THE SELECTION OF THE OPTIMAL PREDICTORS OF SUCCESS IN THE FIRST SEMESTER OF THE ENGINEERING PROGRAM OF THE OKLAHOMA INSTITUTE OF TECHNOLOGY

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CHAPTER I

INTRODUCTION

Nature of the Problem

In recent years enrollments in engineering schools have reached an all-time high. In fact, for the year 1952-53 in which the first data for this study were gathered, there were 343 freshmen enrolled in the Oklahoma Institute of Technology at Oklahoma Agricultural and Mechanical College. In 1955-56 there were 661 freshmen enrolled in the Oklahoma Institute of Technology, which represented a very large increase over 1952-53. These increases have been rather general in the engineering colleges throughout the country. With this steady increase in enrollments, there has been the problem of selecting people who are more likely to succeed in an engineering program.

Many of the students lack the abilities to do passing work in the Oklahoma Institute of Technology. There is a feeling among many people that all a student needs in order to succeed in engineering school is to have an interest in some branch of engineering and to work hard. The problem is not that simple. The problem is one of matching interests with abilities, plus motivation. If a student is lacking in any of these, he may have difficulty in the program; however, some of these factors may be more important than others. For instance, if a person is lacking in ability, there is not much that he can do to improve the situation. Many times a student feels that he can succeed in engineering because he has a relative or a friend who was a successful engineer. This does not mean though that he possesses the ability to complete the training. Counselors and advisers in engineering schools have been searching diligently for tools and techniques which will give them the information by which they can determine in advance if an enrollee in an engineering program will respond successfully or not to training.

It is obvious that a counselor will not be able to use every test recommended to predict success in the freshman program of the engineering school. Many tests have been used to predict success in engineering schools as the review of the related literature will show in a later chapter. Faced with heavier student loads, the counselor must find useful and efficient means which will reveal the students' abilities, achievements and interests quickly and reliably.

This study is an experiment to evaluate all of the tests used as predictors of success in the Oklahoma Institute of Technology at Oklahoma Agricultural and Mechanical College. It deals with the selection of the optimal predictors of success in the first semester freshman program in the Oklahoma Institute of Technology. It is designed to search for tests which will discriminate well between those who succeed or fail in engineering as well as to determine the value of a simple predictive tool like the multiple cutoff technique, which utilizes only a fraction of the time required by prediction by means of regression. A test of differences on the various tests between those students who make a grade point average of 2.00 and above and those students who make a grade point average of 1.99 and below, as well as between seven departments in the Oklahoma Institute of Technology will be made. The study is an experiment to find the best predictors of success in the first semester of the freshman program in the School of Engineering, to study the value of using the grade point average in specific freshman courses of English, chemistry, and mathematics as a criterion of success instead of total grade point average, and to test some predictive techniques.

Purpose of the Study

The purpose of the study was to investigate whether the entrance examinations which are given to the entering freshmen in the Oklahoma Institute of Technology and the examinations given in Engineering Orientation 111 correlate with success in the first semester of the Oklahoma Institute of Technology, or with success in some of the basic pre-engineering courses such as chemistry, English, and mathematics, which are required during the first semester. It is intended that the findings of this study will be presented in such manner that the counselor will be able to guide the prospective and capable engineering student more wisely in the early stages of his program as well as to counsel and direct the student who has an interest in engineering, but who lacks ability along this line, into fields that are more in keeping with his abilities.

Need for the Study

There is a need for more efficient counseling of engineering students, since at the present time thirty-five per cent of all entering students in engineering fail before, or at the conclusion of, the first year's work.

The need for competent engineers in our society has never been as great as it is at the present time. This need is twofold. First, the constant danger of war with Russia, which has existed since the close of World War II, emphasizes the importance of encouraging as many capable high school graduates to select some branch of engineering as their occupational choice. There seems to be some alarm in some quarters that the United States is lagging in its military preparedness race with Russia. There are limitations as to the number of engineers who may be trained each year. Engineering schools have facilities to train a fixed number of engineers. Therefore, it is important that those students who have a greater probability of success in an engineering program in college be selected as students in such a program. If the counselors in the schools of engineering had adequate predictors of success in the engineering programs, it would be possible for them to do more efficient counseling and, therefore, lighten the load of the faculties of the schools of engineering; so that they could do better teaching with the more capable students left in the program. This study is intended to attack some of the problems related to these needs.

Second, industry is growing so rapidly in this country that it has been rather difficult for personnel to be trained fast enough to keep pace. Jordan[1] reports that industry and the government need 80,000 trained engineers each year; whereas, the colleges are graduating only approximately 20,000 per year. Retirement, death and shifting to other jobs increase the deficit to another 30,000 per year. It may be that the low point in enrollment in engineering schools of this country has passed. There has been a steady increase in enrollments in the freshman

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[1]Richard Jordan, "The Role of the University in Training Engineering Students," Selection and Counseling of Students in Engineering, Minnesota Studies in Student Personnel Work, Minneapolis, Minn.: University of Minnesota Press, IV, 1954, pp. 22-25.

classes since the year 1952, which year showed a 40 per cent increase over the previous year.

With the expected increase in enrollments in the engineering schools for the next ten or fifteen years, and in view of inadequate facilities and faculties to handle this increase, the schools may be faced with implementing some type of selective device to choose those students who will more likely respond to training than others. With these points in mind, it is hoped this study will be valuable for counselors and advisers in engineering schools throughout the country.

Statement of the Problem

This is an experiment to (a) determine the optimal combination of predictors of success in the first semester of the first year program of the Oklahoma Institute of Technology at the Oklahoma Agricultural and Mechanical College; (b) determine if there are differences between the group which succeeds and the group which fails, as well as differences between each of seven departments in the Oklahoma Institute of Technology as measured by the tests used as predictors in the experiment; (c) study the value of using for criterion of success in the Oklahoma Institute of Technology the grade point average in specific freshman courses of English, chemistry, and mathematics instead of total grade point average; (d) and to determine if prediction by means of regression is more efficient than prediction by means of the multiple cutoff technique in the first semester of the first year program of the Oklahoma Institute of Technology at Oklahoma Agricultural and Mechanical College.

Specific Hypotheses to be Tested

The specific hypotheses to be tested, stated in the form of null hypotheses, are as follows:

(1) Differences as measured by the scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific Scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology (a) who make a grade point average of 2.00 and above and (b) those who make a grade point average of 1.99 and below, are no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling.

(2) Differences as measured by the scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific Scales of the Kuder Preference Record between those students in the first semester of the freshman program of the Oklahoma Institute of Technology who are enrolled in the department of (a) agricultural engineering, (b) architectural engineering, (c) chemical engineering, (d) civil engineering, (e) electrical engineering, (f) general engineering, (g) and mechanical engineering, are no greater than differences which could be expected to occur as a result of chance fluctuations in

random sampling.

(3) There is no difference in prediction by means of regression and prediction by means of a multiple cutoff technique in predicting total grade point average in the first semester of the freshman program in the Oklahoma Institute of Technology.

(4) There is no difference in prediction by means of regression and prediction by means of a multiple cutoff technique in predicting grade point average in English 115, Mathematics 165, Chemistry 114, and the combined grade point average of the three above courses.

From the information gained in the testing of the four hypotheses, an attempt will be made to (a) determine the optimal combination of predictors of success more effectively in the first semester of the first-year program of the Oklahoma Institute of Technology, and (b) to study the value of using for criterion of success in the Oklahoma Institute of Technology, the grade point average in specific freshman courses in English, chemistry, and mathematics instead of total grade point average.

CHAPTER II

A REVIEW OF THE RELATED LITERATURE

In order to approach the review in a systematic fashion, the prognostic studies have been broken down into the six categories which follow: high school grades and rank; aptitude tests; mental tests; interest inventories; test batteries; and first semester and first year college grades of engineering students.

High School Grades and Rank

Several studies have been made in which high school grades were used either alone or in combination with ability tests to predict success in engineering schools.

Dvorak and Salyer,[1] at the University of Washington, in 1933 conducted such a study. They found an $\underline{R}$ of .68 between freshman grade point average in the Engineering College and high school grades in English, science, social science, mathematics, University Intelligence Test, Iowa Mathematics Test and the Iowa Physics Test. It was further determined in this study that the high school natural science grades were more effective as a predictor than were the scores from the Iowa Physics Test.

[1] A. Dvorak and R. C. Salyer, "Significance of Entrance Requirements for the Engineering College at the University of Washington," Journal of Engineering Education, XXIII, (April 1933), pp. 618-623.

Boardman and Finch[2] in 1934 attempted to discover what combination of high school courses were most related to success in the College of Engineering at the Universityof Minnesota. The results of this study indicated an r of .194 ± .036 between total high school credits in science, mathematics and manual training and total engineering credit. Further inference was made that a definite tendency for additional work in high school in the above subjects would result in better achievement in engineering school in spite of the fact that there is no corresponding increase in rank on the College Aptitude Test. Better performance in college indicated the students gained something from their high school mathematics, science and manual training courses which was not measured by the College Aptitude Test.

Laycock and Hutcheon,[3] in a study at the University of Saskatchewan in 1939, found that grade XII marks were the best single predictor of grade point average in the first year program of the school of engineering. The r was .61 compared with an r of .34 between the scores on the American Council on Education Cooperative General Achievement Tests and first-year marks in engineering. Grade XII marks were nearly as good predictors as a battery of four tests.

Cohen[4] found in a study in 1946 at Worcester Polytechnic Institute

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[2] C. W. Boardman and F. H. Finch, "Relation of Secondary School Preparation to Success in the College of Engineering," Journal of Engineering Education, XXIV, (March 1934), pp. 466-475.

[3] S. R. Laycock and N. B. Hutcheon, "A Preliminary Investigation into the Problem of Measuring Engineering Aptitudes," Journal of Educational Psychology, XXX, (April, 1939), pp. 280-289.

