

8-7-1948

# The Prediction of Academic Success in the University of New Mexico College of Engineering from Data Available During the Students' First Semester of Enrollment

John J. Wittich

Follow this and additional works at: [https://digitalrepository.unm.edu/educ\\_teelp\\_etds](https://digitalrepository.unm.edu/educ_teelp_etds)



Part of the [Educational Administration and Supervision Commons](#), [Educational Leadership Commons](#), and the [Teacher Education and Professional Development Commons](#)

---

## Recommended Citation

Wittich, John J.. "The Prediction of Academic Success in the University of New Mexico College of Engineering from Data Available During the Students' First Semester of Enrollment." (1948). [https://digitalrepository.unm.edu/educ\\_teelp\\_etds/245](https://digitalrepository.unm.edu/educ_teelp_etds/245)

This Thesis is brought to you for free and open access by the Education ETDs at UNM Digital Repository. It has been accepted for inclusion in Teacher Education, Educational Leadership & Policy ETDs by an authorized administrator of UNM Digital Repository. For more information, please contact [disc@unm.edu](mailto:disc@unm.edu).

UNIVERSITY OF NEW MEXICO-UNIVERSITY LIBRARIES



A14429 095295

378.789

Un 3 Ow

1949

cop. 2



WITTICH  
ACADEMIC SUCCESSES IN THE UNIVERSITY OF  
NEW MEXICO COLLEGE OF ENGINEERING

THE LIBRARY  
UNIVERSITY OF NEW MEXICO



Call No.

Accession  
Number

378.789

Un30w

1949

cop.2

130522



DATE DUE

APR 1 1978  
REG. DASH 1378

DEMCO 38-297

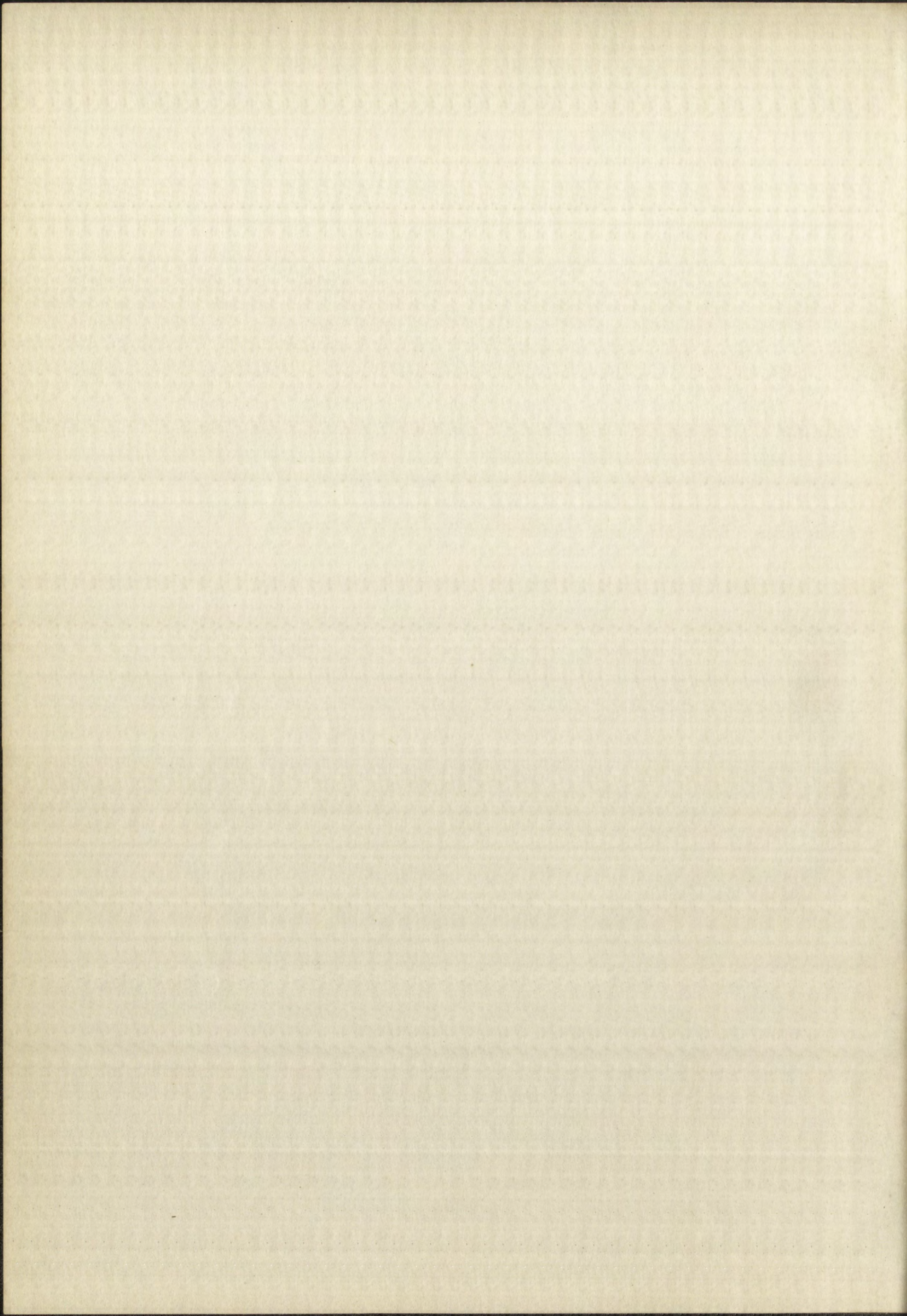
















LIBRARY

FOND

U.S.A.

CRASH

117





STANDARD  
PAPER  
CO.  
U.S.A.  
NEW YORK  
N.Y.



# UNIVERSITY OF NEW MEXICO LIBRARY

## MANUSCRIPT THESES

Unpublished theses submitted for the Master's and Doctor's degrees and deposited in the University of New Mexico Library are open for inspection, but are to be used only with due regard to the rights of the authors. Bibliographical references may be noted, but passages may be copied only with the permission of the authors, and proper credit must be given in subsequent written or published work. Extensive copying or publication of the thesis in whole or in part requires also the consent of the Dean of the Graduate School of the University of New Mexico.

This thesis by ..John J. Wittich.....  
has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

A Library which borrows this thesis for use by its patrons is expected to secure the signature of each user.

NAME AND ADDRESS

DATE

Donald F. Berth - Cornell Univ.  
261 Wall St. Corning N.Y.



WILKINSON THESIS

Unpublished theses submitted to the Faculty of the University of New Mexico are deposited in the University of New Mexico Library and are open for inspection, but are to be used only with the written consent of the author. Photographic reproductions may be made and passages may be copied only with the permission of the author and proper credit must be given in subsequent works or publications. Extensive copying or publication of the thesis without the permission of the author is prohibited. The University of New Mexico also requires that the author of the thesis

This thesis by [Name] has been used by the following persons, whose written acceptance of the above restrictions

A library which borrows this thesis for use in its collection is expected to secure the signature of the author.

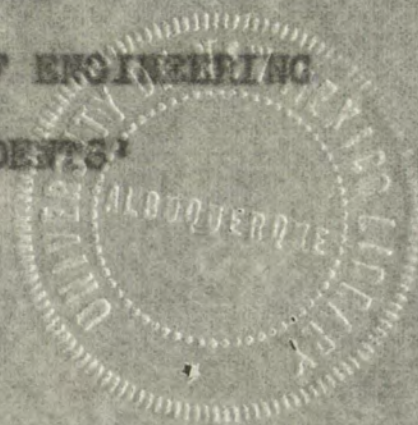
DATE

NAME AND ADDRESS

261 W. 2nd St. - Corral del Rey  
Albuquerque, N.M.



THE PREDICTION OF ACADEMIC SUCCESS  
IN THE UNIVERSITY OF NEW MEXICO COLLEGE OF ENGINEERING  
FROM DATA AVAILABLE DURING THE STUDENTS'  
FIRST SEMESTER OF ENROLLMENT



By

John J. Wittich

A Thesis

Submitted in Partial Fulfillment of the  
Requirements for the Degree of  
Master of Arts in Education

University of New Mexico

1948



THE UNIVERSITY OF CALIFORNIA LIBRARY



IN THE UNIVERSITY OF NEW MEXICO LIBRARY OF THE

FROM DATA AVAILABLE DURING THE STUDY

THE UNIVERSITY OF CALIFORNIA LIBRARY

BY

John D. Wilson

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Arts in Education

University of New Mexico

1948



This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Francis L. Stollen  
DEAN

August 7 - 1948  
DATE

THE PREDICTION OF ACADEMIC SUCCESS  
IN THE UNIVERSITY OF NEW MEXICO COLLEGE OF ENGINEERING  
FROM DATA AVAILABLE DURING THE STUDENTS'  
FIRST SEMESTER OF ENROLLMENT

Thesis committee

B. M. Crawford  
CHAIRMAN  
E. H. Fitch  
S. P. Manning



This thesis directed and approved by the committee on the  
thesis has been accepted by the Graduate Committee of the  
University of Iowa in partial fulfillment of the requirements  
for the degree of

James L. ...

August 15, 1940

THE UNIVERSITY OF IOWA  
LIBRARY

Thesis Committee

Ed. ...  
W. ...



378.789  
Un30w  
1949  
cop. 2

#### ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. Bonner M. Crawford, without whose guidance this study would not have been undertaken. Grateful acknowledgment is also tendered Dean S. P. Nanninga, Dr. A. A. Welck, and Dr. E. H. Fixley not only for aid in the development of this thesis, but for general and valuable contributions to an educational program.



378787  
N30w  
144  
609

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. Bonner M. Crawford, without whose guidance this study would not have been undertaken. Grateful acknowledgment is also tendered Dean S. P. Manning, Dr. A. A. Wells, and Dr. E. H. Wiley for aid in the development of this thesis, not for general and valuable contributions to an educational program.



## TABLE OF CONTENTS

| CHAPTER  | PAGE |
|--|------|
| I. THE PROBLEM . . . . .   | 1    |
| Statement of the problem . . . . .   | 1    |
| Importance of the study . . . . .  | 2    |
| Limitations of the study . . . . .   | 3    |
| Organization of the remainder of the thesis .  | 3    |
| II. REVIEW OF RELATED LITERATURE . . . . .   | 5    |
| Literature on the reliability of high-school<br>marks and the American Council on Educa-<br>tion Psychological Tests . . . . . | 5    |
| Literature on the relation of high-school<br>marks and college success . . . . .   | 7    |
| Literature on the relation of combinations<br>of high-school marks and test results to<br>college success . . . . .            | 10   |
| III. METHOD OF CONDUCTING THE INVESTIGATION . . . . .  | 13   |
| Sources of the data . . . . .  | 13   |
| High-school marks . . . . .  | 14   |
| College marks . . . . .  | 15   |
| The psychological test . . . . .   | 16   |
| The English test . . . . .   | 16   |
| The engineering aptitude test . . . . .  | 16   |
| The mathematics test . . . . .   | 17   |



# TABLE OF CONTENTS

| CHAPTER |   | PAGE |
|---------|---|------|
| I.      | THE PROBLEM . . . . .                                 | 1    |
|         | Statement of the problem . . . . .                    | 1    |
|         | Importance of the study . . . . .                     | 2    |
|         | Limitations of the study . . . . .                    | 3    |
|         | Organization of the remainder of the thesis . . . . . | 3    |
| II.     | REVIEW OF RELATED LITERATURE . . . . .                | 4    |
|         | Literature on the reliability of high-school          |      |
|         | marks and the American Council on Educa-              |      |
|         | tion Psychological Tests . . . . .                    | 4    |
|         | Literature on the relation of high-school             |      |
|         | marks and college success . . . . .                   | 7    |
|         | Literature on the relation of conditions              |      |
|         | of high-school marks and test results to              |      |
|         | college success . . . . .                             | 12   |
| III.    | METHOD OF CONDUCTING THE INVESTIGATION . . . . .      | 13   |
|         | Sources of the data . . . . .                         | 13   |
|         | High-school marks . . . . .                           | 14   |
|         | College marks . . . . .                               | 15   |
|         | The psychological test . . . . .                      | 15   |
|         | The English test . . . . .                            | 16   |
|         | The engineering aptitude test . . . . .               | 16   |
|         | The mathematics test . . . . .                        | 17   |



|  |      |
|--|------|
|  | iv   |
| CHAPTER                                      | PAGE |
| Definition of terms used . . . . .           | 17   |
| College grade-point average . . . . .        | 17   |
| High-school achievement . . . . .            | 18   |
| IV. ANALYSIS OF THE DATA . . . . .           | 19   |
| Relationship between variables of            |      |
| the data . . . . .                           | 20   |
| The prognostic value of the variables        |      |
| in combination . . . . .                     | 27   |
| Validity implications of the UNM Math Test.  | 36   |
| V. CONCLUSIONS AND RECOMMENDATIONS . . . . . | 38   |
| Conclusions . . . . .                        | 38   |
| Recommendations . . . . .                    | 40   |
| BIBLIOGRAPHY . . . . .                       | 41   |
| APPENDIX . . . . .                           | 45   |



|    |  |    |
|----|--|----|
| 11 | Definition of terms used . . . . .           | 11 |
| 12 | College grade-point average . . . . .        | 12 |
| 13 | High-school achievement . . . . .            | 13 |
| 14 | IV. ANALYSIS OF THE DATA . . . . .           | 14 |
| 15 | Relationship between variables of            |    |
| 16 | the data . . . . .                           | 15 |
| 17 | The prognostic value of the variables        |    |
| 18 | in combination . . . . .                     | 17 |
| 19 | Validity implications of the data tests      | 19 |
| 20 | V. CONCLUSIONS AND RECOMMENDATIONS . . . . . | 20 |
| 21 | Conclusions . . . . .                        | 21 |
| 22 | Recommendations . . . . .                    | 22 |
| 23 | BIBLIOGRAPHY . . . . .                       | 23 |
| 24 | APPENDIX . . . . .                           | 24 |



## LIST OF TABLES

| TABLE  | PAGE |
|--|------|
| I. Coefficients of Correlation Between<br>Averages of High-School and College<br>Achievement and Scores Made on Certain<br>Tests by College of Engineering Freshmen . . .  | 21   |
| II. Coefficients of Correlation Between the<br>College Grade-Point Averages and<br>Various Factors . . . . .   | 23   |
| III. Coefficients of Correlation Between Scores<br>Made by Engineering Freshmen on the UNM<br>Math Test, the American Council on Educa-<br>tion Psychological Test and the Cooperative<br>English Test . . . . . | 25   |
| IV. The Coefficients of Correlation Between<br>Scores on the Engineering and Physical<br>Science Aptitude Test and the Scores of<br>the ACE and UNM Mathematics Test . . . . .                                   | 26   |
| V. Comparison of Coefficients of Correlation<br>Between the Same Variables for a Total<br>and Smaller Samples . . . . .  | 29   |
| VI. Intercorrelations of the College Grade-Point<br>Averages and Five Variables for Ninety-Five<br>Students . . . . .  | 31   |



# LIST OF TABLES

## TABLE

|  |    |
|--|----|
| I. Coefficients of Correlation Between           | 1  |
| Averages of High-School and College              |    |
| Achievement and Scores Made on College           |    |
| Tests by College of Engineering Students         | 21 |
| II. Coefficients of Correlation Between the      | 22 |
| College Grade-Point Averages and                 |    |
| Various Factors                                  | 23 |
| III. Coefficients of Correlation Between Scores  | 24 |
| Made by Engineering Students on the GWT          |    |
| Math Test, the Written Contract on Ethics        |    |
| tion Psychological Test and the Cooperative      |    |
| English Test                                     | 25 |
| IV. The Coefficients of Correlation Between      | 26 |
| Scores on the Engineering and Physical           |    |
| Science Aptitude Test and the Scores of          |    |
| the ACT and UMW Mathematics Test                 | 27 |
| V. Comparison of Coefficients of Correlation     | 28 |
| Between the Same Variables for a Total           |    |
| and Scatter Scores                               | 29 |
| VI. Intercorrelations of the College Grade-Point | 30 |
| Averages and Five Variables for Twenty-Five      |    |
| Students   | 31 |



## TABLE

## PAGE

## VII. Means, Standard Deviations, Probable

Errors of the Means, and Critical Ratio  
of the College Grade-Point Averages of

Two Groups on the UNM Math Test . . . . . 36



|   |    |
|---|----|
| VII. Means, Standard Deviations, Probable |    |
| Errors of the Means, and Critical Ratio   |    |
| of the College Grade-Point Averages of    |    |
| Two Groups on the UMN Math Test . . . . . | 36 |



## CHAPTER I

### THE PROBLEM

In the past, when virtually all schools at the secondary level were college preparatory in purpose, there were few serious problems arising because of a lack of objective criteria to use in determining which students should enroll in institutions of higher learning. Today, however, secondary schools attempt to diversify their curricula in order to fit the student for various fields of life work while at the same time retaining as one of their purposes that of preparing for higher education. This expansion of curricula and goals for secondary education accentuates the problem of predicting the degree to which pupils leaving the high school will do successful work at the college level. The making of final recommendations for the acceptance or the rejection of high-school graduates for admission to college is primarily the responsibility of the high-school principal. The solution of the problem that confronts these administrators depends upon the derivation of valid measures or criteria by which success in college can be forecast.

