ABSTRACT OF THESIS

VALUE OF THE ENGINEERING AND PHYSICAL SCIENCE APTITUDE TEST IN COUNSELING PROSPECTIVE ENGINEERING STUDENTS

Submitted by

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In partial fulfillment of the requirements

for the Degree of Master of Education

Colorado

Agricultural and Mechanical College

Fort Collins, Colorado

ABSTRACT OF THESIS

The challenge to Colleges and Universities to discover ever better criteria for use in advising students in a wise choice of a field of endeavor has been apparent for many years. This challenge has been especially persistent in the field of engineering education.

The degree of academic mortality in the Engineering Division at Colorado Agricultural and Mechanical College parallels that of the national situation. Of 221 students admitted to the Engineering Division of the college in the fall quarter of 1946, 30.3 per cent did not maintain a passing average for the first-quarter, and 35 per cent of those who completed one year failed to maintain a passing average for the year.

In the process of counseling, the Testing Bureau at Colorado Agricultural and Mechanical College administered the Engineering and Physical Science Aptitude Test to 59 individuals who were members of either the entering engineering class of 1946-47 or that of 1947-48.

The problem

The problem, then, is: How may scores made on the Engineering and Physical Science Aptitude Test at Colorado Agricultural and Mechanical College be best used for counseling prospective engineering students?

Problem analysis.--In order to aid in answering the problem question, the following sub-questions are presented:

1. What are the relationships between total scores achieved on the Engineering and Physical Science Aptitude Test, the Pre-Engineering Inventory, the entrance tests regularly administered at the college, and grades achieved during the first-quarter and first-year of engineering school?

2. What are the relationships between total scores achieved on the Engineering and Physical Science Aptitude Test and those achieved on the Pre-Engineering Inventory and the entrance tests regularly administered at the College?

3. What are the relationships between various combinations of the total scores achieved on the Engineering and Physical Science Aptitude Test, Pre-Engineering Inventory, College entrance tests, and grades achieved during the first-quarter and first-year of engineering school?

4. What inferences drawn from the available data indicate the value of the Engineering and Physical Science Aptitude Test in counseling prospective engineering students?

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

1. Fifty-nine students who took the Engineering

and Physical Science Aptitude Test in the process of counseling at Colorado Agricultural and Mechanical College and who entered the Engineering Division either during the school year of 1946-47 or that of 1947-48.

2. The following tests: The Engineering and Physical Science Aptitude Test; the Pre-Engineering Inventory; the American Council on Education Psychological Examination for College Freshman, 1943 edition; the Iowa Placement Examination Chemistry Aptitude, series CA-2, Form M; the American Council on Education Cooperative English Test, Form PM; and the Nelson-Denny Reading Test for Colleges and Senior High Schools, Form A.

3. Data obtainable from student records on file in the Office of the Registrar and the Office of Student Affairs, Colorado Agricultural and Mechanical College.

The data used in determining the value of the Engineering and Physical Science Aptitude Test in counseling prospective engineering students were obtained from files in the Office of Student Affairs and the Office of the Registrar, Colorado Agricultural and Mechanical College and were as follows:

1. Raw scores made by the students on the Iowa Placement Examination, series CA-2, Form M, Chemistry Aptitude, to be referred to hereafter as the Chemistry test.

2. Raw scores made by the students on the American Council on Education Psychological Examination

for High School Seniors and College Freshman, 1943 edition, to be referred to hereafter as the A.C.E.

3. 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.

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

5. Composite raw scores made by the students on the Pre-Engineering Inventory Test, to be referred to hereafter as the P.E.I.

6. Composite raw scores made by the students on the Engineering and Physical Science Aptitude Test, to be referred to hereafter as the Aptitude test.

7. Letter grades achieved and quarter credits earned in college subjects by the students.

Sample studied

Data concerning 59 members of the Engineering Division were studied in order to determine the relationship between various test scores and grades achieved during the first-quarter and first-year of engineering school. The 59 members were admitted to the Engineering Division either during the school year of 1946-47 or that of 1947-48. The Engineering and Physical Science Aptitude Test and the Pre-Engineering Inventory were

administered during the process of counseling. The entrance tests are administered to all entering students. Fifty-eight members of the group completed one-quarter in the Division. One member of the original group was marked as "withdrawn passing" but was included in the group in order to obtain the greatest number of scores possible for intercorrelation between variables. Two members of the group failed to complete the Chemistry test and no scores were recorded. Thirty-six members completed the first-year of academic work in the Engineering Division.

Test scores and grade-point averages were available for the following numbers of students:

1.	Aptitude test scores	59
2.	P.E.I. test scores	53
3.	A.C.E. test scores	59
4.	Chemistry test scores	57
5.	Reading test scores	59
6.	English test scores	59
7.	First-quarter grade-point average	58
8.	First-year grade-point average	36

Findings and conclusion

In order to aid in answering the problem, scores made on tests other than the Engineering and Physical Science Aptitude Test were also used. Data obtained from these other tests are presently used in counseling engineering students.

The variables used in this study were as follows:

1. First-quarter grade-point average — Variable 1
2. First-year grade-point average — Variable 2
3. Engineering and Physical Science Aptitude Test — Variable 3
4. American Council on Education Psychological Examination — Variable 4
5. Iowa Placement Examination Chemistry Aptitude — Variable 5
6. Nelson-Denny Reading Test — Variable 6
7. Cooperative English Test, Form PM — Variable 7
8. Pre-Engineering Inventory — Variable 8

Zero-order coefficients of correlation were computed between each variable and first-quarter and first-year grade-point average and resulted in the following coefficients:

1. $r_{12} = .769$
2. $r_{13} = .566$
3. $r_{14} = .427$
4. $r_{15} = .602$
5. $r_{16} = .227$
6. $r_{17} = .415$
7. $r_{18} = .646$
8. $r_{23} = .507$
9. $r_{24} = .431$
10. $r_{25} = .579$
11. $r_{26} = .302$
12. $r_{27} = .579$
13. $r_{28} = .558$

The Chemistry test was considered to be the most efficient of the single variables for prediction of first-quarter grade-point average, $r = .602$, even though

the Pre-Engineering Inventory test produced a somewhat higher coefficient of .646. In determination of efficiency the length of time required for administration of the tests was considered. The P.E.I. test requires approximately six hours for administration while the Chemistry test requires approximately one hour.

For prediction of first-year grade-point average from a single variable, first-quarter grade-point average was considered the most efficient, the correlation coefficient being .769.

Intercorrelation indicated that variables 4, 6, and 7 measured common factors to a considerable degree as likewise did variables 3, 4, 5, and 8.

Multiple coefficients of correlation were computed between various combinations of variables and first-quarter and first-year grade-point averages. The highest coefficients obtained from using three variables were as follows:

1. R1.578 = .694
2. R1.358 = .689
3. R2.178 = .824
4. R2.157 = .822

The highest coefficients obtained from using two variables were as follows:

1. R1.58 = .696
2. R1.48 = .672
3. R2.17 = .820
4. R2.13 = .775

When various combinations of three variables were considered in multiple correlation predictions of first-quarter grade-point average, the Engineering and

Physical Science Aptitude Test was involved in a combination which produced the second highest coefficient. Combinations of three variables which produced the two highest predictions of first-year grade-point average did not involve the Aptitude test. The Aptitude test was not involved in those combinations of two variables which produced the two highest predictions of first-quarter grade-point average but was involved in the combination of two variables which was the second highest predictor of first-year grade-point average.

In general, the addition of the Engineering and Physical Science Aptitude Test to the other tests used in this study did not increase prediction efficiency and it could not be used as a basis for establishing a cutting score which would efficiently serve as a criterion for admission to the Engineering Division. Therefore, it was considered to be of no additional value in counseling prospective engineering students.

T H E S I S

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COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

December 1948

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY LINCOLN ROSS

ENTITLED VALUE OF THE ENGINEERING AND PHYSICAL SCIENCE APTITUDE TEST IN COUNSELING PROSPECTIVE ENGINEERING STUDENTS

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

MAJORING IN GUIDANCE AND COUNSELING

CREDITS 6

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Committee on Final Examination

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A. V. Daubin — Clarence H. Miller

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David H. Morgan
Dean of the Graduate School

Permission to publish this thesis or any part of it must be obtained from the Dean of the Graduate School.