[4] L. Cohen, "Predicting Academic Success in an Engineering College and Suggestions for an Objective Evaluation of High School Marks," Journal of Educational Psychology, XXXVII, (Sept., 1946), pp. 381-384.

that among the variables studied, high school marks were the best predictors of success in the engineering schools. The study was originally given in 1941 and replicated in 1942. The r between high school marks and college marks in the 1941 study was .51 compared with .48 in 1942. A test battery and high school grades were used to predict college marks. This battery consisted of the American Council on Education Cooperative General Achievement Tests in Mathematics, the American Council on Education Cooperative General Achievement Test in Physics and Chemistry, the American Council on Education Cooperative General Achievement Tests in Reading Comprehension, the Iowa Silent Reading Test, Yale University Department of Personnel Study Test II, Form J, Parts 1 and 2, and A Studiousness Questionnaire. The R between the test battery and college marks in the 1941 group was .57 and in the 1942 study it was .51. The results of this study seemed to indicate that high school marks were nearly as good in predicting success in engineering school as a very large battery of tests, which was a costly operation in terms of time and money. The author further stated, however, that there was danger in using high school grades alone in the prediction of success in college because of the great variation in grading found among the high schools.

McClanahan and Morgan[5] in a study at Colorado Agricultural and Mechanical College in 1948 used high school rank with a number of standardized tests to find the relationship between these variables and grade point average of the first year students in the College of

[5]W. R. McClanahan and D. H. Morgan, "Use of Tests in Counseling Engineering Students in College," Journal of Educational Psychology, XXXIX (Dec., 1948), pp. 491-501.

Engineering. The highest zero-order correlation was an *r* of .652 between the scores on the Iowa Placement Examination in Chemistry and grade point average in the first year. The second highest was an *r* of .648 between the scores on the American Council on Education Psychological Examination and grade point average. The lowest *r* was one of .359 between high school rank and grade point average. An *R* of .848 was obtained by combining all of the tests and the high school rank and correlating them with grade point average. An *R* of .848 was obtained by correlating the scores from all the tests, leaving out high school rank, with the grade point average. This evidence seemed to indicate that high school rank added nothing to the predictive powers of the battery.

Aptitude Tests

Much work has been done in recent years to develop aptitude tests to be used to predict whether a person is able to benefit from training. Many colleges and universities have used aptitude tests widely in their testing and counseling programs. Bingham[6] has pointed out that there are many aptitudes which influence success in a college of engineering. A number of aptitude tests have been used in studies in predicting success in schools of engineering in recent years.

Feder and Adler[7] in 1939 reported a study in 1931 at the Uni-

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[6] Walter Van Dyke Bingham, *Aptitudes and Aptitude Testing*, New York: Harper and Brothers, 1937, pp. 170-177.

[7] D. D. Feder and D. C. Adler, "Predicting the Scholastic Achievement of Engineering Students," *Journal of Engineering Education*, XXIX, (Jan., 1939), pp. 380-385.

versity of Iowa. This study was designed to find methods of reducing the high rate of academic failure in the College of Engineering and to direct the student unfit for engineering into fields in which the individual's chances for success were much better. The following tests of the Iowa Qualifying Examinations were used: Iowa High School Content Examination, Iowa Silent Reading Test, and the Mathematics Aptitude and English Training Tests of the Iowa Placement Series. These tests were used as the independent variables. The criteria of success were grade point averages in the first semester and the first year of the College of Engineering. A range in coefficients of correlation from .57 to .72 was reported when each test was correlated with first semester grades and first year grades. The weighted combination of the four tests yielded an R of .74 ± .04 with first year grades. A follow-up study of the original ninety-nine subjects revealed that the twenty-six who were graduated were students of superior ability. It was found that the correlation coefficients for this group were higher than for the total sample. Furthermore, no student was graduated from the college who fell below the 30th percentile on the ability tests.

Dvorak and Salyer[8] in 1939 at the University of Washington found that the Iowa Physics Aptitude Test correlated .55 with freshman total grade point average in the College of Engineering while an R of only .68 was obtained by using grades in four high school courses, the scores on the University Intelligence Test, the Iowa Mathematics Aptitude Test and the Iowa Physics Aptitude Test. Again, inference was

[8] Dvorak and Salyer, p. 5.

made that one good aptitude test, the Iowa Physics Aptitude Test, measured those factors which are related to success in the first-year program of the College of Engineering.

Griffin and Borow[9] in a study at Pennsylvania State College during World War II reported the developing of a battery of effective aptitude tests to be used in differentiating those persons who were likely to show rapid progress in the engineering program from those who were likely to fail. This test battery was named the Engineering and Physical Science Aptitude Test. In correlating the six parts of this test with final grades in mathematics, an R of .732 was obtained. Using final grades in chemistry, an R of .731 was found. The following is a list of other courses in which the final grades were correlated with the six sub-tests: Physics, an R of .738; Manufacturing Process, an R of .456; and Drafting, an R of .429. Using total grade point average in all courses, an R of .763 was found. Combining the grade point average in mathematics, chemistry and physics gave an R of .790. From the evidence gained from this study, it seemed that the Engineering and Physical Science Aptitude Test predicted success better in the basic mathematics, chemistry and physics courses than it did in the applied type courses, e.g., manufacturing processes and drafting. The best criterion, however, was the average grade in the mathematics, chemistry and physics courses taken in combination.

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[9] C. H. Griffin and H. Borow, "An Engineering and Physical Science Aptitude Test," Journal of Applied Psychology, XXVIII, (Oct., 1944), pp. 376-387.

McGehee and Moffie[10] in 1942 in a study at North Carolina State College concluded that aptitude tests were very effective in prognostic work. In estimating final grades in a course of Fabric Inspection, a course in Aeronautical Engineering, scores on the Iowa Chemical Aptitude Examination correlated .819 with final grades. An R of .831 was obtained between final grades in the course and scores on the Otis Self-Administering Test of Mental Ability, the Minnesota Clerical Numbers Test, the Minnesota Clerical Names Test, and the Iowa Chemical Aptitude Test. The Iowa Chemical Aptitude Test correlated nearly as well with the criterion as all the tests combined.

Vaughn[11] in 1944 at the Newark College of Engineering reported a study using the Yale Scholastic Aptitude Test as a predictor of success in the College of Engineering. The Yale Scholastic Aptitude Test battery consisted of the following sections: verbal comprehension, artificial language, quantitative reasoning, spatial visualizing, mathematical aptitude and mechanical ingenuity. The Yale Scholastic Aptitude Test battery correlated from .50 to .66 with grade point averages in the freshman courses. The author reported that the tests of mathematical aptitude and quantitative reasoning were the most effective of the tests in predicting freshman grade point averages. He concluded further that the Mathematical Aptitude Test was the best predictor of all the tests. Another finding was that the tests of verbal comprehension and artificial

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[10] W. McGehee and D. J. Moffie, "Psychological Tests in the Selection of Enrollees in Engineering, Science Management, Defense Courses," Journal of Applied Psychology, XXVI, (Oct., 1942), pp. 584-586.

[11] K. W. Vaughn, "The Yale Scholastic Aptitude Test as Predictors of Success in College Engineering," Journal of Engineering Education, XXXIV (April, 1944), pp. 572-582.

language were more valid in predicting achievement in the required cultural courses included in the engineering students' programs; however, they were poor in predicting success in scientific or engineering subjects.

Treumann and Sullivan[12] in 1949 at the University of Wisconsin found that the Engineering and Physical Science Aptitude Test, which was the best predictor of those used in this study, correlated .53 with first semester grades of freshmen engineers. The American Council on Education Psychological Examination scores correlated .41 and the Iowa Silent Reading Examination correlated .32 with first semester grades.

Halliday and Fletcher[13] in 1950 in the College of Engineering at Ohio State University studied 130 freshmen who were enrolled in a class of engineering drawing. The scores on the Owens-Bennett Test of Mechanical Comprehension correlated .23 with algebra grades, .41 with first quarter grade averages and .46 with engineering drawing grades.

Layton[14] in 1950 at the University of Minnesota in conjunction with others worked to develop a test of engineering aptitude. This test is known as the Engineering Aptitude Test. The test consists of two parts. Part I consists of items designed to measure reading comprehension in mathematics. Part II consists of items designed to measure the abil-

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[12] M. J. Truemann and B. A. Sullivan, "Use of the Engineering and Physical Science Aptitude Test as a Predictor of Academic Achievement of Freshman Engineering Students," Journal of Educational Research, 43:129-33 (1949).

[13] R. W. Halliday and F. M. Fletcher, Jr., "The Relationship of Owens-Bennett Test Scores to First-Year Achievement in an Engineering College," American Psychologist, 5:353 (1950).

[14] Wilbur L. Layton, "Predicting Engineering Grades," Selection and Counseling of Students in Engineering, Minn. Studies in Student Personnel Work, Minn., Minn.: University of Minnesota Press, IV, (1954) pp. 26-31.

ity to visualize objects in space. In 1951 this test was tried out in combination with the Cooperative Algebra Test, Form Y, high school rank, American Council on Education Psychological Examination scores and the Cooperative English Test. The Engineering Aptitude Test correlated .61 with first quarter grades and .64 with first year grades. The Cooperative Algebra Test scores correlated .72 with first year grades. High school rank correlated .54, the American Council on Education Psychological Examination scores correlated .47 and the Cooperative English Scores correlated .53 with first year grades. Combining all the variables in an R gave .82 as the R with first year grades.

The Educational Testing Service in recent years has been working very closely with the American Society for Engineering Education, the Engineers' Council for Professional Development, and the Engineering Manpower Commission of the Engineers' Joint Council in conjunction with the Advisory Council of the Measurement and Guidance project in Engineering Education. These groups have been concerned with the development of predictive techniques which effectively discriminate between those engineering students who show promise of completing the engineering programs and those students who do not have the ability to go on. Some research has been reported as an outcome from this effort.

Schrader and Frederiksen[15] in 1954 reported the use of the Comprehensive Mathematics Test (a two-hour achievement test) of the College Entrance Examining Board and the Mathematics Section (one hour time limit) of the College Entrance Examining Board's Scholastic Aptitude

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[15] William B. Schrader and Norman Frederiksen, "Prediction of Engineering Grades," *Educational Testing Service Developments*, Number 2, (March 1950).

Test in correlating each of the tests with first semester grades in engineering. The r's were .55 and .53 respectively. By using these two tests separately with high school averages in multiple correlations, R's of .66 and .65 respectively were obtained.

Mental Tests

Mental tests have been used widely to predict if people would succeed in an academic program. There probably has been more research done with this type of test than with any other type. Most intelligence tests attempt to measure verbal ability and the ability to do quantitative thinking.

Wilson and Hodges[16] in 1932 at the University of Oklahoma used the average of honor points in all courses taken beyond the freshman year as the criterion and found a validity coefficient of .400 by using the Otis Advanced Intelligeuce Scale. The Otis Advanced Intelligence Scale was used with grades in freshman mathematics, introductory engineering and mechanical drawing, both separate and in combination, to predict upper-class success in the College of Engineering. The Otis Advanced Intelligence Scale gave the lowest coefficient and consequently was the least of the factors in the multiple prediction situation.