Statement of the problem. The purpose of this investigation is to determine with what degree of certainty



## CHAPTER I

### THE PROBLEM

In the past, when virtually all students at the secondary level were college preparatory in purpose, there were few serious problems arising because of a lack of objective criteria to use in determining which students should enroll in institutions of higher learning. Today, however, secondary schools attempt to diversify their curricula in order to fit the student for various fields of life work while at the same time retaining as one of their purposes that of preparing for higher education. This expansion of curriculum and goals for secondary education accentuates the problem of predicting the degree to which pupils leaving the high school will do successfully work at the college level. The making of final recommendations for the acceptance or the rejection of high-school graduates for admission to college is primarily the responsibility of the high-school principal. The solution of the problem that confronts these administrators depends upon the selection of valid measures or criteria by which success in college can be forecast.

Statement of the Problem. The purpose of this investigation is to determine what that degree of correlation



the achievement of freshmen in the College of Engineering at the University of New Mexico can be predicted from an analysis of data available during their first semester of enrollment in college. These data are (1) high-school achievement as indicated by teachers' marks over a four-year period; (2) scores made on a battery of psychological and achievement tests administered at the time of enrollment in the university; and (3) college success attained in the first semester as indicated by semester marks.

Importance of the study. It has been implied that the high-school principal should desire to have access to all possible information which will assist him to render more valid educational guidance to the college-preparatory student. For the purpose of making recommendations to colleges, facts concerning the relative value of high-school marks in contrast to even rough guesses of probable success should be of concern; however, information obtained at the time of college entrance or orientation week may be found to be much more pertinent and reliable. If the additional data obtained by the university test battery materially improves the basis for college recommendations, the implication for high-school principals is obvious. The college test battery should first be administered to prospective engineering students in the high schools.

Although numerous prognosis studies concerning



the achievement of freshmen in the College of Engineering at the University of New Mexico can be predicted from an analysis of data available during their first semester of enrollment in college. These data are (1) high-school achievement as indicated by teachers' marks over a four-year period; (2) scores made on a battery of psychological and achievement tests administered at the time of enrollment in the university; and (3) college success attained in the first semester as indicated by semester marks.

Importance of the study. It has been implied that the high-school principal should desire to have access to all possible information which will assist him to render more valid educational guidance to the college-preparatory student. For the purpose of making recommendations to colleges, facts concerning the relative value of high-school marks in contrast to even rough guesses of probable success should be of concern; however, information obtained at the time of college entrance or orientation week may be found to be much more pertinent and reliable. If the additional data obtained by the university test battery materially improves the basis for college recommendations, the implication for high-school principals is obvious. The college test battery should first be administered to prospective engineering students in the high schools. Although numerous prognostic studies concerning



college success have been made in the past, there have been no recent investigations of this nature at the University of New Mexico. This status of past research is especially true as it pertains to engineering freshmen. Furthermore, since the particular test battery utilized in this study has not been thoroughly examined, it is important that an investigation of its value be made for measuring success to be attained in college.

Limitations of the study. The prognosis of college success is such a broad problem that achievement in any one of several colleges or departments would be of sufficient scope to warrant a separate study. The College of Engineering was chosen for investigation by the writer because a more extensive test battery is administered by the university Bureau of Counseling and Testing to freshman engineering students than to freshmen in other colleges. Thus, the availability of sufficient data needed for careful analysis necessarily limited this study to prediction for this particular college.

Organization of the remainder of the thesis. The remainder of the thesis is divided into four chapters, the Bibliography, and the Appendix. Chapter II is concerned with the review of the related literature; Chapter III with the method of conducting the investigation;



college success have been made in the past, there have been no recent investigations of this nature at the University of New Mexico. This state of past research is especially true as it pertains to engineering freshmen. Furthermore, since the particular test battery utilized in this study has not been thoroughly examined, it is important that an investigation of its value be made for measuring success to be attained in college.

#### Limitations of the study. The prognosis of college

success is such a broad problem that achievement in any one of several colleges or departments would be of sufficient scope to warrant a separate study. The College of Engineering was chosen for investigation by the writer because a more extensive test battery is administered by the University Bureau of Counseling and Testing to freshman engineering students than to freshmen in other colleges. Thus, the availability of sufficient data needed for careful analysis necessarily limited this study to prediction for this particular college.

#### Organization of the remainder of the thesis. The

remainder of the thesis is divided into four chapters, the Bibliography, and the Appendix. Chapter II is concerned with the review of the related literature; Chapter III with the method of conducting the investigation;



Chapter IV with an analysis of the data; Chapter V with conclusions and recommendations; the Bibliography with the articles, books, and monographs studied, and the Appendix with the computation of a multiple coefficient of correlation and the development of a six-variable regression equation.



Chapter IV with an analysis of the data; Chapter V with  
conclusions and recommendations; the Bibliography and  
the statistics, books, and references; and the  
Appendix with the computation of a multiple coefficient  
of correlation and the development of a regression  
regression equation.



## CHAPTER II

### REVIEW OF RELATED LITERATURE

Because of the considerable volume of published and unpublished investigations concerning the prognostic value of such factors as high-school marks and intelligence and achievement tests, the writer will present only the findings which he considers to be the most pertinent. Conclusions derived from earlier investigations that are summarized in more recent literature will not be presented. The persistency with which the prediction of college success has been investigated is evidence that the problem is an important one.

Literature on the reliability of high-school marks and the American Council on Education Psychological Tests. Easley<sup>1</sup> states that the reliability coefficient of the American Council on Education Psychological Tests (1930 edition), as determined by Thurstone, is .95 and consequently the low predictive efficiency which it manifests cannot be due in any large measure to lack of reliability. After deriving a coefficient of correlation of .510 between high-school marks and intelligence, Easley maintains that

---

<sup>1</sup> Howard Easley, "On the Limits of Predicting Scholastic Success," Journal of Experimental Education, 1:272-76, March, 1933.



## CHAPTER II

### REVIEW OF RELATED LITERATURE

Because of the considerable volume of published and unpublished investigations concerning the prognostic value of such factors as high-school marks and intelligence and achievement tests, the writer will present only the findings which he considers to be the most pertinent. Conclusions derived from earlier investigations that are summarized in more recent literature will not be presented. The persistency with which the prediction of college success has been investigated is evidence that the problem is an important one.

Literature on the reliability of high-school marks and the American Council on Educational Psychological Tests. Kasey<sup>1</sup> states that the reliability coefficient of the American Council on Educational Psychological Tests (1930 edition), as determined by Thurstone, is .95 and consequently the low predictive efficiency which it manifests cannot be due in any large measure to lack of reliability. After deriving a coefficient of correlation of .510 between high-school marks and intelligence, Kasey maintains that

---

<sup>1</sup> Howard Kasey, "On the Limits of Predicting Scholastic Success," Journal of Experimental Education, 1:272-76, March, 1933.



the low correlation between the two variables is primarily due to a fundamental lack of relationship, rather than to the unreliability of school marks. This was true not only when marks for a single semester were used but to an even greater degree for marks attained over a two-year period. He further states that such results indicate that simply increasing the reliability of school marks will have practically no effect upon their correlation with intelligence test scores. Easley concludes:

While increasing the reliability would be expected to increase the correlation with test scores, in this case other factors were inevitably introduced which tend to lower the correlation, and the net result is that it remains approximately constant. This relation obviously could not hold for extremely low reliabilities, but teachers' marks would not have to have a reliability of above .30 to make possible a correlation with test scores as high as is usually found.<sup>2</sup>

Heston,<sup>3</sup> on the other hand, presents a divergent and popular, but undocumented, view of the reliability of marks when he states:

When the guesses of different instructors are combined to derive an average (hour-point ratio, grade-point average, etc.) we have much the same result as though we added apples and pears, multiplied the sum by doorknobs, and divided by peanuts. The result is

---

<sup>2</sup> Ibid., p. 274.

<sup>3</sup> Joseph C. Heston, "The Graduate Record Examination vs. Other Measures of Aptitude and Achievement," Educational and Psychological Measurement, 7:618-30, No. 3, Autumn, 1947.



the low correlation between the two variables is primarily due to a fundamental lack of relationship, rather than to the unreliability of either measure. This was shown when marks for a single semester were used only to an extent greater degree for marks obtained over a two-year period. He further stated that a low correlation indicates that although increasing the reliability of second marks will increase slightly no effect upon their correlation with intelligence test scores. (Haley, 1937)

While increasing the reliability of second marks would tend to increase the correlation with test scores, in this case other factors were involved. The third and fourth tests to lower the correlation, and the net result is that it remains approximately constant. This situation obviously could not hold for extremely low reliabilities, but second marks would not be expected to have a reliability of above .50 to make possible a correlation with test scores as high as .70. (Haley, 1937)

Haley, 3, on the other hand, presents a different and popular, but unacknowledged, view of the reliability of marks when he states:

When the process of differentiating marks is confined to derive an average (mean-point) mark, grade-point average, etc., we have seen how some marks are through we added up the marks, and divided the sum by the number, and obtained the average. (Haley, 1937)

2 Ibid., p. 27.

3 Joseph C. Haley, "The Standard Error of Estimation vs. Other Measures of Reliability and Validity," *Journal of Educational Psychology*, 28:1-10, 1937.



arithmetical truth but psychological nonsense.<sup>4</sup>

In 1933 Watts<sup>5</sup> attempted to reweight the various subtests of the American Council on Education Psychological Test (1927 edition) to determine whether they could be made to predict accurately scholastic success for three different college groups, namely, agricultural, engineering and general. After determining the reliability coefficient of .904 for the test, and after studying the results obtained from intercorrelations of the scores made on the subtests (completion, artificial language, analogies, arithmetic, and opposites) by 401 first-year students at the Alabama Polytechnic Institute, Watts concluded:

There is not a sufficient difference in the weight of a given subtest for the different groups, Agricultural, Engineering and General, to warrant differential prediction of scholastic success in college on the basis of the psychological examination of the ACE.<sup>6</sup>

Literature on the relation of high-school marks and college success. In 1930 Stoddard<sup>7</sup> made the general statement

---

<sup>4</sup> Ibid., p. 620.

<sup>5</sup> J. V. Watts, "The Differential Predictive Value of the Psychological Examination of the American Council on Education," Journal of Experimental Education, 1:264-71, 1933.

<sup>6</sup> Ibid., p. 271.

<sup>7</sup> George D. Stoddard, "Quantitative Measurement in Inducting the Student into the Institution of Higher Learning and Predicting His Academic Success," Eighteenth Yearbook of the National Society of College Teachers of Education, Chapter IV, 1930, pp. 80-120.



arithmetic, French, and experimental sciences.

In 1933 Watts attempted to reweight the various

subtests of the American Council on Education Psychological

Test (1927 edition) to determine whether such a test could be used

to predict accurately scientific success for three different

college groups, namely, agricultural, engineering and

general. After determining the reliability coefficients

of .90+ for the test, and after studying the formula

obtained from intercorrelations of the scores made on the

subtests (completion, arithmetic, language, analogies,

arithmetic, and opposites) by 401 first-year students at

the Alabama Polytechnic Institute, Watts concluded:

There is not a significant difference in the weight  
of a given subtest for the different groups, agricultural,  
engineering and general, so various differences  
entail prediction of scholastic success in college on  
the basis of the psychological examination of the test.

Literature on the relation of high school grades and

college success. In 1930 Stoddard made the following statement:

<sup>4</sup> Ibid., p. 620.

<sup>5</sup> J. V. Watts, "The Psychological Examination of the American Council  
on Education," Journal of Experimental Education, 1933, 1: 1-21.

<sup>6</sup> Ibid., p. 271.

<sup>7</sup> George D. Stoddard, "Predictive Measurement in  
Indicating the Student into the Institution of Higher Learning  
and Predicting His Academic Success," Psychological  
Book of the National Society of Education, Chapter IV, 1933, pp. 120-129.



that correlations between high-school and first-semester college marks will tend to center about .40, "although it appears likely that improvements in examination methods may raise this figure somewhat."<sup>8</sup> Stoddard's broad statement does not seem to be accurate even as a generalization, as the following summaries may illustrate.

Pettit,<sup>9</sup> one of the earliest investigators to make a study in this field, computed a correlation coefficient of .63 between averages of high-school and freshman marks at Columbia University.

In the same year Smith<sup>10</sup> derived a correlation coefficient of .53 between high-school and college marks at the University of Iowa.

Using data concerning students graduating from New York State College for Teachers in 1921, 1922, and 1923, Gilkey<sup>11</sup> obtained a coefficient of correlation of .498 between the averages of marks made in high school and marks received in college. This coefficient was greater than any

---

<sup>8</sup> Ibid., p. 102.

<sup>9</sup> Walter W. Pettit, "A Comparative Study of New York High Schools and Columbia College Grades," (unpublished Master's thesis, Teachers College, Columbia University, 1912).

<sup>10</sup> F. O. Smith, A National Basis for Determining Fitness for College Entrance (Studies in Education, No. 31. Iowa City: University of Iowa, 1912), p. 58.

<sup>11</sup> Royal Gilkey, "Relation of Success in Certain Subjects in High School to Success in the Same Subjects in College," School Review, 37:576-588, October, 1929.



that correlations between high-school and first-semester college marks will tend to be lower than .60. Although it appears likely that improvements in teaching methods may raise this figure somewhat, it is not clear that the present does not seem to be quite as good as a generalization as the following summary may indicate.

Pettit,<sup>9</sup> one of the earliest investigators to make a study in this field, computed a correlation coefficient of .63 between averages of high-school and college marks at Columbia University.

In the same year Pettit<sup>10</sup> derived a correlation coefficient of .53 between high-school and college marks at the University of Iowa.

Using data concerning students graduating from New York State College for Teachers in 1901, 1902, and 1903, Gilkey<sup>11</sup> obtained a coefficient of correlation of .493 between the averages of marks made in high school and marks received in college. This coefficient was greater than his

<sup>8</sup> Ibid., p. 182.

<sup>9</sup> Walter W. Pettit, "A Comparative Study of the First High School and College Grades," unpublished Master's thesis, Teachers College, Columbia University, 1912.

<sup>10</sup> W. O. Smith, "A National Study of the Correlation of High School and College Marks," unpublished Master's thesis, Teachers College, Columbia University, 1912.

<sup>11</sup> Royal Gilkey, "Relation of Success in High School to Success in College," School Review, 1903, p. 250.



computed between marks attained in specific subjects taken in both high school and college. The correlation coefficient between high-school English marks and college marks was only slightly lower at .481. He concluded that a student's performance in high-school English is a reliable indication of his intelligence as well as being a good subject upon which to rely for prediction of college success.

Pierson<sup>12</sup> attempted to discover the pattern of subjects taken and the marks attained in both high school and the first year of college that would provide the most efficient index for prediction of scholastic success in the engineering curricula. Studying 463 pre-war graduates of the School of Engineering at the University of Utah for the period 1932-1941, he found that the combined grade-point ratio attained in all high-school subjects was more closely related to general scholarship in engineering than the marks assigned in any high-school subject matter area. Furthermore, he found that general scholarship in engineering could be predicted as efficiently from the total high-school grade-point ratio as from marks earned in English, mathematics, physics, and chemistry combined in a multiple regression equation. The zero-order coefficient of

---

<sup>12</sup> G. A. Pierson, "School Marks and Success in Engineering," Educational and Psychological Measurement, 7:612-17, No. 3, Autumn, 1947.



computed between marks obtained in specific subjects taken in both high school and college. The correlation coefficient between high-school English marks and college marks was only slightly lower at .481. He concluded that a student's performance in high-school English is a reliable indication of his intelligence as well as being a good subject upon which to rely for prediction of college success. Pearson<sup>12</sup> attempted to discover the pattern of subjects taken and the marks obtained in both high school and the first year of college that would provide the most efficient index for prediction of scholastic success in the engineering curriculum. Studying 403 pre-war graduates of the School of Engineering at the University of Utah for the period 1932-1941, he found that the combined grade-point ratio obtained in all high-school subjects was more closely related to general scholarship in engineering than the marks assigned in any high-school subject matter area. Furthermore, he found that general scholarship in engineering could be predicted as efficiently from the total high-school grade-point ratio as from marks earned in English, mathematics, physics, and chemistry combined in a multiple regression equation. The zero-order coefficient of

---

<sup>12</sup> G. A. Pearson, "School Marks and Success in Engineering," Educational and Psychological Measurement, 7:612-17, No. 3, Autumn, 1947.



correlation between marks made in all high-school subjects and marks made in college engineering proved to be .58. The coefficient of multiple correlation (between high-school marks in English, mathematics, physics, and chemistry in combination) and marks made in college engineering was found to be only .52. The marks earned in high-school English were discovered to be as closely related to general achievement in engineering as marks earned in mathematics or science. High-school marks in both mechanical drawing and mechanical arts were found to have little or no relationship to the engineering grade-point ratio. Pierson concluded "that students should be guided in terms of their general scholastic achievement rather than in terms of marks earned in any particular high-school or college subject."<sup>13</sup>

Literature on the relation of combinations of high-school marks and test results to college success. Johnson<sup>14</sup> converted the rank which 1,088 high-school seniors attained in their classes to percentile ranks. Psychological test scores were also converted to percentile ranks and the two were averaged to form combined ratings for each senior. These combined ratings were labeled "CR" ratings. The

---

<sup>13</sup> Ibid., p. 617.

