RELATIONSHIP OF CERTAIN MEASURES OF ABILITY, INTEREST AND PERSONALITY TO ACHIEVEMENT IN THE ENGINEERING PROGRAM AT OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE

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in partial fulfillment of the requirements
for the degree of
DOCTOR OF EDUCATION
August, 1955

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ACKNOWLEDGMENT

The author is deeply grateful to Dr. Harry K. Brobst, Chairman of her Advisory Committee, for his constant encouragement, direction and guidance in this research. She wishes to express gratitude and sincere appreciation to the following members of her committee: to Dr. Roy K. Sommerfeld for his valuable suggestions and advice; to Professor Clemmer Wood for his contributions concerning the problems of guidance and counseling of engineering students and for his cooperation in relinquishing class time for testing purposes; and to Dr. Morris Wallace and Dr. S. L. Reed for their most helpful assistance. Finally the writer wishes to acknowledge Dr. F. A. Graybill who helped develop her knowledge of methods of research and experimental design.

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CHAPTER I

INTRODUCTION

Nature of the Problem

Each year a large number of young men enroll as freshmen in engineering schools throughout the country who seem to lack suitable characteristics for the successful completion of a program of study leading to a bachelor's degree in this field. It appears that there are certain basic qualifications necessary for those who are to successfully fulfill the requirements for graduation in engineering, but as yet there is no complete agreement as to what these qualifications or their relative significance might be. Many student personnel workers are continually seeking to identify these basic qualifications and methods of measuring them in order that vocational and educational guidance may be improved in effectiveness.

At the present time many standardized instruments are available for measuring various forms of human behavior; however, little is known as to which of these instruments can be used to effectively measure the basic traits, or combination of traits, necessary for success in engineering school. It is realized that tests are not infallible and that it is difficult to assess human behavior with the precision that measurements are made in the physical sciences. On the other hand it has been demonstrated many times that personnel workers can be more effective in their counseling by using test results, knowing their limitations, than they can without them. It seems obvious, then, that a genuine effort must be made to discover the usefulness and effectiveness of existing psychological measuring devices for the purposes of measuring and isolating the particlar pattern of capacities that seem to discriminate between successful and unsuccessful engineering students.

Reasons for Undertaking the Study

The purpose of this study is to investigate whether selected objective measures offer information which could be employed by a counselor in assessing the likelihood of student survival through graduation in the engineering program at Oklahoma Agricultural and Mechanical College.

Data from carefully controlled experimental studies are needed on the relationship between standing on objective measures and likelihood of success or failure in college, i.e. graduation in order that a counselor may have more scientific information upon which to base his judgments. Research data are available which give fairly reliable information upon which to base assessments of success or failure at the end of the first semester or first year, but beyond that predictions decrease in dependability. The principal reason, then, for undertaking this study is to attempt to discover some information which might be of some help to the personnel director of the engineering school at Oklahoma Agricultural and Mechanical College in making long-range attrition-survival predictions and in guiding students who seem to lack the necessary traits for success in engineering, but appear to be capable and more suitable for other degree programs. This would strengthen and improve his counseling program.

The high mortality rate among engineering students demands that studies of this nature be made in order that more reliable and helpful techniques be developed and employed in advising students of their probable success. The trial and error method is altogether too expensive in both time and energy for students and college alike.

A study conducted by the Educational Testing Service (18) for the United States Coast Guard in which graduation and withdrawal rates were compiled and analyzed for over 13,000 engineering freshmen (male non-veteran), representing a good cross section of United States engineering colleges, revealed that: (1) one-third or 33 1/3% of the entrants graduated in four years from engineering school or had satisfactorily completed four years of a five year program, (2) 11% were still enrolled and classified as hold-backs, and (3) more than one-half (56%) had withdrawn or dropped from engineering. The study further pointed out that 46% of the entering engineering students in privately-supported colleges graduated at the end of four years while only 25% of the entering engineering students in publicly-supported institutions graduated in engineering at the end of four years. It seems, according to the study, that graduation rates differ geographically as well. In the South Central States, for example, (Arkansas, Louisiana, New Mexico, Oklahoma and Texas) on the average only 18% of college engineering freshmen graduate in four years in contrast to the Northeastern States (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont and New York) where 47% of the engineering entrants graduate in four years. It was pointed out by many officials of the colleges who participated in the study that it was extremely difficult for them to know the reason for many of the withdrawals. One college official commented,

> A large number of students who either are dropped from engineering or who find the program too rigorous are permitted to transfer to our Liberal Arts College or our School of Business, and many of them are accordingly salvaged and receive college degrees in these other areas (18).

In another study conducted at the University of Saskatchewan it was found that 65% of those entering the College of Engineering as freshmen reach the second year, 45% reach the third year, and approximately 35% the fourth year (21). These figures are in line with others reported in the literature.

Oklahoma Agricultural and Mechanical College registration records[1] show that approximately 65% of the students who enroll as freshmen in the Engineering School re-enroll as sophomores in that school the following year. The records further reveal that approximately 33% of the students who enroll as freshmen successfully complete the engineering program and graduate. It appears that Oklahoma Agricultural and Mechanical College is a typical college as far as the attrition-survival rate in engineering is concerned. These figures are in line with the national averages indicated in the Johnson study (18).

It is fully realized by the investigator that the engineering school has the responsibility of training men for public service and it must set its standards high and give degrees only to those who are competent and successfully complete the program. However, it seems that in the interest of sound educational guidance, the school might well consider methods of reducing its mortality rate and of directing the efforts of those students lacking in characteristics necessary for survival in the program into channels and situations where they are more likely to meet with success.

Because of the high mortality rate and the accompanying frustration of students in engineering schools and the cost in time, energy and money to the student and to the school, studies of this nature need to be made to continue the search for satisfactory methods for selecting,

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[1]From information supplied by Professor Clemmer Wood, Director of Student Personnel, Oklahoma Institute of Technology.

classifying and guiding young men who desire to enter the engineering profession.

Statement of the Problem

The Engineering School of Oklahoma Agricultural and Mechanical College, along with engineering schools of many other colleges and universities, is particularly interested in the problem of admitting, classifying and guiding students who enroll in its program. The majority of students who enter the engineering program at Oklahoma Agricultural and Mechanical College can be classified into three groups: (1) those who successfully complete the program and graduate, (2) those who transfer to some other four-year program on the campus and graduate, and (3) those who drop out and do not graduate. Essentially the problem of this investigation is to discover if these groups of students differ with respect to basic characteristics or to any particular combination of characteristics. The specific problem to be investigated in this study is: Do the previously mentioned groups differ significantly in (1) ability, (2) interest, and (3) personality adjustment as measured by certain standardized tests?

Specific Hypotheses to be Tested

The specific hypotheses to be tested, stated as null hypotheses, are as follows:

(1) Differences in aptitude and achievement scores on the American Council on Education Psychological Examination (Total score), Cooperative Algebra test, Oklahoma Agricultural and Mechanical College English Placement test, and the Guilford-Zimmerman Aptitude Survey between those who graduate from the engineering program and (a) those who change programs

and graduate, and (b) those who drop out of school, are no greater than differences which could be expected to arise as a result of chance fluctuations in random sampling.

(2) Differences in interest scores on the Kuder Preference Record between those who graduate from the engineering program and (a) those who change programs and graduate, and (b) those who drop out of school, are no greater than differences which could be expected to arise as a result of chance fluctuations in random sampling.

(3) Differences in personality adjustment scores on the Minnesota Multiphasic Personality Inventory between those who graduate from the engineering program and (a) those who change programs and graduate, and (b) those who drop out of school are no greater than differences which could be expected to arise as a result of chance fluctuations in random sampling.

CHAPTER II

A REVIEW OF THE RELATED LITERATURE

For purposes of orientation a number of studies which have been made at engineering schools in the United States and reported in the literature and which seem to bear directly or indirectly on the subject of this investigation will be summarized. The majority of studies reported in the literature in this area are concerned with the prediction of grade point average at the end of the first semester or first year. Few are concerned with long-range predictions and few use graduation as a criterion of success.

Mental Ability and Success in Engineering School

Several studies have been made on the prediction of first semester or first year grades for engineering freshmen from a battery of achievement or aptitude tests, high school grades, or grades in previous courses. Most of these studies employ a multiple correlation technique which results in a regression or prediction equation with the appropriate weights for each test in the battery, or each variable under consideration.

Wilson and Hodges (34), at the University of Oklahoma, in 1926 conducted such a study. They found a multiple R of .690 between grade point average in all courses taken beyond the freshman year and the Otis Advanced Intelligence Scale and certain grades in freshman courses (mathematics, mechanical drawing and an introductory course in engineering).

Siemens (26), at the University of California, worked out a regression equation to predict upper division grade point average based on lower division all-over grade point average, average grade in college mathematics, average grade in college chemistry and average grade in college physics. The multiple R was .88. Several other equations were developed which were based on various combinations of the variables. A validation study was made in which it was found that a predicted score would not vary from the actual score by more than .20 of a grade point. The correlation between the predicted grade point average and the actual grade point average was .89±.01.

Ritter (24), at Marquette University, conducted a study on the relationship between high school rank, American Council on Education Psychological Examination (ACE) raw score ranks, and grade point average at the end of six quarters. He obtained a high positive correlation (.70) between ACE raw score rank and grade point average; however, he found that not much confidence could be placed on high school rank or performance in determining college success. This is in contradistinction to the normally accepted theory that there is a high positive correlation between these two variables.

An investigation was conducted by Laycock and Hutcheon (21), at the University of Saskatchewan, which resulted in a multiple R of .66 between grade point average of engineering students at the end of the first year and a battery of predictors consisting of the ACE, Physical Science interest scale on the Thurstone Interest Inventory, Form Relations Test of the National Institute of Industrial Psychologists of Great Britain, and average twelfth grade marks. A prediction equation based on these variables was constructed. An interesting finding in this research was that the ACE test correlated only .34 with grade point average of engineering students, whereas the correlation between the ACE and grade point average of Arts and Sciences freshman students was found to be .50. The author could not explain the discrepancy.

A multiple R of .68 between freshman grade point average of engineering students and seven predictors was found in a study conducted by Dvorak and Aayeer (9) at the University of Washington. The seven variables and their relative weights were found to be: average grade in high school English (-.0687), average grade in high school science (.26912), average grade in high school social science (.01765), average grade in high school mathematics (.23836), the University Intelligence Test (-.00129), Iowa Mathematics Test (.01400) and Iowa Physics Test (.00649).

McClanahan and Morgan (22) investigated the predictive value, for engineering freshmen, of various tests regularly administered to all new students at Colorado Agricultural and Mechanical College. They obtained a multiple R of .848 between first year grade point average and a battery of tests consisting of the American Council on Education Cooperative English Test, Iowa Placement Examination Chemistry Aptitude, Nelson-Denny Reading Test, ACE Test and high school rank. When high school rank was omitted the multiple R was still .848. When only the English and Chemistry tests were used the multiple was found to be .814, almost as high as when all variables were employed. A regression equation based on the two tests was constructed which yielded a standard error of estimate of .45. In an empirical follow-up it was found that most of the discrepancies between predicted and actual grade point average occurred at extreme grade levels.

Porter (23) conducted a study in the College of Engineering at the Carnegie Institute of Technology to

> . . . determine the relationship between scholarship while in attendance and: (1) high or preparatory school scholarship; (2) performance on a test of general scholastic ability; (3) performance on objective high school achievement tests; and (4) scholarship during the first semester of the freshman year (23, p. 278).

A regression equation based on these variables permitted the prediction of grade point average (any semester after the first) with a PE of estimate of less than one-half a grade point.

Holcomb and Laslett (17) investigated the possibility of segregating engineering students at Oregon State College into ability groups on the basis of entrance examinations and predicting success (college grades) accordingly. They concluded,

Values of scores of any one of the tests, except possibly the ACE, as a means of predicting academic success in engineering is very small. However, the ACE, the Strong Vocational Interest Analysis Blank, and the Stenquist Mechanical Aptitude Test #2 can be used to give more accurate advice in a personal interview than without them (17, p. 115).

The correlations of these tests with the criterion were found to be: ACE (.555), Strong Vocational Interest Analysis (.322), and Stenquist Mechanical Aptitude Test #2 (.428).

A recent study, at the University of Wisconsin, conducted by Drake and Thomas (8), used the Pre-Engineering Inventory developed by Vaughn (33) and the ACE Test for the purposes of predicting grade point average in the Engineering School. The authors developed expectancy tables indicating the probability of the student earning a particular grade point average depending upon his quartile placement on the Pre-Engineering Inventory and the ACE. The authors concluded, "It is not recommended that such data be used alone for the elimination of students from the study of engineering although it might well be used, along with other data, in making decisions regarding borderline cases for admission to a College of Engineering." (8, p. 276).