Laycock and Hutcheon[17] in 1939 at the University of Saskatchewan

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[16] M. O. Wilson and J. H. Hodges, "Predicting Success in the Engineering College," Journal of Applied Psychology, XVI, 1932, pp. 343-357.

[17] Laycock and Hutcheon, p. 9

found that scores on the American Council on Education Psychological Examination correlated .34 with average first year marks in the College of Engineering. This correlation was much lower than the .50 which was obtained by correlating scores on the American Council on Education Psychological Examination with freshman grades in the College of Arts and Sciences. This discrepancy could not be explained by the experimenters.

McGehee and Moffie[18] in 1942 at North Carolina State College reported using the Otis Self-Administering Test of Mental Ability in predicting final grades in a number of courses in engineering. The validity coefficients follows: Aircraft Inspection .437; Architectural Engineering .227; Chemical Testing .242; Engineering Drawing .487; Fabric Inspection .690; and Material Testing .598. In combining the Otis Self-Administering Tests of Mental Ability with several tests in multiple correlation there was never a situation in which it was the most important factor in the overall estimate.

Garrett[19] reported a study in which an attempt was made to dis-discover if scores on the Ohio State Psychological Examination, which was given to high school students in the senior year, would serve as a reliable guide in predicting college grades. The study was done at the Warren, Ohio High School. With a sample of two hundred, an *r* of .608 ± .030 was reported between raw scores on the Ohio State Psychological Examination and freshman grade point average. This compared

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[18] McGehee and Moffie, p. 14.

[19] W. S. Garrett, "The Ohio State Psychological Examination--An Instrument for Predicting Success in College," Occupations, XXII, (May, 1944), pp. 489-495.

with a validity coefficient of .709 ± .024 in predicting high school grade point average using the same predictor.

Interest Inventories

Interest inventories have been used widely in counseling college students, but they have not been utilized as often to predict academic success as aptitude and ability tests have.

Berdie[20] reported in 1944 a study at the University of Minnesota to determine if the satisfaction a student derived from his college course could be predicted by his responses on the Strong Vocational Interest Blank or by other predictive indices. Results indicated there was no highly significant relationship between satisfaction or interest and academic achievement in engineering. There was an *r* of .23 between the two variables. The author concluded from the results that academic success in engineering could be predicted by Strong's Inventory.

Test Batteries

In recent years many experimenters have used test batteries in order to predict success in engineering schools. The multiple correlation technique and regression equations have been used effectively in prediction problems. These techniques make it possible to combine several variables for predictive purposes. Tests seemed to predict better in combination than individually.

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[20] R. F. Berdie, "Prediction of College Achievement and Satisfaction," *Journal of Applied Psychology*, XXVIII (June, 1944), pp. 239-245.

Feder and Adler[21] in 1939 in the School of Engineering at the University of Iowa were interested in developing a battery of tests to be given at the beginning of the freshman year to predict the first semester grade point average. The authors stated, "The college of engineering shares with the college of medicine the responsibility of training men for public service. Therefore, it must hold up exacting standards of achievement for those to whom it gives its stamp of approval. However, in the interests of sound educational guidance, the college of engineering may well consider methods of reducing its rate of scholastic mortality and directing the efforts of the unfit student into channels which promise greater personal and social growth." The tests used in this battery were the Iowa High School Content Test, the Iowa Silent Reading Test, the Iowa Mathematics Test, and the Iowa English Test. An $\underline{R}$ of .74 existed between the first semester grade point average and the combined tests above.

In 1941 Vaughn[22] did a study of 1300 freshman engineering students in six colleges of engineering. The Yale Aptitude Test battery was used as a predictive device. The battery consisted of tests of Verbal Comprehension, Artificial Language, Quantitative Reasoning, Spatial Visualizing, Mathematical Aptitude, and Mechanical Ingenuity. The criterion was grade point average for the first year. Correlations varying from .50 to .66 were found. The best of the individual tests were Mathematical Aptitude and Quantitative Reasoning which gave validity coefficients of .51 and .48 respectively with the criterion.

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[21] Feder and Adler, p. 11.

[22] Vaughn, p. 14.

In 1947 Berdie and Sutter[23] at the University of Minnesota used as their predictors a combination of achievement tests in mathematics, chemistry and natural science, high school rank, American Council on Education Psychological Examination, and the Cooperative English Test. Combining all the predictors in a multiple correlation gave an <u>R</u> of .62 with first quarter grades. The most efficient predictors reported in this study were high school ranks; the USAFI General Educational Development Test III; Reading Comprehension of the Natural Sciences; and the Cooperative Mathematics Test, Form P.

Berdie[24] in 1948 at the University of Minnesota did a study with the Differential Aptitude Test Battery. This battery yields eight scores: verbal reasoning, numerical ability, abstract reasoning, space relations, mechanical reasoning, language usage I (spelling), language usage II (sentences), and clerical speed and accuracy. High school ranks, American Council on Education Psychological Examination scores, and Cooperative English Test scores were used in the analysis also. Grouping the engineering students into three groups according to their major subjects and using all the sub-tests and tests with high school rank as predictors, and first quarter grades as criteria of success, <u>R</u>'s of .65, .63, and .60 were obtained for each of the groups. The author reported that none of the scores on the Differential Aptitude Test battery were significant except numerical ability. Scores on the numerical ability

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[23] R. F. Berdie and N. A. Sutter, "Predicting Success of Engineering Students," <u>Journal of Educational Psychology</u>, 14:184-90 (1950).

[24] R. F. Berdie, "The Differential Aptitude Tests as Predictors in Engineering Training," <u>Journal of Educational Psychology</u>, 15:114-23 (1951).

and high school rank gave an R of .62 with first year grades. In fact those two predictors produced a multiple correlation equal to the combination of high school rank, General Educational Development Test III, and the Cooperative Mathematics Test administered the previous year at Minnesota by Berdie and Sutter.

Jones[25] in 1948 at Clark University reported a study designed to determine the effectiveness of the predictors used to estimate the scholastic success at different levels of advancement in the engineering college. The tests involved were the Cooperative Mathematics Test, Cooperative Physics Test, Cooperative Chemistry Test, Yale Spatial Visualization Test, the Iowa Physical Science Aptitude Test, the Otis Quick Scoring Mental Ability Test, Cooperative Reading Test, the Carnegie Pre-Engineering Test, and secondary school marks. The most effective combination of tests, which consisted of the Cooperative Mathematics Test, the Cooperative Physics Test, the Cooperative Chemistry Test, and high school marks, correlated .64 with first semester grades and .63 with first year grades.

McClanahan and Morgan[26] in 1948 at Colorado Agricultural and Mechanical College reported a study to investigate the predictive value of the battery of tests regularly administered to new students enrolled in engineering. They found an R of .85 between the criterion of first year grade point average and the battery of the following tests: Cooperative English Test, the Iowa Chemistry Aptitude Test, the Nelson-

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[25] V. Jones, "Prediction of Student Success in an Engineering College," The American Psychologist, III, (July, 1948), p. 295.

[26] McClanahan and Morgan, p. 10.

Denny Reading Test, and the American Council on Education Psychological Examination.

Johnson[27] in 1950 did a follow-up study of the work of Cowles, Cynamon, Lord and Schrader to determine how well the College Entrance Examination Board Mathematical Tests and the Pre-Engineering Inventory forecast academic success in colleges of engineering. The College Entrance Examination Board Mathematical Tests were administered to 721 subjects in five engineering colleges. The College Entrance Examination Board composite (Scholastic Aptitude Test - Mathematics plus Comprehensive Mathematics Test) plus high school records correlated .68, College Entrance Examination Board Comprehensive Mathematics Test plus high school record correlated .65, and College Entrance Examination Board Scholastic Aptitude Test, Mathematics Section plus high school records correlated .66 with first year grades.

R. C. Moore[28] in 1952 reported a study at the College of Engineering at Carnegie Institute of Technology in 1951. The Pre-Engineering Ability Test correlated .68 with weighted averages of course grades for the first semester. Students were excluded from the study if they did not complete the semester or had had previous college work or had foreign language handicaps. Of the 260 students in the study, 57 had taken the Pre-Engineering Inventory. It was found

[27] A. Pemberton Johnson, "College Board Mathematics Test (a) and the Pre-Engineering Inventory (b), as Predictors of Scholastic Success in Colleges of Engineering," American Psychologist, 5:353 (1950).

[28] R. C. Moore, "A Note on the Validity of the Pre-Engineering Ability Test," Journal of Engineering Education, 42:512 (1952).

that the Pre-Engineering Inventory correlated .75 and the Pre-Engineering Ability Test correlated .73 with the weighted average of first year course grades. This was an interesting finding because the Pre-Engineering Ability Test was nearly as good as a predictor as the Pre-Engineering Inventory, and it takes a shorter period of time to administer.

Stinson[29] in 1955 at Oklahoma Agricultural and Mechanical College studied various differences of the following groups in the engineering program: (1) those who successfully complete the program and graduated; (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. The experimenter was interested in whether the three groups differed significantly in ability, interest, and personality adjustment. The following measures were used: the total score of the American Council on Education Psychological Examination, Cooperative Algebra Test, Oklahoma Agricultural and Mechanical College English Placement Test, the Guilford-Zimmerman Aptitude Survey, the Kuder Preference Record, and the Minnesota Multiphasic Personality Inventory. The conclusions were that the three groups showed much variation as far as ability was concerned, were more similar as far as interests were concerned, and were very similar as far as personality traits were concerned.

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[29]Fairlee June Stinson, "Relationship of Certain Measures of Ability, Interest, and Personality to Achievement in the Engineering Program at Oklahoma Agricultural and Mechanical College," Unpublished Doctoral Dissertation, Aug., 1955.

First Semester and First Year
Grade Point Averages

There are a few studies reported in which grade point averages in the first quarter or semester were used to predict overall scholastic success in the engineering school. If the student is unable to do successful work in the first term or semester, it is unlikely that he will show any improvement on up the ladder. Nearly every engineering course has a prerequisite. If the student does not do satisfactory work in the prerequisite, he is unlikely to succeed in the next important subject.

Higgins[30] in 1932 at Cornell University predicted students' average grade for his entire four years in the School of Engineering by using for predictors the combined grade average in analytic geometry and calculus, which were required courses for freshman students in engineering. The *r* was .54.