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Chapter I

INTRODUCTION

The challenge to Colleges and Universities to discover ever better criteria for use in advising students in a wise choice of a field of endeavor has been apparent for many years. This challenge has been especially persistent in the field of engineering education.

The number of students who enter schools of engineering and fail to complete the course of study is notably high. Reasons for leaving are varied, but for the most part the mortality can be attributed to one of two causes; either the achievement of a student as measured by his academic average has fallen below the grade required by the standards of the institution, or he has discovered that his interests and talents lie elsewhere.

Considerable headway has been made, through research in engineering education, towards meeting this challenge as it pertains to the engineering field. Notable among recent efforts in that direction has been the work of the Measurement and Guidance Project, begun in 1943 by the Engineer's Council for Professional Development in cooperation with the Carnegie Foundation for the Advancement of Teaching. One result has been the

formulation of a standardized set of examinations, the Pre-Engineering Inventory, which has been found to have good predictive value for success in engineering college. Other efforts have not been fruitless and so gradually, through test research, valuable tools are being discovered which are a necessity to the proper guidance of prospective engineering students.

But it is a well known fact that a problem such as this, while present in essence in all institutions, will differ among the institutions as to form and degree. Variations in curricula, composition of the student body, and local situations may all have a part in affecting the problem. Because of these differences the treatment of the problem cannot be formulated in terms of an over all prescription, for what may prove to be a good predictor of success in one school may lose its value elsewhere; that which is a good tool for the State College may be of little help to the University. Therefore, it is the task of each institution to find the factors which will be the most helpful in counseling its engineering students.

The degree of academic mortality in the Engineering Division at Colorado Agricultural and Mechanical College parallels that of the national situation. Of 221 students admitted to the engineering division of the college in the fall quarter of 1946, 30.3 per cent did not maintain a passing average for the first quarter, and

35 per cent of those who completed one year failed to maintain a passing average for the year.

In the process of counseling, the Testing Bureau at Colorado Agricultural and Mechanical College administered the Engineering and Physical Science Aptitude Test to 59 individuals who were members of either the entering engineering class of 1946-47 or that of 1947-48. It is the purpose of this study to investigate the results of this test to determine what contribution they may make to the existing data used in prognosis.

The problem

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Problem analysis.--In order to aid in answering the problem question, the following sub-questions are presented:

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Chapter II

REVIEW OF LITERATURE

Investigators have been concerned with the problem of academic mortality for many years. On the college level considerable emphasis has been placed upon the discovery of predictive data.

The findings of many studies dealing with the prediction of scholastic success in College were reported in the literature. Studies that combined and summarized the findings of numerous investigators were made by Douglas (10) in 1931, Segel (33) in 1934, Wagner (40) in 1934, and Mills (29) in 1936. Durflinger (11) summarized the findings of Douglas, Segel, and Wagner in 1943, and the results of other studies made from 1934 to 1943. The greater part of the content of these studies dealt with the results of high-school achievement and general aptitude tests as a means of predicting academic success in College.

An increasing number of studies was reported during the last decade dealing exclusively with the problem of predicting academic achievement in engineering schools.

Four studies are reviewed here that pertained

to the prediction of academic achievement at Colorado Agricultural and Mechanical College. One was concerned with the problem as it related to the general college population, another to forestry students, and two in relation to engineering students.

The entire review of the literature is grouped into the following sections:

Intelligence tests and college achievement
Intelligence tests and engineering grades
High-school achievement and college grades
High-school achievement and engineering grades
Multiple correlation and college grades
Multiple correlation and engineering grades
Personality tests and college achievement
Other variables and engineering grades
Previous studies made at Colorado Agricultural and Mechanical College
The criteria of prediction

Intelligence tests and college achievement

Condit (8), in 1929, reported a study dealing with the scholastic success of 529 Colorado State Teachers College freshman. He found that students who placed in the three lowest deciles in the range of scores made on the Thurstone Psychological Examination comprised over 54 per cent of those who dropped out of school.

Easley (13), in 1933, stated that, when intelligence test scores were correlated with scholastic achievement, the result in a majority of cases was a coefficient close to .50. He added that prognosis on the basis of such correlations would eliminate 13.4 per cent of the error incident to guessing.

Manning (28) reported the results of a study in 1938 which found a correlation of .56 existing between scores made on the Americal Council on Education Psychological Examination and first-semester grades in college.

Langhorne (22), in 1939, reported a correlation of .53 between intelligence test scores and grades achieved by a large number of college students and pointed out that those individuals who failed to remain in school for one quarter had an average percentile rank of 30 on the intelligence test. He stated that the average percentile rank of the class increased steadily with the length of enrollment.

Rigg (32), in 1939, found that the correlation between marks made on the American Council on Education Psychological Examination and first-semester grades ranged from .36 to .64 for seven different groups with a group average of .52. When the test results were correlated with four year achievement the results varied from .22 to .67 with a seven group average of .42.

Nemzek (30), in 1939, investigated the value of

a number of factors as predictors of academic success, including chronological age at entrance to school, amount of education of father and mother, occupational status of father, and intelligence quotient. He stated that none of these factors was significant for direct and differential prediction, but that intelligence was of value for direct prediction.

Durflinger (11), in 1943, found that the summaries made by investigators prior to 1934 were practically identical in that the correlations reported between college grades and intelligence were close to .45, Table 1.

Table 1.--SUMMARIES OF CORRELATIONS BETWEEN INTELLIGENCE AND COLLEGE SCHOLARSHIP FROM DURFLINGER. (11:71)

Author	Date	Number	Median
H. R. Douglas	1931	160	.45
David Segel	1934	100	.44
Mazie E. Wagner	1934	39	.40 to .50

Durflinger (11) also summarized the results of similar investigations made after 1934 and found the median correlation to be .52, Table 2.

Table 2.--CORRELATIONS BETWEEN INTELLIGENCE AND COLLEGE GRADES REPORTED SINCE 1934, FROM DURFLINGER. (11:70)

Investigator	Tests	Criterian Grades	r		
Butsch	Thurstone	First semester	.46 .49 .53	.47 .52 .53	.49 .53 .54
Hepner	A.C.E.	First year	.41		
Leaf	A.C.E.	First year	.57		
Manning	A.C.E.	First year	.30 .57	.45 .60	.48
Manning	Otis S-A	First year	.50	.60	

Durflinger (11) indicated an explanation for the increase in the median correlation coefficient for the years since 1934:

1. The newer intelligence tests, being designed primarily for college students, may measure more of the factors present in scholastic grades than did earlier tests.

2. College instructors may be using intelligence test results to assist them in arriving at the grades awarded to students.

3. College marks may be based upon course examinations and requirements which have a closer relationship with intelligence than was the case a decade or more ago. (11:69)

Lanigan (23), in 1947, investigated the results of a study made at Boston University to determine to what extent the Otis Test of Mental Ability, the American Council on Education Psychological Examination, and the Minnesota Speed of Reading tests predicted scholastic

success in the Liberal Arts College. She stated that the correlation coefficients obtained did not warrant the use of the two intelligence tests for prognostic purposes, although they did appear to differentiate specifically between the extreme of high and low achieving students.

Intelligence tests and engineering grades

Holcomb and Laslett (21) studied the relationship of the American Council on Education Psychological Examination test scores with freshman engineering grades in 1932 and reported a correlation coefficient of .55.

Laycock and Hutcheon (24), in 1939, reported the results of a study concerning 144 students at the University of Saskatchewan. They stated that a correlation coefficient of .34 was found when test marks made on the American Council on Education Psychological Examination were related to first-year engineering grades.

Mann (27), in 1942, reported correlation coefficients ranging from .29 to .56 between scores achieved on Thurstone Psychological tests and academic achievement of some 7,000 engineering students over a period of 22 years.

