 44 freshmen in the Division of Engineering. This multiple coefficient was higher than the .779 found between the best predictive combination of this study and achieved grades.

When the predictive measure developed in this study was compared with the predictive measure developed in McClanahan's study, the difference, .007, between the coefficient of correlation for the variables recommended for use by this study and that for the one recommended by McClanahan was too small to be significant. If one measure were to be selected over the other for predicting grades for engineers, factors other than linear correlation had to be considered.

The correlation charts were studied to determine which device did the better job of separating the student who could not achieve a satisfactory grade of 2.00 from the group of students who would make passing grades. To facilitate this comparison, two straight lines were drawn on the correlation charts. The vertical line which passed through the 2.00 predicted grade-point average indicated that those individuals who fell to the left of that line were predicted to achieve an average grade of less than C. The horizontal line which passed through the 2.00 achieved grade-point average indicated that those who fell below this line failed to achieve a grade of C. The group of individuals who fell to the left of the vertical line and above the horizontal line were of special interest in comparing the predictive measures for they were the individuals who would have been eliminated on the basis of predicted grades, but who did succeed in making passing grades.

Nine students were found to fall in this group on the correlation chart based on predicted grades from the nomographic chart, and 28 fell in this group on the chart comparing the grades estimated from the regression equation based on sub-tests 2 and 4 of the Pre-Engineering Inventory. This meant that on the basis of predictions depending on Pre-Engineering Inventory test scores, 19 more students who achieved satisfactory grades were eliminated than were eliminated by predictions based on the scores of the Chemistry test and the English test. Since it is necessary for a student to maintain a grade-point average of 2.00 to be successful in the Division of Engineering, Colorado Agricultural and Mechanical College, the measure that separates the prospective engineering students into two groups at that point with greater reliability is the better counseling tool for advisers of the Division. Much valuable time may be saved both the students who are destined to fail and the Division of Engineering if such students are guided into other fields before they have lost valuable time taking courses in which they cannot achieve satisfactory marks. On the other hand, the Division of Engineering does not wish to eliminate students who can succeed in attaining satisfactory grades.

The combination that included the Iowa Chemistry Aptitude test and the Cooperative English test also showed considerable superiority over the other measure as a predictor for selecting those who would fail to achieve a grade-point average of less than D. Sixty per cent of the students who were predicted to earn a grade-point average of less than D by this measure actually achieved grade averages of less than D, and no student of this group achieved an average of C. In comparison, only 46 per cent of those who were predicted to make less than the D average on the basis of sub-tests 2 and 4 of the Pre-Engineering Inventory achieved averages that were below that point. Fifteen per cent of this group predicted to earn less than D achieved grade averages that were greater than C, and nearly 39 per cent achieved grade-point averages between D and C.

Time was another factor that favored the use of the Chemistry test scores and the English test scores over the Pre-Engineering Inventory test scores. The Chemistry and English tests could both be administered to a group of students in approximately one hour and 30 minutes, while nearly eight hours were required to administer the Pre-Engineering Inventory. If it were possible to administer sub-tests 2 and 4 and eliminate the other tests, this advantage would be eliminated. Test results of the Chemistry and English tests could be made available to the advisers of the Division of Engineering within a few hours for these score sheets that accompany these two tests could be graded immediately after the student had completed the test. The Pre-Engineering Inventory had to be scored in a center that was often some distance from the institution giving the test, and it was found that sometimes the results were not available for counseling students for several weeks after they had been administered to the student. The week prior to the entrance into class work was found to be the most practical time to give tests to entering college freshmen. Since the results of the Pre-Engineering Inventory were not generally available within a few days, this test was found to be of no value for counseling the student at the time of his enrollment. Person 1/ gave this as the principal reason for giving up

1/Letter from H. T. Person, Head, Civil Engineering Department, University of Wyoming, to Dean Stinson, Director of Testing, Colorado Agricultural and Mechanical College, dated November 18, 1947.

the use of the Pre-Engineering Inventory in the Division of Engineering at the University of Wyoming.

A comparison of costs also favored the Chemistry Aptitude test and the English Aptitude test over the Pre-Engineering Inventory for it was found that the cost of the score sheets for these tests was but a few cents each, while a minimum charge of two dollars must be made each student who was given the Pre-Engineering Inventory.

For the reasons stated above, the nomographic chart developed by McClanahan (30) was selected as the more practical measure for counseling prospective engineering students at Colorado Agricultural and Mechanical College.