Pierson[31] at the University of Utah in 1947 made a detailed study of those students who finished the program and those who dropped out. This study revealed that the grade point average of the typical engineer dropped from 2.1 in high school to 1.55 in the first quarter

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[30] T. J. Higgins, "Study of Mathematical Ability in Relation to Success in Engineering Studies," Journal of Engineering Education, XXIII, (June, 1933), pp. 743-746.

[31] G. A. Pierson, "School Marks and Engineering," Educational and Psychological Measurements, VII (Autumn, 1947), pp. 612-617.

of college; and that at the end of the first quarter one fifth of the graduates failed to achieve a grade point average of 1.0. Furthermore, the grade point average for the first quarter was more closely related to general scholarship than the grades in any particular course. Overall scholarship could be estimated as efficiently from the first quarter grade point average as from the first quarter grades in chemistry, English composition, mathematics, and engineering drawing combined in a regression equation. The correlation between total grade point average in the first quarter and the total grade point average for the four-year program was .67. It is further reported that the total grade point average at the end of the freshman year was 1.4 and that one out of every five failed to achieve a "C" average. It was found that the first year grade point average was more closely related to general success in engineering than grades in any course. A coefficient of correlation of .75 was found here. It appeared from the results of this study that general scholarship in engineering could be determined almost as well from the grade point average at the end of the first quarter as from the grade point average at the close of the year. The experimenters reported that a study of the drop-outs indicated that first quarter college grade point averages predicted success in the College of Engineering much better than did high school marks. From the evidence presented in this study, it might very well be concluded that the freshman year is the crucial year in the college of engineering, and that the first quarter is nearly as good a predictor as the total grade point average for the first year.

Siemans[32] in 1942 at the University of California made an attempt to determine how well the upper division engineering students' success could be forecast. The grade point average for the first semester was used as the predictive device and the grade point average in all the upper division courses was chosen as the criterion of success in the engineering program. There was a coefficient of correlation of .87 between these two variables. Other phases of this study threw some light on related problems in this area. Using grade point average in all the lower division courses as the predictor, an r of .70 was obtained in correlating this variable with grade point average in the upper division courses. Grade point average in college mathematics correlated .69, grade point average of college physics correlated .69, and grade point average in college chemistry correlated .61. In other words, total grade point average in the first semester of freshman engineering students was the best predictor of success in the four-year program in the College of Engineering. No tests were used in this study, but none of the studies in which tests were used as predictors gave as high correlations as were found in this study in which grade point averages were used as predictors.

Summary

In concluding the survey of the literature, many different type studies have been done in an effort to find the best predictors of success in engineering schools throughout the nation and in Canada. High school

[32]C. H. Siemans, "Forecasting the Academic Achievement of Engineering Students," Journal of Engineering Education, XXXII, (April, 1942), pp. 617-621.

grades and ranks seem to be effective predictors in most instances in which they have been used; however, there was one study reported in which negative evidence was found. Aptitude tests were used widely as predictors. The range of the correlations between aptitude tests and grade point averages in engineering schools was from .23 to .81 with most of them between .50 and .60. Correlations of scores on mental tests with grade point averages in engineering schools ranged from .34 to .69. Interest inventories were used in some studies but all of the correlations reported were quite low. In the late thirties test batteries in combination with high school grades and ranks began to be used as predictive devices. The range of these correlations was from .60 to .85. To predict success in the four-year program of engineering, the grade point average for the first semester or first year seemed to be the best predictors found. One correlation was reported of .87 between first semester grade point average and the four-year grade point average. One study reported there were significant differences in abilities between those engineering students who completed the four-year program and those who transferred to other schools on the campus and graduated and those who dropped out of the program and quit school. The three groups were more similar in interests and very similar in personality traits.

Since 1939 there has been a great amount of research on the development of test batteries to predict success in engineering schools. Up until that time most of the experimenting done in trying to find better predictors of success in engineering schools had been done with the use of single predictors or by using several tests which were not developed for the primary purpose of predicting success in schools of engineering.

In most of the studies reported, the total grade point average was used the most frequently as the criterion in predicting success in schools of engineering. It was reported in some of the studies that work had been done on predicting grade point average in specific courses in engineering schools as well as the grade point average in combined specific courses. In most of the studies reported, the coefficient of correlation and regression were the techniques used the most frequently in prediction of success in the schools of engineering.

The review of the related literature served to familarize the reader with what has been done in the area of prediction of success in engineering schools. Much yet remains to be done in order to make prediction more scientific and dependable.

The Relationship of the Review of the Literature to this Experiment

In most of the studies reported in the literature, the computation of the coefficients of correlation was the most important phase of the studies. In this experiment, it serves the purpose of being the foundation on which four specific hypotheses are to be tested. There was no study reported in which differences in abilities, achievements and interests were studied between those who succeed and those who fail in the first semester program of the schools of engineering. Furthermore, there were no studies reported in which differences in abilities, achievements and interests of students were studied between departments within schools of engineering. This experiment deals with these two pertinent problems. This experiment is designed to determine if a multiple cutoff technique would be as valuable as predicting by means of regression. None of the engineering schools reported any work with this device. The multiple cut-off technique is of interest because it is quickly administered. Thorndike[33] used this technique in developing the Air Forces Tests.

The problem of predicting grade point average in specific courses in engineering schools was approached in this experiment in the section dealing with the comparisons of prediction by means of regression and prediction by means of the multiple cutoff technique. If prediction were more accurate in predicting success in the basic mathematics, chemistry, and English courses than the prediction of total grade point average, it would simplify counseling. If a student is not capable of doing successful work in the basic freshman courses in English, chemistry, and mathematics, it is impossible for him to pursue a program further in the engineering school. It is hoped this experiment will throw a little more light on this very important problem.

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[33]R. L. Thorndike, Research Problems and Techniques, AAF Aviation Psychology Research Program, Report No. 3, Washington, D. C.: Government Printing Office, 1947.

CHAPTER III

SUBJECTS, INSTRUMENTS AND PROCEDURE

The description of the subjects, the instruments and the statistical procedure used in testing the hypotheses listed in Chapter I are covered in this chapter.

Subjects

The subjects of this study were divided into two groups. Group I consisted of all the students who were enrolled in the Orientation course (Engineering 111) for freshman engineering students at the Oklahoma Agricultural and Mechanical College in the fall of 1952. There were 343 subjects in this group who were between the ages of sixteen years and nine months old and twenty-five years old. Group II consisted of 200 subjects selected randomly from 492 students who were enrolled in the Orientation (Engineering 111) for freshman engineering students at Oklahoma Agricultural and Mechanical College in the fall of 1955. The range of their ages was sixteen years and ten months to twenty-seven years and ten months. The significance of difference between means of Group I and Group II according to chronological age is given in Table I.

TABLE I

SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF GROUPS I AND II ACCORDING TO CHRONOLOGICAL AGE

	Difference Between Means	t-values	df	P
$t_{I, II}$	.11	.246	541	not sig.

There was no significant difference between the means of Groups I and II according to chronological age. All of the subjects in Groups I and II finished the first semester of their respective years. All of the subjects took the American Council on Education Psychological Examination and the Cooperative Algebra Test during the first week of school for each of the respective years. Each group also took the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, and the Kuder Preference Record during Engineering Orientation 111. In order to motivate the students, some credit was given them for taking the tests.

A Description of the Tests Used in the Study

The following tests were administered to the subjects of each group involved in the study through the cooperation of the Bureau of Tests and Measurements of the Oklahoma Agricultural and Mechanical College:

1. American Council on Education Psychological Examination for College Freshmen, 1948 edition (ACE).[1] This test was designed to estimate the ability of college freshmen to do satisfactory work in their first year at college. The test is used in some 300 colleges and universities. The test consists of two sub-tests: (1) Linguistic (L),

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

which measures vocabulary knowledge and ability to reason with words, and (2) Quantitative (Q), which measures non-verbal reasoning ability, and skill and speed in solving arithmetic problems. By using the scores from each sub-test plus the total score gives three scores which may be used in studies. All three scores were used in parts of the present study and the total score was used throughout it. The split-half reliabilities of the total score range from .95 to .97 and the coefficient of correlation between the American Council on Education Psychological Examination and the Stanford Binet (Form L) is nearly .60 according to Traxler.[2] The test has been used widely in engineering prediction studies.

2. Cooperative Algebra Test, Revised Form (MPT).[3] This test was designed to measure the achievement of the basic skills and principles in elementary algebra through quadratics usually learned in high school. This test has had wide use among the colleges in placing students in adequate mathematics courses.

3. The Kuder Preference Record (Form CM).[4] Kuder worked several years in developing the Record in the early thirties at Ohio State University. The first form of the test was issued in 1939. It was later revised in 1942, which form was used in the present study. The Kuder Preference Record and the Strong's Vocational Interest Blank are the two leading tests of interest on the market today. The Kuder Preference Record is used to predict educational and vocational success. Kuder

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[2] A. E. Traxler, Techniques of Guidance. New York: Harper, 1945, pp. 48-53.

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

[4] Published by the Science Research Associates.

designed this test to measure the motivating factors in ten broad areas. These areas include measurement of interest of the outdoor, mechanical, computational, scientific, persuasive, artistic, literary, musical, social service, and clerical. There is also a V scale which detects if the student has been careless in answering the questions or has tried to fake answers. Reliability coefficients using the Kuder-Richardson reliability formula for 100 eighth grade boys and girls range from .84 to .96; for 125 high school senior boys, the range was from .87 to .93.

Crosby[5] in 1943 reported a study at Cornell University on 140 sophomores in the Colleges of Agriculture and Home Economics who were taking a course in general psychology. High and low scores on the scientific area of the Kuder correlated .64 $\pm$ .05 with chemistry grades and .67 $\pm$ .05 with biological science grades. The high and low scores on the computational scale correlated .67 $\pm$ .05 with accounting grades. This study indicated that motivating factors in form of interests might be essential in predicting academic achievement.

4. The Minnesota Paper Form Board Test, Likert-Quasha Revision (MPFB).[6] The Minnesota Paper Form Board Test seems to measure the ability to perceive spatial relations which is measured through the use of non-verbal and non-numerical items. It is not designed to be an intelligence test, but some items on the test seem to be related to measures of intelligence. The present revision of the test by Likert and Quasha was first published in 1934.

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[5] Richard C. Crosby, "Scholastic Achievement and Measured Interests," Journal of Applied Psychology, 27:101-3, (Fall, 1943).