Bartlett (1), in 1943, reported a correlation coefficient of .44 when the American Council on Education Psychological Examination scores were related to freshman engineering grades, a figure lower than the

coefficients obtained when either Mathematics, English or Chemistry entrance test scores were related to engineering grades.

Garrett (18), in 1944, administered the Ohio State Psychological Test to 200 students who had completed the first semester of engineering college work and found a correlation of .61 between test scores and grade-point averages. Vaughn (39) reported results in 1944 which were nearly the same as those of Garrett. He found that scores made on the Yale Scholastic Aptitude test correlated .58 with the college grades of 979 engineering students.

High school achievement and college grades

Segel (33), in 1934, stated that tests administered at the completion of the high-school course were more reliable than general mental tests for predicting academic achievement in college. He found a median correlation of .55 between average high-school grades and general college scholarship.

Durflinger (11), in 1943, reported a summary of previous investigations of the relation of content examinations with college scholarship in which he stated the median coefficient was .55. He concluded, from contrasting information obtained from the various studies, that since correlation between high-school scholarship and college grades had given practically the same coefficient

as correlation between a two-hour achievement test and college grades, it was more practical to use the achievement test in preference to the more laborious process of computing high-school average.

High-school rank and college achievement.--Tuttle (38), in 1937, from studying a group of 68 students who ranked in the lowest 25 per cent of their high school class, found that none of the group attended college beyond the first-semester and that 49 of the 68 were dropped because of low grades.

Manning (28), in 1938, reported a correlation of .57 between percentile rank in high-school and first-semester grades in college.

Seyler (34), in 1939, asserted that there was a definite relationship between high-school rank and freshman scholarship in college and that it is possible to predict academic achievement in college with a high degree of accuracy from high-school percentile rank. In conclusion, Seyler stated that rank is of definite value in designating to college officials those entering students in need of immediate counseling services.

Freeman and Johnson (16), in 1942, found high-school rank to be the best single predictor of first-year honor-point ratio and that the coefficient of correlation expressing their relation was .72.

Williamson and Bordin (44), in 1942, reported

that the best single predictor of college success was high-school percentile rank, followed by aptitude tests, with achievement tests last.

High school achievement and engineering grades

Laycock and Hutcheon (24), in 1939, asserted that grade-twelve marks were the best predictors of freshman engineering success, having correlated .61 with the criterion. They added that the coefficient of .61 was practically as high as the coefficient of .66 obtained by multiple correlation of five variables with the criterion.

Pierson (31), in the resume of a study made at the University of Utah in 1947, stated that high-school grade-point average was found to be more closely related to general scholarship in engineering school than marks made on any particular subject and could be used as effectively in predicting success as a multiple correlation obtained from combining scores made in English, Physics, Chemistry, and Mathematics.

High-school rank and freshman engineering grades.--Bartlett (1), in 1943, found a striking contrast between an endowed university and a state college in the relationship of high-school rank with academic performance. He stated that the best predictor of freshman engineering grades in the state college was high-school rank while for the university almost any test was better than

high-school rank. He noted that the difference may be due to the fact that the students in the state college received their high-school education within a limited geographical range, where high-school standards were more uniform than in the wide-spread area from which the university had drawn its students.

Berdie (2) reported, in 1944, that he had obtained a correlation of .56 between high-school percentile rank and honor-point ratio achieved by 497 freshman engineering students.

Multiple correlation and college grades

A number of investigations were reported concerning the value of using a combination of variables in the prediction of academic success in college. Crawford (9), in 1930, reported a study made at Yale University and stated that prediction based on a weighted combination of data obtained from entering freshman correlated approximately .70 with their achieved grades for the freshman year. He found that the actual grade obtained by over two-thirds of the group did not differ by more than four points from the predicted grade while only 10 per cent had variations between actual and predicted grades of over seven points. He concluded that with such a predictive base it is possible to pick out effectively those who will be either very weak in academic work or

select for differentiation those with marked ability.

Edds and McCall (14), in 1933, obtained a multiple correlation coefficient of .81 by combining high-school grades, English ability, and intelligence test scores with college grades.

Williamson and Bordin (41), in 1942, found that the addition of an aptitude test to a battery of six achievement tests and high-school percentile rank did not appreciably increase the multiple correlation coefficient, but that the independent contribution of the aptitude test for prognostic purposes was as high as the battery of six achievement tests. They concluded that, because of a saving in time and money, it would be best to use an aptitude test in combination with high-school rank if it is desired to use but a single test.

Manning (28), in 1938, reported that a multiple correlation of .69 was obtained when first-semester college grades were combined with scores made on the American Council on Education Psychological Examination, a Cooperative English Test, and percentile rank in high-school graduating class.

Freeman and Johnson (16), in 1942, reported that the results of using a combination of seven variables and one of three variables for prediction of first-year honor-point ratio. They stated that the coefficient obtained from using the combination of three variables

was practically identical with the coefficient obtained from using seven variables.

Bartlett (1), in 1943, reported a multiple coefficient of .75 when a combination of scholastic and mathematical aptitude tests, college board subject matter examinations, and adjusted high-school rank were related to freshman grade averages.

Many other investigations were made in the effort to improve prediction of academic success through the use of multiple correlation. The results of a large number of these investigations made before 1934, were summarized by Segal (33), Douglas (10), and Wagner (40). Durflinger (11) summarized their findings and those of similar investigations made from 1934 to 1943. The following table was taken from Durflinger and lists the findings of investigations made since 1943.

Table 3.--MULTIPLE CORRELATION COEFFICIENTS REPORTED BY DIFFERENT INVESTIGATORS SINCE 1934. (Table V)(12:77)

Prognostic variables	r	Reporter	Institution
H.S. rank intelligence & h.s. content test	.59 .70	Butsch	Marquette U.
Elem. school I.Q. & 10th grade scholarship	.70	Bryns and Henmon	Wisconsin U.
T.C.P.A. English, intelligence and elementary tests		Durflinger	Nebraska Trs. Col.
men	.54		
women	.55		
T.C.P.A. English, intelligence and elementary tests	.688	Heilman	Colo. St. Col. of Education
H.S. marks, Ohio State intelligence and study performance test	.75	Hartson	Oberlin
T.C.P.A. intelligence and elementary tests	.620	Heilman	Colo. St. Col. of Education
Intelligence and H.S. grades	.56	Hepner	San Diego State
Intelligence, English aptitude, H.S. content tests and H.S. marks	.79	Leaf	La Salle Jr. College
Intelligence, H.S. rank, College aptitude test and freshman English	.83	Root	Hamline U.
Reading, English, immediate recall and Beta-type tests	.70	Selover & Porter	Ohio U.

Multiple correlation and engineering grades

Laycock and Hutcheon (24), in 1939, found a coefficient of .66 when using five variables in multiple correlation with freshman engineering grades. Since final year high-school marks, when correlated with freshman engineering grades, produced a coefficient of .61 the additional work involved in using the five variables was not warranted.

Pierson (31), in 1947, studied the relationship of general achievement in engineering to a combination of first-quarter marks in chemistry, English composition, mathematics, and engineering drawing. He found a correlation of .67 between these variables and the criterion.

Personality tests and college achievement

Stanger (36), in 1933, summarized the results of an investigation of the relation of personality traits to academic success. He concluded:

1. Linear correlations of intelligence, achievement and personality measures are low and are probably so as a result of the inherent nature of the relationship.
2. Extreme personality trends seem to counterbalance advantages in aptitude, making for equal achievement in opposed groups.
3. Personality factors have marked influence on the correlation of aptitude and achievement. (36:655)

Laycock and Hutcheon (24), in 1939, reported

that a study of the relationship of scores made on the Bernreuter Personality Inventory to engineering grades yielded nothing of prognostic significance.

Durflinger (11), in 1943, stated that personality testing as a means for predicting academic success is in experimental stages, which coupled with the fact that some studies have indicated such tests as being meaningless, apart from actual situations in which they function, would partially answer the question as to why they are not more readily used.