Bernreuter and Goodman (3) used the experimental edition of Thurstone's Primary Abilities Tests to study the relationship of test scores to success in the Engineering School at Pennsylvania State College. Their major finding was that only four of the primary mental abilities--number, verbal, induction and reasoning--correlated sufficiently with grades in specific subjects (mathematics, English, drawing, chemistry and psychology courses) to justify their use. Bernreuter (4) presented the study at the Forty-Seventh Annual Meeting of the American Psychological Association at Stanford University in 1939. He emphasized,

> . . . engineering students were found to be significantly different from the high school seniors reported by Thurstone in that they scored higher in the spacial and reasoning factors and scored lower in the verbal and induction factors. (4, p. 548).

At Iowa State Feder and Adler (10) used a battery of tests including the Iowa High School Content Examination, Iowa Silent Reading, Iowa Mathematical Aptitude and Iowa English Training to predict first semester and first year grade point average for engineering students. He obtained a multiple R of .74 ± .03 between the tests in the battery and first semester grade point average and a multiple R of .71 ± .04. between the same tests and first year grade point average. He emphasized the importance of evaluating reading ability and command of English since engineering curriculum experts regard these abilities as important for success in engineering.

A study at the graduate level was conducted by Speer (30) at Illinois Institute of Technology in which the Graduate Record Examination was the measuring instrument. He assumed that in selecting students for graduate work in engineering the applicants should be measured or evaluated in four areas: (1) personal characteristics, (2) factual knowledge, (3) general mental aptitude, and (4) actual achievement (an estimate of the ability of the student to work in a classroom or laboratory situation). The Graduate Record Examination did not seem to meet the requirements of a satisfactory prediction device in all of these areas.

A somewhat different approach was assumed by Sisk (27) who applied the multiple factor analysis technique (centroid method) to the intercorrelations between ACE scores and subject matter grades for freshman engineering students at Cornell University. He found three distinctive factors although he could not attach psychological significance to each. He tentatively termed the factors as follows: Factor I--a linguistic or verbal factor which was present in all engineering courses; Factor II--a perceptual factor which might be a study or interest factor; and Factor III--a factor with significant loadings with chemistry and drawing.

A few studies using the discriminate function technique[2] are reported by Schmitz and Holmes (25) in their review of the literature of this subject. According to these authors, Dean, at Iowa State College, developed discriminate functions and probability tables for each of the criteria employed in his study. In developing these functions he used as variables the pre-matriculation data, Quantitative and Linguistic scores of the ACE, scores on the United States Armed Forces Institute Test on Correctness and Effectiveness of Expression, scores on the Iowa State College Mathematics Placement test and the high school grade point averages. The three criteria of success were: (1) the probability of beginning the fourth quarter in engineering; (2) the probability of graduation in engineering; and (3) the probability of graduation in engineering in the upper half of the class.

Schmitz and Holmes (25) also report a study made by Bailey at the University of New Mexico using the discriminate function technique. Bailey used as variables the number of Carnegie units in mathematics,

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[2]This technique, developed by Fisher (11), gives the relative weights of each variable for the purposes of predicting a dichotomous criterion. In addition to the weights a multiple biserial R is obtained.

first semester grade point average in college, and the Q and L scores of the ACE. He found that the probability of graduation in engineering ranged from fourteen chances out of one-hundred for the less capable students to sixty-four chances out of one-hundred for the more capable students.

In a preliminary study conducted by Schmitz and Holmes (25) at Iowa State College five variables were selected (high school average, ACE Total score, English Placement Test for Iowa Universities and Colleges, Owens-Bennett Mechanical Comprehension Test and the Iowa State College Mathematics Placement Test) and analyzed for their relationship to success in the Engineering School. They used as criteria: (1) the tendency to have a grade point average during the first year of 2.00 or above (four point scale), and (2) the tendency to be in the upper ten percent the first year. The multiple biserial coefficient of correlation for the first criterion was found to be .72 and for the second it was .77. Discriminate function equations for each of the criteria were developed.

Interests and Success in Engineering School

Psychologists and personnel workers are generally of the opinion that some measure of interest is essential to adequate prediction of achievement or success in an engineering program. Few, however, have investigated the predictive power of existing interest tests.

Speer (29) used the Kuder Preference Record to study the interest patterns of freshman engineering students and liberal arts students at Illinois Institute of Technology. He found the interest patterns of engineering students to differ significantly from those of non-engineering students. The engineering students had high (above the 75th percentile) mechanical, computational, scientific interests whereas there seemed to be no such uniformity of interests for the liberal arts students.

Speer's (28) data further show that all engineering groups, except Industrial and Fire Protection, tend to be in the lower twenty-five percent on the persuasive interest scale when compared with men in general. Likewise all groups are below average (except Civil Engineering, which is just average) in social service interest. Speer concluded, "These studies indicate that the engineering student has an interest, even as a freshman, in social institutions, and in the improvement of mankind, but he lacks a personal interest in peoples as individuals" (28, p. 89). When the student groups were compared with two groups of graduate engineers in the field it was found that the two populations differed in social service interests with the more mature group scoring higher on the social service scale.

A study was conducted by Berdie (2) at the University of Minnesota with the purpose of determining if vocational interest tests could be used to predict an engineering student's satisfaction with his curriculum and his achievement. The students were divided into four groups on the basis of their scores on the Strong Vocational Interest Blank: (1) primary interest pattern in engineering, (2) secondary interest pattern in engineering, (3) tertiary interest pattern in engineering, and (4) no interest pattern in engineering. Analysis of variance was used to test the significance of the difference between the means of the groups in terms of grade point average and curriculum satisfaction as measured by a blank devised to assess this variable. No significant differences existed between the groups on the basis of grades, but they differed significantly (.05 level of probability) on the basis of curriculum satisfaction. The group having no pattern was less satisfied than the groups having interest patterns in engineering.

Barnette (1) made a follow-up study of veterans who went into engineering as a result of the guidance of the Vocational Service Center of the YMCA of New York City. He used the Kuder Preference Record to find out if there were significant differences in terms of interest patterns between the successful group (those persons still in engineering school with no plans for change) and the failure group (those who dropped out of engineering school). He found the groups to differ (.05 level of probability) on four of the scales: (1) computational--higher for the successful, (2) scientific--higher for the successful, (3) persuasive--higher for the failure, and (4) clerical--higher for the successful.

Interests, as measured by the Strong Vocational Interest Blank, appear to differentiate engineering and liberal arts students at Pennsylvania State College according to a study made by Goodman (13). The engineering students scored high on the following keys: Chemist, Engineer, Production Manager, Farmer, Carpenter, Printer, Policeman and Mathematics-Science Teacher. In contrast the liberal arts students scored high on the following keys: YMCA Secretary, Social Science High School Teacher, Musician, Banker, Office Man, Sales Manager, Real Estate Salesman, Life Insurance Salesman, Advertising Man, and Lawyer.

There appears to be evidence available suggesting that successful engineering students tend to be interested in activities of a mathematical and scientific nature.

Personality and Success in Engineering School

There seem to be marked differences of opinion among psychologists as to the relationship between personality and success in Engineering School. Not much research has been done on this specific problem. Occasionally studies appear to show definite relationships between measured personality traits and academic success, whereas other reports seem to be contradictory. Two studies dealing specifically with the relationship of measured personality traits and success in Engineering School are reported here.

In the previously mentioned study (13) made by Goodman engineering students were found to be significantly more stable and more self-sufficient than the liberal arts students as indicated by responses on the Bernreuter Personality Inventory. There was no significant difference between the two groups on the dominance trait.

Blum (5) made a comparison of the scores on the scales of the Minnesota Multiphasic Personality Inventory for various schools (Education, Law, Journalism, Medicine and Engineering) at the University of Wisconsin. An analysis of variance revealed significant differences to exist among five groups on three of the personality traits: (1) mechanical engineers scored highest on the hysteria scale, (2) engineers scored lowest on the schizophrenia scale and medical students scored highest, and (3) engineers scored highest on the social introversion scale.

Stagner (31) at the University of Wisconsin conducted a study which, although not directly concerned with engineering students, yielded outcomes that seem pertinent. He concluded that it

> . . . . becomes increasingly clear that personality influences achievement in an indirect way, by affecting the degree to which use is made of the individual's potentialities and may explain the low correlations between personality test scores and achievement. At some point along the distribution personality is an advantage in academic work while different amounts of the same personality variable may be disadvantageous, or may be operative in one direction in one case, the opposite in a similar situation (31, 660).

Summary

Mental ability tests, interest tests and personality inventories have been used by various investigators in an attempt to predict success (usually first semester or first year grade point average) in engineering schools. Tests of aptitude and achievement have been used much more extensively than measures of interest and personality. Multiple R's between batteries of tests and the criterion of success reported in the literature range from .62 to .88. Validation studies, on the whole, have yielded relatively high correlations between predicted grade point average and actual grade point average.

Studies involving interest tests have usually been concerned with the Kuder Preference Record or the Strong Vocational Interest Blank. The scales on the Kuder Preference Record which seem to discriminate engineering students from those in other schools are the computational, scientific, and to some degree the mechanical scale.

The literature seems to be relatively lacking in studies specifically involving the relationship of measured personality traits to success in engineering school. The two studies reported here conclude that engineering students differ from students in other programs of study in specific traits as measured by the scales of the tests.

The related literature reviewed in this chapter serves to acquaint the reader with some of the indices of relationships between measures of ability, interest and personality to achievement in engineering schools which have been established by various investigators. Although many studies have been made to discover this relationship, many questions concerning the problem remain unanswered. The results of the present investigation will perhaps provide answers to some of these questions.

CHAPTER III

SUBJECTS, INSTRUMENTS AND PROCEDURE

Following is a description of the subjects, the instruments and the statistical procedure used in testing the hypotheses listed in Chapter I.

Subjects

The subjects of this investigation are male students who were enrolled in the Orientation course (Engineering III) for freshmen engineering students at Oklahoma Agricultural and Mechanical College in the fall of 1949. At that time the subjects were between seventeen and nineteen years of age. In the summer of 1954, after a lapse of time sufficient to fulfill the requirements for graduation, the students were divided into three groups: (1) those who had successfully completed the engineering program and graduated (referred to as Group I); (2) those who had transferred from engineering to another four-year course on the campus and graduated (referred to as Group II); and (3) those who had dropped out of the Engineering School for any reason and who did not transfer to another college at the time (referred to as Group III). Thirty subjects were randomly selected from each of the above groups to constitute the sample of this study. The size of the sample was estimated from the formula[3]

$$n = \frac{t^2 \sigma^2}{d^2}$$

where $t = 1.96$ (t value for the 95% level of confidence), $\sigma = 23.94$

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[3]This formula, developed by Cochran and Cox (6, pp. 17-23) provides a basis for estimating the number of replications needed in an experiment to obtain a significant F-value if the difference between the mean of the sample and the mean of the population is estimated to be a certain amount.

(the standard deviation, based on the national norms for 1949, of the ACE test, i.e., the test in the study with the largest standard deviation), and d = 10 the value that should not be greater than the difference between the mean of the sample and the mean of the population from which the sample was drawn on the ACE tests. This difference had to be hypothesized before the size of the sample could be estimated. The calculated n was 21.93, but in order to be sure of an adequate sample, n for each group was chosen to be 30.

That the subjects in these groups (90 cases) are representative of the freshmen engineering classes entering Oklahoma Agricultural and Mechanical College is shown by applying the t-test to determine the significance of the difference between the means of the ACE for the sample and for each of four subsequent years (1950-1953).

Table 1 shows the mean, standard deviation, number of cases and t-values for the years 1950 through 1953.

TABLE 1

Results Based Upon Data from the American Council on Education Psychological Examination for Five Samples of Freshmen Engineering Students at Oklahoma Agricultural and Mechanical College

Year	Mean	SD	N	SE_m	SE_d	t*
Sample (1949)	104.50	22.06	90	2.32		
Fall 1950	100.56	22.92	431	1.10	2.57	1.53
Fall 1951	101.04	23.70	451	1.12	2.58	1.34
Fall 1952	99.40	23.70	695	2.38	3.32	1.23
Fall 1953	100.70	22.55	549	2.24	3.22	1.18

*None of these values approach the .05 level of significance.