<sup>14</sup> J. B. Johnson, "Predicting College Success for the High-School Senior," The Vocational Guidance Magazine, 6:289-94, April, 1928.



correlation between marks made in all high school science  
 and marks made in college entrance examination (College Entrance  
 Examination) of English, mathematics, physics, and chemistry in  
 combination) and marks made in college entrance examination  
 found to be only .52. The marks earned in high school  
 English were discovered to be as closely related to general  
 achievement in engineering as marks earned in mathematics  
 or science. High school marks in both mathematics and  
 and mechanical arts were found to have little or no rela-  
 tionship to the engineering grade-point average. It was  
 concluded "that students should be guided in terms of their  
 general scholastic achievement rather than in terms of marks  
 earned in any particular high school or college subject."  
 Literature on the relation of high school marks to college  
 school marks and test results in college entrance examination  
 converted the rank which 1,000 high school students attained  
 in their classes in particular subjects. The converted rank  
 scores were also converted to percentiles and the two  
 were averaged to form a combined average for each subject.  
 These combined ratings were labeled "combined rank".

13 Ibid., p. 617.  
 14 L. E. Johnson, "Predicting College Success from the  
 High-School Senior," The Yearbook of the National Association  
 of Educational Statistics, 1935, p. 289-94.



investigator predicted that girls whose CR was twenty-five or less, and boys whose CR was thirty-five or less, would not secure the required satisfactory standing of "C" in their college studies. As a result, a certain 208 students were predicted to fall below a "C" average. Of these 208 only three secured the "C" standing. Johnson maintained:

This method identifies in advance more than one-half of those who are unable to do college work. These are equal to about twenty per cent of the class and comprise three hundred to four hundred students in a large state university. Of the forty per cent who stand lowest in the combined ratings, only one-tenth make satisfactory records in college.<sup>15</sup>

In 1932 Crawford and Burnham<sup>16</sup> found after studying four freshman classes at Yale University (3,277 students in all) that secondary school marks correlated .57 with first year university marks while scores made on the College Board Examinations correlated only .47 with the same criterion.

Garrett<sup>17</sup> made a study involving the records of two hundred students who graduated from the same high school and who subsequently attended fifty-two colleges. He found that scores made on the Ohio State Psychological Examination

---

<sup>15</sup> Ibid., p. 293.

<sup>16</sup> A. B. Crawford and P. S. Burnham, "Entrance Examinations and College Achievement," School and Society, 36:344-52, September 10, 1932.

<sup>17</sup> Wiley S. Garrett, "The Ohio State Psychological Examinations," Occupations, 22:489-95, May, 1944.



investigator predicted that girls whose IQ was twenty-five or less, and boys whose IQ was thirty-five or less, would not secure the required satisfactory standing of "C" in their college studies. As a result, a certain 200 students were predicted to fall below a "C" average. Of these 200 only three secured the "C" standing. Johnson maintained:

This method identified in advance more than one-half of those who are unable to do college work. These are equal to about twenty per cent of the class and comprise three hundred to four hundred students in a large state university. Of the forty per cent who stand lowest in the combined ratings, only one-fifth make satisfactory records in college.

In 1935 Crawford and Rabinowitz found after studying

four freshman classes at Yale University (3,277 students

in all) that secondary school marks correlated .57 with

first year university marks while scores made on the College

Board Examinations correlated only .47 with the same or-

terion.

Garnett<sup>17</sup> made a study involving the records of two

hundred students who graduated from the same high school

and who subsequently attended fifty-two colleges. He found

that scores made on the Ohio State Psychological Examination

<sup>17</sup> Ibid., p. 293.

<sup>18</sup> A. B. Crawford and P. S. Rabinowitz, "Entrance Examinations and College Achievement," *School and Society*, 36:344-52, September 10, 1932.

<sup>19</sup> Wiley S. Garnett, "The Ohio State Psychological Examinations," *Psychological Monographs*, 22:489-97, May, 1934.



and college marks attained correlated .608 with each other. The correlation coefficient between college and high-school marks attained was .665. Since the coefficient of correlation derived between the psychological test scores and the high-school grade-point average was .709, Garrett concluded that the Ohio State Psychological Examination is a reliable guide for predicting college marks, but the high-school grade-point average, representing four years of study, is better.

Cohen<sup>18</sup> prepared his data by subtracting high-school averages from the certification grades of the various high schools. He stated:

Analysis showed that the average of the high-school mathematics and science (chemistry and/or physics) marks minus the corrected certification grade correlated .51 with first semester Tech marks and .57 with the final aptitude test battery which, as noted above, consisted of mathematics and science achievement tests and a spatial relations test. This low correlation might indicate that math and science high-school grades, at least as corrected by this study, are determined by factors other than ability and achievement, and the rather large correlation with college marks might indicate that those intangible factors of personality, studiousness, etc. necessary for success in college are measured by these corrected high-school marks.<sup>19</sup>

---

<sup>18</sup> Leonard L. Cohen, "Predicting Academic Success in Engineering College and Suggestions for an Objective Evaluation of High-School Marks," Journal of Educational Psychology, 37:381-384, September, 1946.

<sup>19</sup> Ibid., p. 383.



and college marks attained correlated .668 with each other. The correlation coefficient between college and high-school marks attained was .665. Since the coefficient of correlation derived between the psychological test scores and the high-school grade-point average was .709, Garret concluded that the Ohio State Psychological Examination is a reliable guide for predicting college marks, but the high-school grade-point average, representing four years of study, is better.

Cohen<sup>18</sup> prepared his data by subtracting high-school averages from the certification grades of the various high schools. He stated:

Analysis showed that the average of the high-school mathematics and science (chemistry and/or physics) marks minus the corrected certification grade correlated .51 with first semester Tech marks and .57 with the final aptitude test battery which, as noted above, consisted of mathematics and science achievement tests and a spatial relations test. This low correlation might indicate that math and science high-school grades, at least as corrected by this study, are determined by factors other than ability and achievement, and the rather large correlation with college marks might indicate that those intangible factors of personality, studiousness, etc. necessary for success in college are measured by these corrected high-school marks.

<sup>18</sup> Leonard L. Cohen, "Predicting Academic Success in Engineering College and Suggestions for an Objective Evaluation of High-School Marks," *Journal of Educational Psychology*, 37:381-384, September, 1946.



## CHAPTER III

### METHOD OF CONDUCTING THE INVESTIGATION

For the purpose of greater clarity this chapter is divided into two sections, of which one describes the sources and method of collecting the data and the other is devoted to a definition of the terms used.

#### I. SOURCES OF THE DATA

The raw data upon which this study is based were recorded from three university sources: (1) the office of the College of Engineering, (2) the office of the Registrar, and (3) The Bureau of Counseling and Testing.

The names of 120 first-semester freshmen in the College of Engineering in the fall of 1947 were selected at random from the class rolls of the required beginning course, "Introduction to Engineering."

High-school records were obtained for these 120 students from the high-school transcripts on file in the Registrar's office. Both subjects pursued and marks attained were recorded.

The scores made by the group on the intelligence and achievement tests were recorded from the files of the Bureau of Counseling and Testing.

The final first-semester marks attained by these



## CHAPTER III

### METHOD OF CONDUCTING THE INVESTIGATION

For the purpose of greater clarity this chapter is divided into two sections, of which one describes the sources and method of collecting the data and the other is devoted to a definition of the terms used.

#### I. SOURCES OF THE DATA

The raw data upon which this study is based were recorded from three university sources: (1) the office of the College of Engineering, (2) the office of the Registrar, and (3) The Bureau of Counseling and Testing. The names of 150 first-semester freshmen in the College of Engineering in the fall of 1947 were selected at random from the class rolls of the reported beginning course, "Introduction to Engineering."

High-school records were obtained for these 150 students from the high-school transcripts on file in the Registrar's office. Both subjects pursued and marks attained were recorded.

The scores made by the group on the Intelligence and achievement tests were recorded from the files of the Bureau of Counseling and Testing.

The final first-semester marks attained by these



selected students were recorded from the files in the general office of the College of Engineering at the conclusion of the semester.

In order that the reader may better understand the raw data composed of school marks and test scores, a brief enumeration and description is presented.

High-school marks. In passing, the writer wishes to emphasize his cognizance of the many criticisms directed toward the unreliability of teachers' marks. The view of Heston<sup>1</sup> that marks are "psychological nonsense" is popular and may sometimes be well-founded. It is true that the variability and the subjectivity of marks cannot be ignored, yet it must be remembered that, inefficient and unfair as some marks may be, they are virtually the only means which are used to evaluate success in the American system of formal education. Crawford states, in this regard:

Nevertheless, marks are still used very extensively as "yardsticks" both within and outside the modern educational structure. As achievement measures, to a large degree, they determine whether pupils are admitted to college, fail or pass their courses, receive aspired Ph.D.'s, play on athletic teams, are invited to or rejected by social and honorary societies, secure or lose prospective positions when other factors are equal. Many other examples

---

<sup>1</sup> Heston, op. cit., p. 619.



selected students were recorded from the files in the  
general office of the College of Engineering at the con-  
clusion of the semester.

In order that the reader may better understand the  
raw data composed of school marks and test scores, an  
enumeration and description is presented.

High-school marks. In general, the high-school  
to emphasize his cognizance of the many criticisms directed  
toward the unreliability of teachers' marks. The view of  
Heston<sup>1</sup> that marks are "psychological phenomena" is popular  
and may sometimes be well-founded. It is true that the  
variability and the subjectivity of marks cannot be ignored,  
yet it must be remembered that "reliability and validity are  
some marks may be, they are virtually the only means which  
are used to evaluate students in the American system of  
formal education. Crawford states, in this regard:

Nevertheless, marks are still used very extensively  
as "yardsticks" both within and outside the school  
educational structure. As educational resources, to  
a large degree, they determine whether pupils are  
admitted to colleges, fall or pass their courses,  
receive awards, etc. It is an established fact  
are invited to or rejected by social and economic  
societies, secure or lose prospective positions  
when other factors are equal. Many other situations

---

<sup>1</sup> Heston, op. cit., p. 143.



such as these point undeniably to the fact that marks are used as achievement criteria, if for no other reason than that none better are available.<sup>2</sup>

In this study high-school marks in English, mathematics, the physical sciences, and the biological sciences were recorded.

College marks. The marks used in this study were attained in subjects of the required program for engineering college freshmen. These courses and the number of credit hours per semester for each are:

College Algebra, three credit hours.

Solid Geometry, three credit hours.

Engineering and Descriptive Geometry, three credit hours.

Chemistry, four credit hours.

Introduction to Engineering, one credit hour.

The battery of tests used to evaluate engineering freshmen included (1) the 1946 edition of the American Council on Education Psychological Examination for College Students; (2) the Cooperative English Test; (3) the Engineering and Physical Science Aptitude Test; and (4) the

---

<sup>2</sup> B. M. Crawford, "Guidance Implications Obtained from the Use of Four Types of Interest Measurements," (unpublished Doctor's dissertation, The University of Michigan, Ann Arbor, 1945), p. 69.

USE  
BOOK  
MARK

PLEASE  
DO NOT  
BEND  
CORNERS  
OR MARK  
PAGES

THE  
DIETER  
BOOK  
BINDING  
CO.  
DENVER,  
COLO.





such as these point undeniably to the fact that marks are used as achievement criteria, if for no other reason than that none better are available.<sup>2</sup>

In this study high-school marks in English, mathematics, the physical sciences, and the biological sciences were recorded.

College marks. The marks used in this study were obtained in subjects of the required program for engineering college freshmen. These courses and the number of credit hours per semester for each are:

College Algebra, three credit hours.

Solid Geometry, three credit hours.

Engineering and Descriptive Geometry, three credit

hours.

Chemistry, four credit hours.

Introduction to Engineering, one credit hour.

The battery of tests used to evaluate engineering

freshmen included (1) the 1945 edition of the American Council on Education Psychological Examination for College Students; (2) the Cooperative English Test; (3) the Engineering and Physical Science Aptitude Test; and (4) the

---

<sup>2</sup> B. M. Crawford, "Guidance Implications Obtained from the Use of Four Types of Interest Measurements," (unpublished Doctor's dissertation, The University of Michigan, Ann Arbor, 1945), p. 69.



## University of New Mexico Mathematics Test.

The psychological test. The American Council on Education Psychological Examination for College Students (ACE) is divided into two sections, the L section and the Q section. The L section is a measure of verbal aptitudes such as are involved in social science or language courses. It is subdivided into three parts: (1) same-opposites, (2) verbal analogies, and (3) vocabulary. There is a total raw score of 120 points on this section. The Q section is a measure of quantitative aptitudes involved in such courses as mathematics, physical science, and accounting. The Q section is subdivided into three parts: (1) mathematics, (2) figure analogies, and (3) number series. A total of eighty points is possible on this section.

The English test. The score of the Cooperative English Test (which is published by the Cooperative Test Service) is based on usage, grammar, punctuation, spelling, and basic English skills. The scores made on this test are used to classify students in the freshman English classes.

The engineering aptitude test. The Engineering and Physical Science Aptitude Test includes (1) tests of mathematical abilities, (2) ability to understand and remember scientific terms and concepts, and (3) ability to analyze



University of New Mexico Mathematics Test.

The Psychological Test. The American Council on Education Psychological Examination for College Students (ACE) is divided into two sections, the I section and the II section. The I section is a measure of verbal aptitudes such as are involved in social science or language courses. It is subdivided into three parts: (1) name-opposites, (2) verbal analogies, and (3) vocabulary. There is a total raw score of 120 points on this section. The II section is a measure of quantitative aptitudes involved in such courses as mathematics, physical science, and accounting. The II section is subdivided into three parts: (1) mathematics, (2) figure analogies, and (3) number series. A total of eighty points is possible on this section.

The English Test. The score of the Cooperative English Test (which is published by the Cooperative Test Service) is based on usage, grammar, punctuation, spelling, and basic English skills. The scores made on this test are used to classify students in the freshman English classes.

The Engineering Aptitude Test. The Engineering and Physical Science Aptitude Test includes (1) tests of mathematical aptitudes, (2) ability to understand and remember scientific terms and concepts, and (3) ability to analyze



and understand basic principles used in physics. This test is published by the Psychological Corporation.

The mathematics test. The University of New Mexico Mathematics Test samples basic algebraic procedures. This test was devised by H. P. Rogers of the university mathematics department.

## II. DEFINITION OF TERMS USED

College grade-point average. All of the first-semester college marks of the students included in this investigation were given a numerical point value; an "A" was assigned a value of four, a "B" was assigned a value of three, a "C" was assigned a value of two, a "D" was assigned a value of one, and an "F," indicative of failing work, was assigned a value of zero. These values were multiplied by the number of course hours in which the marks were obtained and the products added. The sum was then divided by the total number of course hours taken to determine the grade-point average. For example, a student who had earned three semester hours of "A," three hours of "B," three hours of "C," three hours of "D," and three hours of "F" would have a total of thirty grade-points. This total divided by fifteen, the number of course hours, has a quotient of a grade-point average of 2.0, a straight "C" average.



and understand basic principles used in physics. This test is published by the Psychological Corporation.

The mathematics test. The University of New Mexico Mathematics Test samples basic algebraic procedures. This test was devised by H. P. Rogers of the University Mathematics department.

## II. DEFINITION OF TERMS USED

College grade-point average. All of the first-semester college marks of the students included in this investigation were given a numerical point value; an "A" was assigned a value of four, a "B" was assigned a value of three, a "C" was assigned a value of two, a "D" was assigned a value of one, and an "F," indicative of failing work, was assigned a value of zero. These values were multiplied by the number of course hours in which the marks were obtained and the products added. The sum was then divided by the total number of course hours taken to determine the grade-point average. For example, a student who had earned three semester hours of "A," three hours of "B," three hours of "C," three hours of "D," and three hours of "F" would have a total of thirty grade-points. This total divided by fifteen, the number of course hours, has a quotient of a grade-point average of 2.0, a straight "C" average.



High-school achievement. The degree of high-school achievement as used in this study was determined by assigning to high-school marks numerical values identical with those for computing college grade-point averages. If, for example, a student had a record of four "A's" and four "B's" for eight semesters of English work, he had accumulated twenty-eight points which, when divided by eight, produces an average score of 3.5, midway between a straight "A" and a straight "B" average. The high-school average was computed by following this procedure for all of the high-school subjects for which data were available.



High-school activities and the degree of achievement

achievement as well as this study and the degree of achievement

ing to high-school work, a numerical value is assigned to

those for comparing college grade-point averages. For

example, a student had a record of being "A" for 10

for eight semesters of English work, he had earned

twenty-eight points which, when divided by eight, produced

an average score of 3.5, midway between a "B" and

a straight "B" average. The high-school average was

puted by following this procedure for all of the high-

school subjects for which data were available.