Other variables and engineering grades

Boardman and Finch (3), in 1934, reported that studies made of the scores achieved by 1,900 engineering students on the Cooperative Test in Mathematics showed a correlation of .57 with grade average at the end of the first year and of .52 at the end of the second. Cooperative English Test scores correlated with average grades received by the students during the first and second years to the extent of .45 and .37 respectively.

Iowa Placement Examinations and engineering grades.--In 1933, Dvorak and Salyer (12) asserted that the Iowa Physics and Iowa Mathematics test scores, in addition to natural sciences and mathematics grade averages, were indicative of student success in engineering.

Feder and Adler (15), in 1939, reported the results of a study conducted to determine the relationship of the Iowa Qualifying Examination battery to the academic achievement of freshman engineering students. They found that the battery yielded a composite score which correlated .74 with first-semester grades and .71 with total first-year achievement. When used singly, the tests were found to give satisfactory measures of achievement and correlated with first-semester and first-year grades, respectively, as follows: Iowa High School Content Test, .69 and .69; Iowa Silent Reading Test, .57 and .50; Iowa Mathematics Aptitude Test, .72 and .69; Iowa English Training Test, .62 and .60. No student who scored below the 30th percentile on these tests was successful in completing the engineering training program.

Mann (27), in 1942, stated that coefficients as high as .70 had been gained from correlation of Iowa and Mann placement tests with first-year scholarship in engineering schools.

Bartlett (1), in 1943, reported that correlation of three of the Iowa Placement Examinations with first-semester grades in engineering resulted in the following: Iowa English Training Test, .48; Iowa Mathematics Aptitude Test, .69; and Iowa Chemistry Aptitude Test, .57.

First-year grades and four-year achievement.--

Wilson and Hodges (42) in 1932, Brush (5) in 1941, and Siemens (35) in 1942, asserted that freshman grades are a very good indicator of the level of student achievement for the full engineering course. Correlations reported by the three investigators ranged from .58 to .91 for the relationship of first-year grades to four-year achievement.

The Engineering and Physical Science Aptitude Test.--Borrow (4), in 1943, stated that a very high correlation (r = .73) was found to exist when average grades achieved in five technical subjects, during a nine-weeks introductory engineering course, were related to scores achieved on the Engineering and Physical Science Aptitude Test. Correlations between the sub-scores on the test and average final grade ranged from .49 in mechanical comprehension to .63 in mathematics. The study involved 188 freshman engineering students in a special summer session at Pennsylvania State College.

The Pre-Engineering Inventory.--Vaughn (39), in 1947, reported the results of correlating the Pre-Engineering Inventory test scores with first-semester grade-point average. The test was administered to various sized groups in 10 colleges of engineering. He stated that the median correlation of the seven parts of the test with first-semester grade-point average ranged from .38 to .62. A composite score--based upon only the three

tests in the battery which were designed to measure technical verbal ability, comprehension of scientific materials, and general mathematical ability--showed a median correlation of .62 when related to first-semester grade-point average.

Previous studies at Colorado Agricultural and Mechanical College

The findings of a study made at Colorado Agricultural and Mechanical College (then known as Colorado State College of Agriculture and Mechanic Arts) were reported by Gould (19) in 1944. His study was made to determine the best predictors of first-semester grade-point average for the general college population from a battery of variables consisting of the American Council on Education Psychological Examination, the Iowa Chemistry Aptitude Test, the Cooperative English Test, the Iowa Mathematics Aptitude Test, and high-school rank. He found the Psychological Examination to be the best single predicator, followed by high-school rank and the chemistry test. The same three variables were also reported as being the most efficient combination in multiple correlation with the criterion.

McClanahan (26), in 1947, studied the relationship of high-school rank and the entrance tests regularly administered at the College to freshman engineering grades. He reported that the best single predictor of

first-year engineering grades was the Iowa Chemistry Aptitude Test which, when combined with the Cooperative English Test, was the best predictive battery. From the results of this combination, a regression equation and standard error of estimate were calculated and a nomographic chart constructed to show the probability of obtaining a particular grade-point average from scores achieved on the two tests.

Stinson (37), in 1948, reported the results of studying the relationship of various test scores of 278 freshman engineering students to academic achievement. The study was made to determine the most effective means of discovering--before entry into college--those students who would fail in engineering. The test scores under consideration were achieved by the students on the Council on Education Psychological Examination, the Iowa Chemistry Aptitude Test, and the Pre-Engineering Inventory. He found that correlation of the Pre-Engineering Inventory with either first-quarter or first-year grade-point average showed results only slightly higher than did the chemistry test used in combination with the same criteria and that the psychological test produced the lowest correlation coefficient of the three. First-quarter grades were found to produce a coefficient of .841 when correlated with first-year grades.

Clevenger (7), in 1948, found that the

Cooperative English Test was the best single predictor of first-year grade-point average of forestry students and that a combination of the English and Iowa Chemistry Aptitude Tests was the most practical to use in counseling. A nomographic predictive chart, similar to that constructed by McClanahan (26), was devised for counseling prospective forestry students.

A summary of the four previous studies reviewed here is found in Table 4.

Table 4.--SUMMARY OF THE FINDINGS OF PREVIOUS STUDIES MADE AT COLORADO AGRICULTURAL AND MECHANICAL COLLEGE

Investigator	Criterion and Population	Single variable*	r	Multiple Variables*	R
Gould	First-semester grade-point average	1	.634	1,2,5	.740
	General college population	2	.589		
		4	.559		
		5	.606		
		6	.526		
McClanahan	First-year grade-point average	1	.648	1,2,3,4	.848
		2	.652	2,3,4	.846
		3	.495	2,4	.814
	Engineering division	4	.583		
		5	.359		
Stinson	First-quarter grade-point average	1	.406		
		2	.598		
		7	.609		
	Engineering division				
	First-year grade-point average	2	.558		
		7	.572		
	Engineering division				

Table 4.--SUMMARY OF THE FINDINGS OF PREVIOUS STUDIES MADE AT COLORADO AGRICULTURAL AND MECHANICAL COLLEGE--Continued

Investigator	Criterion and Population	Single variable*	r	Multiple Variables*	R
Clevenger	First-year grade-point average Forestry division	1	.618	1,2,5	.762
		2	.496	1,2,4	.756
		3	.547	2,4	.721
		4	.637		
		5	.521		

*Variables
1. American Council on Education Psychological Examination
2. Iowa Chemistry Aptitude Test
3. Nelson-Denny Reading Test
4. Cooperative English Test
5. High-school rank
6. Iowa Mathematics Aptitude Test
7. Pre-Engineering Inventory Test

The criteria of prediction

Dvorak and Salyer (12), in 1933, reviewed studies dealing with the prediction of academic success that had been reported in books and periodical publications. They asserted that most of the studies were concerned with prediction of success, as measured by college grades, through the use of single variables. They summarized the conclusions reached in such studies and stated:

1. Each of these single variables correlates to some degree with college success.
2. The correlations between college success and these single variables are too low to

permit the admission or rejection of potential students without serious errors in the cases of individual students.

3. No single criterion is a safe basis for the selection of successful students. (12:619)

Butsch (3), in 1939, from the results of a study examining the possibilities of improving the criteria for predicting scholastic success, concluded that the variability shown by the criteria was wide, and that data which could be used to advantage at one college might be of little value at another.

Leaf (25), in 1940, asserted:

> Studies have shown definitely that it is impossible to foretell the scholastic achievement of all the students in a given group, and that many cases of success or failure can not be discovered until the student has tried to do college work. (25:303)

Williamson and Bordin (41), in 1942, in a discussion of the use of grades as the sole criterion of achievement stated:

> Prediction studies have commonly taken as their point of departure the assumption that honor-point ratios are the most valid criteria of college achievement available. That the assumption is not without error is duly acknowledged by most investigators; nevertheless honor-point ratios are usually employed as the sole criterion. Certain questions may be raised concerning grades as a criterion of achievement. Are honor-point ratios comparable? Is an A in chemistry equivalent to an A in French? Does a C from Professor Jones mean the same as a C from Professor Smith? The answer is probably no; and just so long as such an unstable criterion as grades is used, validity coefficients higher than approximately .72 may never be attained. (41:26-27)

Douglas (6), in 1943, asserted that differences in the abilities required for success vary between colleges in nature and degree to such an extent that it is unwise to advise a student as to whether he should go to college or predict his scholastic record. He stated that the institution attended, student abilities, and the curriculum pursued have a sizeable effect upon the variability.