None of the t-values are significant at the .05 level or beyond, giving evidence that the sample used in this investigation is representative of freshman engineering classes at Oklahoma Agricultural and Mechanical College. It will be noted that the mean of the sample, although not significantly so, is somewhat higher than the other means in the table. This is probably due to the existence of a selection factor. The subjects in the sample represent a group who continued in the engineering program at least the first semester of the 1949-1950 term because the tests in the battery were taken at various times throughout the semester. The subjects represented in the subsequent years took the ACE during the first week of school in early September as a part of the general orientation program and many dropped out before the end of one semester.

A Description of the Tests Used in the Study

The following tests were administered to the students involved in the study by the Bureau of Tests and Measurements at Oklahoma Agricultural and Mechanical College in the fall of 1949 and with the exception of the English Placement Test are described or referred to in Greene (14):

1. American Council on Education Psychological Examination for College Freshmen (1945 edition).[4]

The purpose of this test is to measure general scholastic aptitude of college freshmen. It consists of two sub-tests: (1) Linguistic (L), which is a measure of vocabulary knowledge and ability to reason with words; and (2) Quantitative (Q), which is a measure of non-verbal reasoning ability, and skill and speed in solving arithmetic problems. Speed is very important

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[4]Constructed by L. L. and T. G. Thurstone. A new form of the test is published each August by the Educational Testing Service.

in both sub-tests. The total score was used in this investigation.

The coefficient of correlation between the ACE and the Stanford Binet (Form L) is approximately .60, while the split-half reliabilities of the total score range from .95 to .97 (32).

2. Cooperative Algebra Test (Revised Form S).[5]

This test was designed to provide a measure of achievement of the basic skills and principles in elementary algebra through quadratics. The problems in the test cover mechanical and manipulative skills and verbal reasoning. The odd-even reliabilities reported in the literature range from .92 to .94. The median correlation with algebra grades is reported as .73 for boys in secondary schools (7).

3. Oklahoma Agricultural and Mechanical College English Placement Test.[6]

This test attempts to measure achievement in grammar. Students scoring in the lower quartile were required to take a refresher, non-credit course in English before going on with the regular courses. The split-half reliability of the test is approximately .88 and the validity when assessed against grades in Freshman English is about .58.

4. Guilford-Zimmerman Aptitude Survey.[7]

The authors of the survey plan eventually to develop tests to measure approximately twenty primary mental abilities (15). The seven tests already developed purpose to cover the principle factors in three general areas: (1) abstract intelligence (Verbal Comprehension, General Reasoning); (2) clerical aptitude (Numerical Operations, Perceptual Speed); and (3)

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[5]One of the American Council on Education Cooperative Tests published by the Educational Testing Service.

[6]Constructed by Lloyd Douglas, Professor of English at Oklahoma Agricultural and Mechanical College, for purposes of screening students for freshman English classes; it has not been published.

[7]Published by Sheridan Supply Co.

mechanical aptitude (Spatial Relations, Spatial Visulization, and Mechanical Experience).

Each of the seven tests of the survey is designed to measure one primary ability. When the tests were factor analyzed, fairly satisfactory results indicating factorial uniqueness were obtained. The odd-even reliability coefficients range from .88 to .92. As yet validity coefficients are lacking; however, the authors of the survey estimate them, on the basis of known factorial composition of very similar tests, to be of the magnitude of .60 to .80. The reported intercorrelations, as they should be, are low. They range from .10 to .19 (15).

Following is a description of each of the factors in the battery:

a. Verbal Comprehension. This test measures the ability to understand the meanings of words and verbal concepts. It is essentially a vocabulary test, and is presented as a power test.

b. General Reasoning. General Reasoning and Verbal Comprehension are measures of the two most common components of verbal intelligence tests, although they are relatively independent (15). The General Reasoning Test measures the ability to solve problems, particularly arithmetic-reasoning problems. It, too, is a power test.

c. Numerical Operations. This factor is a test of one's ability to work accurately and rapidly with numbers. The four fundamental operations, addition, subtraction, multiplication and division are about equally distributed throughout the test. Speed is an important factor while difficulty is minimized, allowing nearly all examinees to solve the problems correctly, given sufficient time.

d. Perceptual Speed. This test consists of short matching items which require the subject to apprehend slight similarities and differences in the forms and details of common objects. It measures the ability to perceive visual objects quickly and accurately. Speed is also an important factor in this test.

e. Spatial Relations. This test measures the ability to visualize objects in space in reference to the human body. Each item presents two views of the prow of a motorboat. The task is to determine what directions (right or left, risen or fallen, and/or tilted right or left) the boat has moved in order to reach the position presented in the second picture. This ability appears to be important in learning to pilot an airplane, and in jobs involving machine operations (15).

f. Spatial Visualization This factor involves the ability to visualize three dimensions in two dimensional space. This test is reported to be different from the usual spatial test in that it does not combine space relations and visualization and does not stress the general reasoning factor (15).

g. Mechanical Experience. This test is designed to measure one's acquired knowledge or experience with common tools, automobile parts, carpentry, plumbing, welding, etc. The authors of the survey offer evidence to justify their conclusion that the experience factor is the only unique factor in mechanical tests. Not all subjects have an equal opportunity to acquire this kind of knowledge, but the test results seem to indicate those who will succeed in jobs of a mechanical nature (15).

5. Kuder Preference Record (Form BB, 1942)[8].

Kuder, the author of the Preference Record, states that one of the purposes of his test is to measure the motivating factors that contribute

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[8]Published by Science Research Associates.

to success in school and work (19). The test provides a measure of an individual's interests and a profile of these interests in nine areas: mechanical, computational, scientific, persuasive, artistic, literary, musical, social service and clerical. The 1951 revision added a tenth area, outdoor interest.

Each item is in the form of a forced choice among three possible alternatives. The subject chooses the one he likes best and the one he likes least. Each choice made by the subject is scored in the appropriate interest area. The raw scores for each of the nine scales are converted into percentile ranks which compare the subject in terms of these measured interests with those of men or women in general.

Kuder (19) reports the following reliability coefficients for seven of the nine interest scales: scientific .87, computational .85, musical .98, artistic .90, literary .90, social service .84 and persuasive .90.

6. Minnesota Multiphasic Personality Inventory (MMPI)[9].

The test consists of 566 questions to be judged by the subject as "true," "false," or "cannot say," depending upon whether he regards the statement as true of himself or not. It is applicable for persons sixteen years of age or older who can read.

The authors state that the inventory is ". . . designed ultimately to provide, in a single test, scores on all the more important phases of personality" (16). The nine clinical scales comprising the inventory are: hypochondriasis (Hs), depression (D), hysteria (Hy), psychopathic deviate (Pd), masculine-femininity (Mf) and hypomania (Ma). The scores were developed by comparing normal groups with mental patients. The higher one scores on any of the scales, the more his answers are like those

[9]Published by the Psychological Corporation.

given by psychiatric patients diagnosed to be in that classification.

The MMPI provides four additional scales which are used to estimate the validity of a subject's response to the items. These scales are the "validity score" (K), the "lie score" (L), the "question score" (?), and the "fake score" (F).

The test-retest reliability coefficients reported for the various scales of the MMPI range from .46 to .93 (14).

Garrett (12) suggests that validity coefficients of correlation of .50 or greater are adequate for group predictions, and that reliability coefficients of correlation must be .85 to .95 to be regarded as high. The validity and reliability data presented for the tests used in this investigation seem to justify their use for a study of this nature.

Statistical Design of the Research

In order to test the previously stated hypotheses the analysis of variance technique, which seemed to be most appropriate, was applied to the data. A completely randomized type of design was used, and the .05 level of probability was assumed. Results of each test were analyzed separately to determine if there were differences among the means of the three groups. If a significant F resulted the t-test was applied in order to find out which specific two means were different.

In addition, a comparison of the mean values for Group I and an average of the mean values for Groups II and III was made for those tests yielding a significant F for between groups. This was done in order to find out if the engineering graduates were different from those who were not successful in graduating from Engineering School regardless of whether they graduated from another program or dropped out of school.

Tables of percentile ranks for Groups I, II and III were compiled for each test (see Appendix A) showing the percentile rank corresponding to raw scores. To illustrate the use of the tables, suppose a freshman engineering student made a raw score of 100 on the ACE test. When compared with engineering graduates he would score at the twenty-third percentile (Appendix A-1). This means that he did better than twenty-three percent of the engineering graduate group while seventy-seven percent did better than he. When compared with non-engineering graduates, the student making a raw score of 100 on the ACE test would obtain a percentile rank of forty-three and when compared with the drop-out group the student would score at the sixty-third percentile. It was believed by the writer that these tables might provide the counselor with a definite tool for counseling engineering students.

After analyzing the variance for each test separately, an analysis of maximum separation was made on a combination or composite of test scores using the four tests which seemed to discriminate with the highest degree of efficiency. A discriminant function based on the four selected tests was computed as well as a multiple triserial R. A last step in the research was to use the discriminant function for computing critical or cutting scores for the three groups and to interpret how these scores might be used by the counselor.

CHAPTER IV

TREATMENT OF DATA AND ANALYSIS OF RESULTS

The following chapter is devoted to a detailed account of the statistical treatment of the data and an analysis of the results.

Aptitude and Achievement

When the variance for the ability test results was analyzed, it was found that the data for each test resulted in a significant F. Thus, hypothesis 1, that there are no significant differences between the groups in mental ability, had to be rejected at the .05 level of probability or beyond for each test. When the t-test was applied it was found, however, that each group did not differ significantly from every other group. Each aptitude or achievement test has a unique analysis and will be discussed separately.

1. American Council on Education Psychological Examination.

TABLE 2

Analysis of Variance of ACE Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	88	49860.22			
Between	2	8027.72	4013.86	8.25	.01
I vs II, III	1	6061	6061	12.5	.01
Error	86	41832.50	486.42		

Table 2 shows the break down of the variance of the ACE test scores.

The F (8.25) is significant beyond the .01 level of confidence which means that at least one of the obtained differences is large enough that it could have occurred by chance only once in a hundred times.

A comparison of the engineering graduates (Group I) with an average of the non-engineering graduates (Group II) and the drop-outs (Group III) resulted in a significant F-value. This indicates that a real difference exists between the successful and the unsuccessful engineering students in terms of total scores on the ACE. The means for the groups are shown in Table 3.

TABLE 3

Means and N's for Groups I, II and III on ACE Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	116.1	104.4	93.0	104.5	22.06
N	30	29	30	89	

The engineering graduates have a mean of 116.1 which is significantly higher than the mean of 104.4 obtained by the non-engineering graduates. The drop-out group has a mean of 93.0 which is significantly lower than the mean for the engineering graduates, but, although it approaches significance, does not differ significantly from the mean of the non-engineering graduates group.

Table 4 shows the t-values obtained by comparing the means on the ACE for the three groups.

One can conclude, then, that on scores on the ACE those who graduate from Engineering School differ from those who graduate from other

TABLE 4

Significance of Differences Between Means of Groups I, II and III on ACE Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	11.7	2.082	57	.05
$t_{I, III}$	23.1	4.09	58	.01
$t_{II, III}$	11.4	1.99	57	not sig.

schools on the campus and from those who drop out, but those who graduate from other schools on the campus do not differ significantly from those who drop out of school.

2. Cooperative Algebra Test.

The analysis of variance of the results of the Cooperative Algebra test are essentially the same as for the ACE test as shown in Table 5.

TABLE 5

Analysis of Variance of Cooperative Algebra Test Scores for Groups I, II and III.

Source	df	SS	MS	F	P
Total	66	12836.87			
Between	2	3586.01	1793.01	12.40	.01
I vs II, III	1	3670.43	3670.43	25.40	.01
Error	64	9250.86	144.54		

The between-group F-value is significant at the .01 level of confidence and indicates that the groups differ with respect to scores on this test. Again a significant F-value is obtained when a comparison is made of Group I with an average of Groups II and III. This can be interpreted to mean that those who graduate from the engineering program tend to have, as freshmen, a better knowledge of algebra and mathematical concepts than those freshmen engineering students who do not succeed in graduating from the program.

Table 6 shows the t-values when the means of the three groups on the Cooperative Albegra test are compared.

TABLE 6

Significance of Differences Between Means of Groups I, II and III on Cooperative Algebra Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	12.4	3.57	46	.01
$t_{I, III}$	17.3	4.74	42	.01
$t_{II, III}$	4.9	1.31	40	not sig.

Again we find the students who graduated from the engineering program to be significantly different from the non-engineering graduates and drop-out groups, but the non-engineering and drop-out groups do not differ in performance on the Cooperative Algebra test.