[6] Constructed by Rensis Likert and William H. Quasha. Published by The Psychological Corporation.

Likert and Quasha[7] reported that the reliability between the two forms of the test was .79 and the split-half reliability was .92.

Validity has been fairly well established for this test. Berdie[8] found a low but significant correlation of .22 between scores on the test and grade point averages for 154 engineering students. Brush[9] studied 100 engineering students at the University of Maine and obtained correlations of .42 and .175 with first year grades and .43 and .21 with four year grades. He found this was one of the best aptitude tests used in his study. This test seems to measure abilities of those students who do well in designing, drawing and structuring of buildings in art and in architectural engineering. It is true, however, that in some fields a student must have abilities of another nature along with the abilities this test measures in order to succeed in those fields.

5. Pre-Engineering Ability Test, Form ZPA (Pre-Eng).[10] The Pre-Engineering Ability Test is an eighty minute test which is very easy to administer and is designed to predict whether high school graduates who choose engineering for a career are capable of doing successful work in college engineering programs. The forerunner of this test was the ten-hour pre-Engineering Inventory. The former test is divided

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[7] W. H. Quasha and R. Likert, "Revised Minnesota Paper Form Board Test," Journal Educational Psychology, 1937, XXVIII, pp. 195-204.

[8] R. F. Berdie, "Prediction of College Achievement and Satisfaction." Journal Applied Psychology, XXVIII, 1944, pp. 239-245.

[9] Edward N. Brush, "Mechanical Ability as a Factor in Engineering Aptitude." Journal of Applied Psychology, XXV, pp. 300-312, 1941.

[10] Published by the Educational Testing Service.

into two divisions which deal with Comprehension of Scientific Materials and General Mathematical Ability consisting mostly of basic arithmetic and algebraic reasoning problems.

The authors report the reliability coefficient estimate was .90 by using the Kuder-Richardson Formula 20 on scores from a sample of 305 freshman engineering students at an eastern university.

The validity coefficient of this test reported by Lord, Cowles and Cynamon[11] was .60 using first year grades as criteria. There are norms for the test for public college freshmen and private college freshmen. R. C. Moore[12] reported validity coefficients nearly as high for the Pre-Engineering Ability Test as he did for the Pre-Engineering Inventory. It seems that the Pre-Engineering Ability Test is the type of test that has been needed by engineering schools for a long time. They have needed a test which will predict as accurately as possible, and one which did not require too much time to administer. Both of these features seem to be embodied in the Pre-Engineering Ability Test.

Statistical Design of the Study

The Pearsonian r was used to compute the test intercorrelations as well as the correlations between the tests and the criterion. In order to select the tests which correlated significantly with the criterion, only tests whose correlations with the criterion were significant at the .05 level of confidence and below were used for further research in

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[11] F. Lord, J. T. Cowles and M. Cynamon, "The Pre-Engineering Inventory as a Predictor of Success in Engineering Colleges," Journal of Applied Psychology, XXXIV, No. 1, (Feb. 1950)

[12] R. C. Moore, "A Note on the Validity of the Pre-Engineering Ability Test," Journal of Engineering Education, 42: 512 (1952).

the problem.

The analysis of variance technique was used to test the differences as measured by the scores on the six tests, which were selected through the study of correlations of those students in the first semester of the freshman program in the Oklahoma Institute of Technology who made a grade point average of 2.00 and above and those who made a grade point average of 1.99 and below. Differences between seven of the departments in the Oklahoma Institute of Technology were tested also by analysis of variance. A nested type of analysis of variance design was used, and the .05 level of probability was selected as the level of significance. The results of the six tests were analyzed separately to determine if there were differences between departments on each of the tests. Fiducial limits were set on the population mean of each test to determine which departments varied significantly from the mean.

By the use of Yule's technique, beta weights were developed to be used in the prediction equations. From these, regression equations were developed for the tests to be used to predict total grade point average and grade point average in English 115, Mathematics 165, Chemistry 114, and the combined grade point average of these three courses. A multiple cutoff score was developed by computing the standard deviation and mean of each test and by setting the cutting line at one-half a standard deviation below the mean on each test. This corresponds approximately to the upper limits of the "D" line on the college grading system. Ten separate studies were made comparing prediction by means of regression with prediction by means of the multiple cutoff score. The differences were tested by the chi-square test of independence.

CHAPTER IV

TREATMENT OF DATA AND ANALYSIS OF RESULTS

Since the present study deals with the selection of the best predictors from those now being used in the counseling program of the Oklahoma Institute of Technology, all of the tests used for the years 1952-53 and 1955-56 were evaluated. Many of the tests used gave more than one score. In such cases all scores of the sub-tests were used. There were eighteen tests or sub-tests in the present study. With the grade point average for the first semester, there were nineteen variables.

Intercorrelations of the Tests and Validity Coefficients

Group I consisted of all the students who were freshmen in the Oklahoma Institute of Technology for the school year 1952-53. Group II consisted of 492 students who were freshmen in the school year 1955-56 and had completed all the tests as well as completing the first semester courses in which they were enrolled. Correlations were computed between each test and the criterion, grade point average, as well as between each of the tests. In predicting by means of regression, the tests with the highest positive weights were used. These were the ones which had the lowest correlations with each other and the highest correlations with the criterion. In other words, if two tests correlated higher with each other than either did with the criterion there was good evidence that each test was measuring the same trait or factor. Consequently, the first step in this study was to develop a matrix of correlations between all the tests and sub-tests and between the tests and sub-tests and the criterion, grade point average, for the first semester for all the subjects in the present study.

The American Council on Education Psychological Examination gave three scores: the linguistic, the quantitative, and the two combined in a total score. The Cooperative Algebra Test gave one score, as did the Minnesota Paper Form Board Test. Scores were obtained on the Kuder on the following ten scales: outdoor, mechanical, computational, scientific, persuasive, artistic, literary, musical, social service and clerical. There is also a V scale which detected if the student had been consistent in answering the questions. The Pre-Engineering Ability Test gave three scores: a section on the comprehension of scientific materials, a section on general mathematical ability, and a combined total score.

Correlation of the Test Scores with the Criterion

All of the correlations between the tests and the criterion and all the test intercorrelations are given in Table II.[1] For Group I the correlations between the scores on each of the tests and sub-tests and the

[1] Explanation of symbols for Table II: ACE Q, American Council on Education Psychological Examination, Quantitative Score; ACE L, American Council on Education Psychological Examination, Language Score: ACE T, American Council on Education Psychological Examination, Total Score. Eng I, Pre-Engineering Ability Test, Part I; Eng II, Pre-Engineering Ability Test, Part II; Eng T, Pre-Engineering Ability Test, Total Score. MPFB, Minnesota Paper Form Board. Math Fl, Cooperative Algebra Test. GPA, Total Grade Point Average.

TABLE II

TEST INTERCORRELATIONS AND CORRELATIONS BETWEEN THE TEST AND THE CRITERION OF ALL TESTS USED IN GROUP I, 1952-53.

	ACE L	ACE T	Eng I	Eng II	Eng T	MP FB	Math Pl	Kuder 0	1	2	3	4	5	6	7	8	9	GPA
ACE Q	.61	.83	.57	.52	.60	.38	.58	.05	.02	.13	-.002	-.12	-.03	-.03	.06	-.13	-.04	.42
ACE L		.85	.58	.43	.77	.29	.45	.05	.05	.04	.10	-.15	.007	.03	.09	-.16	-.07	.41
ACE T			.55	.49	.61	.39	.52	-.04	.01	.13	.07	-.12	-.01	.02	.06	-.16	-.03	.42
Eng I				.63	.90	.31	.66	.01	.09	.14	.18	-.16	-.05	.09	.01	-.22	-.04	.51
Eng II					.85	.35	.76	.02	.13	.19	.10	-.11	-.006	-.04	-.01	-.14	.04	.47
Eng T						.32	.78	.04	.07	.18	.18	-.17	-.03	.06	.02	-.19	-.02	.58
MPFB							.33	.14	.08	.01	.09	-.11	.18	.15	-.13	-.03	-.13	.26
Math Pl								.07	.08	.19	.16	-.18	-.08	-.02	-.06	-.13	.02	.58
Kuder 0 Outdoor									.29	-.08	.24	-.40	-.08	-.23	-.22	.002	-.24	.20
1 Mechanical										-.09	.35	-.30	-.03	-.32	-.32	-.12	-.25	-.07
2 Computational											.15	-.15	-.21	.03	-.10	-.12	.40	.21
3 Scientific												-.28	-.20	-.21	-.27	-.08	-.19	.14
4 Persuasive													-.01	.05	.13	-.007	.09	-.15
5 Artistic														-.03	.004	-.20	-.10	-.08
6 Literary															.16	-.21	-.02	.11
7 Musical																-.25	.03	-.14
8 Social Service																	-.18	-.05
9 Clerical																		.004

N = 343

criterion ranged from -.15 to .58. The lowest correlation was between the scores on section (4), persuasive, of the Kuder and grade point average. In fact, all of the correlations between the scores on the various sub-tests of the Kuder and grade point average were low except the Computational which yielded a correlation of .21, the Outdoor with a correlation of .20, and the Scientific with a correlation of .14 with first semester grade point average. The highest correlations of .58 were between the total scores on the Pre-Engineering Ability Test and grade point average and the scores on the Mathematics Placement Test and grade point average.

The total score of the American Council on Education Psychological Examination did not correlate any better with the criterion than did the Quantitative section. The correlation coefficient was .42. The Language section correlated .41 with the first semester total grade point average of the freshman engineers, which was very similar to the r obtained with the Quantitative and the total scores.

The total scores of the Pre-Engineering Ability Test correlated .58 with the criterion which was higher than the correlation of .51 between the section on the comprehension of scientific materials and the criterion and the correlation of .47 between its section on mathematical ability and the criterion. Thus, the total score of the Pre-Engineering Ability Test yielded a higher coefficient of correlation than did the scores of the two sections used separately. The Minnesota Paper Form Board Test and grade point average for the first semester correlated .26.

The six variables, out of the original eighteen, which showed the closest relationship with the criterion, were chosen for further study. The six variables chosen were the total score of the American Council on Education Psychological Examination, the total score of the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, the Kuder Computational Score and the Kuder Scientific score. All of these scores correlated higher with the criterion than did the scores of the other tests.