## CHAPTER IV

### ANALYSIS OF THE DATA

In order to facilitate clear understanding, this study will employ the following arbitrarily determined descriptive and quantitative values to interpret coefficients as recommended by Darley:<sup>1</sup>

- .80 and up equals very high correlation
- .50 to .80 equals substantial correlation
- .30 to .50 equals some correlation
- .20 to .30 equals slight correlation
- .00 to .20 equals practically no correlation

The initial treatment of the data consisted of determining the coefficients of correlation ( $r$ ) between twenty-eight different combinations of variables and the probable errors ( $P.E._r$ ) of these coefficients. These computations were made for two reasons: (1) to determine the extent of relationship which exists between such variables of the data as intelligence, aptitudes, and marks attained in high school and college, and (2) to select the variables to use for later computation of coefficients of multiple correlation ( $R$ ) and to develop regression equations for predicting the degree of success to be attained in the engineering college by a prospective student. The coefficients of

---

<sup>1</sup> John G. Darley, Testing and Counseling in the High-School Guidance Program (Chicago: Science Research Associates, 1943), p. 71.



## CHAPTER IV

### ANALYSIS OF THE DATA

In order to facilitate clear understanding, this study will employ the following arbitrarily determined descriptive and quantitative values to interpret coefficients as recommended by Darley:<sup>1</sup>

.80 and up equals very high correlation  
.50 to .80 equals substantial correlation  
.30 to .50 equals some correlation  
.20 to .30 equals slight correlation  
.00 to .20 equals practically no correlation

The initial treatment of the data consisted of determining the coefficients of correlation ( $r$ ) between twenty-eight different combinations of variables and the probable errors ( $P.E.$ ) or these coefficients. These computations were made for two reasons: (1) to determine the extent of relationship which exists between each variable of the data as intelligence, aptitudes, and marks obtained in high school and college; and (2) to select the variables to use for later computation of coefficients of multiple correlation ( $R$ ) and to develop regression equations for predicting the degree of success to be attained in the engineering college by a prospective student. The coefficients of

---

<sup>1</sup> John B. Darley, Testing and Counseling in the High School Guidance Program (Chicago: Science Research Assoc., 1933), p. 71.



correlation between the average marks attained in all high-school subjects, average marks received in certain high-school subject matter areas, and scores made on various tests are presented in Table I.

#### I. RELATIONSHIP BETWEEN VARIABLES OF THE DATA

The reader will notice the lack of substantial correlation between the high-school average marks and the Q, L, and T scores of the American Council on Education Psychological Test (ACE). This seems to indicate that the relationship between marks attained in high school and later achievement on an intelligence test administered in college is so low as to be almost nonexistent. Since the coefficients obtained are less or only slightly greater than three times the product of their respective probable errors, the three coefficients are statistically unreliable. On the assumption that the ACE results are a valid measure of pupil ability, one may imply that other factors than ability determine marks assigned in high school.

It is interesting to note that even the Q score of the ACE and averages of high-school marks attained in such quantitative subjects as mathematics and the physical sciences does not manifest a coefficient greater than .170. One may thus conclude that the relationship between marks attained in high school and intelligence as measured by



correlation between the average marks obtained in all high-school subjects, average marks received in certain high-school subject matter areas, and scores made on various tests are presented in Table I.

# I. RELATIONSHIP BETWEEN VARIABLES OF THE DATA

The reader will notice the lack of substantial correlation between the high-school average marks and the Q, I, and T scores of the American Council on Education Psychological Test (ACE). This seems to indicate that the relationship between marks obtained in high school and later achievement on an intelligence test administered in college is as low as to be almost nonexistent. Since the coefficients obtained are less or only slightly greater than three times the product of their respective probable errors, the three coefficients are statistically unreliable. On the assumption that the ACE results are a valid measure of pupil ability, one may imply that other factors than ability determine marks assigned in high school.

It is interesting to note that even the Q score of the ACE and averages of high-school marks obtained in such quantitative subjects as mathematics and the physical sciences does not manifest a coefficient greater than .170. One may thus conclude that the relationship between marks obtained in high school and intelligence as measured by



TABLE I

COEFFICIENTS OF CORRELATION BETWEEN AVERAGES OF HIGH-SCHOOL  
AND COLLEGE ACHIEVEMENT AND SCORES MADE ON CERTAIN  
TESTS BY COLLEGE OF ENGINEERING FRESHMEN

| Measures<br>correlated   | Number<br>of cases | r    | P.E. <sub>r</sub> |
|--|--------------------|------|-------------------|
| HIGH-SCHOOL ACHIEVEMENT  |                    |      |                   |
| High-School Average with   |                    |      |                   |
| Q Score of the ACE   | 104                | .047 | .066              |
| L Score of the ACE   | 104                | .213 | .063              |
| T Score of the ACE   | 104                | .222 | .062              |
| HIGH-SCHOOL SUBJECT MATTER AREAS                                 |                    |      |                   |
| Q Score of the ACE with  |                    |      |                   |
| High-School Biological Science                                   | 83                 | .085 | .073              |
| High-School Mathematics  | 107                | .170 | .063              |
| High-School Physical Science                                     | 92                 | .130 | .069              |
| HIGH-SCHOOL SUBJECT MATTER AREAS<br>AND RELATED COLLEGE AVERAGES |                    |      |                   |
| High-School Biological Science<br>and College Chemistry          | 79                 | .233 | .022              |
| High-School Physical Science<br>and College Chemistry            | 88                 | .524 | .016              |
| High-School Mathematics and<br>College Mathematics               | 88                 | .437 | .018              |
| High-School English and<br>College English                       | 89                 | .404 | .059              |
| COLLEGE ACHIEVEMENT  |                    |      |                   |
| College Average with   |                    |      |                   |
| Q Score of the ACE   | 111                | .379 | .069              |
| L Score of the ACE   | 111                | .400 | .053              |
| T Score of the ACE   | 111                | .466 | .050              |



TABLE I

COEFFICIENTS OF CORRELATION BETWEEN AVERAGES OF HIGH-SCHOOL  
AND COLLEGE ACHIEVEMENT AND SCORES MADE ON CERTAIN  
TESTS BY COLLEGE OF ENGINEERING FRESHMEN

| Measures<br>correlated   | Number<br>of cases | r    | P.E.T. |
|--|--------------------|------|--------|
| HIGH-SCHOOL ACHIEVEMENT  |                    |      |        |
| High-School Average with   |                    |      |        |
| Q Score of the ACE   | 104                | .047 | .066   |
| I Score of the ACE   | 104                | .213 | .063   |
| T Score of the ACE   | 104                | .222 | .062   |
| HIGH-SCHOOL SUBJECT MATTER AREAS                                 |                    |      |        |
| Q Score of the ACE with  |                    |      |        |
| High-School Biological Science                                   | 83                 | .085 | .073   |
| High-School Mathematics  | 107                | .170 | .063   |
| High-School Physical Science                                     | 92                 | .130 | .069   |
| HIGH-SCHOOL SUBJECT MATTER AREAS<br>AND RELATED COLLEGE AVERAGES |                    |      |        |
| High-School Biological Science<br>and College Chemistry          | 79                 | .233 | .022   |
| High-School Physical Science<br>and College Chemistry            | 88                 | .224 | .016   |
| High-School Mathematics and<br>College Mathematics               | 88                 | .437 | .018   |
| High-School English and<br>College English                       | 89                 | .404 | .059   |
| COLLEGE ACHIEVEMENT  |                    |      |        |
| College Average with   |                    |      |        |
| Q Score of the ACE   | 111                | .379 | .069   |
| I Score of the ACE   | 111                | .400 | .053   |
| T Score of the ACE   | 111                | .466 | .050   |



the ACE is negligible. It would certainly be hazardous to predict a pupil's degree of performance on the ACE when only his high-school record is known. It may be important to add, however, that the relationships between marks attained in high-school subjects such as physical science, mathematics, and English and marks attained in respectively related subjects in college are considerably greater. The coefficients for the relationships are .524, .437, and .404 respectively. Furthermore, an analysis of Table I reveals that, although the relationships are not great, the coefficients between the Q, L, and T scores of the ACE and average marks attained in the first semester of engineering college are considerably greater. In summary, one may conclude: (1) that some relationship exists between scores made on the ACE and average college marks; (2) that almost no relationship is manifest between scores made on the ACE and marks received in high school; (3) that there is a tendency for marks attained in respectively related areas of high-school and college subject matter to be related.

Table II indicates that the relationship between marks attained in high school and those received in the first semester of engineering college is greater than between marks attained in high school and scores made on the ACE.

In this regard the coefficient of .569 computed



the ACE is negligible. It would certainly be hazardous to predict a pupil's degree of performance on the ACE when only his high-school record is known. It may be important to add, however, that the relationships between marks attained in high-school subjects such as physical sciences, mathematics, and English and marks attained in respectively related subjects in college are considerably greater. The coefficients for the relationships are .52%, .43%, and .40% respectively. Furthermore, an analysis of Table I reveals that, although the relationships are not great, the coefficients between the Q, I, and T scores of the ACE and average marks attained in the first semester of engineering college are considerably greater. In summary, one may conclude: (1) that some relationship exists between scores made on the ACE and average college marks; (2) that almost no relationship is manifest between scores made on the ACE and marks received in high school; (3) that there is a tendency for marks attained in respectively related areas of high-school and college subject matter to be related.

Table II indicates that the relationship between marks attained in high school and those received in the first semester of engineering college is greater than between marks attained in high school and scores made on the ACE.

In this regard the coefficient of .56% computed



between marks received in high school and those attained in college surpasses the coefficient of .222 between marks received in high school and subsequent scores made on the ACE. Thus, since this coefficient is higher than any

TABLE II

COEFFICIENTS OF CORRELATION BETWEEN THE COLLEGE  
GRADE-POINT AVERAGES AND VARIOUS FACTORS

| Correlated with the college<br>grade-point averages | Number<br>of cases | r    | P.E. <sub>r</sub> |
|---|--------------------|------|-------------------|
| High-School Average                                 | 103                | .569 | .044              |
| High-School English Average                         | 107                | .461 | .051              |
| Engineering and Physical<br>Science Aptitude Test   | 107                | .616 | .040              |
| Cooperative English Test                            | 103                | .472 | .051              |
| UNM Math Test                                       | 104                | .495 | .049              |

computed between marks received in the first semester of engineering college and scores made on the ACE, it would appear that average high-school marks are a more reliable indicator of success in engineering college than performance on the ACE. In fact, all the coefficients presented in Table II are greater than any coefficients derived between Q, L, and T scores of the ACE and marks attained in the first semester of the College of Engineering as previously discussed. As a cautionary measure, the writer wishes to suggest that even the greatest coefficient of .616 derived



between marks received in high school and those received in college surveys the coefficient of .73 between marks received in high school and university scores made on the ABE. Thus, since this coefficient is higher than any

TABLE II

COEFFICIENTS OF CORRELATION BETWEEN THE COLLEGE GRADE-POINT AVERAGES AND THE UNIVERSITY FACTORS

| Correlated with the college grade-point averages |     | University factors |     |
|--|-----|--------------------|-----|
|  |     | Factor             | r   |
| <hr/>  |     |                    |     |
| High-School Average                              | .73 | 101                | .73 |
| High-School English Average                      | .73 | 102                | .73 |
| Engineering and Physical Science Aptitude Test   | .73 | 103                | .73 |
| Cooperative English Test                         | .73 | 104                | .73 |
| UM Math Test                                     | .73 | 105                | .73 |

computed between marks received in the first semester of engineering college and scores made on the ABE, it would appear that average high-school marks are a more reliable indicator of success in engineering college than performance on the ABE. In fact, all the coefficients presented in Table II are greater than any coefficient derived between 9, I, and F scores of the ABE and marks obtained in the first semester of the College of Engineering as noted and discussed. As a cautionary measure, the writer wishes to suggest that even the greater coefficient of .73 derived



between scores made on the Engineering and Physical Science Aptitude Test and average college marks received indicates only a relatively strong tendency for relationship, but is, at the same time, extremely unreliable for individual prediction.

The substantial relationship between the college grade-point averages and scores made on the EPSA ( $r = .616$ ), shows this test to be the best single indicator of college success, although the coefficient of .569 computed between average marks received in high school and average marks made in college is only slightly less. This latter coefficient of correlation closely approximates the findings of Crawford and Burnham, who found that high-school marks correlated .57 with first-year averages.<sup>2</sup> This relationship is also in accord with the conclusions of Pierson, who maintained that students should be guided according to their scholastic achievement and not by marks earned in any particular or individual high-school or college subject.<sup>3</sup>

In Table III it will be noted that the UNM Math Test correlates with the T, the Q, and the L scores of the ACE and the Cooperative English Test (CET) respectively in an order of decreasing significance. Although none of the

---

<sup>2</sup> Crawford and Burnham, op. cit., p. 350.

<sup>3</sup> Pierson, op. cit., p. 617.



between scores made on the Engineering and Physical Science Aptitude Test and average college marks received indicates only a relatively strong tendency for relationship, but is, at the same time, extremely unreliable for individual prediction.

The substantial relationship between the college grade-point averages and scores made on the EPST ( $r = .616$ ), shows this test to be the best single indicator of college success, although the coefficient of .569 computed between average marks received in high school and average marks made in college is only slightly less. This latter coefficient of correlation closely approximates the findings of Crawford and Burnham, who found that high-school marks correlated .57 with first-year averages.<sup>2</sup> This relationship is also in accord with the conclusions of Pierson, who maintained that students should be guided according to their scholastic achievement and not by marks earned in any particular or individual high-school or college subject.<sup>3</sup> In Table III it will be noted that the UMN Math Test correlates with the T, the Q, and the I scores of the AGT and the Cooperative English Test (CET) respectively in an order of decreasing significance. Although none of the

<sup>2</sup> Crawford and Burnham, *op. cit.*, p. 350.

<sup>3</sup> Pierson, *op. cit.*, p. 617.



TABLE III

COEFFICIENTS OF CORRELATION BETWEEN SCORES MADE BY  
ENGINEERING FRESHMEN ON THE UNM MATH TEST, THE  
AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL  
TEST, AND THE COOPERATIVE ENGLISH TEST

| Correlated with UNM Math Test | Number<br>of cases | r    | P.E. <sub>r</sub> |
|-------------------------------|--------------------|------|-------------------|
| Q Score of the ACE            | 106                | .412 | .054              |
| L Score of the ACE            | 106                | .365 | .056              |
| T Score of the ACE            | 106                | .419 | .054              |
| Cooperative English Test      | 106                | .299 | .059              |

coefficients is indicative of a high relationship, an interesting observation should be made. It appears that the variables which require greater ability to think quantitatively correlate higher with scores made on the UNM Math Test (T score,  $r = .419$  and Q score,  $r = .412$ ) than do variables which are concerned for the most part with the remembrance of learned rules and vocabulary. Thus, the scores made on the UNM Math Test correlate only .365 and .299 respectively with scores attained on the L section of the ACE and the Cooperative English Test.

The Engineering and Physical Science Aptitude Test (EPSA) has been extensively used by colleges of engineering for prediction of success to be attained by prospective



TABLE III

COEFFICIENTS OF CORRELATION BETWEEN SCORES MADE BY  
ENGINEERING FRESHMEN ON THE UWM MATH TEST, THE  
AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL  
TEST, AND THE COOPERATIVE ENGLISH TEST

| Correlated with UWM Math Test | Number<br>of cases | r    | P. < .05 |
|-------------------------------|--------------------|------|----------|
| Q Score of the ACE            | 106                | .412 | .054     |
| I Score of the ACE            | 106                | .365 | .056     |
| T Score of the ACE            | 106                | .419 | .054     |
| Cooperative English Test      | 106                | .299 | .059     |

coefficient is indicative of a high relationship, an interesting observation should be made. It appears that the variables which require greater ability to think quantitatively correlate higher with scores made on the UWM Math Test (T score,  $r = .419$  and Q score,  $r = .412$ ) than do variables which are concerned for the most part with the remembrance of learned rules and vocabulary. Thus, the scores made on the UWM Math Test correlate only .365 and .299 respectively with scores attained on the I section of the ACE and the Cooperative English Test.