The means and N's for the three groups are presented in Table 7.

TABLE 7

Means and N's for Groups I, II and III on Cooperative Algebra Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	41.2	28.8	23.9	32.0	12.02
N	25	23	19	67	

Group I has a mean score of 41.2, while Group II has a mean score of 28.8 and the mean score for Group III is 23.9. Complete data were not available for this test since certain students who entered the program several weeks after it began were placed in mathematics without the benefit of this examination.

3. English Placement Test.

A somewhat different situation is indicated from an analysis of the English Placement test results. These data are presented in Table 8.

TABLE 8

Analysis of Variance of English Placement Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	68	53794.56			
Between	2	14266.15	7133.08	11.91	.01
I vs II, III	1	45762.67	45762.67	76.4	.01
Error	66	39528.41	598.92		

The table shows that there are significant differences among the means of the test scores for the groups. This is indicated by the significant (.01 level of confidence) F-value for the between-group comparison. The results of the analysis further show that the F-value is significant at the .01 level of confidence when a comparison is made between those who succeeded in the engineering program (Group I) and those who did not succeed in the engineering program (a combination of Groups II and III).

Table 9 shows the results of the t-tests for comparing the means of the three groups on the English Placement test.

TABLE 9

Significance of Differences Between Means of Groups I, II and III on English Placement Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	8.7	1.23	48	not sig.
$t_{I, III}$	34.9	4.75	43	.01
$t_{II, III}$	26.2	3.54	42	.01

The t-values reveal that Group I is not significantly different from Group II in terms of scores on the English Placement test. Group I is significantly different from Group III and likewise Group II differs significantly from Group III. The implication here is that one must do well in the type of ability (achievement in English grammar) that this test measures in order to graduate from college regardless of whether it be from the engineering program or from some other program on the campus.

Table 10 shows the means on the English Placement test for the three groups.

TABLE 10

Means and N's for Groups I, II and III on English Placement Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	74.0	65.3	39.1	60.8	24.47
N	25	24	20	69	

The mean for the engineering graduates is 74.0, that for the non-engineering graduates is 65.3, while the drop-out group has a mean of only 39.1. The mean of Group III is so much lower than the mean of Group I or Group II that where averaged with the mean of Group II the difference between Group I and the combination of Groups II and III becomes significant beyond the .01 level of probability.

4. Guilford-Zimmerman Aptitude Survey.

a. Verbal Comprehension. The analysis of variance data for the Verbal Comprehension test results are presented in Table 11.

TABLE 11

Analysis of Variance of Verbal Comprehension Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	11354.90			
Between	2	1166.07	583.04	4.98	.01
I vs II, III	1	649.8	649.8	5.6	.05
Error	87	10188.83	117.11		

The picture presented in this table is very similar to that presented for the English Placement test results. This is perhaps as it should be inasmuch as both tests deal with words and verbal concepts. The F-value is significant at the .01 level of confidence for between-groups and at the .05 level for the comparison of Group I with Groups II and III.

The results of the t-tests for the three groups on the Verbal

Comprehension test data are presented in Table 12.

TABLE 12

Significance of Differences Between Means of Groups I, II and III on Verbal Comprehension Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	2.7	.97	58	not sig.
$t_{I, III}$	8.6	3.12	58	.01
$t_{II, III}$	5.9	2.14	58	.05

These results show that Groups I and II do not differ in terms of performance on this test while Groups I and III and Groups II and III differ significantly. It appears that the ability to understand the meaning of words and verbal concepts is just as essential for the successful completion of the engineering program as for the successful completion of programs in fields other than engineering. The engineering graduates and the non-engineering graduates do not differ in this ability, but those who drop out of school score significantly lower in this ability than those who graduate.

Table 13 presents the means of the Verbal Comprehension test and N's for each of the three groups, the combined mean, and the standard deviation based on the pooled variance of the three groups.

TABLE 13

Means and N's for Groups I, II and III on Verbal Comprehension Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	28.4	25.7	19.8	24.6	10.87
N	30	30	30	90	

b. General Reasoning. The results of the analysis of variance of the General Reasoning test are shown in Table 14.

TABLE 14

Analysis of Variance of General Reasoning Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	2577.79			
Between	2	550.82	275.41	11.82	.01
I vs II, III	1	486.8	486.8	20.9	.01
Error	87	2026.97	23.30		

The analysis shows the F-value to be significant at the .01 level of confidence for both between-groups and for a comparison of Group I and an average of Groups II and III.

The results of the t-tests for testing the significance of the difference between the means on the General Reasoning test for the three groups are shown in Table 15.

TABLE 15

Significance of Differences Between Means of Groups I, II and III on General Reasoning Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	3.9	3.17	58	.01
$t_{I, III}$	6.0	4.88	58	.001
$t_{II, III}$	2.1	1.71	58	not sig.

The P-values presented in Table 15 suggest that in addition to there being a significant difference between those who succeed in the Engineering School and those who do not (combining the graduates from other schools and the drop-outs), the engineering graduates also differ from the graduates of other schools and the drop-outs when these groups are considered separately. The non-engineering graduates do not differ, however, from the drop-outs in the type of ability that is measured in the General Reasoning test.

The means of the scores on this test for the three groups are presented in Table 16.

TABLE 16

Means and N's for Groups I, II and III on General Reasoning Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	16.1	12.2	10.1	12.8	4.83
N	30	30	30		

In the light of the evidence presented, it seems safe to conclude that the ability to solve problems, particularly arithmetic-reasoning problems, is fairly important for success in the engineering program. On the other hand, this particular ability does not appear to be required to such an extent for success in graduating from some other program inasmuch as the scores of drop-outs and non-engineering graduates do not differ on this test.

c. Numerical Operations. The same results are obtained from an analysis of the Numerical Operations test as were presented for the

General Reasoning test. These are shown in Table 17.

TABLE 17

Analysis of Variance of Numerical Operations Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	29259.29			
Between	2	2615.62	1307.81	4.27	.05
I vs II, III	1	2606.81	2606.81	8.51	.01
Error	87	26643.67	306.25		

Again there are significant differences as revealed by the F-test in the analysis of variance. The differences appear to be between the engineering graduates and the other two groups and not between the non-engineering graduates and the drop-outs. Table 18 shows the t-values for determining the significance of the difference between the means of the three groups.

TABLE 18

Significance of Differences Between Means of Groups I, II and III on Numerical Operations Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	11.0	2.21	58	.05
$t_{I, III}$	11.8	2.63	58	.05
$t_{II, III}$	.8	.17	58	not sig.

The differences between the means of Groups I and II, and Groups I and III are shown to be significant at the .05 level of probability. The t-value between Groups II and III is less than 1.00 and indicates no significant difference between these groups.

The means for the three groups on the Numerical Operations test are presented in Table 19.

TABLE 19

Means and N's for Groups I, II and III on Numerical Operations Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	63.3	52.3	51.5	55.7	17.5
N	30	30	30	90	

An inspection of the table of means shows the mean of Group I to be 63.3 which is eleven points higher than the mean of Group II (52.3); while there is only .8 of a point difference between Groups II and III. These results imply that the ability to work accurately with numbers is a desirable characteristic for success in the Engineering School, whereas those who lack this ability might succeed in graduating from some other school on the campus. At any rate there is no difference between the non-engineering graduates and those who drop out of Engineering School in terms of Numerical Operations.

d. Perceptual Speed. The results of Perceptual Speed test are different from those of the other tests in the battery. The means of the groups are presented in Table 20.

TABLE 20

Means and N's for Groups I, II, and III on Perceptual Speed Test Data with the Mean and Standard Deviation of the Three Groups Combined

	I	II	III	Combined	SD
M	47.3	43.1	44.7	45.0	2.18
N	30	30	30	90	

In contrast to the pattern or trend found in the previous tests with Group I having the highest mean, followed by Group II and Group III with the lowest, in this situation the mean for Group I is 47.3 which is the highest, the mean for Group II is 43.1 which is the <u>lowest</u>, and Group III has a mean of 44.7. The standard deviation for the combined groups is small (2.18). The analysis of variance results for the Perceptual Speed test are reported in the following table.

TABLE 21

Analysis of Variance of Perceptual Speed Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	7678.99			
Between	2	265.69	132.85	27.96	.01
I vs II, III	1	228.94	228.94	48.2	.01
Error	87	413.30	4.75		

Although the differences between the means are small, they are significant at the .01 level of confidence. The significant F for the comparisons of Group I with the average of Groups II and III indicates that those who succeed in the Engineering School score significantly higher on this test than those who do not succeed in graduating from Engineering School.

The results of the t-test for testing the significance of the differences between the means of the Perceptual Speed test are presented in Table 22.

TABLE 22

Significance of Differences Between Means of Groups I, II and III on Perceptual Speed Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	4.2	7.50	58	.001
$t_{I, III}$	2.6	4.64	58	.001
$t_{II, III}$	1.6	2.86	58	.01

The t-values reveal that <u>all</u> groups differ significantly at the .01 level or beyond in this ability (the ability to perceive visual objects quickly and accurately) as measured by this test. An explanation as to why the drop-out students (Group III) do better as a group than the non-engineering graduates is lacking at this time. There is some reason to believe, on the basis of empirical observation, that those who are more alert intellectually perceive elements in the environment more quickly and more extensively than those not as able intellectually. The test probably measures aspects of this capacity. However, why Group III should do better than Group II is not clear if this supposition has any validity, unless it can be assumed that Group II was composed of subjects who tended to work more slowly on a task demanding speed.

e. Spatial Relations. Table 23 shows the means of the Spatial Relations test for the three groups.

TABLE 23

Means and N's for Groups I, II and III on Spatial Relations Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	24.3	15.8	19.3	19.8	9.7
N	30	30	30	90	

As in the Perceptual Speed test, the means of scores on the Spatial Relations test deviate from the usual trends of the findings based on the tests previously discussed. Table 23 shows the engineering graduates to have the highest mean (24.3) and the non-engineering graduates to have the lowest (15.8). The drop-outs' mean score is 19.3 which is quite similar to the combined mean (19.8) for the three groups.

TABLE 24

Analysis of Variance of Spatial Relations Test Scores for Groups I, II, and III

Source	df	SS	MS	F	P
Total	89	9284.79			
Between	2	1094.02	547.01	5.81	.01
I vs II, III	1	906.76	906.76	9.63	.01
Error	87	8190.77	94.14		

The analysis of variance data for the Spatial Relations test are presented in Table 24.

The F-values indicate a significant difference between the means of these groups. The F-value for the comparison of Group I (successful engineering graduates) with Groups II and III (those who did not succeed) is also significant beyond the .01 level of confidence. However, when the t-test was applied to these data, it was discovered that the difference between the means of Groups II and III is no greater than that to be expected as a result of chance fluctuation in random sampling. These results are shown in Table 25.

TABLE 25

Significance of Differences Between Means of Groups I, II and III on Spatial Relations Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	8.5	4.17	58	.001
$t_{I, III}$	5.0	2.45	58	.05
$t_{II, III}$	3.5	1.72	58	not sig.

The results in the table further indicate that Group I (engineering graduates) differs significantly at the .05 level or beyond from each of the other groups. These results imply that the ability to visualize objects in space in reference to the human body is important for success in engineering school, but apparently the non-engineering graduates do not differ in spatial orientation ability as measured by this test from those who drop out of the engineering program and do not seek a college education in some other curriculum.

g. Spatial Visualization. Means on the Spatial Visualization test for the three groups are presented in Table 26.

TABLE 26

Means and N's for Groups I, II and III on Spatial Visualization Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	37.8	27.2	27.1	30.7	12.87
N	30	30	30	90	

The mean for Group I is 10.6 points higher than that for Group II, but the mean for Group II is only .1 point higher than that of Group III. The analysis of variance data for this test are shown in Table 27.

TABLE 27

Analysis of Variance of Spatial Visualization Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	16679.66			
Between	2	2261.62	1130.81	6.82	.01
I vs II, III	1	2261.36	2261.36	13.6	.01
Error	87	14418.04	165.72		

The F-values are significant beyond the .01 level of confidence for both the between-group and the comparison of Group I with Groups II and III. The t-test data, presented in Table 28, reveal that the significant differences are between the engineering graduates and the other groups.

TABLE 28

Significance of Differences Between Means of Groups I, II and III on Spatial Visualization Test Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	10.6	3.22	58	.01
$t_{I, III}$	10.7	3.25	58	.01
$t_{II, III}$	.1	$<1.$	58	not sig.