Summary

Evidence was obtained from the review of literature which gives support to the following conclusions:

1. The correlation of measures of intelligence, general achievement, high-school grades, and high-school rank with general college achievement show positive relationships.

2. Similar results are obtained when these measures are related to academic achievement in schools of engineering.

3. Various combinations of these measures (variables) tend to result in a higher correlation with the criteria of achievement than when considered singly.

4. Prediction of high and low achievement is apparently more certain than prediction near the middle of the distribution.

5. Factors measured by the Cooperative English and

Iowa Chemistry Aptitude Tests are apparently of significance to the attainment of academic success in the Divisions of Forestry and Engineering at Colorado Agricultural and Mechanical College.

6. Because of the wide range of variability in predictive measures from school to school and within divisions of schools, each institution should consider local situations in seeking the most efficient and reliable criteria of academic success.

Chapter III

METHODS AND MATERIALS

In order to determine the relationship between various predictive data and grades achieved by freshman engineering students who availed themselves of counseling services before or shortly after entrance into engineering college, data were studied concerning 59 members of the Engineering Division admitted as freshman either during the school year of 1946-47 or that of 1947-48. The following data were obtained from the Office of the Registrar and the Office of Student Affairs:

1. Raw scores made by the students on the Iowa Placement Examination, series Ca-2, Form M, Chemistry Aptitude, to be referred to hereafter as the Chemistry test.

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

3. 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.

4. Raw scores made by the students on the

Cooperative English Test, Form PM, to be referred to hereafter as the English test.

5. Composite raw scores made by the students on the Pre-Engineering Inventory Test, to be referred to hereafter as the P.E.I.

6. Composite raw scores made by the students on the Engineering and Phusical Science Aptitude Test, to be referred to hereafter as the Aptitude test.

7. Letter grades achieved and quarter credits earned in college subjects by the students.

The grade-point average earned by each student during the first-quarter and first-year was used as the measure of academic success for the first-quarter and first-year in the Engineering Division.

Grade-point average was computed by the following method:

1. Letter grades were weighted so that an "A" equaled 4, a "B" equaled 3, a "C" equaled 2, a "D" equaled 1, and an "F" equaled 0. Courses marked "withdrawn failing" were counted as an "F", those marked "withdrawn passing" were not included in the computation.

2. The weighted value of the grade for each subject was then multiplied by the quarter credits allowed for the subject.

3. The products were added to obtain the quality points.

4. Total quality points were divided by total quarter credit hours for which a student had registered and the result was the grade-point average.

A student must maintain a grade-point average of 2.0 or better to remain in good academic standing at Colorado Agricultural and Mechanical College.

Sample studied

Data concerning 59 members of the Engineering Division were studied in order to determine the relationship between various test scores and grades achieved during the first-quarter and first-year of engineering school. The 59 members were admitted to the Engineering Division either during the school year of 1946-47 or that of 1947-48. The Engineering and Physical Science Aptitude Test and the Pre-Engineering Inventory were administered during the process of counseling. The entrance tests are administered to all entering students. Fifty-eight members of the group completed one-quarter in the Division. One member of the original group was marked as "withdrawn passing" but was included in the group in order to obtain the greatest number of scores possible for intercorrelation between variables. Two members of the group failed to complete the Chemistry test and no scores were recorded. Thirty-six members completed the first-year of academic work in the Engineering Division.

Test scores and grade-point averages were available for the following numbers of students:

1. Aptitude test scores 59
2. P.E.I. test scores 53
3. A.C.E. test scores 59
4. Chemistry test scores 57
5. Reading test scores 59
6. English test scores 59
7. First-quarter grade-point average 58
8. First-year grade-point average 36

Detailed data for each member of the sample are found in the Appendix.

Chapter IV

ANALYSIS OF DATA

Raw data used in determinging the value of the Engineering and Physical Science Aptitude Test in counseling prospective engineering students were obtained from files in the Office of Student Affairs and the Office of the Registrar, Colorado Agricultural and Mechanical College. These data consisted of raw scores achieved by the sample group on the Aptitude test, the Pre-Engineering Inventory Test, the entrance tests regularly administered at the College (the American Council on Education Psychological Examination, Chemistry, Reading, and English tests), and grade-point averages earned.

Data were assembled for the sample group in order to determine the relationship of the various test scores to first-quarter and first-year grade-point averages.

The relationship of the various test scores to the criteria of success (first-quarter and first-year grade-point averages) was determined by statistical analysis of the assembled data.

Statistical methods

Statistical analysis of the assembled data, for

the purpose of determining the relationship between test scores and first-quarter and first-year grade-point averages, involved the following steps:

1. Computation of zero-order coefficients of correlation to determine the relationship between first-quarter and first-year grade-point averages and each other variable. These coefficients of correlation were computed by the Pearsonian Product-Moment Method. (17:265-71)

2. Computation of coefficients of inter-correlation for all possible combinations of two variables to determine the extent to which the various variables measured common factors.

3. Computation of coefficients of multiple correlation between various combinations of first-quarter and first-year grade-point averages and other variables to determine the existing relationships. These multiple coefficients were computed according to the method outlined by Griffin (20).

Zero-order coefficients of correlation

Zero-order coefficients of correlation were computed between first-quarter and first-year grade-point averages, and all other variables, and between all possible combinations of two variables, Table 5. The Pearsonian Product-Moment Method was used. (17:265-71)

Table 5.--ZERO-ORDER COEFFICIENTS OF CORRELATION BETWEEN ALL COMBINATIONS OF VARIABLES

Variable*	Variable*							
	2	3	4	5	6	7	8	1
2	x	.566	.427	.602	.227	.415	.646	.769
3	x	x	.607	.722	.505	.622	.706	.507
4	x	x	x	.646	.777	.750	.814	.431
5	x	x	x	x	.387	.488	.634	.579
6	x	x	x	x	x	.748	.463	.302
7	x	x	x	x	x	x	.643	.579
8	x	x	x	x	x	x	x	.558

*Variables
1. First-year grade-point average
2. First-quarter grade-point average
3. Engineering and Physical Science Aptitude Test
4. American Council on Education Psychological Examination
5. Iowa Chemistry Aptitude Test
6. Nelson-Denny Reading Test
7. Cooperative English Test
8. Pre-Engineering Inventory Test

First-quarter grade-point average was best predicted singly by the P.E.I., the correlation coefficient being .646. This was followed by the Chemistry test, $r = .602$ with first-quarter grade-point average. The Aptitude test was the third-best predictor with .566; the A.C.E. fourth with .427; the English, fifth with .415; and the Reading test, $r = .227$, was the lowest single predictor of first-quarter grade-point average.

First-year grade-point average was best

predicted singly by first-quarter grade-point average, the correlation coefficient of the two being .768. The next-best predictors were considerably lower. In order of the magnitude of the coefficient of correlation, they were: the Chemistry and English tests, both with .579; the P.E.I. with .558; the Aptitude with .507; the A.C.E. with .431, and the Reading with .302, Table 5.

Intercorrelations between the variables indicated that the A.C.E., Reading, and English tests measured common factors to a considerable degree, as likewise did the Aptitude, P.E.I., Chemistry, and A.C.E. tests, Table 5. With the exception of the English and A.C.E. tests, the Reading test was found to exhibit a relatively low correlation with the other variables as well as being the lowest single predictor of both first-quarter and first-year grade-point average.

The efficiency of the Engineering and Physical Science Aptitude Test in the establishment of a cutting score, for use in admitting prospective students to the Engineering Division, was determined by constructing scattergraphs. The relationships between the Aptitude test scores and first-quarter and first-year grade-point averages, as shown in the scattergraphs, indicated that the Aptitude test scores could not be used as a basis for establishing a cutting score which would efficiently serve as a criterion for admission to the Engineering

Division.