The Engineering and Physical Science Aptitude Test (EPSA) has been extensively used by colleges of engineering for prediction of success to be attained by prospective



students. The substantial correlations presented in Table IV emphasize a relationship that the reader may have noted previously. Evidence of the importance of one

TABLE IV

THE COEFFICIENTS OF CORRELATION BETWEEN SCORES ON THE  
ENGINEERING AND PHYSICAL SCIENCE APTITUDE TEST AND  
THE SCORES ON THE ACE AND UNM MATHEMATICS TEST

| Correlated with the Engineering<br>and Physical Science Aptitude<br>Test | Number<br>of cases | r    | P.E. <sub>r</sub> |
|--|--------------------|------|-------------------|
| Q Score of the ACE   | 109                | .491 | .049              |
| L Score of the ACE   | 109                | .665 | .036              |
| T Score of the ACE   | 109                | .696 | .033              |
| UNM Math Test  | 106                | .556 | .040              |

of the functional concomitants of English, the ability to read with understanding, is apparent. The L scores of the ACE correlate substantially with scores made on the EPSA ( $r = .665$ ). This result is in agreement with Pierson,<sup>4</sup> who found a marked relationship between success attained in a college of engineering and high-school English. The Q score of the ACE has a less significant relationship with

<sup>4</sup> Pierson, op. cit., p. 617.



students. The substantial correlations presented in Table IV emphasize a relationship that the reader may have noted previously. Evidence of the importance of one

TABLE IV

THE CORRELATIONS OF CORRELATION BETWEEN SCORING ON THE ENGINEERING AND PHYSICAL SCIENCE APTITUDE TEST AND THE SCORES ON THE ACE AND THE UNIVERSITY TEST

| Correlated with the Engineering and Physical Science Aptitude Test |      |                |
|--|------|----------------|
| Number of cases  | r    | r <sup>2</sup> |
| 9 Score of the ACE   | .491 | .241           |
| I Score of the ACE   | .667 | .445           |
| T Score of the ACE   | .663 | .438           |
| UHS Math Test  | .755 | .570           |

of the functional consequences of English, the ability to read with understanding, is apparent. The I score of the ACE correlate substantially with scores made on the EPSSA ( $r = .667$ ). This result is in agreement with Pearson who found a marked relationship between success attained in a college of engineering and high-school English. The 9 score of the ACE has a less significant relationship with

<sup>1</sup> Pearson, op. cit., p. 612.



the EPSA, as indicated by the coefficient of .491. Since the scores on the EPSA correlate substantially with the T scores of the ACE ( $r = .693$ ), it would appear that the EPSA is also a measure of general ability. The coefficient of correlation of .556 between scores on this latter measure and the scores on the UNM Math test may reflect the influence of common elements, for example basic algebra, which is a substantial part of the engineering test. However, in passing, the reader will recall that the scores made on the L section of the ACE, a measure of language ability, correlate almost as highly (.655) with scores made on the EPSA.

## II. THE PROGNOSTIC VALUE OF THE VARIABLES IN COMBINATION

Since the greatest coefficient of correlation manifesting relation to college engineering success was found to be between college grade-point averages and scores made on the EPSA ( $r = .616$ ), the writer desires to make the following comment. Even though a coefficient of .616 may be considered as substantial according to the arbitrary classification system used in this study, all that a coefficient of such magnitude really implies is that for another sampling of cases similarly selected a substantial relationship would also result. In terms of providing a basis for predicting the success to be attained by a prospective



the EPBA, as indicated by the coefficient of .491. Since the scores on the EPBA correlate substantially with the T scores of the ACE ( $r = .693$ ), it would appear that the EPBA is also a measure of general ability. The coefficient of correlation of .556 between scores on this latter measure and the scores on the UMN Math test may reflect the influence of common elements, for example basic algebra, which is a substantial part of the engineering test. However, in passing, the reader will recall that the scores made on the I section of the ACE, a measure of language ability, correlate almost as highly (.655) with scores made on the EPBA.

## II. THE PROGNOSTIC VALUE OF THE VARIABLES IN COMBINATION

Since the greatest coefficient of correlation manifesting relation to college engineering success was found to be between college grade-point averages and scores made on the EPBA ( $r = .616$ ), the writer desires to make the following comment. Even though a coefficient of .616 may be considered as substantial according to the arbitrary classification system used in this study, all that a coefficient of such magnitude really implies is that for another sampling of cases similarly selected a substantial relationship would also result. In terms of providing a basis for predicting the success to be attained by a prospective



engineering student in relation to the data so far presented, a coefficient of correlation of only .616 is extremely unreliable and little better than a rough guess. Consequently, in order to ascertain to what degree, if any, the reliability of prognosis can be increased, the investigator combined variables used in this study in order to compute multiple coefficients of correlation and to develop regression equations for the purpose of facilitating individual prediction.

Two criteria used for selection of the variables to combine for the development of the regression equations may be stated in the form of two questions: (1) Which variables manifest the greatest correlation with college grade-point averages or achievement? and (2) Which variables appear to have the most unique value for this investigation in contrast with studies made elsewhere in the country?

Since the Engineering and Physical Science Aptitude Test (EPSA), high-school average marks, the UNM Math test, the Cooperative English Test (CET), and the T score of the ACE provided data which correlated highest with college grade-point averages, the above with one exception were chosen. Because the T score of the ACE includes the L score, a measure of verbal aptitudes, the closely related CET was eliminated from further statistical treatment.

In order to compute the multiple coefficients of



engineering student in relation to the data so far presented, a coefficient of correlation of only .61 is extremely unreliable and little better than a rough guess. Consequently, in order to ascertain to what degree, if any, the reliability of prognoses can be increased, the investigator combined variables used in this study in order to compute multiple coefficients of correlation and to develop regression equations for the purpose of facilitating individual prediction.

Two criteria used for selection of the variables to combine for the development of the regression equations may be stated in the form of two questions: (1) Which variables manifest the greatest correlation with college grade-point averages or achievement? and (2) Which variables appear to have the most unique value for this investigation in contrast with studies made elsewhere in the country?

Since the Engineering and Physical Science Aptitude Test (EPST), high-school average marks, the UNK Math test, the Cooperative English Test (CET), and the T score of the ACE provided data which correlated highest with college grade-point averages, the above with one exception were chosen. Because the T score of the ACE includes the I score, a measure of verbal aptitudes, the closely related CET was eliminated from further statistical treatment.

In order to compute the multiple coefficients of



correlation and develop regression equations, it was necessary to select a constant number of cases for which complete data were available. Ninety-five cases were subsequently discovered to satisfy this criterion. Table V presents the coefficient of correlation computed for both the constant sampling of ninety-five cases and the original sampling.

TABLE V

COMPARISON OF COEFFICIENTS OF CORRELATION BETWEEN THE SAME VARIABLES FOR A TOTAL AND SMALLER SAMPLES

| Correlation between college grade-point average and | Coefficient of correlation for all cases |      |                   | Coefficients of correlation for ninety-five cases |      |                   |
|---|--|------|-------------------|---|------|-------------------|
|   | N  | r    | P.E. <sub>r</sub> | N   | r    | P.E. <sub>r</sub> |
| T of the ACE  | 111                                      | .466 | .050              | 95  | .504 | .051              |
| High-School English Average                         | 107                                      | .461 | .051              | 95  | .462 | .054              |
| High-School Average                                 | 103                                      | .569 | .044              | 95  | .597 | .044              |
| UNM Math Test                                       | 104                                      | .495 | .049              | 95  | .555 | .048              |
| Engineering and Physical Science Aptitude Test      | 107                                      | .616 | .040              | 95  | .619 | .042              |

The reader will note that the coefficients remain relatively stable even though the number of cases in the constant sampling was reduced. The greatest difference is



correlation and develop regression equations, it was necessary to select a constant number of cases for which complete data were available. Ninety-five cases were subsequently discovered to satisfy this criterion. Table V presents the coefficient of correlation computed for both the constant sampling of ninety-five cases and the original sampling.

TABLE V

COMPARISON OF COEFFICIENTS OF CORRELATION BETWEEN THE SAME VARIABLES FOR A TOTAL AND SMALLER SAMPLES

| Correlation between college grade-point average and | Coefficient of correlation for all cases |      | Coefficient of correlation for ninety-five cases |      |
|---|--|------|--|------|
|   | N  | r    | N  | r    |
| T of the AGE  | 111                                      | .466 | 95   | .451 |
| High-School English Average                         | 107                                      | .461 | 95   | .454 |
| High-School Average                                 | 103                                      | .569 | 95   | .577 |
| UWM Math Test                                       | 104                                      | .495 | 95   | .525 |
| Engineering and Physical Science Aptitude Test      | 107                                      | .616 | 95   | .619 |

The reader will note that the coefficients remain relatively stable even though the number of cases in the constant sampling was reduced. The greatest difference is



an increase of .060 between college grade-point averages and scores on the UNM Math Test in favor of the constant sampling.

Since the computation of multiple coefficients of correlation ( $R$ 's) necessitates the determination of all the possible intercorrelations between the variables to be later combined, the coefficients computed are presented in Table VI. Three of these coefficients of correlation merit comment. The previously noted relation between the  $T$  scores of the AGE and the EPSA results, which produced a coefficient of correlation of .693, is increased to .766 when computed using the ninety-five cases for which all data were available. This increase serves to emphasize further the view that the EPSA measures general ability to a large extent. The very high relationship between the high-school English averages and the total high-school averages ( $r = .846$ ) is probably influenced by the factor of common elements, namely, English courses which comprise one quarter of the entire high-school curriculum. The relation between ability in English and general ability has been previously commented upon. The lack of relationship manifested by the coefficient of correlation of .024 between the high-school English averages and scores on the UNM Math Test is in accord with the opinion stated earlier that there is no relationship between these abilities.



an increase of .000 between adjacent grade-point averages and scores on the UYM test in favor of the constant sampling.

Since the computation of multiple coefficients of correlation ( $R^2$ ) necessitates the determination of all the possible intercorrelations between the variables to be inter combined, the coefficients computed are presented in Table II. Three of these coefficients of correlation are significant. The previously noted relation between the  $\bar{Y}$  scores of the AGE and the EPBA results, which produced a coefficient of correlation of .69, is increased to .90 when grouped among the ninety-five cases for which all data were available. This increase serves to emphasize further the fact that the EPBA measures general ability to a large extent. The very high relationship between the high-school English averages and the total high-school averages ( $r = .85$ ) is obviously influenced by the factor of common elements, namely, English courses which comprise one quarter of the entire high-school curriculum. The relation between ability in English and general ability has been previously commented upon. The lack of relationship manifested by the coefficient of correlation of .024 between the high-school English averages and scores on the UYM test is viewed with interest. An opinion stated earlier that there is no relationship between these abilities.



TABLE VI

INTERCORRELATIONS OF THE COLLEGE GRADE-POINT AVERAGES  
AND FIVE VARIABLES FOR NINETY-FIVE STUDENTS

|   | Total High-School<br>Averages | High-School English<br>Averages | UNM Math Test | Engineering and<br>Physical Science<br>Aptitude Test | T Score of the ACE |
|---|-------------------------------|---------------------------------|---------------|--|--------------------|
| College Grade-<br>Point Averages                          | .597                          | .462                            | .555          | .619   | .504               |
| T Score of the<br>ACE                                     | .241                          | .296                            | .452          | .766   |                    |
| Engineering<br>and Physical<br>Science Apti-<br>tude Test | .322                          | .279                            | .559          |  |                    |
| UNM Math Test   | .112                          | .024                            |               |  |                    |
| High-School<br>English Aver-<br>ages                      | .846                          |                                 |               |  |                    |







Although the partial correlations of this study were computed primarily for use in the development of regression equations,<sup>5</sup> the former are also of interest because a partial  $r$  denotes a relationship of two variables when the influence of other factors (variables) is held constant. An example of the effect of this technique upon a coefficient of correlation may be illustrated by considering the relationship between the college grade-point averages and the T Scores of the ACE ( $r = .504$ ). When the influence of the Engineering and Physical Science Aptitude Test is held constant, the first-order coefficient decreases to .059. Since stabilizing the remaining variables does not result in a significant increase in correlation, one may conclude that the relationship between college grade-point averages and the T scores of the ACE is dependent upon a number of factors which are an integral part of some of the other variables, especially the Engineering and Physical Science Aptitude Test.

In contrast to the decrease of relationship by partial correlation in the preceding paragraph, the correlation between college grade-point averages and high-school English averages when T scores of the ACE, scores on the Engineering

---

<sup>5</sup> The summary of derived measures, including partial coefficients of correlation and their computation, may be found in the Appendix.



Although the partial correlations of this study were computed primarily for use in the development of regression equations,<sup>5</sup> the former are also of interest because a partial  $r$  denotes a relationship of two variables when the influence of other factors (variables) is held constant. An example of the effect of this technique upon a coefficient of correlation may be illustrated by considering the relationship between the college grade-point averages and the T scores of the ACE ( $r = .504$ ). When the influence of the Engineering and Physical Science Aptitude Test is held constant, the first-order coefficient decreases to .059. Since stabilizing the remaining variables does not result in a significant increase in correlation, one may conclude that the relationship between college grade-point averages and the T scores of the ACE is dependent upon a number of factors which are an integral part of some of the other variables, especially the Engineering and Physical Science Aptitude Test.

In contrast to the decrease of relationship by partial correlation in the preceding paragraph, the correlation between college grade-point averages and high-school English averages when T scores of the ACE, scores on the Engineering

<sup>5</sup> The summary of derived measures, including partial coefficients of correlation and their computation, may be found in the Appendix.



and Physical Science Aptitude Test, and scores on the UNM Math Test are held constant, is fairly significant ( $r_{15,234} = .466$ ). Thus, the relationship between the correlated variables is a result of the lack of factors held in common with the variables held constant.

The basic data for the development of a six-variable regression equation using the results obtained on the score of the ACE, the Engineering and Physical Science Aptitude Test, the UNM Math Test, the high-school English averages and the total high-school averages in combination follows:

$X_1$  = College Grade-Point Averages

$X_2$  = T Score of the ACE

$X_3$  = Engineering and Physical Science Aptitude Test

$X_4$  = University of New Mexico Mathematics Test

$X_5$  = High-School English Average

$X_6$  = High-School Average

$$M_1 = 1.932$$

$$\sigma_1 = \pm .980$$

$$M_4 = 21.02$$

$$\sigma_4 = 5.56$$

$$M_2 = 109.02$$

$$\sigma_2 = \pm 20.04$$

$$M_5 = 2.44$$

$$\sigma_5 = \pm .78$$

$$M_3 = 89.95$$

$$\sigma_3 = \pm 20.07$$

$$M_6 = 2.48$$

$$\sigma_6 = .525$$



and Physical Science Aptitude Test, and scores on the U.S. Math Test are held constant, is fairly significant ( $r_{12,23} = .466$ ). Thus, the relationship between the correlated variables is a result of the lack of factors held in common with the variables held constant.

The basic data for the development of a six-variable regression equation using the results obtained on the score of the ACE, the Engineering and Physical Science Aptitude Test, the U.S. Math Test, the high-school English averages and the total high-school averages in combination follows:

$X_1$  = College Grade-Point Averages

$X_2$  = T Score of the ACE

$X_3$  = Engineering and Physical Science Aptitude Test

$X_4$  = University of New Mexico Mathematics Test

$X_5$  = High-School English Averages

$X_6$  = High-School Averages

$$M_1 = 89.92$$

$$M_2 = 102.02$$

$$M_3 = 1.932$$

$$\sigma_1 = 20.07$$

$$\sigma_2 = 20.04$$

$$\sigma_3 = 2.980$$

$$M_4 = 2.48$$

$$M_5 = 2.44$$

$$M_6 = 21.02$$

$$\sigma_4 = 2.22$$

$$\sigma_5 = 2.78$$

$$\sigma_6 = 2.25$$



Zero Order Coefficients of Correlation:

|                 |                 |                 |
|-----------------|-----------------|-----------------|
| $r_{12} = .504$ | $r_{16} = .597$ | $r_{26} = .241$ |
| $r_{13} = .619$ | $r_{23} = .766$ | $r_{34} = .559$ |
| $r_{14} = .555$ | $r_{24} = .452$ | $r_{35} = .279$ |
| $r_{15} = .462$ | $r_{25} = .296$ | $r_{36} = .322$ |
| $r_{45} = .024$ | $r_{46} = .112$ | $r_{56} = .846$ |

Regression Equation: (score form for six-variable equation)

$$\bar{X}_1 = b_{12.3456}X_2 + b_{13.2456}X_3 + b_{14.2356}X_4 + b_{15.2346}X_5 + b_{16.2345}X_6 + K$$

The following equations show the improvement obtained in the size of multiple R by using successively two, three, four, five, and six variables.

Regression Equations:

$$\bar{X}_1 = .024X_2 - .68$$

$$\bar{X}_1 = .003X_2 + .028X_3 - .91$$

$$\bar{X}_1 = .002X_2 + .020X_3 + .052X_4 - 1.198$$

$$\bar{X}_1 = .007X_2 + .024X_3 + .065X_4 + .479X_5 - 3.51$$

$$\bar{X}_1 = .014X_2 + .016X_3 + .031X_4 - .162X_5 + 1.145X_6 - 4.117$$

Standard Error of Estimate:

$$\sigma_{X_1} = .849$$

$$\sigma_{X_1} = .769$$

$$\sigma_{X_1} = .732$$

$$\sigma_{X_1} = .650$$

$$\sigma_{X_1} = .614$$

Coefficient of Correlation:

$$r_{12} = .504$$

$$R_{1(23)} = .620$$

$$R_{1(234)} = .664$$

$$R_{1(2345)} = .748$$

$$R_{1(23456)} = .773$$



Zero Order Coefficients of Correlation:

|                 |                 |                 |
|-----------------|-----------------|-----------------|
| $r_{12} = .504$ | $r_{18} = .797$ | $r_{26} = .241$ |
| $r_{13} = .619$ | $r_{23} = .766$ | $r_{34} = .559$ |
| $r_{14} = .755$ | $r_{24} = .452$ | $r_{35} = .279$ |
| $r_{15} = .462$ | $r_{25} = .296$ | $r_{36} = .323$ |
| $r_{16} = .024$ | $r_{26} = .112$ | $r_{36} = .846$ |

Regression Equation: (score form for six-variable equation)

$$X_1 = .12.345X_2 + .13.245X_3 + .14.235X_4 + .15.234X_5 + .16.234X_6$$

The following equations show the improvement obtained in the size of multiple R by using successively two, three, four, five, and six variables.