Implications

The nomographic chart based on a regression equation that included the raw scores achieved by individuals on the English and Chemistry tests was just as good a predictor in terms of correlation as a regression equation based on scores made on sub-tests 2 and 4 of the Pre-Engineering Inventory. The nomographic chart did the better job of selecting, for this particular group of 90 students entering Colorado Agricultural and Mechanical College in 1947, the individuals who would probably fail to succeed in engineering. The results of the English and the Chemistry tests are available at the time the student is registering for classes, while the results of the Pre-Engineering Inventory are not available until after he would have begun class work, and the cost of the first group is less.

For the reasons stated above, the English and Chemistry tests scores seemed to be the more practical combinations of measures for counselors of students who desire to enter the Division of Engineering, Colorado Agricultural and Mechanical College.

Recommendations for further studies

The regression equation, based on sub-tests 2 and 4 of the Pre-Engineering Inventory, and developed on the freshman engineering class of 1946 seemed to have some value for predicting the probability of success for members of the succeeding class in engineering. It did not, however, select as well as the nomographic chart, based on the Iowa Chemistry Aptitude test scores and the Co-operative English test scores, those students who are apt to fail in the Division of Engineering.

Other studies might be made from time to time to determine whether the English-Chemistry nomographic chart would predict with comparable efficiency for succeeding classes those who would fail to achieve satisfactory grades in the Division of Engineering.

Studies to determine the efficiency of both measures for predicting graduation from engineering college might be valuable to counselors of engineering students.

A study combining some of the items from sub-test 2 and sub-test 4 into a single test might develop a measure that would be more efficient than the regression equation, based on these separate tests, for predicting engineering grades.

Chapter VI

SUMMARY

The Office of Student Affairs at Colorado Agricultural and Mechanical College furnishes faculty student advisers with data on the tests administered to the students prior to their enrollment in the college. The faculty advisers in the Division of Engineering are given, in addition to the data on the regular battery of entrance tests, the various scores made by the individual members on the Pre-Engineering Inventory. The present study was undertaken to determine whether the Pre-Engineering Inventory contributed to the regular guidance data which included scores on the American Council on Education Psychological Examination, the Cooperative English test (form P M), the Iowa Placement test, Chemistry Aptitude, the Nelson-Denny Reading test, and rank in the high school graduating class.

The data for this study consisted of eight scores achieved on the Pre-Engineering Inventory and marks earned by 100 freshman students who entered the Division of Engineering of the college in September, 1946.

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

1. r_{01} .481

2. r_{02} .709

3. r_{03} .620

4. r_{04} .737

5. r_{05} .416

6. r_{06} .354

7. r_{07} .417

8. r_{08} .734

Multiple coefficients of correlation were calculated for various combinations of variables. The combinations which produced the highest coefficients are as follows:

1. $r_{0.12345}$ .787

2. $r_{0.1234}$ .783

3. $r_{0.245}$ .784

4. $r_{0.24}$ .779

The combination of sub-test 2, "Technical verbal ability," and sub-test 4, "Ability to do quantitative thinking," was selected as the most practical battery to use in counseling, and a regression equation using those variables was calculated. This equation follows:

$$\text{Grade-point average} = .028X_2 + .0336X_4 - .325$$

X_2 = Score on sub-test 2

X_4 = Score on sub-test 4

The standard error of estimate of the regression equation was found to be .55 grade-point average.

The zero-order coefficient of correlation between grades predicted from the above equation and earned grades for two quarters of the 90 students who entered the freshman engineering classes in September, 1947, was found to be .515. The coefficient of correlation between the earned grades of this group and grades predicted from the English-Chemistry nomographic chart by McClanahan (30) was found to be .508. The nomographic chart was found to be a better instrument for selecting the students who would succeed, or would not succeed, in attaining a satisfactory grade of C in the Division of Engineering.

Correlation charts comparing the predictive efficiency of the above tests and the nomographic chart, based on the English and Chemistry tests indicated that the latter chart constructed by McClanahan (30) was the better predictor for the students at the lower end of the chart.

The standard error of estimate of the regression equation was found to be .55 grade-point average.