It appears that the Spatial Visualization test discriminates between the engineering graduates (Group I) and those who are not successful in the engineering program (Groups II and III); however, there is no significant difference between the non-engineering graduates and the drop-outs in terms of this ability.

Lawshe (20) suggests that spatial visualization tests are essentially measures of abstract intelligence or abstract reasoning. The results of the current investigation tend to substantiate Lawshe's argument in view of the fact that the trend (Group I significantly different from Groups II and III, but no difference between Groups II and III) is the same for the ACE test (which is considered to be a measure of general intelligence), and the Cooperative Algebra, General Reasoning, Numerical Operations and Spatial Orientation tests. Attempts were made by the authors to remove, at least not stress, the general reasoning factor in this test, and it appears to discriminate between these groups as do other tests of abstract intelligence and general reasoning.

f. Mechanical Experience. The results of the Mechanical Experience test are rather interesting in that a somewhat different picture is presented and different implications must be inferred. Table 29 shows the means to be in a similar pattern on this test as on some of the other tests.

TABLE 29

Means and N's for Groups I, II and III on Mechanical Experience Test Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	35.1	28.8	32.3	32.1	8.51
N	30	30	30	90	

The analysis of variance data are presented in Table 30.

TABLE 30

Analysis of Variance of Mechanical Experience Test Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	6901.60			
Between	2	597.80	298.90	4.13	.05
I vs II, III	1	414.04	414.04	5.7	.05
Error	87	6303.80	72.46		

The analysis results in a significant F-value, at the .05 level of confidence, for between-groups and for the comparison between Group I and an average of Groups II and III. The unique results are revealed by an inspection of Table 31 which shows the t-values for testing the significance of the difference between the means for each combination of groups.

TABLE 31

Significance of Differences Between Means of Groups I, II and III on Mechanical Experience Test Data

	Difference Between Means	t-values	df	P
$t_{I,\ II}$	6.3	2.88	58	.01
$t_{I,\ III}$	2.8	1.28	58	not sig.
$t_{II,\ III}$	3.5	1.60	58	not sig.

The engineering graduates differ significantly from the non-engineering graduates with respect to mechanical experience as measured by this test, but the engineering graduates do not differ from the drop-outs in this capacity. This is the only test in which Group I does not differ from Group III. Neither do the non-engineering graduates differ from the drop-outs as far as acquired mechanical knowledge or experience with tools is concerned. A possible explanation or interpretation of these results is that those students who comprise the drop-out group are an example of the young boys in senior high school whose interests are in owning and tinkering with old cars (the "hot-rod" group). They, perhaps become very familiar with tools and acquire a great deal of mechanical knowledge, but upon entering college find that they lack the ability to effectively master the more formal and academic courses in the engineering curriculum or even in any other curriculum leading to a bachelor's degree. The engineering graduates still maintain their superiority, however, which indicates that mechanical knowledge is associated with success in engineering school, although it apparently is not necessary for success in other programs of study outside of engineering. A further implication is that the drop-outs of the engineering program might well succeed in some job requiring mechanical skill but which does not demand a professional engineering education.

Summary of Ability Test Data

Table 32 presents a summary of the analysis of the ability tests.

TABLE 32

Summary Table of Significant Data for Ability Tests Employed in the Investigation (Means for Groups I, II and III, Combined Mean and Standard Deviation for the Three Groups and F-values)

Test	Mean				SD	F
	I	II	III	Comb.		
ACE	116.1	104.4	93.0	104.5	22.06	8.25**
Coop. Algebra	41.2	28.8	23.9	32.0	12.02	12.40**
Eng. Place.	74.0	65.3	39.1	60.8	24.47	11.91**
Verb. Comp.	28.4	25.7	19.8	24.6	10.87	4.98**
Gen. Reas.	16.1	12.2	10.1	12.8	4.83	11.82**
Num. Oper.	63.3	52.3	51.5	55.7	17.5	4.27*
Perc. Speed.	47.3	43.1	44.7	45.0	2.18	27.96**
Spatial Relations	24.3	15.8	19.3	19.8	9.7	5.81**
Spatial Vis.	37.8	27.2	27.1	30.7	12.87	6.82**
Mech. Experience	35.1	28.8	32.3	32.1	8.51	4.13*

* Significant at the .05 level of probability
** Significant at the .01 level of probability

It is interesting to note that the means for the engineering graduates on the tests studied are significantly higher than the means for either the non-engineering graduates or the drop-outs. The means for the non-engineering graduates are higher than the means for the drop-outs for every test except Perceptual Speed, Spatial Orientation and Mechanical Knowledge. The F-values for scores on Numerical Operations and Mechanical Knowledge are significant at the .05 level of confidence and all other F-values are significant beyond the .01 level of confidence.

For a more complete picture of the situation, the t-values are presented in Table 33.

TABLE 33

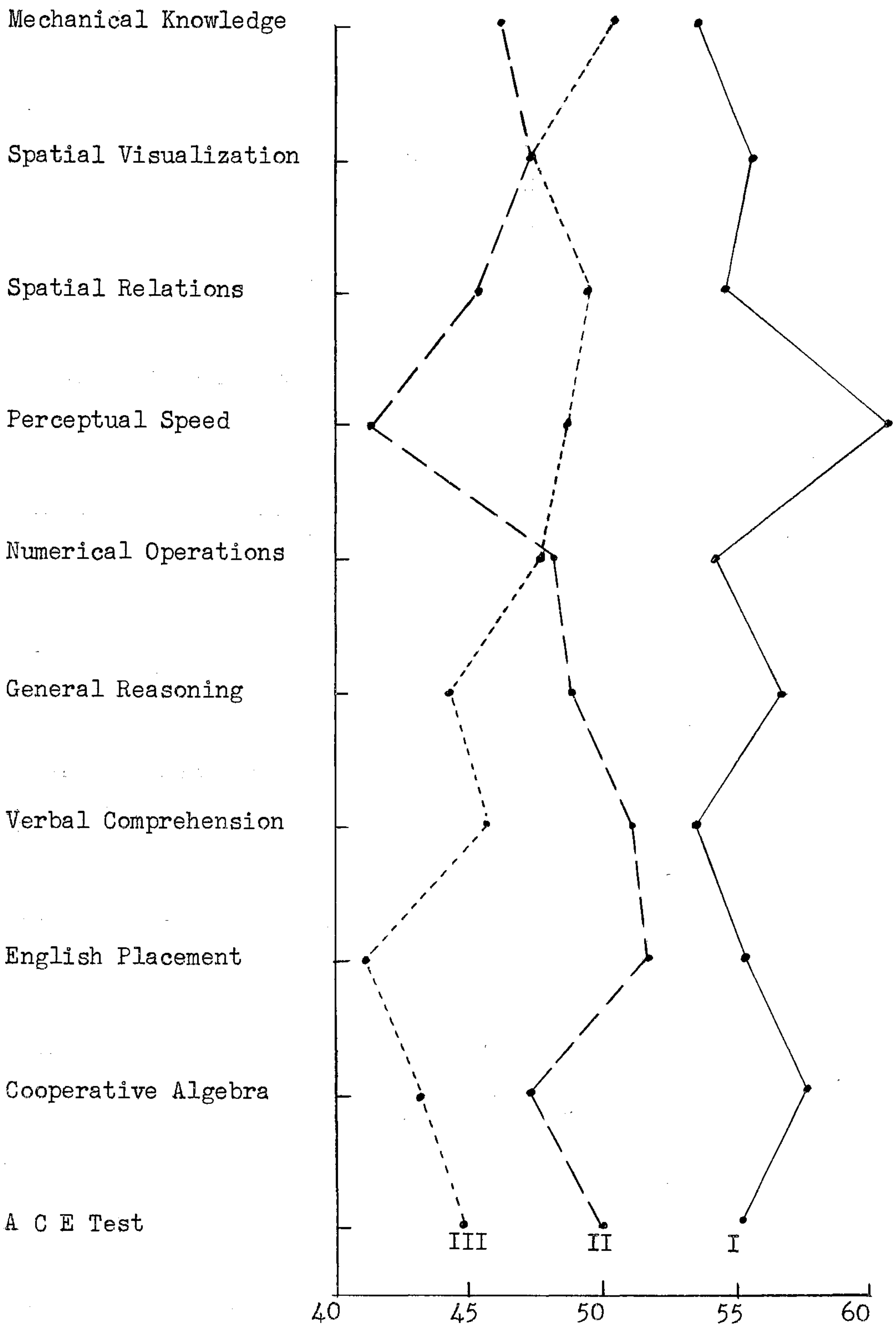
Significance of Differences Between Means of Groups I, II and III on Ten Measures of Ability used in this Investigation

Test	$t_{(I, II)}$	$t_{(I, III)}$	$t_{(II, III)}$
ACE	2.042*	4.09**	1.99
Coop. Algebra	3.57**	4.74**	1.31
Eng. Place.	1.23	4.75**	3.54**
Verb. Comp.	.97	3.12**	2.14*
Gen. Reas.	3.17*	4.88**	1.71
Num. Oper.	2.21*	2.63**	.17
Perc. Speed	7.50**	4.64**	2.86**
Spatial Relations	4.17**	2.45*	1.72
Spatial Visual.	3.22**	3.25**	<1
Mech. Experience	2.88**	1.28	1.60

* Significant at the .05 level of probability
** Significant at the .01 level of probability

The engineering graduates tended to score significantly higher than the non-engineering graduates on all tests but English Placement and Verbal Comprehension. Engineering graduates do not differ from other college graduates in terms of these verbal abilities, i.e., achievement in English grammar and verbal comprehension aptitude. Furthermore it is evident that the engineering graduates differ significantly from the drop-outs on all abilities as measured by these tests with the exception of mechanical knowledge. On the other hand only three of the tests discriminate between the non-engineering graduates and the drop-outs. They are English Placement, Verbal Comprehension and Perceptual Speed. The drop-outs do better on the Perceptual Speed test than the non-engineering graduates. Apparently the ability to comprehend verbal concepts and a knowledge of English grammar are significant factors for successfully graduating from college regardless of the school one attends. They are the only abilities represented by these tests in which the non-engineering graduates are significantly higher than the drop-outs. In conclusion, the results imply that: (1) the engineering students appear to need certain specific and abstract abilities in addition to general verbal abilities and achievement in English to succeed in the engineering program; (2) the lack of verbal comprehension and adequate achievement in English is associated with failure to graduate from college, and (3) many engineering freshmen who seem to lack desirable mental abilities for success in engineering school might, as a result of effective counseling, succeed in other programs of study inasmuch as those who transfer to other programs and graduate are not significantly more capable in any of the abilities considered in this study except verbal comprehension and knowledge of English grammar.

The results of the analysis of the mental ability test data are presented graphically in Figure 1.



Group I Engineering graduates
Group II Non-engineering graduates
Group III Drop-outs

Figure 1. A Profile showing the mean scores of the ability tests for Groups I, II and III in standard scores with a mean of 50 and a standard deviation of 10.

In order to show the relative standings of the three groups on the tests, the mean raw scores were converted to standard scores with a mean of 50 and a standard deviation of 10. Again, it is immediately seen that the trend is for engineering graduates to score higher on all of the tests but as was pointed out earlier they do not score significantly higher on Verbal Comprehension and English Placement than Group II, nor significantly higher in Mechanical Knowledge than Group III. The differences between Groups II and III are not nearly as striking as those between Groups I and II. The most pronounced differences seem to exist on the Perceptual Speed test with the engineering graduates scoring over one standard deviation above the mean and the non-engineering graduates scoring approximately .85 standard deviations below the mean. A possible explanation of these differences was presented earlier in the discussion.

The results of the preceding analyses justified the writer in rejecting hypothesis 1, that there are no significant differences between the means of the ability test scores for the three groups. The hypothesis was rejected at the .05 level of probability or beyond for each test.

Interest Patterns

An analysis of variance was made for each scale of the Kuder Preference Record in order to test the second hypothesis, that there are no significant differences between the groups with respect to measured interests. The hypothesis was rejected for two of the scales (Scientific and Clerical); however, the difference between the groups on the other scales was found to be no larger than that which could be attributed to chance fluctuations in random sampling. The null hypothesis for those scales could not be rejected and had to be accepted as tenable.

The analysis of variance data for the Scientific scale are presented in Table 34. The F-value is significant beyond the .01 level of confidence for between-groups and for the comparison between Group I and an average of Groups II and III.

TABLE 34

Analysis of Variance of Scientific Scale Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	18648.46			
Between	2	2914.49	1457.25	8.06	.01
I vs II, III	1	2912.09	2912.09	16.1	.01
Error	87	15733.97	180.85		

The raw score means for the three groups are shown in Table 35.