Regression Equations:

$$\begin{aligned} \bar{X}_1 &= .024X_2 - .68 \\ \bar{X}_1 &= .003X_2 + .028X_3 - .91 \\ \bar{X}_1 &= .002X_2 + .020X_3 + .022X_4 - 1.198 \\ \bar{X}_1 &= .007X_2 + .024X_3 + .065X_4 + .479X_5 - 3.21 \\ \bar{X}_1 &= .014X_2 + .016X_3 + .031X_4 + .162X_5 + .145X_6 - 4.117 \end{aligned}$$

Standard Error of Estimate:

$$\begin{aligned} s_{X_1} &= .849 \\ s_{X_1} &= .769 \\ s_{X_1} &= .732 \\ s_{X_1} &= .650 \\ s_{X_1} &= .614 \end{aligned}$$

Coefficient of Correlation:

$$\begin{aligned} r_{12} &= .504 \\ R^2(2) &= .620 \\ R^2(3) &= .664 \\ R^2(4) &= .748 \\ R^2(5) &= .773 \end{aligned}$$



It is evident that the final equation is not significantly better for predicting the grade-point average that a student will obtain in the engineering college than the preceding one consisting of five variables. The standard error of estimate for the final equation is slightly less (.036) and the multiple R is greater by only .025. The two increases of multiple R that are of any consequence result when the third variable EPSA, and the fifth variable, high-school English averages, are added to the equations. The latter addition results in a multiple R of .748, a much more significant coefficient than the initial zero order of .504 for predicting the probable success of a group. However, the final R of .773 indicates that the entire combination of six variables has only a 38 per cent forecasting efficiency for predicting the grade-point average an individual student will obtain in the College of Engineering of the University of New Mexico. Since the coefficient must be greater than .87 for the forecasting efficiency to be better than 50 per cent, the degree of dependability found in this study does not warrant the use of the regression equations for the prediction of success to be attained by an individual.



It is evident that the final equation is not  
sufficiently better for predicting the final  
that a student will obtain in the engineering college than  
the preceding one consisting of three variables. The stan-  
dard error of estimate for the final equation is 11.71  
less (.036) and the multiple R is greater by .011.  
The two increases of multiple R that are of any consequence  
result when the third variable is added, and the fifth variable  
high-school English average, are added to the equation.  
The latter addition results in a multiple R of .743, a  
much more significant coefficient than the initial zero  
order of .504 for predicting the graduate average of a  
group. However, the final R of .773 indicates that the  
entire combination of six variables has only a 15 per cent  
forecasting efficiency for predicting the graduate average  
an individual student will obtain in the College of Engi-  
neering of the University of New Mexico. Hence the coeffi-  
cient must be greater than .87 for the forecasting effi-  
ciency to be better than 50 per cent. The degree of  
dependability found in this study does not warrant the use  
of the regression equations for the prediction of success  
to be attained by an individual.



### III. VALIDITY IMPLICATIONS OF THE UNM MATH TEST

Because the UNM Math Test is a non-standardized test with a substantial relationship to the college grade-point averages ( $r = .555$ ), it was further analyzed for indications of validity. The criterion used to measure validity was the capacity of the test to discriminate between known groups. Of the ninety-five students for whom all data were available, the means of the college grade-point averages of the twenty students who made highest scores and the twenty students who made lowest scores on the UNM Math Test were compared. Table VII summarizes these findings. A critical

TABLE VII

MEANS, STANDARD DEVIATIONS, PROBABLE ERRORS OF THE MEANS,  
AND CRITICAL RATIO OF THE COLLEGE GRADE-POINT  
AVERAGES OF TWO GROUPS ON THE UNM MATH TEST\*

| Known groups          | Mean        | S.D.                     | P.E. <sub>M</sub> |
|-----------------------|-------------|--------------------------|-------------------|
| High                  | 2.67        | .72                      | .109              |
| Low                   | <u>1.36</u> | <u>.76</u>               | <u>.115</u>       |
| Difference            | 1.31        | P.E. <sub>d</sub> = .158 |                   |
| Critical Ratio = 8.23 |             |                          |                   |

\* Critical Ratio =  $\frac{\text{Difference of the Means}}{\text{Probable Error of the Difference of the Means}}$



ratio of 4.0 obtained by the formula used would guarantee  
that the difference between the means is statistically sig-  
nificant. The critical ratio of 5.5 which was obtained  
between the college grade-point averages of the two groups  
is more than twice the necessary magnitude. This is evi-  
dence of the exceptionally high level of ability of  
the UMW Math Test and implies that it is not influenced by  
chance sampling. Such a manifestation of ability warrants  
the continued use of the test in the battery administered  
to engineering freshmen.



## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### I. CONCLUSIONS

1. The Engineering and Physical Science Aptitude Test is the best single indicator of success in first-semester engineering, and the high-school average is the next most reliable.

2. Although the coefficients of correlation are so low as to be valueless for prediction of success to be attained by an individual, the college marks correlate higher with the American Council on Education Psychological Test than do high-school marks.

3. The University of New Mexico Mathematics Test and the Cooperative English Test are better indicators of success in the first semester in the College of Engineering than the American Council on Education Psychological Test or the high-school English average.

4. The high-school English average is a good indicator of general ability.

5. In summary of the foregoing, the predictive efficiency of the American Council on Education Psychological Test, a widely used instrument for student classification and prognosis, ranks behind the Engineering and Physical



## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### I. CONCLUSIONS

1. The Engineering and Physical Science Aptitude Test is the best single indicator of success in first-semester engineering, and the high-school average is the next most reliable.

2. Although the coefficients of correlation are so low as to be valueless for prediction of success to be attained by an individual, the college marks correlate higher with the American Council on Education Psychological Test than do high-school marks.

3. The University of New Mexico Mathematics Test and the Cooperative English Test are better indicators of success in the first semester in the College of Engineering than the American Council on Education Psychological Test or the high-school English average.

4. The high-school English average is a good indicator of general ability.

5. In summary of the foregoing, the predictive efficiency of the American Council on Education Psychological Test, a widely used instrument for student classification and prognosis, ranks behind the Engineering and Physical



Science Aptitude Test, the high-school averages, and the Cooperative English Test when organized in a decreasing scale of relationship to the college grade-point averages.

6. High-school marks have no value for predicting the degree of success to be attained on the American Council on Education Psychological Test administered at the time of enrollment in engineering college.

7. Respectively related areas of high-school and college subject matter manifest some correlation (approximately .45).

8. In general, ability in mathematics is no indication of ability in English and vice versa.

9. The combining of variables for computation of a multiple coefficient of correlation and development of regression equations for six variables does not yield a "forecasting efficiency" for individual prediction that is great enough to warrant the effort expended. As an indicator of the tendency for success to be attained by a group, the final derived coefficient of .773 is worthy of merit.

10. Although the University of New Mexico Mathematics Test is non-standardized, the capacity with which it discriminates between known groups implies considerable validity. The test should be retained in the battery.



Science Aptitude Test, the high-school averages, and the Cooperative English Test when organized in a decreasing scale of relationship to the college grade-point averages.

6. High-school marks have no value for predicting the degree of success to be attained on the American Council on Education Psychological Test administered at the time of enrollment in engineering college.

7. Negatively related areas of high-school and college subject matter manifest some correlation (approximately .47).

8. In general, ability in mathematics is no indication of ability in English and vice versa.

9. The combining of variables for computation of a multiple coefficient of correlation and development of regression equations for six variables does not yield a "forecasting efficiency" for individual prediction that is great enough to warrant the effort expended. As an indicator of the tendency for success to be attained by a group, the final derived coefficient of .773 is worthy of merit.

10. Although the University of New Mexico Mathematics Test is non-standardized, the capacity with which it discriminates between known groups is considerable.

validity. The test should be retained in the battery.



## II. RECOMMENDATIONS

1. The Engineering and Physical Science Aptitude Test should be included in the high-school test files for evaluation of prospective engineering students.

2. The high-school English average as well as the total high-school average made by a prospective engineering student should be carefully evaluated since each is a good indicator of general ability. Both are also good indicators of success to be attained in engineering college.

3. The University of New Mexico Mathematics Test should be included in the test files of New Mexico high schools for evaluation of prospective engineering students.

4. The results made on all the measures considered in this study are unreliable for predicting success to be attained by an individual. However, if the data are consistently high, the high school principal should recommend the student for college since these measures have a 38 per cent forecasting efficiency.



## II. RECOMMENDATIONS

1. The Engineering and Physical Science Aptitude Test should be included in the high-school test files for evaluation of prospective engineering students.

2. The high-school English average as well as the total high-school average made by a prospective engineering student should be carefully evaluated since each is a good indicator of general ability. Both are also good indicators of success to be attained in engineering college.

3. The University of New Mexico Mathematics Test should be included in the test files of New Mexico high schools for evaluation of prospective engineering students.

4. The results made on all the measures considered in this study are unreliable for predicting success to be attained by an individual. However, if the data are consistently high, the high school principal should recommend the student for college since these measures have a 38 per cent forecasting efficiency.



## BIBLIOGRAPHY



BIBLIOGRAPHY



## BIBLIOGRAPHY

- Benz, H. E., "Students Entering College Without Credit in High-School Mathematics," School Review, 54:334-41, June, 1946.
- Bolton, F. B., "The Value of Several Intelligence Tests for Predicting Scholastic Achievement," Journal of Educational Research, 41:133-38, October, 1947.
- Byrns, Ruth, and V. H. C. Henman, "Long Range Predictions of College Achievement," School and Society, 41:877-80, June 24, 1935.
- Cohen, Leonard L., "Predicting Academic Success in an Engineering College and Suggestions for Objective Evaluation of High-School Marks," Journal of Educational Psychology, 37:381-84, September, 1946.
- Crawford, A. B., and P. S. Burnham, "Entrance Examinations and College Achievement," School and Society, 36:344-52, September, 1932.
- Crawford, B. M., "Guidance Implications Obtained from the Use of Four Types of Interest Measurements," Unpublished Doctor's dissertation, The University of Michigan, Ann Arbor, 1945. 263 pp.
- Darley, John G., Testing and Counseling in the High-School Guidance Program. Chicago: Science Research Associates, 1943. 222 pp.
- Douglass, H. R., "Selecting Good College Risks," School and Society, 35:140-47, January 30, 1932.
- Easley, Howard, "On the Limits of Predicting Scholastic Success," Journal of Experimental Education, 1:272-76, March, 1933.
- Garrett, Wiley S., "The Ohio State Psychological Examinations," Occupations, 22:489-95, May, 1944.
- Geberich, J. R., "Factors Related to the College Achievement of High-Aptitude Students Who Fail of Expectations and Low-Aptitude Students Who Exceed Expectations," Journal of Educational Psychology, 32:253-54, April, 1941.



# BIBLIOGRAPHY

Benn, H. E., "Students Entering College Without Credit in High-School Mathematics," School Review, 54:33-41, June, 1946.

Bolton, F. B., "The Value of Several Intelligence Tests for Predicting Scholastic Achievement," Journal of Educational Research, 41:113-38, October, 1947.

Byrns, Ruth, and V. H. C. Newman, "Long Range Predictions of College Achievement," School and Society, 41:877-80, June 24, 1935.

Cohen, Leonard L., "Predicting Academic Success in an Engineering College and Suggestions for Objective Evaluation of High-School Marks," Journal of Educational Psychology, 37:381-84, September, 1946.

Crawford, A. B., and P. S. Burnham, "Entrance Examinations and College Achievement," School and Society, 36:34-52, September, 1932.

Crawford, E. M., "Guidance Implications Obtained from the Use of Four Types of Interest Measurements," Unpublished Doctor's dissertation, The University of Michigan, Ann Arbor, 1945. 263 pp.

Darley, John G., Testing and Counseling in the High-School Guidance Program. Chicago: Science Research Associates, 1943. 222 pp.

Douglas, H. B., "Selecting Good College Risks," School and Society, 37:140-47, January 30, 1932.

Eastey, Howard, "On the Limits of Predicting Scholastic Success," Journal of Experimental Education, 1:272-76, March, 1933.

Gartlett, Wiley S., "The Ohio State Psychological Examinations," Occupations, 22:489-95, May, 1944.

Gerbich, J. H., "Factors Related to the College Achievement of High-Aptitude Students Who Fall of Expectations and Low-Aptitude Students Who Exceed Expectations," Journal of Educational Psychology, 32:253-54, April, 1941.



- Gilkey, Royal, "The Relation of Success in Certain Subjects in High School to Success in the Same Subjects in College," School Review, 37:576-88, October, 1929.
- Gould, G., "Predictive Value of Certain Selective Measures," Educational Administration and Supervision, 33:208-12, April, 1947.
- Heston, Joseph C., "The Graduate Record Examination vs. Other Measures of Aptitude and Achievement," Educational and Psychological Measurement, 7:618-30, No. 3, Autumn, 1947.
- Hurd, A. W., "The Problem of Predicting College Success," Journal of Educational Research, 38:217-19, November, 1944.
- Johnson, J. B., "Predicting College Success for the High-School Senior," The Vocational Guidance Magazine, 6:289-94, April, 1928.
- \_\_\_\_\_, "Predicting Success in College at the Time of Entrance," School and Society, 23:82-88, January 16, 1926.
- Jones, E. S., "Predictions for High-School Performance," School and Society, 27:339-40, March 17, 1928.
- Pettit, Walter W., "A Comparative Study of New York High Schools and Columbia College Grades," Unpublished Master's thesis, Teachers College, Columbia University, 1912. pp.
- Pierson, G. A., "School Marks and Success in Engineering," Educational and Psychological Measurement, 7:612-17, No. 3, Autumn, 1947.
- Segel, David, Prediction of Success in College (Bulletin of the United States Office of Education, 1934, No. 15. Washington, D. C.: United States Government Printing Office, 1935), 88 pp.
- Smith, F. O., A National Basis for Determining Fitness for College Entrance. Studies in Education, No. 31. Iowa City: University of Iowa, 1932. pp.



Gilkey, Royal, "The Relation of Success in Certain Subjects in High School to Success in the Same Subjects in College," School Review, 37:576-88, October, 1929.

Gould, G., "Predictive Value of Certain Selective Measures," Educational Administration and Supervision, 33:208-12, April, 1947.

Heston, Joseph C., "The Graduate Record Examination vs. Other Measures of Aptitude and Achievement," Educational and Psychological Measurement, 7:618-30, No. 3, Autumn, 1947.

Hurd, A. W., "The Problem of Predicting College Success," Journal of Educational Research, 38:217-19, November, 1944.

Johnson, J. B., "Predicting College Success for the High-School Senior," The Vocational Guidance Magazine, 6:289-94, April, 1928.

\_\_\_\_\_, "Predicting Success in College at the Time of Entrance," School and Society, 23:82-83, January 16, 1926.

Jones, E. S., "Predictions for High-School Performance," School and Society, 27:339-40, March 17, 1928.

Pettit, Walter W., "A Comparative Study of New York High Schools and Columbia College Grades," Unpublished Master's thesis, Teachers College, Columbia University, 1912.

Peterson, G. A., "School Marks and Success in Engineering," Educational and Psychological Measurement, 7:612-17, No. 3, Autumn, 1947.

Segel, David, Prediction of Success in College (Bulletin of the United States Office of Education, 1934, No. 17, Washington, D. C.: United States Government Printing Office, 1935), 88 pp.

Smith, F. O., A National Basis for Determining Fitness for College Entrance. Studies in Education, No. 31, Iowa City: University of Iowa, 1932.



Stoddard, George D., "Quantitative Measurement in Inducting the Student into the Institution of Higher Learning and Predicting His Academic Success," Eighteenth Year-book of the National Society of College Teachers of Education, Chapter IV. Chicago, Illinois: University Press, 1930. Pp. 80-120.

Watts, J. V., "The Differential Predictive Value of the Psychological Examination of the American Council on Education," Journal of Experimental Education, 1:264-71, March, 1933.

Weintraub, R. G., and R. E. Salley, "Graduation Prospects of an Entering Freshman," Journal of Educational Research, 39:116-26, October, 1945.



Stoddard, George D., "Quantitative Research in Industry  
the Student into the Institution of Higher Learning  
and Predicting His Academic Success," Michigan Journal  
of the National Council of College Teachers of  
Education, Chapter IV, Chicago, Illinois University  
Press, 1930. pp. 80-120.

Watts, J. V., "The Differential Predictive Value of the  
Psychological Examination of the American Council on  
Education," Journal of Experimental Education,  
1:254-271, March, 1931.

Weintramp, H. G., and H. E. Bailey, "Prediction of Success  
of an Entering Freshman," Journal of Educational  
Research, 39:116-26, Oct.-Nov., 1927.