The zero-order coefficient of correlation between grades predicted from the above equation and earned grades for two quarters of the 90 students who entered the freshman engineering classes in September, 1947, was found to be .515. The coefficient of correlation between the earned grades of this group and grades predicted from the English-Chemistry nomographic chart by McClanahan (30) was found to be .508. The nomographic chart was found to be a better instrument for selecting the students who would succeed, or would not succeed, in attaining a satisfactory grade of C in the Division of Engineering.

Correlation charts comparing the predictive efficiency of the above tests and the nomographic chart, based on the English and Chemistry tests indicated that the latter chart constructed by McClanahan (30) was the better predictor for the students at the lower end of the chart.

APPENDIX

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Appendix A.--VARIANTS USED IN THE STUDY OF SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Appendix A.--VARIANTS USED IN THE STUDY OF SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	First year grade-point average	Pre-Engineering Inventory scores							
		Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Composite
1	2.6	14	49	37	39	21	03	17	125
2	2.7	83	53	65	49	36	39	55	167
3	2.4	24	29	35	36	19	16	33	100
4	1.9	11	46	32	36	09	27	19	114
5	2.4	28	41	29	46	10	42	20	116
6	3.8	88	77	83	79	36	40	46	239
7	2.4	14	38	34	39	28	07	13	111
8	3.2	63	69	73	63	31	36	49	205
9	2.7	56	67	73	74	47	32	48	214
10	2.2	29	46	44	42	26	25	34	132
11	2.5	57	44	43	34	06	37	26	121
12	2.1	69	64	56	49	21	37	43	169
13	.9	06	14	24	24	14	31	13	62
14	2.3	13	37	57	29	36	28	30	123
15	1.8	21	35	53	33	17	27	20	121
16	2.8	45	52	60	55	14	28	35	167
17	3.0	31	49	47	45	20	13	27	141
18	3.5	62	49	54	58	34	46	44	161
19	3.0	59	54	57	47	29	46	40	158
20	3.8	86	69	79	77	32	36	35	225
21	2.1	18	38	30	27	13	12	08	95
22	1.3	16	35	32	30	27	13	17	97

Appendix A.--VARIANTS USED IN THE STUDY OF SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	First year grade-point average	Pre-Engineering Inventory scores							
		Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Composite
23	.9	40	37	37	16	17	29	23	90
24	3.8	29	64	43	54	23	40	22	161
25	2.3	20	45	51	47	33	20	21	143
26	3.9	66	70	77	80	37	33	38	227
27	.5	02	36	53	30	21	41	08	119
28	.6	27	32	46	45	26	41	25	123
29	1.9	14	37	28	32	13	17	27	97
30	2.3	42	39	55	57	38	41	20	151
31	2.2	59	51	78	44	23	32	55	173
32	2.6	38	54	51	44	29	40	40	149
33	2.0	80	53	36	31	17	35	34	120
34	3.1	47	53	70	57	26	34	34	180
35	3.2	34	56	75	65	28	48	34	196
36	1.3	12	23	26	31	18	24	10	80
37	2.2	21	50	18	33	10	24	12	101
38	2.2	18	59	41	22	16	29	21	122
39	1.2	46	28	38	36	18	33	32	102
40	2.4	54	47	47	44	31	34	31	138
41	2.8	52	62	45	35	14	29	24	142
42	3.5	63	64	56	56	35	40	38	176
43	2.1	12	40	43	33	18	22	36	116
44	2.6	23	29	28	41	26	24	30	98

Appendix A.--VARIANTS USED IN THE STUDY OF SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	First year grade-point average	Pre-Engineering Inventory scores							
		Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Composite
45	3.2	41	58	59	54	26	21	53	171
46	2.5	18	31	31	26	17	29	18	88
47	.6	28	33	26	27	13	12	34	86
48	1.2	11	26	17	13	07	09	26	56
49	2.3	22	49	51	48	11	11	29	148
50	.7	23	39	24	15	06	19	22	78
51	2.3	31	43	36	46	31	39	17	125
52	.4	18	11	31	12	07	26	15	54
53	2.4	37	39	31	29	17	12	27	99
54	.3	11	18	14	22	15	16	13	54
55	.5	07	15	25	10	15	13	08	50
56	.4	03	19	17	00	00	00	07	38
57	2.1	65	64	50	58	26	35	45	172
58	1.7	80	44	43	36	21	37	38	123
59	2.8	26	36	41	36	18	27	27	113
60	2.6	17	38	47	47	08	12	23	132
61	2.8	19	52	43	45	27	38	16	140
62	2.0	52	49	55	43	24	35	39	147
63	3.7	35	57	62	53	27	09	38	172
64	2.1	33	54	48	36	26	47	24	138
65	2.2	21	40	28	25	07	24	27	93
66	1.8	23	43	28	38	10	28	19	109