TABLE 35

Means and N's for Groups I, II and III on Scientific Scale Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	74.0	61.7	62.1	65.9	13.45
N	30	30	30	90	

The means are 74.0, 61.7 and 62.1 respectively. The mean score for the drop-outs is slightly higher than that for the non-engineering graduates although not significantly so, as verified by the t-test. These data are presented in Table 36.

Engineering graduates have high scientific interests which according to Kuder's interpretation means that they "like to discover new facts and solve problems" (19). Kuder (19) further reports that "doctors, chemists, nurses, engineers, radio repairmen, aviators and dietitians usually have scientific interests."

TABLE 36

Significance of Differences Between Means of Groups I, II and III on Scientific Scale Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	12.3	3.58	58	.01
$t_{I, III}$	11.9	3.46	58	.01
$t_{II, III}$	.4	<1	58	not sig.

There is also a difference in clerical interest for the groups as indicated by the significant F when an analysis of variance was made for this scale. These data are presented in Table 37.

TABLE 37

Analysis of Variance of Clerical Scale Scores for Groups I, II and III

Source	df	SS	MS	F	P
Total	89	16285.16			
Between	2	1276.03	638.02	3.70	.05
I vs II, III	1	1070.67	1070.67	6.2	.05
Error	87	15009.13	172.52		

The F-value is significant at the .05 level of confidence for both between groups and a comparison of Groups I vs. II and III. The table of means is presented as 38.

The data reveal that the engineering graduates scored the lowest (47.3), the drop-outs scored highest (56.5), and the non-engineering

TABLE 38

Means and N's for Groups I, II and III on Clerical Scale Data with the Mean and Standard Deviation for the Three Groups Combined

	I	II	III	Combined	SD
M	47.3	52.8	56.5	52.5	13.13
N	30	30	30	90	

graduates scored in between (52.8).

When t-tests were made to test the significance of the difference between these means, the results in Table 39 were obtained.

TABLE 39

Significance of Differences Between Means of Groups I, II and III on Clerical Scale Data

	Difference Between Means	t-values	df	P
$t_{I, II}$	5.5	1.63	58	not sig.
$t_{I, III}$	9.2	2.74	58	.01
$t_{II, III}$	3.7	1.10	58	not sig.

The significant difference is between Groups I and II, while Group II does not differ significantly from either Group I or Group III. These results imply that those who drop out of the engineering program may be more likely to "like office work that requires precision and accuracy" than do those who succeed in graduating from the program (19). This is in contrast to the results obtained by Barnette (1) who found that the successful engineering students scored significantly higher on the Clerical scale of the Kuder Preference Record than the unsuccessful.

No significant differences at the .05 level or beyond were found to exist between the groups on any of the other scales of the Kuder Preference Record when an analysis of variance was made. Table 40 presents a summary of the results of the analyses.

TABLE 40

Summary Table of Significant Data for Interest Scales Employed in this Investigation (Means for Groups I, II and III, Combined Mean and Standard Deviation for the Three Groups and F-values)

Scale	Mean				SD	F
	I	II	III	Comb.		
Mech.	92.7	84.0	89.1	88.6	18.53	1.67
Comp.	37.7	36.9	40.6	38.4	9.85	1.16
Scien.	74.0	61.7	62.1	65.9	13.45	8.06**
Persuas.	69.3	75.8	71.6	72.2	17.70	1.02
Art.	51.9	50.3	53.3	51.8	14.18	< 1
Lit.	40.1	46.9	44.4	43.8	14.53	1.68
Mus.	14.5	17.4	14.2	15.4	8.78	1.23
Soc. Serv.	61.3	58.4	57.8	59.2	17.47	< 1
Cler.	47.3	52.8	56.5	52.2	13.13	3.70*

* Significant at the .05 level of probability.
** Significant at the .01 level of probability.

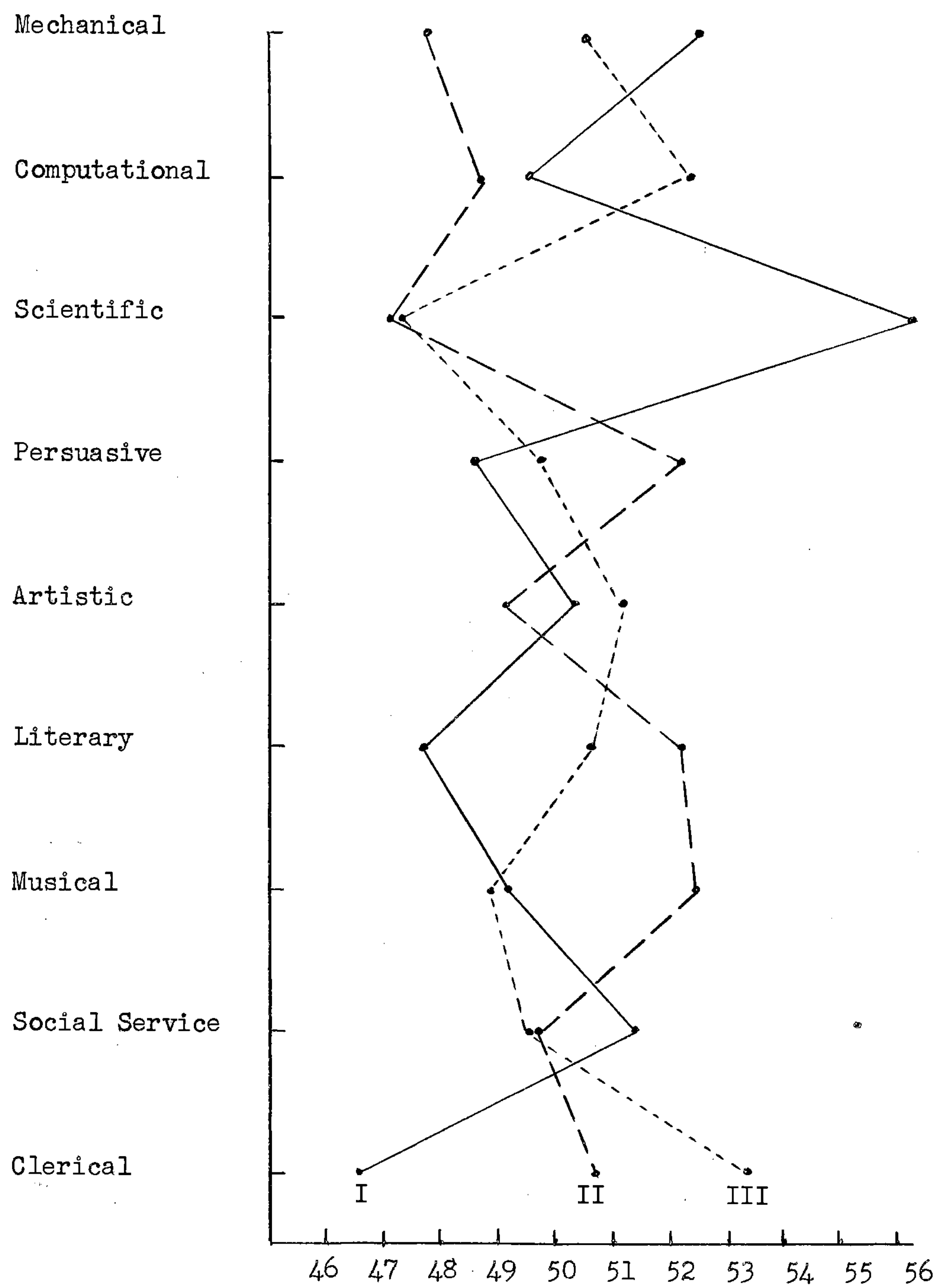
Some of these results are of interest in that they are not what one might suspect. Mechanical interest, for example, is usually very high for engineering students, but apparently it is no higher for those engineering students who graduate from an engineering program than for those who transfer to another program, or from those who drop out. The trend, although not significant, is for the engineering graduates to have higher mechanical interest scores than the other two groups. The drop-out group, however, seems to have a higher mechanical interest than the non-engineering graduates. These results seem to follow the same pattern as those for the analysis of the Mechanical Experience test discussed earlier. This indicates that mechanical interest and mechanical knowledge might be related.

Another interesting result appears in examining the means of the Computational scale. The differences are not significant but the mean for the drop-out group is higher than the means for the other two groups. Perhaps these students have a higher (although not significant) computational interest than the engineering graduates, but their ability to deal with numerical operations and concepts is not as great as those who succeed in graduating from the engineering program as was shown by the analysis of the Cooperative Algebra and Numerical Operations tests.

The results of the analysis of data from the Persuasive, Artistic, Literary, Musical and Social Service scales are not significant and do not present any unusual trends.

The results of the analysis of the Kuder Preference Record are represented graphically in Figure 2. The raw scores of the scales were transformed to standard scores, with a mean of 50 and a standard deviation of 10, for purposes of comparison. The figure shows the three groups to be much more homogeneous with respect to measured interests than they are with respect to ability (see Figure 1, page 50).

The most noticeable difference is on the Scientific scale where the engineering students score 1.1 standard deviation above the mean. The



Group I Engineering graduates
Group II Non-engineering graduates
Group III Drop-outs

Figure 2. A Profile of the means of the nine interest scales of the Kuder Preference Record in standard scores with a mean of 50 and a standard diviation of 10.

only other significant difference is on the Clerical scale where the engineering graduates score almost .9 standard deviation below the mean and the drop-outs score slightly more than .3 standard deviation above the mean.

Personality Adjustment

When an analysis of variance was made for the nine clinical scales of the MMPI, none of the F-values were found to be significant at the .05 level of probability or beyond. In other words no significant differences between the means of the three groups on any of the scales were found and hypothesis 3 had to be accepted as tenable. This suggests that there is no "engineering personality," as measured by the nine scales on the MMPI.

Table 41 is a summary of the results obtained from an analysis of the scales.

TABLE 41

Summary Table of Significant Data for Personality Scales Employed in this Investigation (Means for Groups I, II and III, Combined Mean and Standard Deviation for the Three Groups, and F-values)

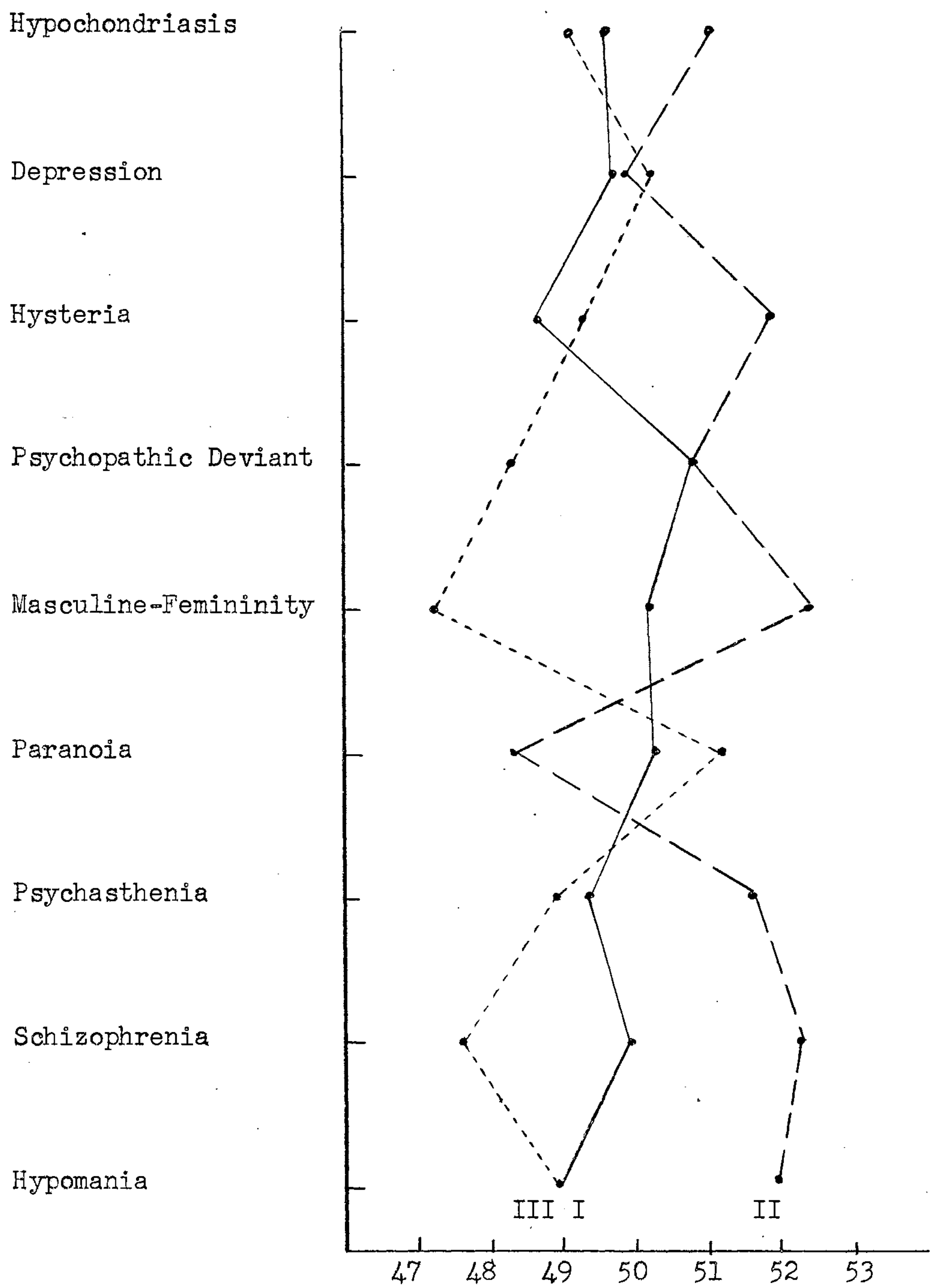
	Mean					
Scale	I	II	III	Comb.	SD	F
Hs	11.8	12.3	11.7	11.9	3.52	<1
D	18.1	18.2	18.8	18.4	14.52	<1
Hy	18.8	20.3	19.1	19.4	4.72	<1
Pd	22.1	22.1	21.3	21.8	3.98	<1
Mf	24.0	25.0	22.8	23.9	4.76	1.56
Pa	9.2	8.6	9.5	9.1	3.18	<1
Pt	26.7	27.8	26.7	27.0	4.76	<1
Sc	25.3	26.5	24.2	25.3	5.21	1.54
Ma	19.1	20.3	19.2	19.5	3.9	<1