APPENDIX



APPENDIX



## APPENDIX

### EXHIBIT A

#### FORMULAS AND COMPUTATIONS FOR THE DETERMINATION OF A MULTIPLE COEFFICIENT OF CORRELATION (R) AND DERIVATION OF THE ACCOMPANYING REGRESSION EQUATION INVOLVING SIX VARIABLES

##### 1. Regression Equation

$$\bar{X}_1 = b_{12.3456}X_2 + b_{13.2456}X_3 + b_{14.2356}X_4 \\ + b_{15.2346}X_5 + b_{16.2345}X_6 + K$$

$$\bar{X}_1 = .014X_2 + .016X_3 + .031X_4 + .162X_5 + 1.145X_6 - 4.117$$

##### 2. Regression Coefficients

$$b_{12.3456} = r_{12.3456} \frac{\sigma_{1.23456}}{\sigma_{2.13456}} \\ = .179 \frac{.614}{8.11} = .014$$

$$b_{13.2456} = r_{13.2456} \frac{\sigma_{1.23456}}{\sigma_{3.12456}} \\ = .275 \frac{.614}{10.3} = .016$$

$$b_{14.2356} = r_{14.2356} \frac{\sigma_{1.23456}}{\sigma_{4.12356}} \\ = .190 \frac{.614}{3.73} = .031$$



# APPENDIX

## EXHIBIT A

FORMULAS AND COMPUTATIONS FOR THE DETERMINATION OF  
A MULTIPLE CORRELATION COEFFICIENT (R) AND REGRESSION  
OF THE ASSOCIATING REGRESSION EQUATION  
INVOLVING TWO VARIABLES

### 1.1.1... Regression Equation

$$\bar{X}_1 = b_{12} \cdot 3.456 + b_{13} \cdot 2.345 + b_{14} \cdot 1.234$$

$$\bar{X}_1 = .014 \cdot 2.345 + .011 \cdot 1.234 + .010 \cdot 1.234$$

### 2.2.2... Regression Coefficients

$$b_{12} = \frac{712.3456}{2.12345} = 335.456$$

$$b_{13} = \frac{10.123}{8.11} = 1.25$$

$$b_{14} = \frac{13.2345}{2.12345} = 6.234$$

$$b_{15} = \frac{10.123}{10.1} = 1.002$$

$$b_{16} = \frac{14.2345}{4.12345} = 3.456$$

$$b_{17} = \frac{10.123}{3.12} = 3.245$$



$$b_{15.2346} = r_{15.2346} \frac{\sigma_{1.23456}}{\sigma_{5.12346}}$$

$$= -.071 \frac{.614}{.268} = -.162$$

$$b_{16.2345} = r_{16.2345} \frac{\sigma_{1.23456}}{\sigma_{6.12345}}$$

$$= .334 \frac{.614}{.177} = 1.145$$

### 3. Partial r's

#### (a) r's of the fourth order

$$r_{12.3456} = \frac{r_{12.345} - r_{16.345}r_{26.345}}{\sqrt{1-r_{16.345}^2} \sqrt{1-r_{26.345}^2}}$$

$$= \frac{-.131 - .331(-.741)}{.9440 \times .6726} = .179$$

$$r_{13.2456} = \frac{r_{13.456} - r_{12.456}r_{23.456}}{\sqrt{1-r_{12.456}^2} \sqrt{1-r_{23.456}^2}}$$

$$= \frac{.336 - .207(.721)}{.9777 \times .6940} = .275$$

$$r_{14.2356} = \frac{r_{14.235} - r_{16.235}r_{46.235}}{\sqrt{1-r_{16.235}^2} \sqrt{1-r_{46.235}^2}}$$

$$= \frac{.416 - .509(.549)}{.8617 \times .8352} = .190$$



$$p_{15.2346} = \frac{p_{15.2346}}{p_{15.2346}} = 1$$

$$= \frac{1}{1} = 1$$

$$p_{16.2346} = \frac{p_{16.2346}}{p_{16.2346}} = 1$$

$$= \frac{1}{1} = 1$$

3. Partial r's

(a) r's of the fourth order

$$r_{15.2346} = \frac{r_{15.2346}}{r_{15.2346}} = 1$$

$$\sqrt{1 - r_{15.2346}^2} = \sqrt{1 - 1} = 0$$

$$= \frac{0}{0} = 0$$

$$r_{13.2456} = \frac{r_{13.2456}}{r_{13.2456}} = 1$$

$$\sqrt{1 - r_{13.2456}^2} = \sqrt{1 - 1} = 0$$

$$= \frac{0}{0} = 0$$

$$r_{14.2356} = \frac{r_{14.2356}}{r_{14.2356}} = 1$$

$$\sqrt{1 - r_{14.2356}^2} = \sqrt{1 - 1} = 0$$

$$= \frac{0}{0} = 0$$



$$r_{15.2346} = \frac{r_{15.234} - r_{16.234}r_{56.234}}{\sqrt{1-r_{16.234}^2} \sqrt{1-r_{56.234}^2}}$$

$$= \frac{.461 - .539 (.934)}{.8417 \times .3676} = -.071$$

$$r_{16.2345} = \frac{r_{16.234} - r_{15.234}r_{56.234}}{\sqrt{1-r_{15.234}^2} \sqrt{1-r_{56.234}^2}}$$

$$= \frac{.539 - .461 (.934)}{.8879 \times .3676} = .334$$

(b) r's of the third order

$$r_{12.345} = \frac{r_{12.45} - r_{13.45}r_{23.45}}{\sqrt{1-r_{13.45}^2} \sqrt{1-r_{23.45}^2}}$$

$$= \frac{.209 - .424 (.696)}{.9075 \times .7141} = -.131$$

$$r_{16.345} = \frac{r_{16.34} - r_{15.34}r_{56.34}}{\sqrt{1-r_{15.34}^2} \sqrt{1-r_{56.34}^2}}$$

$$= \frac{.593 - (.523 \times .850)}{.8542 \times .5268} = .331$$

$$r_{26.345} = \frac{r_{26.34} - r_{25.34}r_{56.34}}{\sqrt{1-r_{25.34}^2} \sqrt{1-r_{56.34}^2}}$$

$$= \frac{-.135 - .283 (.850)}{.9600 \times .5268} = -.741$$



$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

(b) 1.8 of this order

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$

$$\frac{15.2346}{1.1-2.18.2346} = 15.2346$$



$$\begin{aligned}
 r_{13.456} &= \frac{r_{13.45} - r_{16.45}r_{36.45}}{\sqrt{1-r_{16.45}^2} \sqrt{1-r_{36.45}^2}} \\
 &= \frac{.425 - .422(.326)}{.9075 \times .9440} = .336
 \end{aligned}$$

$$\begin{aligned}
 r_{12.456} &= \frac{r_{12.45} - r_{16.45}r_{26.45}}{\sqrt{1-r_{16.45}^2} \sqrt{1-r_{26.45}^2}} \\
 &= \frac{.209 - .422(.050)}{.9075 \times .9987} = .207
 \end{aligned}$$

$$\begin{aligned}
 r_{23.456} &= \frac{r_{23.45} - r_{26.45}r_{36.45}}{\sqrt{1-r_{26.45}^2} \sqrt{1-r_{36.45}^2}} \\
 &= \frac{.696 - .050(.326)}{.9987 \times .9440} = .721
 \end{aligned}$$

$$\begin{aligned}
 r_{14.235} &= \frac{r_{14.23} - r_{15.23}r_{45.23}}{\sqrt{1-r_{15.23}^2} \sqrt{1-r_{45.23}^2}} \\
 &= \frac{.314 - (.378)(.173)}{.9250 \times .9854} = .416
 \end{aligned}$$

$$\begin{aligned}
 r_{16.235} &= \frac{r_{16.23} - r_{15.23}r_{56.23}}{\sqrt{1-r_{15.23}^2} \sqrt{1-r_{56.23}^2}} \\
 &= \frac{.546 - .378(.903)}{.9250 \times .4359} = .509
 \end{aligned}$$



$$13.450 = \frac{13.450 \times 1000}{1000} = 13.450$$

$$V_{OS} = \frac{(0.001554 - 0.001554)}{0.001554} = 0$$

$$= \frac{153.452}{\sqrt{1-1.50.42}} = \frac{153.452 - 150.4230.42}{\sqrt{1-1.50.42}} = 153.452$$

$$= \frac{714.532}{\sqrt{1-0.53}} = 984.53$$

$$\frac{1}{\sqrt{1-t^2}} = \frac{1}{\sqrt{1-\frac{1}{4}}} = \frac{1}{\sqrt{\frac{3}{4}}} = \frac{1}{\frac{\sqrt{3}}{2}} = \frac{2}{\sqrt{3}} = \frac{2\sqrt{3}}{3}$$



$$\begin{aligned}
 r_{46.235} &= \frac{r_{46.23} - r_{45.23}r_{56.23}}{\sqrt{1-r_{45.23}^2} \sqrt{1-r_{56.23}^2}} \\
 &= \frac{.08 - (-.173)(.903)}{.9854 \times .4359} = .549
 \end{aligned}$$

$$\begin{aligned}
 r_{15.234} &= \frac{r_{15.23} - r_{14.23}r_{45.23}}{\sqrt{1-r_{14.23}^2} \sqrt{1-r_{45.23}^2}} \\
 &= \frac{.378 - .314(-.173)}{.9507 \times .9854} = .461
 \end{aligned}$$

$$\begin{aligned}
 r_{16.234} &= \frac{r_{16.23} - r_{14.23}r_{46.23}}{\sqrt{1-r_{14.23}^2} \sqrt{1-r_{46.23}^2}} \\
 &= \frac{.546 - .314(.08)}{.9507 \times .9968} = .539
 \end{aligned}$$

$$\begin{aligned}
 r_{56.234} &= \frac{r_{56.23} - r_{45.23}r_{46.23}}{\sqrt{1-r_{45.23}^2} \sqrt{1-r_{46.23}^2}} \\
 &= \frac{.903 - (-.173)(.08)}{.9854 \times .9968} = .934
 \end{aligned}$$

(c)  $r$ 's of the second order

$$\begin{aligned}
 r_{12.34} &= \frac{r_{12.3} - r_{14.3}r_{24.3}}{\sqrt{1-r_{14.3}^2} \sqrt{1-r_{24.3}^2}} \\
 &= \frac{.059 - .323(.057)}{.9479 \times .9982} = .043
 \end{aligned}$$



$$\frac{140.235}{\sqrt{1-0.80}} = 140.235$$

$$\frac{115.234}{\sqrt{1-0.80}} = 115.234$$

$$\frac{110.234}{\sqrt{1-0.80}} = 110.234$$

$$\frac{105.234}{\sqrt{1-0.80}} = 105.234$$

(a) r's of the second order

$$\frac{118.34}{\sqrt{1-0.80}} = 118.34$$



$$r_{15.34} = \frac{r_{15.4} - r_{13.4} r_{35.4}}{\sqrt{1-r_{13.4}^2} \sqrt{1-r_{35.4}^2}}$$

$$= \frac{.538 - .446(.175)}{.8930 \times .9854} = .523$$

$$r_{25.34} = \frac{r_{25.4} - r_{23.4} r_{35.4}}{\sqrt{1-r_{23.4}^2} \sqrt{1-r_{35.4}^2}}$$

$$= \frac{.319 - .706(.175)}{.7042 \times .9854} = .283$$

$$r_{16.34} = \frac{r_{16.4} - r_{13.4} r_{36.4}}{\sqrt{1-r_{13.4}^2} \sqrt{1-r_{36.4}^2}}$$

$$= \frac{.644 - .446(.318)}{.8930 \times .9474} = .593$$

$$r_{56.34} = \frac{r_{56.4} - r_{35.4} r_{36.4}}{\sqrt{1-r_{35.4}^2} \sqrt{1-r_{36.4}^2}}$$

$$= \frac{.850 - .175(.318)}{.9854 \times .9474} = .850$$

$$r_{26.34} = \frac{r_{26.4} - r_{23.4} r_{36.4}}{\sqrt{1-r_{23.4}^2} \sqrt{1-r_{36.4}^2}}$$

$$= \frac{.215 - .706(.318)}{.7042 \times .9474} = -.135$$



12

$$\frac{4.75^2 + 4.75^2 - 4.75^2}{4.75^2 - 1} \sqrt{1 - 1} = 48.71^T$$

$$ES_1 = \frac{(200)(1000) - 1000}{4000 \times 0.001} =$$

$$\frac{4.75^2 + 4.75^2 - 4.75^2}{4.75^2 - 1} \sqrt{1 - 1} = 48.75^T$$

$$ES_2 = \frac{(200)(1000) - 1000}{4000 \times 0.001} =$$

$$\frac{4.75^2 + 4.75^2 - 4.75^2}{4.75^2 - 1} \sqrt{1 - 1} = 48.76^T$$

$$ES_3 = \frac{(200)(1000) - 1000}{4000 \times 0.001} =$$

$$\frac{4.75^2 + 4.75^2 - 4.75^2}{4.75^2 - 1} \sqrt{1 - 1} = 48.77^T$$

$$ES_4 = \frac{(200)(1000) - 1000}{4000 \times 0.001} =$$

$$\frac{4.75^2 + 4.75^2 - 4.75^2}{4.75^2 - 1} \sqrt{1 - 1} = 48.78^T$$

$$ES_5 = \frac{(200)(1000) - 1000}{4000 \times 0.001} =$$



$$r_{13.45} = \frac{r_{13.4} - r_{15.4}r_{35.4}}{\sqrt{1-r_{15.4}^2} \sqrt{1-r_{35.4}^2}}$$

$$= \frac{.446 - .538(.175)}{.8417 \times .9854} = .425$$

$$r_{16.45} = \frac{r_{16.4} - r_{15.4}r_{56.4}}{\sqrt{1-r_{15.4}^2} \sqrt{1-r_{56.4}^2}}$$

$$= \frac{.644 - .538(.850)}{.8417 \times .5268} = .422$$

$$r_{36.45} = \frac{r_{36.4} - r_{35.4}r_{56.4}}{\sqrt{1-r_{35.4}^2} \sqrt{1-r_{56.4}^2}}$$

$$= \frac{.318 - .175(.850)}{.9854 \times .5268} = .326$$

$$r_{12.45} = \frac{r_{12.4} - r_{15.4}r_{25.4}}{\sqrt{1-r_{15.4}^2} \sqrt{1-r_{25.4}^2}}$$

$$= \frac{.339 - .538(.319)}{.8417 \times .9474} = .209$$

$$r_{26.45} = \frac{r_{26.4} - r_{25.4}r_{56.4}}{\sqrt{1-r_{25.4}^2} \sqrt{1-r_{56.4}^2}}$$

$$= \frac{.215 - .319(.850)}{.9474 \times .5268} = .050$$



$$\frac{1.1547 \times 10^{-1} - 4.517}{1.1547 \times 10^{-1} - 4.517} = 74.317$$

$$0.52 = \frac{(0.52 \times 10^{-1} - 4.517)}{1.1547 \times 10^{-1} - 4.517}$$

$$\frac{1.1547 \times 10^{-1} - 4.517}{1.1547 \times 10^{-1} - 4.517} = 74.317$$

$$0.52 = \frac{(0.52 \times 10^{-1} - 4.517)}{1.1547 \times 10^{-1} - 4.517}$$

$$\frac{1.1547 \times 10^{-1} - 4.517}{1.1547 \times 10^{-1} - 4.517} = 74.317$$

$$0.52 = \frac{(0.52 \times 10^{-1} - 4.517)}{1.1547 \times 10^{-1} - 4.517}$$

$$\frac{1.1547 \times 10^{-1} - 4.517}{1.1547 \times 10^{-1} - 4.517} = 74.317$$

$$0.52 = \frac{(0.52 \times 10^{-1} - 4.517)}{1.1547 \times 10^{-1} - 4.517}$$

$$\frac{1.1547 \times 10^{-1} - 4.517}{1.1547 \times 10^{-1} - 4.517} = 74.317$$

$$0.52 = \frac{(0.52 \times 10^{-1} - 4.517)}{1.1547 \times 10^{-1} - 4.517}$$



$$\begin{aligned}
 r_{23.45} &= \frac{r_{23.4} - r_{25.4}r_{35.4}}{\sqrt{1-r_{25.4}^2} \sqrt{1-r_{35.4}^2}} \\
 &= \frac{.706 - .319(.175)}{.9474 \times .9854} = .696
 \end{aligned}$$

$$\begin{aligned}
 r_{14.23} &= \frac{r_{14.2} - r_{13.2}r_{34.2}}{\sqrt{1-r_{13.2}^2} \sqrt{1-r_{34.2}^2}} \\
 &= \frac{.423 - .422(.374)}{.9075 \times .9290} = .314
 \end{aligned}$$

$$\begin{aligned}
 r_{15.23} &= \frac{r_{15.2} - r_{13.2}r_{35.2}}{\sqrt{1-r_{13.2}^2} \sqrt{1-r_{35.2}^2}} \\
 &= \frac{.378 - .422(.085)}{.9075 \times .9968} = .378
 \end{aligned}$$

$$\begin{aligned}
 r_{45.23} &= \frac{r_{45.2} - r_{34.2}r_{35.2}}{\sqrt{1-r_{34.2}^2} \sqrt{1-r_{35.2}^2}} \\
 &= \frac{(-.129) - .374(.085)}{.9290 \times .9968} = -.173
 \end{aligned}$$

$$\begin{aligned}
 r_{16.23} &= \frac{r_{16.2} - r_{13.2}r_{36.2}}{\sqrt{1-r_{13.2}^2} \sqrt{1-r_{36.2}^2}} \\
 &= \frac{.566 - .422(.221)}{.9075 \times .9755} = .546
 \end{aligned}$$



$$\frac{1.25 \times 10^3 \times 1.5 \times 10^3}{1.25 \times 10^3 \times 1.5 \times 10^3} = 1.5 \times 10^3$$

$$\frac{1.25 \times 10^3 \times 1.5 \times 10^3}{1.25 \times 10^3 \times 1.5 \times 10^3} = 1.5 \times 10^3$$

$$\frac{1.25 \times 10^3 \times 1.5 \times 10^3}{1.25 \times 10^3 \times 1.5 \times 10^3} = 1.5 \times 10^3$$

$$\frac{1.25 \times 10^3 \times 1.5 \times 10^3}{1.25 \times 10^3 \times 1.5 \times 10^3} = 1.5 \times 10^3$$

$$\frac{1.25 \times 10^3 \times 1.5 \times 10^3}{1.25 \times 10^3 \times 1.5 \times 10^3} = 1.5 \times 10^3$$



$$\begin{aligned}
 r_{56.23} &= \frac{r_{56.2} - r_{35.2}r_{36.2}}{\sqrt{1-r_{35.2}^2} \sqrt{1-r_{36.2}^2}} \\
 &= \frac{.837 - .085(.221)}{.9968 \times .9755} = .903
 \end{aligned}$$

$$\begin{aligned}
 r_{46.23} &= \frac{r_{46.2} - r_{34.2}r_{36.2}}{\sqrt{1-r_{34.2}^2} \sqrt{1-r_{36.2}^2}} \\
 &= \frac{.003 - .374(.221)}{.9290 \times .9755} = -.088
 \end{aligned}$$