Multiple correlation coefficients

Coefficients of multiple correlation were computed between first-quarter grade-point average and all possible combinations of two variables using the method outlined by Griffin (20). The results of these correlations are listed in Table 6.

Table 6.--MULTIPLE CORRELATION COEFFICIENTS OF TWO VARIABLES AND FIRST-QUARTER GRADE-POINT AVERAGE

Combined Variables*	Variable*				
	3	4	5	6	7
R1.2x	.579	.632	.566	.575	.666
R1.3x	x	.602	.462	.457	.672
R1.4x	x	x	.600	.619	.696
R1.5x	x	x	x	.440	.654
R1.6x	x	x	x	x	.652

*Variables
1. First-quarter grade-point average
2. Engineering and Physical Science Aptitude Test
3. American Council on Education Psychological Examination
4. Iowa Chemistry Aptitude Test
5. Nelson-Denny Reading Test
6. Cooperative English Test
7. Pre-Engineering Inventory Test

A combination of the Chemistry and P.E.I. tests with first-quarter grade-point average produced a correlation coefficient of .696, which was only slightly

higher than the coefficient of .672 resulting from a combination of the A.C.E. and P.E.I. tests with the criterion, and the .666 resulting from a combination of the Aptitude and P.E.I. tests with the criterion.

The addition of the P.E.I. test to any combination of a single variable and first-quarter grade-point average caused a marked positive increase in the correlation coefficients, Column 7, Table 6.

Using those variables which produced the highest coefficients of correlation with first-year grade-point average while at the same time showing the lowest intercorrelation (Table 5) coefficients of multiple correlation were computed for several combinations of two variables with first-year grade-point average, Table 7.

Table 7.--VARIOUS MULTIPLE CORRELATION COEFFICIENTS OF TWO VARIABLES AND FIRST-YEAR GRADE-POINT AVERAGE

Combined Variables*	Variable*			
	3	4	5	6
R1.2x	.773	.775	.820	.785
R1.6x	.630	.595	.672	x
R1.5x	.627	x	x	x

*Variables
1. First-year grade-point average
2. First-quarter grade-point average
3. Pre-Engineering Inventory Test
4. Engineering and Physical Science Aptitude Test
5. Cooperative English Test
6. Iowa Chemistry Aptitude Test

Coefficients of correlation resulting from other possible combinations of two variables and first-year grade-point average were considered too low to be of value for this study.

The best combination of two variables for predicting first-year grade-point average was the English test and first-quarter grade-point average, which produced a coefficient of .820 when correlated with the criterion. This was somewhat higher than the coefficients of .785 and .775 resulting from a combination of the Chemistry test, first-quarter, and first-year grade-point averages, and one of the Aptitude test, first-quarter, and first-year grade-point averages respectively.

The addition of first-quarter grade-point average to combinations of single variables and first-year grade-point average produced a positive increase in the correlation coefficient, Table 7.

Coefficients of multiple correlation were computed for various combinations of three variables and first-quarter and first-year grade-point average, each in turn. Only those variables showing high correlation with the criterion and low intercorrelation were used, Table 8.

Table 8.--COEFFICIENTS OF MULTIPLE CORRELATION BETWEEN VARIOUS COMBINATIONS OF THREE VARIABLES AND FIRST-QUARTER AND FIRST-YEAR GRADE-POINT AVERAGE

Combined Variables*	Variable*			
	4	5	6	7
R1.23x	.703	.822	.824	x
R1.25x	x	x	.784	x
R2.34x	x	.663	x	x
R2.35x	x	x	.694	x
R2.45x	x	x	.689	.631

*Variables
1. First-year grade-point average
2. First-quarter grade-point average
3. Cooperative English Test
4. Engineering and Physical Science Aptitude Test
5. Iowa Chemistry Aptitude Test
6. Pre-Engineering Inventory Test
7. American Council on Education Psychological Examination

The highest multiple correlation of three variables and first-quarter grade-point average was obtained by a combination of the English, Chemistry, and P.E.I. tests, the multiple coefficient being .694. This was only slightly higher than the coefficient of .689 obtained from a combination of the Aptitude, Chemistry, and P.E.I. tests.

The three variables producing the highest coefficient, .824, when correlated with first-year grade-point average were first-quarter grade-point average, and the English and P.E.I. tests. The second highest

multiple coefficient, .822, was obtained by a combination of first-quarter grade-point average, and the English and Chemistry tests.

The investigations of Butsch (6), Durflinger (11), Freeman and Johnson (16), Laycock and Hutcheon (24), McClanahan (26), and Pierson (31) have shown that little was gained towards improving the efficiency of forecasting scholastic achievement by the use of a combination of variables greater than two or three. In consideration of their findings, and, more specifically, in consideration of the generally high intercorrelation between the variables used in this study, multiple correlation coefficients involving greater combinations of variables than those reported were not computed. Any slight increase in the coefficients of multiple correlation resulting from the addition of a greater number of variables was considered unimportant to the purpose of this study and would not have warranted the additional time and effort spent.

Chapter V

DISCUSSION

The problem concerning the best use of scores made on the Engineering and Physical Science Aptitude Test at Colorado Agricultural and Mechanical College in counseling prospective engineering students was resolved into the following sub-problems:

1. Relationships between scores achieved on the Engineering and Physical Science Aptitude Test, the Pre-Engineering Inventory, the entrance tests regularly administered at the College, and grades achieved during the first quarter and first year of engineering school.

2. Relationships between total scores achieved on the Engineering and Physical Science Aptitude Test and those achieved on the Pre-Engineering Inventory and the entrance tests.

3. Relationships between various combinations of the total scores achieved on the Engineering and Physical Science Aptitude Test, Pre-Engineering Inventory, college entrance tests, and grades achieved during the first quarter and first year of engineering school.

4. Inferences drawn from the available data that indicate the value of the Engineering and Physical Science

Aptitude Test in counseling prospective engineering students.

Test scores and first-quarter and first-year grades

The discussion of the relationships found in this study between the single variables and first-quarter and first-year grade-point averages was so arranged that a separate heading appears for each of the variables used.

Aptitude test and grades.--The correlation coefficients of .566 and .507 found in this study between the Aptitude test scores and first-quarter and first-year engineering grade-point averages respectively, were considerably lower than the correlation coefficient of .73 reported by Borrow (4). However, it should be noted that the study reported by Borrow was concerned with the relationship of the Aptitude test scores to grades achieved by students in a nine-week introductory course during a special summer session, whereas the engineering grades achieved by students involved in this study were made during the regular school year. The average of grades achieved on five technical courses (Mathematics, Chemistry, Physics, Maunfacturing Processes, and Drafting) was used as the criterion of success in the study reported by Borrow, while for this study the criterion was the average grade achieved in courses in Chemistry, Mathematics,

English Composition, Mechanical Drawing, General Physics, and a study of the Engineering Profession. Comparison of the above coefficients should take these differences into consideration.

Pre-Engineering Inventory and grades.--Correlation of the Pre-Engineering Inventory scores with first-quarter grade-point average resulted in a coefficient of .646 for this study. Stinson (37) reported a coefficient of .609 for his study and Vaughn (39) found a median correlation of .62 for 10 college groups when a composite score, based on three sections of the test, was related to first-semester grade-point average. Correlation of the Pre-Engineering Inventory with first-year grade-point average resulted in a coefficient of .558 which was only slightly lower than the coefficient of .572 reported by Stinson. The findings of this study as shown here are in close agreement with the results of these other investigators.

Chemistry test and grades.--In this study the Chemistry test was found to correlate .602 with first-quarter grade-point average which differs but slightly from the .598 reported by Stinson (37), who considered first-quarter engineering grades, and the .589 reported by Gould (19), who considered first-semester grades in the general college population. It is a little higher than the r = .57 reported by Bartlett (1), in 1943, for

the correlation of the chemistry test with first-semester grades in engineering.