Appendix A.--VARIANTS USED IN THE STUDY OF SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	First year grade-point average	Pre-Engineering Inventory scores							
		Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Composite
67	3.0	41	44	49	38	35	44	28	131
68	2.1	85	81	84	61	28	46	55	226
69	3.0	69	45	42	35	20	45	38	122
70	2.4	26	36	49	35	29	44	16	120
71	2.4	70	44	51	50	12	31	54	145
72	2.5	39	50	47	45	21	41	31	142
73	1.4	28	19	24	33	13	16	26	76
74	2.9	16	40	37	37	20	37	20	114
75	2.8	45	58	52	49	22	45	45	159
76	2.5	43	42	43	39	27	07	47	124
77	3.1	75	69	58	67	34	45	26	194
78	1.6	21	49	26	21	09	25	27	96
79	1.6	13	38	32	42	24	06	15	112
80	2.1	26	33	23	45	06	16	27	101
81	2.5	31	41	31	45	08	22	20	117
82	2.4	10	33	42	43	28	30	23	118
83	1.1	30	35	28	38	17	28	28	101
84	2.8	72	63	69	62	24	33	53	194
85	1.8	56	49	73	39	23	44	54	161
86	3.6	21	48	43	63	20	34	28	154
87	1.1	19	31	16	29	17	10	11	76
88	2.5	34	54	52	39	26	24	21	145

Appendix A.--VARIANTS USED IN THE STUDY OF SEPTEMBER, 1946, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	First year grade-point average	Pre-Engineering Inventory scores							
		Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Composite
89	2.5	20	38	36	29	18	28	18	103
90	1.0	12	34	19	23	20	24	25	76
91	2.6	17	29	33	35	13	06	23	97
92	2.5	12	42	33	31	11	19	15	106
93	3.5	45	54	39	44	16	12	20	137
94	.7	14	20	22	26	06	14	35	68
95	3.0	34	47	61	62	26	39	32	170
96	2.8	36	56	54	43	20	44	26	153
97	1.2	34	49	25	36	13	19	08	110
98	3.4	34	50	51	55	23	34	32	156
99	2.8	62	62	56	38	24	29	41	156
100	1.9	20	44	28	32	14	24	21	104

Appendix B.--VARIANTS USED IN THE STUDY OF SEPTEMBER, 1947, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Appendix B.--VARIANTS USED IN THE STUDY OF THE SEPTEMBER, 1947, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	(1) P.E.I. test 2	(2) P.E.I. test 4	(3) Grades estimated from (1)&(2)	(4) Grades achieved by students	(5) Grades estimated from (6)&(7)	(6) English scores	(7) Chemistry scores
1	19	19	.85	2.68	2.66	196	78
2	27	19	1.07	1.76	2.14	154	66
3	64	00	1.47	2.14	3.22	230	96
4	37	33	1.82	2.48	2.20	171	47
5	23	27	1.23	1.65	1.84	128	62
6	58	23	2.07	1.10	1.82	118	66
7	15	26	.97	1.37	1.58	152	31
8	27	22	1.17	2.20	2.18	131	79
9	65	43	2.94	2.87	3.67	246	121
10	30	25	1.35	2.10	2.22	142	78
11	47	19	1.63	3.67	1.58	55	81
12	33	28	1.54	2.35	2.45	206	60
13	27	31	1.47	2.50	1.83	152	48
14	33	20	1.27	2.18	2.68	208	72
15	56	45	2.75	3.37	3.40	217	113
16	17	26	1.02	2.14	1.64	145	39
17	33	32	1.67	2.61	1.67	70	78
18	19	19	.85	1.65	1.44	124	38
19	35	21	1.36	3.06	2.18	134	78
20	26	33	1.51	2.59	2.38	138	91
21	06	19	.48	1.83	1.24	117	29
22	38	30	1.75	1.38	2.68	195	80