None of the F-values even approach significance; however, the data do present several trends. These will be discussed later. All groups apparently are equally well-adjusted as measured by the MMPI.

Figure 3 presents a picture of the personality adjustment patterns for the three groups. The means are plotted in standard score units (with a mean of 50 and a SD of 10) in order to compare one scale with another. The line (solid) representing the engineering graduates does not deviate much from 50 (the mean of the distribution) and on nearly all scales (except Hy) lies between the lines representing the other two groups. The non-engineering graduates (dashed line) tend to score highest on all scales except D and Pa (on which they are the lowest). Although none of these differences are significant, the trends might be indicative of a unique pattern of personality characteristics that would describe each group as a general class.

Summary of Ability, Interest and Personality Test Data

The three groups can be compared with respect to ability, interest, and personality by examining Figures 1, 2 and 3. It is seen immediately that the groups are quite homogeneous in terms of personality adjustment (Figure 2); but the wide differences in abilities (Figure 1) indicate a very pronounced heterogeneous sample. One might conclude, on the basis of these results, that it is primarily in the realm of mental abilities that one can discriminate between those who might succeed in graduating from Engineering School and those who might not. It further can be concluded that mental capacity is primarily the deciding factor in determining the difference between those engineering students who will succeed in Engineering School, those who will graduate



Group I Engineering graduates
Group II Non-engineering graduates
Group III Drop-outs

Figure 3. A profile of the means of the nine clinical scales of the Minnesota Multiphasic Personality Inventory for Groups I, II and III in standard scores with a mean of 50 and a standard deviation of 10.

from some other school on the campus, and those who will drop out.

The Discriminant Function

Significant differences were found between the means of the three groups on twelve of the twenty-eight tests involved in this study. Each of the twelve tests when used individually is therefore useful to the personnel officer in advising freshmen engineering students. Psychologists and counselors unanimously agree, however, that some type of composite measure, based on different aspects of behavior, is more useful for guidance than are individual measures.

One further step in this research is to develop a composite measure which will distinguish between the engineering graduates, the non-engineering graduates, and the drop-outs. The composite measure is based on four of the twelve variables on which significant F-values were obtained from the analysis of variance. All twelve variables might have been used, but the arithmetical computations involved (solving twelve simultaneous equations with twelve unknowns) would be too laborious for a study of this nature. The four variables selected were: (1) total scores on the ACE test, (2) Verbal Comprehension, (3) General Reasoning, and (4) Scientific Interest. These particular four variables were empirically selected on the basis of rules recommended by Garrett (12). He suggests that the correlation of each test with the criterion be high, but the intercorrelations among the tests be low. In this instance, each of the four selected tests is estimated to have a high correlation with the criterion because the F-values obtained in the analysis of variance for these tests are significant at the .01 level of probability or beyond. They are further believed to have reasonably low intercorrelations because, on the basis of the descriptions of the tests, they appear to measure different aspects of human behavior.

Discriminate analysis is a method of estimating the relationship between two variables when one occurs as a continuous function and the other occurs as a dichotomy (or a trichotomy, etc.). Multiple discriminate analysis is similar to multiple regression analysis except that in the former a multiple biserial R (triserial R, etc.) is obtained and the latter results in a multiple product-moment R. Multiple discriminate analysis, like multiple regression analysis, results in an equation which can be used for predicting the criterion dichotomy (or trichotomy, etc.).

The discriminate equation was originally developed by Fisher (11) and recently has been found useful in educational and psychological research. It seems to be particularly useful and appropriate for attrition-survival studies in an educational program or in specific courses (35). It has also been useful in finding patterns or combinations of abilities, interests and personality traits which distinguish certain groups (35). The present study involves both of these applications. The development of the method is included in some detail since it is unfamiliar to many workers in psychology and education. The analysis is based upon the 30 subjects in each group studied in this investigation.

The general formula for computing any multiple point serial R is (35)

$$R_p = \frac{1}{\sqrt{\Sigma\left[\frac{(Z_l - Z_h)^2}{p}\right]}} \sqrt{\frac{\Delta}{N}}$$

which is more conveniently written as

$$R_p = \sqrt{\frac{\Delta}{N\Sigma\left[\frac{(Z_l - Z_h)^2}{p}\right]}}$$

and where Δ equals the differences in the means of predicted scores for the groups

N = the number of cases

Z_l = height of ordinate at lower end of interval

Z_h = height of ordinate at upper end of interval

p = proportion of total group in a category

The general equations for deriving the discriminant function from four variables are: (34)

$$\sum x_1y = a_1\sum x_1^2 + a_2\sum x_1 x_2 + a_3\sum x_1 x_3 + a_4\sum x_1 x_4$$
$$\sum x_2y = a_1\sum x_1 x_2 + a_2\sum x_2^2 + a_3\sum x_2 x_3 + a_4\sum x_2 x_4$$
$$\sum x_3y = a_1\sum x_1 x_3 + a_2\sum x_2 x_3 + a_3\sum x_3^2 + a_4\sum x_3 x_4$$
$$\sum x_4y = a_1\sum x_1 x_4 + a_2\sum x_2 x_4 + a_3\sum x_3 x_4 + a_4\sum x_4^2$$

where

x_1 = ACE raw score

x_2 = Verbal Comprehension raw score

x_3 = General Reasoning raw score

x_4 = Scientific Interest raw score

Table 42 presents both the information needed to solve the left-hand side of the equations and the data for computing the multiple triserial R.

The z-values (ordinates) were obtained from a table of ordinates and areas of the normal curve. The $Z_l - Z_h$ values were obtained by subtracting the z value at the top of the interval from the interval at the bottom.

The $\frac{Z_l - Z_h}{p}$ column are the y values to be used in solving the $\sum xy$'s for the simultaneous equations listed above. The $\frac{(Z_l - Z_h)^2}{p}$ column is to be used in computing the multiple triserial R. The sums for the tests were previously computed in the analysis of variance.

TABLE 42

INFORMATION FOR DERIVING DISCRIMINATE FUNCTION AND MULTIPLE TRISERIAL R

Group	N	P	Z	S_1-Z_h	$\frac{Z_1-Z_h}{p}$ (y)	$\frac{(Z_1-Z_h)^2}{p}$	Sums ACE	Sums VERB REAS.	Sums GEN REAS.	Sums SCIEN INT.
			0							
I	30	.33 1/3		.3636	1.0909	.4015	3483	853	483	2219
			.3636							
II	30	.33 1/3		0	0	0	3132	770	366	1851
			.3636							
III	30	.33 1/3		-.3636	1.0909	.4015	2789	594	304	1863
			0							
Total	90	1.00								
						.8030	49860.22	11354.90	2577.79	18648.46

The $\sum xy$ values are as follows:

$\sum x_1 y = 694$

$\sum x_2 y = 259$

$\sum x_3 y = 179$

$\sum x_4 y = 356$

The cross products needed to substitute in the right-hand side of the general equations are:

$\sum x_1 x_2 = 17114$	$\sum x_2 x_3 = 2039$
$\sum x_1 x_3 = 6412$	$\sum x_2 x_4 = 1515$
$\sum x_1 x_4 = 5561$	$\sum x_3 x_4 = 689$

When the xy values and the cross products are substituted in the general equations, they become:

$$694 = 49860a_1 + 17114a_2 + 6412a_3 + 14235a_4$$

$$259 = 17114a_1 + 11355a_2 + 2039a_3 + 4453a_4$$

$$179 = 6412a_1 + 2039a_2 + 2578a_3 + 1880a_4$$

$$356 = 14233a_1 + 4453a_2 + 1880a_3 + 18648a_4$$

When this system of equations is solved simultaneously, the following values for the weights are obtained:

$a_1 = .002092$

$a_2 = .006168$

$a_3 = .051452$

$a_4 = .010834$

which when substituted in the equations yield the discriminant function in deviation form

$$v = .002092\ x_1 + .006168\ x_2 + .051452\ x_3 + .010834\ x_4$$

The value of Δ can now be determined by substituting in the following equation the previously computed values of the weights and $\sum xy$'s.

$$\Delta = a_1 \sum x_1 y + a_2 \sum x_2 y + a_3 \sum x_3 y + a_4 \sum x_4 y$$

$$\Delta = 16.116172$$

By substituting in the formula for serial correlation, R is computed

$$R = \sqrt{\frac{\Delta}{N \sum \left[\left(\frac{Z_l - Z_h}{p} \right)^2 \right]}}$$

$$R = .472$$

and when adjusting for coarse grouping (35)

$$R = (.472)\ (1.088) = .51$$

To test whether the multiple correlation is significantly different from zero the F-value was calculated from the formula

$$F_{m, N-m-1} = \frac{\Delta (N - m - 1)}{\left[N \sum \left(\frac{Z_l \quad Z_h}{p} \right)^2 - \Delta \right] m}$$

m = number of tests

N = number of cases

$$F_{4, 85} = 4.822$$

This value is significant beyond the .01 level of confidence and indicates that the multiple triserial R of .51 is different from zero.

Analysis of Maximum Separation

The question as to whether the composite measure distinguishes between the groups can be answered by applying the following F-test (35).

$$F_{m, N-m-1} = \frac{N-m-1}{m} \left(\frac{k_1 \quad k_2 \quad k_3}{N} \right) D$$

where

D = difference in means of the three groups on the four variables and k_1 K_2 K_3 are the frequencies in the distribution.

The differences in the means for each of the tests are shown in Table 43. D is found by substituting the differences of the means for the four tests for x_1, x_2, x_3 and x_4 in the discriminant function.

TABLE 43

Differences Between Means of Groups on Four Measures Employed in the Discriminant Analysis.

	ACE d_1	VERB. COMP. d_2	GEN. REAS. d_3	SCIEN. INT. d_4
Group I vs II	11.7	2.7	3.9	2.3
Group II vs III	11.4	5.9	2.1	9.6

Thus:

$$D_{(I,II)} = (.002092)\ (11.7) + (.006168\ \ (2.7) + (.051452)\ (3.9) + (.010834)\ (2.3) = .266711$$

$$D_{(II,III)} = (.002092)\ (11.4) + (.006168)\ (5.9) + (.051452)\ (2.1) + (.010834)\ (.6) = .272296$$

The F-value can now be computed as follows:

$$(I,\ II)\ F\ 4,85 = \frac{60-4-1}{4}\ \frac{(30x30)}{(60)}\ (.266711) = 55.07$$

$$(II,\ III)\ F\ 4,85 = \frac{(60-4-1)}{4}\ \frac{(30x30)}{60}\ (.272296) = 56.10$$

Both F-values are significant far beyond the .01 level of probability and offer ample evidence that the composite score of the four variables does discriminate between the groups.