The intercorrelations between the tests chosen for further study were not as what would be desired because, as was mentioned previously, for tests to be good predictors they must have high correlations with the criterion and low intercorrelations with the tests. The intercorrelations were not sufficiently low in most cases to contribute anything extra to prediction. For example, the American Council on Education Psychological Examination total score correlated .42 with grade point average and the Pre-Engineering total correlated .58 with the criterion, and the two tests correlated .61 with each other. This high intercorrelation indicated the two tests were measuring essentially the same factors because their correlations with the criterion were less than the intercorrelation of .61. In fact, the reason that the Kuder Scientific and Computational scales were included was that their correlations with the criterion were higher than the other sections of the Kuder, and because their intercorrelations with the four other tests selected were lower than the correlations with the criterion. It was felt that under these circumstances the Kuder Computational and Scientific scales were sampling some factors not covered by the other tests.

It is usually better not to base judgments on only one group of subjects. In order to cross-validate the results obtained on Group I of 1952, the study was repeated on a similar group in 1955. This group was known as Group II. The six variables selected for special study on the first group were applied to the second group. These variables were the total score on the American Council on Education Psychological Examination, the total score on the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, the Kuder Computational score and the Kuder Scientific score. The criterion of success was the grade point average for the first semester of the school year 1955-56. The tests were given during the regular Orientation class required of all freshman engineers and during the period in which the entrance examinations were given at the opening of school. Test intercorrelations and correlations between the tests and the criterion were computed.

The test intercorrelations and correlations between the test and the criterion of all tests used in Group II, 1955-56 are given in Table III.

TABLE III

TEST INTERCORRELATIONS AND CORRELATIONS BETWEEN THE TEST AND THE CRITERION OF ALL TESTS USED IN GROUP II, 1955-56.

	ENG T	MPFB	MPT	KUDER COMP	KUDER SCIEN	GPA
ACE T	.72	.31	.69	.08	.07	.50
ENG T		.11	.75	.12	.11	.60
MPFB			.30	-.07	-.14	.17
MPT				.13	.03	.55
KUDER COMPUTATIONAL					.16	.22
KUDER SCIENTIFIC						.18

N = 200

The intercorrelations on Group I between the scores on the American Council on Education Psychological Examination and the scores on the following tests were: Pre-Engineering Ability, .61; Minnesota Paper Form Board, .39; Cooperative Algebra Test, .52; Kuder Computational, .13; and the Kuder Scientific, .07. On Group II, the intercorrelations were respectively as follows: .72; .31; .69; .08; and .07. The intercorrelations on Group I between the scores on the Pre-Engineering Ability Test and the scores on the following tests were: Minnesota Paper Form Board, .32; Cooperative Algebra Test, .78; the Kuder Computational, .13; and the Kuder Scientific, .13. On Group II, the intercorrelations were respectively as follows: .11; .75; .12; and .11. The scores on the Minnesota Paper Form Board Test on Group I correlated .33 with the scores on the Cooperative Algebra Test, .01 with the scores on the Kuder Computational Scale and .09 with the scores on the Kuder Scientific Scale compared with the following correlations respectively on Group II: .30; -.07; and -.14. The scores on the Cooperative Algebra Test on Group I correlated .21 with the scores on the Kuder Computational Scale and .16 with the scores on the Kuder Scientific Scale compared to correlations of .13 and .03 respectively on Group II. The scores on the Kuder Computational Scale on Group I correlated .15 with the scores on the Kuder Scientific Scale compared to a correlation of .16 on Group II. These intercorrelations seemed to be rather similar for Groups I and II.

The correlations in Group I compared favorably with those of Group II. These correlations are reproduced in Table IV.

TABLE IV

VALIDITY COEFFICIENTS FOR THE SIX SELECTIVE TESTS FOR GROUPS I AND II.

Variable	Correlation with the Criterion	
	Group I N = 343	Group II N = 200
ACE Total Score	.42**	.50**
Eng Total Score	.58**	.60**
MPFB	.26**	.17*
MPT	.58**	.55**
Kuder Computational	.21**	.22**
Kuder Scientific	.14*	.18*

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

In Group I the scores on the American Council on Education Psychological Examination gave a validity coefficient of .42 compared with .50 in Group II. In Group I the scores on the Pre-Engineering Ability Test correlated .58 with the criterion compared with a correlation of .60 for Group II. The scores on the Minnesota Paper Form Board Test correlated .26 with the criterion in Group I and .17 for Group II. The correlation between the scores on the Cooperative Algebra Test and grade point average was .58 for Group I and .55 for Group II. The scores on the Kuder Computational scale correlated .21 with the criterion for Group I and .22 for Group II. The scores on the Kuder Scientific scale correlated .14 with the criterion on Group I and .18 on Group II. All of these correlations were significant at the .05 level of confidence. The cross-validation study was worthwhile because it gave evidence to substantiate the findings on Group I. In order to select tests for the remainder of the study which had a significant correlation with the criterion, the computed r's between the scores on the tests and the criterion were compared with the tabulated r's given by Fisher and reproduced by Garrett.[2] All of these r's were significant at the .05 level of confidence for Groups I and II. This seemed to be evidence that the six tests selected had value in discriminating between those students who succeeded in the first semester program of the Oklahoma Institute of Technology and those students who failed.

The evidence gained thus far was used to study differences between various groups in the freshman classes of the school years 1952-53 and 1955-56 in the Oklahoma Institute of Technology and to develop multiple correlation coefficients, multiple regression equations, and multiple cutoff scores todetermine the most efficient predictive techniques.

Differences Between Groups and Departments

The study of the correlations between the tests and the criterion gave evidence that six tests may be useful in further research in exploring the many possibilities in finding the prediction devices which might be used economically and efficiently in the counseling program of the Oklahoma Institute of Technology. The six tests chosen for further study and experimentation were the total score of the American Council on Education Psychological Examination, the total score of the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder

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[2] Henry E. Garrett, Statistics in Psychology and Education, New York, Longmans, Green and Co., p. 437.

Preference Record. In order to study the differences between those students who made a grade point average of "C" or above and those who made a grade point average of "D" and below in the first semester of the freshman program of the Oklahoma Institute of Technology, two groups were formed. The upper group consisted of those students who made a grade point average of 2.00 or above. The lower group consisted of those students who made a grade point average of 1.99 and below. This cutting line was chosen on the basis that a total grade point average of 2.00 or above was necessary for graduation. Likewise, students were selected from each of seven departments in the Oklahoma Institute of Technology in order to study departmental differences.

The specific hypotheses to be tested were: first, differences in scores made on the American Council on Education Psychological Examination, the Pre-Engineering Ability test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology (a) who made a grade point average of 2.00 and above, and (b) those who made a grade point average of 1.99 and below, are no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling; second, differences in scores made on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology who are enrolled in the department of (a) agricultural engineering, (b) architectural engineering, (c) chemical engineering, (d) civil engineering, (e) electrical engineering, (f) general engineering, and (g) mechanical engineering, are no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling.

The analysis of variance technique was used as the statistical tool to test the above hypotheses. It was planned to select at random twenty students from the upper group and twenty students from the lower group for each of the seven departments in the Oklahoma Institute of Technology. It was decided to use all the students in the departments in which there were fewer than twenty students enrolled. In the departments which had more than twenty students, the selections were made through the use of a table of random numbers given by Snedecor.[3] In the upper group there were five students from the department of agricultural engineering, fourteen students from the department of architectural engineering, twenty students from the department of chemical engineering, sixteen students from the department of civil engineering, twenty students from the department of electrical engineering, twenty students from the department of general engineering, and twenty students from the department of mechanical engineering. In the lower group there were three students from the department of agricultural engineering, fifteen students from the department of architectural engineering, eight students from the department of chemical engineering, nine students from the department of civil engineering, twenty students from the department of electrical engineering, twenty students from the department of general engineering, and twenty students from the department of mechanical engineering.

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[3]George W. Snedecor, Statistical Methods, The Iowa State College Press, Ames, Iowa, 1953, pp. 10-13.

A two by six by seven analysis of variance design was made. In this design there were two groups, upper and lower, six tests which included the total scores on the American Council on Education Psychological Examination, the total score on the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scale of the Kuder Preference Record, and seven departments, which included the departments of agricultural, architectural, chemical, civil, electrical, general, and mechanical engineering at the Oklahoma Institute of Technology. In testing the hypotheses above, the .05 level of confidence was selected as the appropriate test.

The analysis of variance as described above was completed. The summary of the results may be found in Table V.

TABLE V

ANALYSIS OF VARIANCE OF UPPER AND LOWER GROUPS IN SEVEN DEPARTMENTS ON SIX TESTS OF THE FIRST SEMESTER FRESHMEN IN THE OKLAHOMA INSTITUTE OF TECHNOLOGY IN 1952-53.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Between Groups	1	20,887.86	20,887.86	62.71**
Between Departments	6	7,008.33	1,168.06	3.51**
Between Tests	5	806,294.79	161,258.96	
Individuals (error)	196	65,287.43	333.10	
Interactions:				
Groups x Departments	6	417.07	69.51	.21
Groups x Tests	5	10,929.15	2,185.83	19.36**
Departments x Tests	30	10,710.83	357.03	3.16**
Tests x Students within Groups and Departments (error)	980	110,641.53	112.90	
Groups x Departments x Tests	30	2,216.70	73.89	.65
TOTAL	1259	1,034,393.69		

**Significant at the .01 level of confidence.

There was a significant difference between the means of the upper and lower groups on the scores of the six tests used. The F value of 62.71 with 1 and 196 d.f. was significant at the .01 level of confidence. Therefore, the hypothesis that the differences in scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology in 1952-53 (a) who made a grade point average of 2.00 and above and (b) those who made a grade point average of 1.99 and below, were no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling was rejected. There seemed to be highly significant differences between the upper and lower groups by using the scores of all the tests in combination to determine the differences. The six tests used seemed to discriminate very well between those first semester freshman engineering students who did successful work and those students who did not. This evidence indicated the tests used in this study measured those aptitude, achievement, and interest factors which must be possessed by an engineering student for him to do satisfactory work.

Table V indicated further that there were departmental differences in addition to group differences. The F value of 3.51 with 6 and 196 d.f. was significant at the .01 level of confidence. Thus, the hypothesis that differences in scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the

Computational and Scientific scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology in 1952-53 who were enrolled in the department of (a) agricultural engineering, (b) architectural engineering, (c) chemical engineering, (d) civil engineering, (e) electrical engineering, (f) general engineering, and (g) mechanical engineering, were no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling, was rejected.