The correlation of the chemistry test and first-year grade-point average was .579, a figure somewhat lower than the .652 found by McClanahan (26), in 1947, but a little higher than the .558 reported by Stinson (37) in 1948. While this study and those of McClanahan and Stinson show a relatively high correlation between the Chemistry test and engineering grades at Colorado Agricultural and Mechanical College, Clevenger (7), in 1948, reported a correlation of .496 between the Chemistry test and first-year grade-point average in the Forestry Division of the College. This parallels the findings of Butsch (6) and Freeman and Johnson (16) who reported a variability in predictive data between the various schools of a University.

A.C.E. test and grades.--The correlation of the A.C.E. test and first-quarter grade-point average in this study, $r = .427$, differs but slightly from the $r = .406$ reported by Stinson (37) and approximates the median correlation of other similar studies.

The A.C.E. test correlated .431 with first-year grade-point average which was considerably lower than the .648 found by McClanahan (26) but practically identical to the .44 reported by Bartlett (1), in 1943, and somewhat higher than the .34 reported by Laycock and

Hutcheon (24) in 1939.

While the findings of this study closely approximate those of Bartlett (1) and vary but little from those of Laycock and Hutcheon (24), there is a considerable difference between the results reported by McClanahan (26) and those of this study in the relationship of the A.C.E. test scores to first-year grades. This may possibly be due to differences in the samples studied. The sample studied by McClanahan was composed of 57 members of the freshman class of 1945 and conceivably did not contain as high a proportion of war veterans as would be found in the classes of 1946-47 and 1947-48 from which the sample for this study was drawn. It should also be pointed out that the study of McClanahan deals with the general population of engineering students, while this study was concerned with those engineering students who had availed themselves of counseling services. Because of these differences it might be argued that the findings of this study are more pertinent to the counseling of war veterans. A need for further study is indicated.

English test and grades.--The correlation of the English test with first-quarter grade-point average produced a coefficient of .415. Bartlett (1) and Feder and Adler (15) found coefficients which were higher than that of this study, the results being .48 and .62 respectively.

When the relationship of the English test to first-year grade-point average was computed in this study the coefficient obtained was .579. This compares favorably with the r = .583 found by McClanahan (26) and the r = .60 reported by Feder and Adler (15). The increase in the coefficient from a first-quarter to a first-year relationship with the English test scores, .415 to .579, might possibly be due to the fact that comprehension of English is a more important factor in scholastic achievement for the first-year as a whole in the Engineering Division than it is for the first-quarter.

Reading test and grades.--The lowest zero-order coefficient of correlation found in this study resulted from the relationship of the Reading test scores to first-quarter grade-point average, r = .227. This was considerably lower than the r = .57 reported by Feder and Adler (15).

Correlation of the Reading test scores with first-year grade-point average produced a coefficient of .302 which was also considerably lower than the r = .495 found by both Feder and Adler (15) and McClanahan (26).

The correlation of the Reading test with grades is much lower than that found by McClanahan (26), as was the case in the relationship of the A.C.E. test to grades when the two studies were compared. This may be considered as a further indication that variations may

possibly be due to differences in the samples studied.

Relationships between tests

Intercorrelation between the tests used in this study indicated that the A.C.E., Reading, and English tests measured common factors to a considerable degree. The coefficients expressing the relationships are as follows: A.C.E. and English, r = .750; A.C.E. and Reading r = .777; English and Reading, r = .748. This measurement of common factors by the three tests was also found by Clevenger (7) and McClanahan (26). The coefficients reported in the two studies differ only slightly from those above. Measurement of common factors to a considerable degree was also indicated by intercorrelation of the Engineering and Physical Science Aptitude Test, Pre-Engineering Inventory Test, Chemistry, and American Council on Education Psychological Examination, the coefficients ranging from .607 to .814.

The Reading test produced relatively low intercorrelations as follows: Reading and Aptitude, r = .505; Reading and Chemistry, r = .387; Reading and P.E.I., r = .463. Clevenger (7) reported a range of .147 to .270 for the intercorrelations of the Chemistry test with the Reading, A.C.E., and English tests in his study of forestry students, and McClanahan (26) found a range of .157 to .543 for the same intercorrelations in his study of

engineering students.

The fact that none of the variables used in this study produced low intercorrelations and high correlation with the criteria of success is an explanation of why multiple correlation failed to increase the coefficients to the extent found in the studies of Clevenger (7) and McClanahan (26).

Combinations of test scores and first-quarter and first-year grades

Combinations and first-quarter grades.--The highest coefficient of multiple correlation found in this study for the prediction of first-quarter grade-point average, R = .796, resulted from a combination of the Chemistry and P.E.I. tests and first-quarter grade-point average. All other possible combinations of two variables and first-quarter grade-point average produced multiple coefficients which ranged from .440 to .672. Whenever the Chemistry or P.E.I. tests were included in the combinations there was an increase in the multiple coefficient. Clevenger (7) in his study of forestry students found that the Chemistry test increased the coefficient when included in multiple correlation.

Various combinations of three variables and first-quarter grade-point average resulted in multiple coefficients which ranged from .631 to .694, the highest

being produced by a combination of the Chemistry, English, and P.E.I. tests and first-quarter grade-point average.

The combinations of variables which produced the highest correlation with first-quarter grade-point average in this study included the P.E.I. test. When it was included with the Chemistry and English tests the coefficient was .694, and when the Chemistry and English tests were used alone the coefficient dropped to .619. However, the increase in the coefficient gained by the addition of the P.E.I. test does not seem to be warranted as it requires approximately six hours to administer while the Chemistry and English tests require approximately one hour apiece. Therefore, it is considered that, of the tests considered in this study, a battery of the English and Chemistry tests is the most efficient predictor of first-quarter grades.

Combinations and first-year grades.--The highest multiple coefficient found for combinations of variables and first-year grade-point average was .824. This resulted from correlation of the English and P.E.I. tests and first-quarter grade-point average with first-year grade-point average. Almost identical results were obtained by substitution of the Chemistry test in place of the P.E.I., the coefficient being .822. The elimination of first-quarter grade-point average from these combinations and others used to predict first-year grades caused

a marked drop in the multiple coefficient. In this study the correlation between first-quarter and first-year grade-point averages was found to be .768. Stinson (37) reported a correlation of .841 between first-quarter and first-year grade-point average. It appears that the most efficient method of predicting a student's first-year grade-point average after completion of one quarter is by referral to his first-quarter grade-point average.

When first-quarter grades were not considered as a factor, the best predictor of first-year grade-point average, through multiple correlations, was a combination of the Chemistry and English tests. When the scores made on these two tests were combined with first-year grade-point average the resulting multiple coefficient was .672. McClanahan (26) found that, of the tests which he considered, the best and most economical battery for predicting freshman engineering grades at Colorado Agricultural and Mechanical College was a combination of the Chemistry and English tests. This combination produced a multiple coefficient of .814 when correlated with freshman grades. His findings are among the highest reported in the literature for multiple correlation of variables and first-year grades.

The fact that there is a considerable difference between the .672 reported in this study and the .814 reported by McClanahan (26), when both studies

considered the same variables in relation to identical criteria, is a further implication that variations in results found may possibly be due to differences in the samples studied.

Use of data in counseling

Scores achieved on the Engineering and Physical Science Aptitude Test by the students used in this study correlated .566 with first-quarter grade-point average and .507 with first-year grade-point average. When the scores were used in multiple correlation with various combinations of the other variables included in the study, they failed to increase the coefficients to any marked degree. Variables other than the Aptitude test were found to be better predictors of academic achievement, either when considered singly or in multiple correlation, and are presently employed in counseling prospective engineering students at Colorado Agricultural and Mechanical College.

Apparently, because the Aptitude test was but a fair predictor of achievement and measured common factors to a considerable degree, it failed to add much of value to multiple correlation.

Because of these findings, no recommendation is made for the addition of the Aptitude test to the battery already employed in counseling prospective engineering

students at Colorado Agricultural and Mechanical College.