Critical Scores

The discriminant function is often used to determine critical scores for various groups or categories. Critical scores are very useful to the counselor because they enable him to report to the student which group his particular pattern of traits most nearly parallels.

For this study critical scores may be found by solving the discriminant function three times, once by substituting the mean values of the tests for the engineering graduates, then the mean values for the non-engineering graduates, and a third time by substituting the mean values of the drop-outs in the discriminant equation.

Table 44 presents the mean scores for the three groups on each test used in the discriminant analysis.

TABLE 44

Mean Scores for the Four Measures Employed in the Discriminant Analysis

GROUP	ACE x_1	VERB. COMP. x_2	GEN. REAS. x_3	SCIEN. INT. x_4
I	116.1	28.4	16.1	74.0
II	104.4	25.7	12.2	61.7
III	93.0	19.8	10.1	62.1

When the discriminant function is solved using the mean values in Table 44, the following predicted v-scores are obtained:

$v = 2.048146$ (Group I)
$v = 1.673095$ (Group II)
$v = 1.509139$ (Group III)

The critical scores are considered to be midway between the predicted v-scores and are as follows:

Group I = 1.860621 and above
Group II = Between 1.591117 and 1.860621
Group III = 1.591117 and below

If a student's raw scores on the four tests are inserted in the discriminant function a v-score results for him. If the v-score is greater than 2.048146, his pattern of measured traits most closely resembles that of the engineering graduates. If his v-score lies between 1.591117 and 1.860621, he is most apt to be like those engineering students who transfer to another college on the campus and graduate, in terms of the traits measured by these four tests. On the other hand, if his v-score is below 1.591117 his pattern of measured traits is more in line with those engineering students who drop out of school.

The discriminant function and critical scores are of the utmost value to the counselor in effectively guiding freshman engineering students. The counselor must, however, exercise caution and discretion in using and interpreting the discriminant function. This is particularly so if predicted v-scores are on the border line between the critical scores of two groups. At this point the counselor must rely more heavily on other sources of information in counseling the student such as grades, motivation, part-time work activities and general attitude toward the engineering program.

CHAPTER V

SUMMARY AND CONCLUSIONS

General Summary of the Investigation

It must be made clear to the reader that this investigation did not attempt to compare, on the basis of scores from the tests used in this study, engineering students at Oklahoma Agricultural and Mechanical College with students enrolled in other schools on the campus. Neither were the scores made by engineering students on these tests compared with national norms, although this might be of interest and might be a worthwhile study.

The investigator was interested in testing the null hypotheses that the three groups of engineering students did not differ in ability, interest and personality adjustment as measured by certain standardized tests.

The primary purpose of this study was to investigate whether the following objective measures (1) American Council on Education Psychological Examination, (2) Cooperative Algebra test, (3) Oklahoma Agricultural and Mechanical College English Placement test, (4) Guilford-Zimmerman Aptitude Survey, (5) Kuder Preference Record, and (6) Minnesota Multiphasic Personality Inventory, offer information which could be employed by the counselor in assessing the likelihood of student survival through graduation in the engineering program at Oklahoma Agricultural and Mechanical College. The general procedure for the investigation was to randomly select thirty students from each of three groups of engineering students: (1) those who successfully completed the program and graduated, (2) those who transferred to another school on the campus and graduated, and (3) those who dropped out of the engineering program and did not transfer to another school on the campus. The analysis of variance technique was applied to the data of each of the ability, interest and personality measures that were administered to the students during the first semester of their freshman year. Four of the test variables, which seemed appropriate, were selected as a composite measure and were used in computing a multiple discriminant function, a triserial R and critical scores for the three groups.

Summary of Results

The results of the study may be summarized as follows:

(1) Each of the ability tests resulted in a significant F-value. The engineering graduates scored significantly higher (at the .05 level of probability or beyond) than the non-engineering graduates on all tests except English Placement and Verbal Comprehension. The engineering graduates scored significantly higher than the drop-out group on all tests except Mechanical Experience. There were no significant differences between the non-engineering graduates and the drop-outs except in English Placement, Verbal Comprehension and Perceptual Speed. The mean values for the English Placement and Verbal Comprehension tests were significantly higher for the non-engineering graduates, but the drop-outs scored significantly higher on Perceptual Speed. The implications of these results were that verbal ability is of the utmost importance in graduating from any college program; however, engineering graduates must, in addition to verbal ability, possess certain abstract abilities such as general reasoning and the ability to work effectively with mathematical concepts.

(2) Significant differences were found to exist among the groups on the Scientific and Clerical scales of the Kuder Preference Record. The engineering graduates had significantly higher scientific interests than either the non-engineering graduates or the drop-outs. There was no significant difference, however, between the non-engineering graduates and the drop-outs on this scale. The engineering graduates scored significantly <u>lower</u> (the .05 level of probability or beyond) on the clerical scale than did the drop-outs, but there were no significant differences between the engineering graduates and non-engineering graduates in clerical interest. Neither were the differences significant between the non-engineering graduates and the drop-outs. None of the other scales of the Kuder Preference Record resulted in a significant F-value.

(3) The analysis of the nine clinical scales of the Minnesota Multiphasic Personality Inventory failed to provide any evidence of an "engineering personality." None of the scales seemed to discriminate between the three groups, however, several trends were noted and discussed.

(4) The three groups differed widely in terms of ability, were somewhat more homogeneous with respect to interests, but were very much alike in terms of personality characteristics.

(5) Four of the tests (ACE, Verbal Comprehension, General Reasoning and Scientific Interest) were selected as a composite measure for predicting purposes. The multiple discriminate function was found to be

$$v = .002092x_1 + .006168x_2 + .051452x_3 + .010834x_4$$

and the multiple triserial R was .51 which was found to be significantly different from zero. The critical scores were as follows:

Group I = 1.860621 and above

Group II = Between 1.591117 and 1.860621

Group III = 1.591117 and below

The analysis of maximum separation yielded significant F-values which gave evidence to conclude that the composite measure discriminates or distinguishes between the three groups.

Concluding Statement

There is unanimous agreement that no mathematical analysis of a single factor or a combination of factors for predicting success in engineering school will be one hundred percent satisfactory. There is further agreement, however, that prediction should be based upon more than random choice, and guidance should be based upon more than hasty interviews. The writer offers the results of this study in the hope that they may be useful in guiding and counseling engineering freshmen more effectively and scientifically.

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A P P E N D I X   A

Distribution of Percentile Ranks for Raw Score

Test Data for Groups I, II and III

TABLE A-1

Distribution of Percentile Ranks for ACE Raw Scores for Groups I, II and III.

Raw Scores	I	II	III
165	99	99	99
160	98	99	99
155	96	99	99
150	94	98	99
145	91	97	99
140	86	95	98
135	81	92	97
130	74	88	95
125	66	83	93
120	57	77	89
115	48	69	84
110	39	61	78
105	31	52	71
100	23	43	63
95	17	34	54
90	12	26	44
85	8	19	36
80	5	14	28
75	3	9	21
70	2	6	15
65	1	4	10
60	1	2	7
55	0	1	4
50	0	1	3
45	0	0	1
40	0	0	0

TABLE A-2

Distribution of Percentile Ranks for Cooperative Algebra Raw Scores for Groups I, II and III

Cooperative Algebra	I	II	III
70	99	99	99
65	98	99	99
60	94	99	99
55	88	99	99
50	77	96	99
45	63	91	96
40	47	82	91
35	31	69	82
25	9	37	53
20	4	23	37
15	1	12	23
10	0	6	12
5	0	2	6

TABLE A-3

Distribution of Percentile Ranks for English Placement Raw Scores for Groups I, II and III

Raw Scores	I	II	III
190	99	99	99
130	99	99	99
120	97	99	99
110	93	97	99
100	86	92	99
90	74	85	98
80	59	73	95
70	44	58	90
60	28	42	81
50	16	27	67
40	8	15	52
30	4	8	36
20	1	3	22
10	0	1	12

TABLE A-4

Distribution of Percentile Ranks for Verbal Comprehension Raw Scores for Groups I, II and III

Raw Scores	I	II	III
60	99	99	99
55	99	99	99
50	98	99	99
45	94	96	99
40	86	91	97
35	74	81	92
30	57	66	83
25	39	48	68
20	23	30	51
15	13	16	33
10	5	7	18
5	2	3	9

TABLE A-5

Distribution of Percentile Ranks for General Reasoning Raw Scores for Groups I, II and III

Raw Scores	I	II	III
27	99	99	99
26	98	99	99
25	97	99	99
24	95	99	99
23	92	99	99
22	89	98	99
21	84	97	99
20	79	96	98
19	73	92	97
18	65	88	95
17	58	84	92
16	49	79	89
15	41	72	84
14	33	64	79
13	26	57	73
12	20	48	65
11	14	40	58
10	10	32	49
9	7	25	41
8	5	19	33
7	3	14	26
6	2	10	20
5	1	7	14
4	0	4	10
3	0	3	7
2	0	2	5
1	0	1	3

TABLE A-6

Distribution of Percentile Ranks for Numerical Operations Raw Scores for Groups I, II and III

Raw Scores	I	II	III
100	98	99	99
95	96	99	99
90	94	98	99
85	89	97	97
80	83	94	95
75	75	90	91
70	65	84	86
65	54	77	78
60	42	67	69
55	32	56	58
50	22	45	46
45	15	34	35
40	9	24	25
35	5	16	17
30	3	10	11
25	1	6	7
20	1	3	4
15	0	2	2

TABLE A-7

Distribution of Percentile Ranks for Perceptual Speed Raw Scores for Groups I, II and III

Raw Scores	I	II	III
53	99	99	99
52	98	99	99
51	95	99	99
50	89	99	99
49	78	99	98
48	63	99	93
47	56	96	86
46	28	91	73
45	15	82	56
44	7	66	37
43	2	52	22
42	1	30	11
41	0	17	4
40	0	8	2
39	0	3	0

TABLE A-8

Distribution of Percentile Ranks for Spatial Relations Raw Scores for Group I, II and III

Raw Scores	I	II	III
45	98	99	99
42.5	97	99	99
40	95	99	98
37.5	91	99	97
35	86	98	95
32.5	80	96	91
30	72	93	86
27.5	63	89	80
25	53	83	72
22.5	42	75	63
20	33	67	53
17.5	24	57	42
15	17	46	33
12.5	11	37	24
10	7	27	17
7.5	4	19	11
5	2	14	7
2.5	1	8	4

TABLE A-9

Distribution of Percentile Ranks for Spatial Visualization Raw Scores for Groups I, II and III

Raw Scores	I	II	III
65	98	99	99
60	96	99	99
55	91	98	99
50	83	96	96
45	71	92	92
40	57	84	84
35	41	73	73
30	27	59	59
25	16	43	43
20	8	28	28
15	4	17	17
10	2	9	9
5	0	4	4

TABLE A-10

Distribution of Percentile Ranks for Mechanical Experience Raw Scores for Groups I, II and III

Raw Scores	I	II	III
55	99	99	99
52.5	98	99	99
50	96	99	98
47.5	93	99	96
45	88	97	93
42.5	81	95	88
40	72	90	82
37.5	61	85	73
35	50	77	63
32.5	38	67	51
30	27	56	39
27.5	16	44	29
25	12	33	19
22.5	7	23	13
20	4	15	7
17.5	2	9	4
15	1	5	2
12.5	0	3	1
10	0	1	0

TABLE A-11

Distribution of Percentile Ranks for Scientific Interest Raw Scores for Groups I, II and III.

Raw Scores	I	II	III
105	99	99	99
100	97	99	99
95	94	99	99
90	88	98	98
85	79	96	96
80	67	91	91
75	53	84	83
70	38	73	72
65	25	60	59
60	15	45	44
55	8	31	30
50	4	19	18
45	2	11	10
40	1	5	5
35	0	3	2
30	0	1	1

TABLE A-12

Distribution of Percentile Ranks for Clerical Interest Raw Scores for Groups I, II and III

Raw Scores	I	II	III
15	1	0	0
20	2	1	0
25	4	2	1
30	9	4	2
35	17	9	5
40	29	17	11
45	43	28	19
50	58	42	31
55	72	57	46
60	83	71	61
65	91	82	74
70	96	90	85
75	98	95	92
80	99	98	96
85	99	99	99

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The content and form have been checked and approved by the author and thesis adviser. The Graduate School Office assumes no responsibility for errors either in form or content. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

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