These departmental differences may have several meanings. One conclusion that might be drawn is that the more capable and interested students are selecting some departments while the least capable and interested students are selecting others. It would be of value to know which departments attract the various types of students. With this thought in mind, fiducial limits were set on the means of all the tests, both singly and with all tests combined by departments. The departmental mean differences computed from all tests combined may be found in Table VI.

TABLE VI

DEPARTMENTAL MEAN DIFFERENCES (ALL TESTS COMBINED)
GROUP I

Departments	N	ΣX	M
Agriculture	48	1824	28.00**
Architecture	174	8172	46.97
Chemical	168	8530	50.77**
Civil	150	7048	46.99
Electrical	240	11565	48.19
General	240	11025	45.94
Mechanical	240	11110	46.29
OIT - Total	1260	59274	47.04

SD = 28.65 (Standard Deviation)

SE_m = .81 (Standard Error of the Mean)

$\bar{X} \pm t_{.05}SE_m$ = 45.45---48.63 (Confidence limits set on the population mean at the .05 level.)

$\bar{X} \pm t_{.01}SE_m$ = 44.95---49.13 (Confidence limits set on the population mean at the .01 level.)

**Significant at the .01 level of confidence.

The mean of the scores of the combined tests for all departments was 47.04. The standard error of the mean was .81. The mean of the scores of the agricultural engineering students was 38.00 and that of the chemical engineers was 50.77. Both of these means varied significantly from the population mean at the .01 level of confidence. These findings indicated the students in chemical engineering scored high on the six tests used in this present study, while those students in agricultural engineering had a tendency to score low. The architectural, civil, electrical, general and mechanical engineering students seemed to be homogeneous as far as these tests used in combination were concerned.

The departmental mean differences computed from the scores on the American Council on Education Psychological Examination are given in Table VII.

TABLE VII

DEPARTMENTAL MEAN DIFFERENCES (AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION) GROUP I

Departments	N	ΣX	M
Agriculture	8	629	78.63**
Architecture	29	3120	107.59**
Chemical	28	3096	110.57**
Civil	25	2563	102.52
Electrical	40	4026	100.65
General	40	3967	99.18
Mechanical	40	3919	97.98*
OIT - Total	210	21320	101.52

SD = 22.26

SE_m = 1.54

$\bar{X} \pm t_{.05}SE_m$ = 98.49---104.55

$\bar{X} \pm t_{.01}SE_m$ = 97.52---105.52

**Significant at the .01 level of confidence

*Significant at the .05 level of confidence

In studying the departmental differences of the scores of the students on the American Council on Education Psychological Examination, it was found that the population mean was 101.52 with a standard error of 1.54. The mean of the scores of the agricultural engineering students was 78.63, that of the architectural engineering students was 107.59, and that of the chemical engineering students was 110.57. All were significant at the .01 level of confidence. The mean of the scores of the mechanical engineering students was 97.98 which was significant at the .05 level of confidence. This evidence indicated that the architectural and chemical engineering students entered the engineering school with higher quantitative and language aptitudes, and those students who entered the agricultural and mechanical engineering programs seemed to come into the situation with somewhat less proficiency in the factors as measured by this test. The civil, electrical and general engineering students seemed to be homogeneous as far as the factors are concerned as measured by the American Council on Education Psychological Examination.

The departmental mean difference computed from the scores on the Minnesota Paper Form Board Test are given in Table VIII. The population mean of the scores of the students on the Minnesota Paper Form Board Test was 45.87 with a standard error of .57. The mean of the scores of students in agricultural engineering on this test was 41.13, and those in architectural engineering was 48.34. These means differed significantly from the population mean at the .01 level of confidence. The chemical engineering students had a mean of 47.14 which was significant at the .05 level of confidence. In other words, the scores of

TABLE VIII

DEPARTMENTAL MEAN DIFFERENCES (MINNESOTA PAPER FORM BOARD TEST)
GROUP I

Departments	N	ΣX	M
Agriculture	8	329	41.13**
Architecture	29	1402	48.34**
Chemical	28	1320	47.14*
Civil	25	1128	45.12
Electrical	40	1832	45.80
General	40	1821	45.53
Mechanical	40	1801	45.03
OIT - Total	210	9633	45.87

$SD = 8.28$
$SE_m = .57$
$\bar{x} \pm t_{.05} SE_m = 44.75 — 46.99$
$\bar{x} \pm t_{.01} SE_m = 44.39 — 47.35$
**Significant at the .01 level of confidence
*Significant at the .05 level of confidence

the architectural and chemical engineering students indicated that these students had ability as measured by the Minnesota Paper Form Board Test, and that the students in agricultural engineering were lacking in this capacity. The scores of the students in civil, electrical, general and mechanical engineering did not seem todeviate significantly from the population mean of the Minnesota Paper Form Board Test.

The departmental mean difference computed from scores of the Pre-Engineering Ability Test are given in Table IX. The mean of the scores of all the students in the analysis of variance study on the Pre-Engineering Ability Test was 32.77 with a standard error of .34. The mean of the scores of students in agricultural engineering was 22.25

TABLE IX

DEPARTMENTAL MEAN DIFFERENCES (PRE-ENGINEERING ABILITY TEST)
GROUP I

Departments	N	ΣX	M
Agriculture	8	178	22.25**
Architecture	29	1010	34.83*
Chemical	28	1031	36.82**
Civil	25	798	31.92
Electrical	40	1354	33.85
General	40	1214	30.35**
Mechanical	40	1296	32.40
OIT - Total	210	6881	32.77

SD = 12.20
SE_m = .84
$\bar{X} \pm t_{.05} SE_m$ = 31.12---34.42
$\bar{X} \pm t_{.01} SE_m$ = 30.59---34.95

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

on this test. The mean of the scores of the students in chemical engineering was 36.32, and the mean of the scores of general engineering students was 30.35. These were significant at the .01 level of confidence. The results indicated that those students enrolled in agricultural and general engineering scored lower on the Pre-Engineering Ability Test than those students enrolled in chemical engineering. The mean of the scores of the students in architectural engineering was 34.83, which varied significantly from the population mean, at the .05 level of confidence. The students in civil, electrical and mechanical engineering seemed to be very similar to the population mean on the Pre-Engineering Ability Test.

The departmental mean difference computed from the scores on the Cooperative Algebra Test are given in Table X.

TABLE X

DEPARTMENTAL MEAN DIFFERENCES
(COOPERATIVE ALGEBRA TEST)
GROUP I

Departments	N	ΣX	M
Agriculture	8	156	19.50**
Architecture	29	875	30.17
Chemical	28	864	30.86*
Civil	25	729	29.16
Electrical	40	1156	28.90
General	40	1080	27.00
Mechanical	40	1114	27.85
OIT - Total	210	5974	28.45

$SD = 13.43$
$SE_m = .93$
$\bar{X} \pm t_{.05} SE_m = 26.62 \text{---} 30.28$
$\bar{X} \pm t_{.01} SE_m = 26.03 \text{---} 30.87$
**Significant at the .01 level of confidence
*Significant at the .05 level of confidence

In comparing the means of the scores on the Cooperative Algebra Test, the students in agricultural engineering had a mean of 19.50 and those in chemical engineering had a mean of 30.86. The mean of 19.50 differed significantly from the population mean of 28.45 on this test at the .01 level of confidence, while the mean of 30.86 was significantly above the population mean at the .05 level of confidence. This indicated that the agricultural engineering students were lacking in algebra achievement as measured by this test. The chemical engineering students seemed to have possessed knowledge measured by the Mathematics Placement Test. The students in the architectural, civil, electrical, general and mechanical engineering departments seemed to be homogeneous and did not vary significantly from the population mean.

The departmental mean differences computed from the scores of the Computational scale of the Kuder Preference Record are given in Table XI.

TABLE XI

DEPARTMENTAL MEAN DIFFERENCES (KUDER PREFERENCE RECORD – COMPUTATIONAL SCALE)
GROUP I

Departments	N	ΣX	M
Agriculture	8	197	24.63**
Architecture	29	779	26.86**
Chemical	28	788	28.14*
Civil	25	798	31.92**
Electrical	40	1254	31.35**
General	40	1183	29.58
Mechanical	40	1166	29.15
OIT – Total	210	6165	29.36

SD = 7.99
SE_m = .55
$\bar{X} \pm t_{.05}SE_m$ = 28.28——30.44
$\bar{X} \pm t_{.01}SE_m$ = 27.93——30.79
**Significant at the .01 level of confidence
*Significant at the .05 level of confidence

The study of departmental means through the use of analysis of variance revealed that there was much variation between departments on the Computational scale of the Kuder Preference Record. The mean for the population of the study on this test was 29.36. The mean of 24.63 of the agricultural engineering students, the mean of 26.86 of the architectural engineering students, and the mean of 31.92 of the civil engineering students differed significantly from the population mean at the .01 level of confidence. The mean of 28.14 of the chemical engineering students differed significantly at the .05 level of confidence. This evidence indicated that the people enrolled in agricultural and architectural engineering seemed to have little interest in computational activities, and those in chemical engineering had much interest. The study further indicated that the students enrolled in civil and electrical engineering seemed to have much interest of a computational nature. Students in general and mechanical engineering seemed more like the population mean.

The departmental mean differences computed from the scores on the Scientific scale of the Kuder Preference Record are given in Table XII.

TABLE XII

DEPARTMENTAL MEAN DIFFERENCES (KUDER PREFERENCE RECORD - SCIENTIFIC SCALE) GROUP I

Departments	N	ΣX	M
Agriculture	8	335	41.38**
Architecture	29	986	34.00**
Chemical	28	1431	51.11**
Civil	25	1032	41.28**
Electrical	40	1943	48.58**
General	40	1760	44.00
Mechanical	40	1814	45.35
OIT - Total	210	9301	44.29

SD = 11.35
SE_m = .78
$\bar{x} \pm t.05SE_m$ = 42.75---45.83
$\bar{x} \pm t.01SE_m$ = 42.26---46.32
**Significant at the .01 level of confidence
*Significant at the .05 level of confidence

The results of the comparison of the departmental means on the Scientific scale of the Kuder Preference Record was very similar to those found in the study of the Computational scale. The mean of the students in the study was 44.29. The following means varied significantly from the population mean at the .01 level of confidence: agriculture, 41.38; architecture, 34.00; chemical, 51.11; civil, 41.28; and electrical, 48.58. These results indicated that those students enrolled in agricultural, architectural and civil engineering had a low interest in those activities of a scientific nature as measured by the above inventory. It may be that these areas were ones in which a greater emphasis was placed on the arts instead of the sciences. The study further indicated that those people in chemical and electrical engineering had a high interest in scientific areas as measured by this test. This seemed to indicate that these people may be oriented toward the scientific fields and that there may be an emphasis placed on the scientific in these departments. Again, the general and mechanical engineering students seemed to be very similar to the population average.