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Case number	(1) P.E.I. test 2	(2) P.E.I. test 4	(3) Grades estimated from	(4) Grades achieved by	(5) Grades estimated from	(6) English scores	(7) Chemistry scores
23	03	19	.40	1.17	.93	52	42
24	14	31	1.11	1.76	1.69	145	43
25	39	14	1.24	1.15	1.89	116	70
26	38	27	1.65	1.74	2.50	164	84
27	36	33	1.79	1.73	2.72	177	91
28	32	28	1.51	2.23	1.29	116	68
29	40	51	2.51	1.71	2.87	164	107
30	22	19	.93	1.56	1.06	57	46
31	25	10	.71	.89	.90	93	20
32	48	32	2.09	2.93	3.04	188	105
33	27	11	.80	.96	1.61	124	48
34	26	34	1.55	2.52	2.67	193	80
35	60	29	2.33	2.35	2.39	150	84
36	33	24	1.40	1.60	1.81	128	59
37	20	12	.64	.74	1.83	178	35
38	32	28	1.51	2.23	2.19	127	67
39	43	30	1.89	2.57	2.44	134	95
40	33	26	1.47	1.34	1.57	101	56
41	34	12	1.03	1.38	2.27	184	60
42	26	13	.84	.00	2.25	223	40
43	47	44	2.47	3.43	3.21	230	96
44	03	31	.80	.88	.93	65	32

Appendix B.--VARIANTS USED IN THE STUDY OF THE SEPTEMBER, 1947, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	(1) P.E.I. test 2	(2) P.E.I. test 4	(3) Grades estimated from (1)&(2)	(4) Grades achieved by students	(5) Grades estimated from (6)&(7)	(6) English scores	(7) Chemistry scores
45	12	28	.95	1.53	1.15	100	32
46	26	33	1.51	1.00	1.77	128	56
47	34	10	.96	1.77	1.54	110	51
48	15	26	.97	2.47	1.82	132	58
49	50	26	1.95	1.50	2.07	120	78
50	12	12	.41	.86	1.42	109	38
51	61	33	2.49	1.98	2.73	161	99
52	33	38	1.88	2.32	2.86	118	79
53	56	49	2.89	2.69	2.43	130	97
54	31	19	1.18	1.36	1.59	134	42
55	59	42	2.74	1.46	2.74	181	91
56	37	35	1.79	.93	1.64	99	63
57	57	34	2.43	2.40	2.82	182	95
58	30	39	1.83	.93	1.03	110	19
59	11	19	.62	2.31	1.10	29	60
60	43	15	1.38	1.64	2.52	150	92
61	56	48	2.86	2.98	2.22	87	105
62	39	33	1.89	2.25	2.14	153	67
63	30	24	1.32	.80	2.24	153	77
64	08	11	.27	.69	1.19	118	25
65	15	12	.50	.58	1.44	128	36
66	38	47	2.32	1.70	2.84	176	99

Appendix B. --VARIANTS USED IN THE STUDY OF THE SEPTEMBER, 1947, SAMPLE OF FRESHMAN ENGINEERING STUDENTS.

Case number	(1) P.E.I. test 2	(2) P.E.I. test 4	(3) Grades estimated from (1)&(2)	(4) Grades achieved by students	(5) Grades estimated from (6)&(7)	(6) English scores	(7) Chemistry scores
67	77	74	4.32	2.55	3.80	274	110
68	16	17	.69	2.00	1.96	154	62
69	42	34	1.99	3.19	2.21	165	66
70	23	20	.99	1.26	1.60	90	65
71	30	26	1.39	2.22	1.95	146	59
72	82	66	4.19	2.84	3.58	243	112
73	25	36	1.59	1.61	2.38	192	63
74	13	16	.58	.71	1.36	102	44
75	65	56	3.38	1.91	3.55	245	109
76	40	26	1.67	.37	2.07	124	77
77	26	31	1.44	1.56	1.76	105	67
78	56	37	2.49	2.54	2.89	173	104
79	37	28	1.65	2.06	2.23	218	40
80	30	24	1.32	2.06	2.02	127	73
81	11	25	.82	1.60	.96	70	35
82	31	35	1.72	2.44	2.37	114	110
83	43	40	2.22	2.87	2.86	204	87
84	43	33	1.99	1.79	2.70	155	101
85	02	20	.40	.97	1.39	125	34
86	22	14	.76	.65	1.72	111	62
87	17	23	.92	1.93	2.00	149	61
88	09	12	.33	.84	.98	101	25
89	41	32	1.90	2.89	2.50	191	71
90	36	25	1.52	1.83	1.72	137	49

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