Recommendations for further study

The Engineering and Physical Science Aptitude Test was administered to entering engineering freshman in the fall of 1948 at Colorado Agricultural and Mechanical College. Test scores of 136 students are available. Results of a study to determine the relationship of test scores to academic achievement in the general population of the Engineering Division may prove useful to counselors. A factor analysis of the six parts of the test may also be of value.

The findings of studies already completed at Colorado Agricultural and Mechanical College have shown that there is a variability in predictive data between the Divisions of Forestry and Engineering. Similar studies should be conducted to determine the most efficient predictors of academic success in the several Divisions of the College.

This study has indicated that there may be variations between groups within the population of a Division as well as between the Divisions of the College. Some of these groups are clearly differentiated, such as the Departments of Botany and Plant Pathology, Mathematics, Chemistry, and Physics within the Division of Science and Arts. Others are less clearly defined,

such as the group considered in this study.

The necessity of periodic research along these lines seems apparent from the fact that the composition of college student bodies has been considerably changed by the veterans program and will undergo further change as the number of veteran students decreases.

Chapter VI

SUMMARY

The Engineering and Physical Science Aptitude Test was administered to 59 students who entered the Engineering Division at Colorado Agricultural and Mechanical College either during the school year of 1946-47 or that of 1947-48. All of the students in this group had received counseling at the College, either voluntarily or upon faculty suggestion, prior to, or shortly after admission.

The purpose of this study was to determine what value the Engineering and Physical Science Aptitude Test might have towards improving the data used in counseling prospective engineering students. In order to aid in answering the problem, scores made on tests other than the Engineering and Physical Science Aptitude Test were also used. Data obtained from these other tests are presently used in counseling engineering students.

The variables used in this study were as follows:

1. First-quarter grade-point average Variable 1
2. First-year grade-point average Variable 2

3. Engineering and Physical Science Aptitude Test — Variable 3
4. American Council on Education Psychological Examination — Variable 4
5. Iowa Placement Examination Chemistry Aptitude — Variable 5
6. Nelson-Denny Reading Test — Variable 6
7. Cooperative English Test, Form PM — Variable 7
8. Pre-Engineering Inventory — Variable 8

Zero-order coefficients of correlation were computed between each variable and first-quarter and first-year grade-point average and resulted in the following coefficients:

1. $r_{12} = .769$
2. $r_{13} = .566$
3. $r_{14} = .427$
4. $r_{15} = .602$
5. $r_{16} = .227$
6. $r_{17} = .415$
7. $r_{18} = .646$
8. $r_{23} = .507$
9. $r_{24} = .431$
10. $r_{25} = .579$
11. $r_{26} = .302$
12. $r_{27} = .579$
13. $r_{28} = .558$

The Chemistry test was considered to be the most efficient of the single variables for prediction of first-quarter grade-point average, $r = .602$, even though the Pre-Engineering Inventory test produced a somewhat higher coefficient of .646. In determination of efficiency the length of time required for administration of

the tests was considered. The P.E.I. test requires approximately six hours for administration while the Chemistry test requires approximately one hour.

For prediction of first-year grade-point average from a single variable, first-quarter grade-point average was considered the most efficient, the correlation coefficient being .769.

Intercorrelation indicated that variables 4, 6, and 7 measured common factors to a considerable degree as likewise did variables 3, 4, 5, and 8.

Multiple coefficients of correlation were computed between various combinations of variables and first-quarter and first-year grade-point averages. The highest coefficients obtained from using three variables were as follows:

1. R1.578 = .694
2. R1.358 = .689
3. R2.178 = .824
4. R2.157 = .822

The highest coefficients obtained from using two variables were as follows:

1. R1.58 = .696
2. R1.48 = .672
3. R2.17 = .820
4. R2.13 = .775

When various combinations of three variables were considered in multiple correlation predictions of first-quarter grade-point average, the Engineering and Physical Science Aptitude Test was involved in a combination which produced the second highest coefficient.

Combinations of three variables which produced the two highest predictions of first-year grade-point average did not involve the Aptitude test. The Aptitude test was not involved in those combinations of two variables which produced the two highest predictions of first-quarter grade-point average but was involved in the combination of two variables which was the second highest predictor of first-year grade-point average.

In general, the addition of the Engineering and Physical Science Aptitude Test to the other tests used in this study did not increase prediction efficiency, and it could not be used as a basis for establishing a cutting score which would efficiently serve as a criterion for admission to the Engineering Division. Therefore, it was considered to be of no additional value in counseling prospective engineering students.

APPENDIX

VARIATES USED IN THE STUDY OF THE SAMPLE

Case No.	Grade-point Average		Raw Score					
	First-quarter	First-year	Aptitude	P.E.I.	A.C.E.	Chemistry	Reading	English
1	1.27	1.27	92	91	133	32	138	178
2	2.50	2.44	124	156	129	82	91	207
3	2.00	2.23	104	115	121	63	64	172
4	1.50		66	81	74	48	38	99
5	3.19	2.63	101	133	136	80	94	160
6	1.19	1.00	82	118	113	60	77	142
7	2.13		68	95	96	104	56	119
8	1.88	1.79	113	150	130	94	88	164
9	1.31	1.35	83	112	130	69	102	129
10	1.28	1.12	62	80	101	35	41	98
11	1.50	1.29	94	91	109	42	88	203
12	3.19	3.13	116	177	141	89	113	249
13	1.21	0.97	52	56	70	31	37	69
14	1.38	1.69	96	114	121	63	90	127

Case No.	Grade-point Average		Raw Score					
	First-quarter	First-year	Aptitude	P.E.I.	A.C.E.	Chemistry	Reading	English
15	2.07	1.86	120	140	115	87	105	216
16	1.56	2.31	41	54	66	18	39	80
17	2.58	2.24	77	132	119	67	80	230
18	2.23	2.42	85	93	105	59	64	181
19	2.56		94	114	93	42	64	178
20	1.64	1.77	36	115	87	25	41	91
21	0.75		82	92	125	42	124	224
22	1.73	1.72	66	96	80	36	59	130
23	0.00		54	71	106	36	69	134
24	1.63	1.51	105	138	130		88	178
25	3.05	3.12	132	215	151	113	75	205
26	1.33	1.51	123	146	135	92	91	175
27	2.50	2.39	91	106	114	63	62	143
28	3.31	3.04	128	153	125	96	68	175
29	2.19	2.02	97	122	127	59	82	163

Case No.	Grade-point Average		Raw Score					
	First-quarter	First-year	Aptitude	P.E.I.	A.C.E.	Chemistry	Reading	English
30	2.23	2.00	72	80	85	41	58	149
31	0.00	2.22	100	71	113	42	101	223
32	3.19	2.65	111	117	125	89	110	184
33	1.07		101		100	101	52	119
34	1.69		91	58	108	54	79	137
35	1.38		89	70	100	31	68	152
36	2.77		88	104	120	48	47	152
37	2.11	2.69	96	134	116	90	137	185
38	2.00	2.11	83	97	130	84	84	142
39	1.82	2.02	81	55	81	38	75	100
40	3.53	3.32	112	163	141	93	111	247
41	1.00		109	43	61	42	28	52
42	2.08	2.02	107	114	120	90	77	148
43	3.50		108	134	102	105	90	188
44	3.00		127	134	109	104	56	176

Case No.	Grade-point Average		Raw Score					
	First-quarter	First-year	Aptitude	P.E.I.	A.C.E.	Chemistry	Reading	English
45	0.00		54	41	85	37	52	132
46	2.00	1.87	95	97	93	42	53	94
47	0.42		16		69		37	76
48	1.38		51	74	106	60	87	184
49	0.88		35	49	85	32	44	85
50	1.40	1.38	57	100	109	63	49	99
51	0.00		63		86	30	63	118
52	0.69	1.34	47	35	93	25	46	118
53	0.58		64	67	99	36	63	128
54	2.19		102	83	100	46	76	113
55	1.05		91		128	48	96	180
56	0.71		70	61	99	44	78	102
57	2.00	1.96	63	104	122	40	92	218
58	2.13		61		129	48	73	89
59	1.88		114		155	94	117	257

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