(d)  $r$ 's of the first order

$$\begin{aligned}
 r_{12.3} &= \frac{r_{12} - r_{13}r_{23}}{\sqrt{1-r_{13}^2} \sqrt{1-r_{23}^2}} \\
 &= \frac{.504 - .619(.766)}{.7846 \times .6380} = .059
 \end{aligned}$$

$$\begin{aligned}
 r_{12.4} &= \frac{r_{12} - r_{14}r_{24}}{\sqrt{1-r_{14}^2} \sqrt{1-r_{24}^2}} \\
 &= \frac{.504 - .555(.452)}{.8352 \times .8930} = .339
 \end{aligned}$$

$$\begin{aligned}
 r_{13.4} &= \frac{r_{13} - r_{14}r_{34}}{\sqrt{1-r_{14}^2} \sqrt{1-r_{34}^2}} \\
 &= \frac{.619 - .555(.559)}{.8352 \times .8285} = .446
 \end{aligned}$$



$$\frac{1.25 \times 10^3}{\sqrt{1 - 0.33^2}} = 1.56 \times 10^3$$

$$= \frac{1.56 \times 10^3 \times 0.33}{1.56 \times 10^3} = 0.33$$

$$\frac{1.56 \times 10^3}{\sqrt{1 - 0.33^2}} = 1.88 \times 10^3$$

$$= \frac{1.88 \times 10^3 \times 0.33}{1.88 \times 10^3} = 0.33$$

(d)  $\tau$  is of the first order

$$\frac{1.56 \times 10^3}{\sqrt{1 - 0.33^2}} = 1.88 \times 10^3$$

$$= \frac{1.88 \times 10^3 \times 0.33}{1.88 \times 10^3} = 0.33$$

$$\frac{1.88 \times 10^3}{\sqrt{1 - 0.33^2}} = 2.22 \times 10^3$$

$$= \frac{2.22 \times 10^3 \times 0.33}{2.22 \times 10^3} = 0.33$$

$$\frac{2.22 \times 10^3}{\sqrt{1 - 0.33^2}} = 2.67 \times 10^3$$

$$= \frac{2.67 \times 10^3 \times 0.33}{2.67 \times 10^3} = 0.33$$



$$\begin{aligned}
 r_{23.4} &= \frac{r_{23} - r_{24}r_{34}}{\sqrt{1-r_{24}^2} \sqrt{1-r_{34}^2}} \\
 &= \frac{.766 - .452(.559)}{.8930 \times .8285} = .706
 \end{aligned}$$

$$\begin{aligned}
 r_{15.4} &= \frac{r_{15} - r_{14}r_{45}}{\sqrt{1-r_{14}^2} \sqrt{1-r_{45}^2}} \\
 &= \frac{.462 - .555(.024)}{.8352 \times .9998} = .538
 \end{aligned}$$

$$\begin{aligned}
 r_{35.4} &= \frac{r_{35} - r_{34}r_{45}}{\sqrt{1-r_{34}^2} \sqrt{1-r_{45}^2}} \\
 &= \frac{.279 - .559(.024)}{.8285 \times .9998} = .175
 \end{aligned}$$

$$\begin{aligned}
 r_{25.4} &= \frac{r_{25} - r_{24}r_{45}}{\sqrt{1-r_{24}^2} \sqrt{1-r_{45}^2}} \\
 &= \frac{.296 - .452(.024)}{.8930 \times .9998} = .319
 \end{aligned}$$

$$\begin{aligned}
 r_{16.4} &= \frac{r_{16} - r_{14}r_{46}}{\sqrt{1-r_{14}^2} \sqrt{1-r_{46}^2}} \\
 &= \frac{.597 - .555(.112)}{.8352 \times .9939} = .644
 \end{aligned}$$



$$\frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$0.07 = \frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$\frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$0.07 = \frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$\frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$0.07 = \frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$\frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$0.07 = \frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$\frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$

$$0.07 = \frac{1.57 - 1.57}{\sqrt{1-0.5}} = 4.57$$



$$\begin{aligned}
 r_{36.4} &= \frac{r_{36} - r_{34}r_{46}}{\sqrt{1-r_{34}^2} \sqrt{1-r_{46}^2}} \\
 &= \frac{.322 - .559(.112)}{.8235 \times .9939} = .318
 \end{aligned}$$

$$\begin{aligned}
 r_{56.4} &= \frac{r_{56} - r_{45}r_{46}}{\sqrt{1-r_{45}^2} \sqrt{1-r_{46}^2}} \\
 &= \frac{.846 - .024(.112)}{.9998 \times .9939} = .850
 \end{aligned}$$

$$\begin{aligned}
 r_{26.4} &= \frac{r_{26} - r_{24}r_{46}}{\sqrt{1-r_{24}^2} \sqrt{1-r_{46}^2}} \\
 &= \frac{.241 - .452(.112)}{.8930 \times .9939} = .215
 \end{aligned}$$

$$\begin{aligned}
 r_{15.2} &= \frac{r_{15} - r_{12}r_{25}}{\sqrt{1-r_{12}^2} \sqrt{1-r_{25}^2}} \\
 &= \frac{.462 - .504(.296)}{.8660 \times .9539} = .378
 \end{aligned}$$

$$\begin{aligned}
 r_{13.2} &= \frac{r_{13} - r_{12}r_{23}}{\sqrt{1-r_{12}^2} \sqrt{1-r_{23}^2}} \\
 &= \frac{.619 - .504(.766)}{.8660 \times .6380} = .422
 \end{aligned}$$



$$\frac{1.35 - 1.34}{\sqrt{1 - 1.35} \sqrt{1 - 1.34}} = 4.25^T$$

$$818. = \frac{(511.1577 - 888.}{0000. \times 0000.} =$$

$$\frac{1.35 - 1.34}{\sqrt{1 - 1.35} \sqrt{1 - 1.34}} = 4.25^T$$

$$070. = \frac{(511.1577 - 888.}{0000. \times 0000.} =$$

$$\frac{1.35 - 1.34}{\sqrt{1 - 1.35} \sqrt{1 - 1.34}} = 4.25^T$$

$$215. = \frac{(511.1577 - 888.}{0000. \times 0000.} =$$

$$\frac{1.35 - 1.34}{\sqrt{1 - 1.35} \sqrt{1 - 1.34}} = 4.25^T$$

$$872. = \frac{(511.1577 - 888.}{0000. \times 0000.} =$$

$$\frac{1.35 - 1.34}{\sqrt{1 - 1.35} \sqrt{1 - 1.34}} = 4.25^T$$

$$501. = \frac{(511.1577 - 888.}{0000. \times 0000.} =$$



$$r_{14.2} = \frac{r_{14} - r_{12}r_{24}}{\sqrt{1-r_{12}^2} \sqrt{1-r_{24}^2}}$$

$$= \frac{.555 - .504(.452)}{.8660 \times .8930} = .423$$

$$r_{34.2} = \frac{r_{34} - r_{23}r_{24}}{\sqrt{1-r_{23}^2} \sqrt{1-r_{24}^2}}$$

$$= \frac{.559 - .766(.452)}{.6380 \times .8930} = .374$$

$$r_{45.2} = \frac{r_{45} - r_{24}r_{25}}{\sqrt{1-r_{24}^2} \sqrt{1-r_{25}^2}}$$

$$= \frac{.024 - .452(.296)}{.8930 \times .9539} = -.129$$

$$r_{35.2} = \frac{r_{35} - r_{23}r_{25}}{\sqrt{1-r_{23}^2} \sqrt{1-r_{25}^2}}$$

$$= \frac{.279 - .766(.296)}{.6380 \times .9539} = .085$$

$$r_{16.2} = \frac{r_{16} - r_{12}r_{26}}{\sqrt{1-r_{12}^2} \sqrt{1-r_{26}^2}}$$

$$= \frac{.597 - .504(.241)}{.8660 \times .9708} = .566$$



$$\frac{1.417}{\sqrt{1-0.54}} = \frac{1.417}{0.693} = 2.044$$

$$\frac{1.345}{\sqrt{1-0.54}} = \frac{1.345}{0.693} = 1.941$$

$$\frac{1.273}{\sqrt{1-0.54}} = \frac{1.273}{0.693} = 1.837$$

$$\frac{1.201}{\sqrt{1-0.54}} = \frac{1.201}{0.693} = 1.733$$

$$\frac{1.129}{\sqrt{1-0.54}} = \frac{1.129}{0.693} = 1.629$$



$$\begin{aligned}
 r_{36.2} &= \frac{r_{36} - r_{23}r_{26}}{\sqrt{1-r_{23}^2} \sqrt{1-r_{26}^2}} \\
 &= \frac{.322 - .766(.241)}{.6380 \times .9708} = .221
 \end{aligned}$$

$$\begin{aligned}
 r_{46.2} &= \frac{r_{46} - r_{24}r_{26}}{\sqrt{1-r_{24}^2} \sqrt{1-r_{26}^2}} \\
 &= \frac{.112 - .452(.241)}{.8930 \times .9708} = .003
 \end{aligned}$$

$$\begin{aligned}
 r_{56.2} &= \frac{r_{56} - r_{25}r_{26}}{\sqrt{1-r_{25}^2} \sqrt{1-r_{26}^2}} \\
 &= \frac{.846 - .296(.241)}{.9539 \times .9708} = .837
 \end{aligned}$$

(e) Zero-order r's

These coefficients are found on page 34.

4. Standard Deviations

$$\begin{aligned}
 \sigma_{1.23456} &= \sigma_1 \sqrt{1-r_{12}^2} \sqrt{1-r_{13.2}^2} \sqrt{1-r_{14.23}^2} \\
 &\quad \sqrt{1-r_{15.234}^2} \sqrt{1-r_{16.2345}^2} \\
 &= .98 \times .8660 \times .9075 \times .9507 \times .8879 \times .9440 \\
 &= .614
 \end{aligned}$$



$$= \frac{1.36 - 1.27}{\sqrt{1 - 0.25}} = 0.36$$

$$= \frac{1.36 - 1.27}{\sqrt{1 - 0.25}} = 0.36$$

$$= \frac{1.36 - 1.27}{\sqrt{1 - 0.25}} = 0.36$$

$$= \frac{1.36 - 1.27}{\sqrt{1 - 0.25}} = 0.36$$

$$= \frac{1.36 - 1.27}{\sqrt{1 - 0.25}} = 0.36$$

$$= \frac{1.36 - 1.27}{\sqrt{1 - 0.25}} = 0.36$$

(e) Zero-order

These coefficients are found on page 34.

Standard Deviations

$$1.23 \pm 0.05 = \frac{1.23 - 1.18}{\sqrt{1 - 0.25}}$$

$$\sqrt{1 - 0.25} = 0.87$$

$$= 0.05 \times 0.87 = 0.0435$$



$$\begin{aligned}
 \sigma_{2.13456} &= \sigma_2 \sqrt{1-r^2_{23}} \sqrt{1-r^2_{24.3}} \sqrt{1-r^2_{25.34}} \\
 &\quad \sqrt{1-r^2_{26.345}} \sqrt{1-r^2_{12.3456}} \\
 &= 20.04 \times .6380 \times .9982 \times .9600 \times .6726 \times .9837 \\
 &= 8.11
 \end{aligned}$$

$$\begin{aligned}
 \sigma_{3.45621} &= \sigma_3 \sqrt{1-r^2_{34}} \sqrt{1-r^2_{35.4}} \sqrt{1-r^2_{36.45}} \\
 &\quad \sqrt{1-r^2_{23.456}} \sqrt{1-r^2_{13.2456}} \\
 &= 20.07 \times .8285 \times .9854 \times .9440 \times .6940 \times .9629 \\
 &= 10.3
 \end{aligned}$$

$$\begin{aligned}
 \sigma_{4.12356} &= \sigma_4 \sqrt{1-r^2_{24}} \sqrt{1-r^2_{34.2}} \sqrt{1-r^2_{45.23}} \\
 &\quad \sqrt{1-r^2_{46.235}} \sqrt{1-r^2_{14.2356}} \\
 &= 5.56 \times .8930 \times .9290 \times .9854 \times .8352 \times .9818 \\
 &= 3.727
 \end{aligned}$$



$$\alpha = 5.13428 = \alpha \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}}$$

$$\sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}}$$

$$= 50.04 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380$$

$$= 3.11$$

$$\alpha = 3.42581 = \alpha \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}}$$

$$\sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}}$$

$$= 50.04 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380$$

$$= 10.3$$

$$\alpha = 4.15158 = \alpha \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}}$$

$$\sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}} \sqrt{\frac{1}{1-0.5}}$$

$$= 5.50 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380 \times 0.9380$$

$$= 3.752$$



$$\begin{aligned}
 \sigma_{5.12346} &= \sigma_5 \sqrt{1-r^2_{25}} \sqrt{1-r^2_{35.2}} \sqrt{1-r^2_{45.23}} \\
 &\quad \sqrt{1-r^2_{56.234}} \sqrt{1-r^2_{15.2346}} \\
 &= .78 \times .9539 \times .9968 \times .9854 \times .3676 \times .9975 \\
 &= .268
 \end{aligned}$$

$$\begin{aligned}
 \sigma_{6.12345} &= \sigma_6 \sqrt{1-r^2_{26}} \sqrt{1-r^2_{36.2}} \sqrt{1-r^2_{46.23}} \\
 &\quad \sqrt{1-r^2_{56.234}} \sqrt{1-r^2_{16.2345}} \\
 &= .525 \times .9708 \times .9755 \times .9968 \times .3676 \times .9440 \\
 &= .176
 \end{aligned}$$

### 5. Standard Error of Estimate

$$\sigma_{(\text{est. } X_1)} = .614$$

### 6. Coefficient of Multiple Correlation, R.

$$\begin{aligned}
 R_{1(23456)} &= \sqrt{1 - \frac{\sigma_{1.23456}^2}{\sigma_1^2}} \\
 &= \sqrt{1 - \frac{.3769}{.9604}} = .773
 \end{aligned}$$





$$\sigma^2 = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2$$

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2$$

$$= \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \left( \frac{\sum_{i=1}^n x_i}{n} \right)^2$$

$$= \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2$$

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \left( \frac{\sum_{i=1}^n x_i}{n} \right)^2$$

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2$$

$$= \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \left( \frac{\sum_{i=1}^n x_i}{n} \right)^2$$

$$= \frac{1}{n} \sum_{i=1}^n x_i^2 - \bar{x}^2$$

## 5. Standard Error of Estimate

$$\sigma_{(est. \hat{x}_i)} = \sigma \sqrt{1 - R^2}$$

## 6. Coefficient of Multiple Correlation, $R$

$$R^2 = \frac{\sum_{i=1}^n (\hat{x}_i - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2} = \frac{\sum_{i=1}^n (\hat{x}_i - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

$$R^2 = \frac{\sum_{i=1}^n (\hat{x}_i - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2}$$



CONFIDENTIAL  
ZERASE B  
HAGGOTTEN













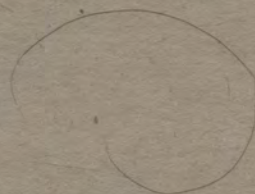






# IMPORTANT!

Special care should be taken to prevent loss or damage of this volume. If lost or damaged, it must be paid for at the current rate of typing.





24  
1950

1950