In summarizing the study of departmental differences in the Oklahoma Institute of Technology, rather conclusive evidence was secured that the students in agricultural engineering came into the program lacking in abilities, achievements and interests as measured by the predictive instruments in use by the school. In all seven of the comparisons made, the mean scores of students in agricultural engineering varied significantly below the population mean at the .01 level of confidence. In contrast, the mean scores of students in chemical engineering varied significantly above the population mean in six of the comparisons made at the .05 level of confidence. It seemed that the most capable students selected chemical engineering as their major and that the least capable students selected agricultural engineering as their choice. The sample for agricultural engineering was very small which could have been a factor in the results. It was impossible to enlarge the sample because every student in agricultural engineering was taken in the sample. The architectural engineering students were significantly below the mean on the Computational and Scientific scales of the Kuder. Architecture seemed to be a branch of engineering in which it was not necessary for students to have had interests as measured by the Computational and Scientific scales of the Kuder in order to do well. General engineering students were significantly below the population mean on the Pre-Engineering Ability Test. The students in chemical engineering were significantly below the population mean on the Computational scale of the Kuder, and the civil engineering students were significantly below the population mean on the Scientific scale of the Kuder. The students in mechanical engineering were significantly below the population mean on the American Council on Education Psychological Examination.

The students in architectural engineering were significantly above the population mean on the American Council on Education Psychological Examination, the Minnesota Paper Form Board Test and the Pre-Engineering Ability Test. The students who majored in electrical engineering were significantly above the population mean on the Computational and Scientific scales of the Kuder, and the students who majored in civil engineering were significantly above the population mean on the Computational scale of the Kuder.

This information may be of some value for counseling, because it has given some insight into the abilities, achievements and interests of entering students in the Oklahoma Institute of Technology according to a departmental analysis.

The hypotheses related to the analysis of group and departmental differences have been tested, but there were related facts gathered from the study which should be presented. An evaluation of differences between tests was meaningless here, for the tests were not comparable since each had a different mean, standard deviation and range. There were many sources of variation in the analysis of variance classification. Interaction effects were present, but generalization here was risky because of the uncertainty of the source. Interaction between groups and departments was tested, and the result was a non-significant F value of .208. This seemed to infer that the seven engineering departments studied were rather consistent in their marking system. Groups times tests interaction was significant at the .01 level of confidence. An F value of 19.36 with 5 and 980 d.f. was obtained. This was variation not accounted for in the treatment of groups and tests alone but was variation due to the joint effects of the two acting together. The same could be said of departments times tests interaction in which there was an F value of 3.16 with 30 and 980 d.f. which was significant at the .01 level of confidence. Groups times departments times tests interaction was not significant. An F value of .65 was obtained with 30 and 980 d.f. It was too difficult to determine the exact source of variation in experiments with human subjects because of the many effects due to learning.

Cross-Validation Study of Differences Between Groups and Departments

In order to confirm the findings of the original study of 1952-53, the analysis was repeated on a similar group of entering students in the school year 1955-56. Similar classifications were made in an analysis of variance with two groups consisting of an upper group composed of those students who made a grade point average of 2.00 or above and a lower group composed of those students who made a grade point average of 1.99 and below for the first semester of the freshman year in the Oklahoma Institute of Technology. Similar classifications were made for the seven departments of agricultural engineering, architectural engineering chemical engineering, civil engineering, electrical engineering, general engineering and mechanical engineering, and for the six tests used in the study. Again, there was a two by seven by six analysis of variance design. See Table XIII.

TABLE XIII

ANALYSIS OF VARIANCE OF UPPER AND LOWER GROUPS IN SEVEN DEPARTMENTS ON SIX TESTS OF THE FIRST SEMESTER FRESHMEN IN THE OKLAHOMA INSTITUTE OF TECHNOLOGY IN 1955-56

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Between Groups	1	18,127.47	18,127.47	57.12**
Between Departments	6	4,661.23	776.87	2.45*
Between Tests	5	890,872.07	178,174.41	
Individuals (error)	216	68,553.46	317.38	
Interactions:				
Groups x Departments	6	1,363.64	227.27	.72
Groups x Tests	5	6,297.75	1,259.55	10.30**
Departments x Tests	30	9,463.64	315.45	2.58**
Tests x Students within Groups & Departments (error)	1080	132,063.40	122.28	
Groups x Departments x Tests	30	3,345.47	111.52	.91
TOTAL	1379	1,134,748.13		

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

There was a significant difference between the means of the upper and lower groups on the scores of the six tests used. The F value was 57.12 with 1 and 216 d.f., which was significant at the .01 level of confidence. Therefore, the hypothesis that the differences in scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology in 1955-56 (a) who made a grade point average of 2.00 and above, and (b) those who made a grade point average of 1.99 and below, were no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling, was rejected. Again, there seemed to be highly significant differences between the upper and lower groups when the scores of all the tests in combination were used to compare the groups. The evidence was rather conclusive that the six tests used seemed to discriminate very well between those first semester freshman engineering students who did well and those who did not.

The cross-validation study confirmed the earlier study that there were departmental differences. The F value from the analysis of variance between departments was 2.45 with 6 and 216 d.f. which was significant at the .05 level of confidence. Again, the hypothesis that differences in scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology in 1955-56 who were enrolled in the department of (a) agricultural engineering, (b) architectural engineering, (c) chemical engineering, (d) civil engineering, (e) electrical engineering, (f) general engineering, and (g) mechanical engineering, were no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling, was rejected.

The comparison of departmental mean differences of Group I with Group II using the scores on six tests is given in Table XIV.

TABLE XIV

COMPARISON OF DEPARTMENTAL MEAN DIFFERENCES OF GROUP I WITH GROUP II USING THE SCORES ON SIX TESTS

Dept	SCORE OF ALL TESTS COMB. Groups I	II	A C E Groups I	II	M P F B Groups I	II	PRE-ENG Groups I	II	A P T Groups I	II	K C Groups I	II	K S Groups I	II
Agri	28.00**	46.49	78.63**	100.83	41.13**	46.42	22.25**	34.58	19.50**	23.75**	24.63**	27.83**	41.88**	45.50*
Arch	46.97	46.56	107.59**	104.66	48.34**	50.17**	34.83*	34.17	30.17	30.34**	26.86**	26.63**	34.00**	33.40*
Chem	50.77**	51.05**	110.57**	107.00**	47.14*	46.88	36.82**	36.46**	30.86*	30.23**	28.14*	32.92**	51.11**	52.80*
Civil	46.99	48.31	102.52	104.11	45.12	47.46*	31.92	34.65	29.16	29.08	31.92**	32.35**	41.28**	42.19
Elec	48.19	47.45	100.65	99.75	45.80	44.75**	33.85	32.48	28.90	26.85	31.35**	32.10**	48.58**	48.75*
Gen	45.94	44.50**	99.18	95.45**	45.53	44.25**	30.35**	30.50**	27.00	24.30**	29.58	29.30	44.00	43.18
Mech	46.29	46.29	97.98*	102.73	45.03	44.43**	32.40	32.08	27.85	26.58	29.15	29.23	45.35	42.70
OIT-Total	47.04	47.09	101.52	101.84	45.87	46.20	32.77	33.23	28.45	27.48	29.36	30.19	44.29	43.63

*Significant at .05 level of confidence.

**Significant at .01 level of confidence.

The evidence gathered in studying Group II seemed to confirm the finding of Group I that the six tests selected from the original eighteen were discriminating between those students who did well and those who did poorly.

The departmental mean differences computed by using all tests combined are summarized in Table XV.

TABLE XV

DEPARTMENTAL MEAN DIFFERENCES
(ALL TESTS COMBINED)
GROUP II

Departments	N	ΣX	M
Agriculture	72	3347	46.49
Architecture	210	9778	46.56
Chemical	156	7964	51.05**
Civil	222	10724	48.31
Electrical	240	11387	47.45
General	240	10679	44.50**
Mechanical	240	11109	46.29
OIT-Total	1380	64988	47.09

SD = 28.67
SE_m = .77
$\bar{x} \pm t.05 SE_m$ = 45.58---48.60
$\bar{x} \pm t.01 SE_m$ = 45.10---49.08
**Significant at .01 level of confidence
*Significant at .05 level of confidence

The population mean of the scores of the combined tests for all departments on the 1955-56 group was 47.09 compared to a mean score of 47.04 for the 1952-53 group, a score which was nearly identical. Again, the students in chemical engineering varied significantly above the population mean as they did in the 1952-53 study. Themean for the chemical engineering students was 51.05 which was significant at the .01 level of confidence. The group which deviated the farthest below the mean using the total scores of the combined tests was a mean of 44.50 of the students in the general engineering department. This was significant at the .01 level of confidence. The students in agricultural, architectural, civil, electrical and mechanical engineering did not vary significantly from the mean.

The cross-validation investigation gave rather similar results in the study of departmental differences of the scores of the students on the American Council on Education Psychological Examination. Departmental mean differences computed from the scores on the American Council on Education Psychological Examination are given in Table XVI.

TABLE XVI

DEPARTMENTAL MEAN DIFFERENCES (AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION) GROUP II

Departments	N	ΣX	M
Agriculture	12	1210	100.83
Architecture	35	3663	104.66
Chemical	26	2782	107.00**
Civil	37	3852	104.11
Electrical	40	3990	99.75
General	40	3818	95.45**
Mechanical	40	4109	102.73
OIT-Total	230	23424	101.84

$SD = 22.27$
$SE_m = 1.47$
$\overline{X} \pm t.05SE_m = 98.94$---104.74
$\overline{X} \pm t.01SE_m = 98.02$---105.65
**Significant at the .01 level of confidence

The population mean was found tobe 101.84 with a standard error of 1.47 which was very similar to the mean of 101.52 found on the study of the 1952-53 group. The chemical engineering students in the 1955-56 study varied significantly at the .01 level of confidence above the mean on this test with a mean value of 107.00. This compared well with the findings of the 1952-53 group. The department which varied the most significantly below the mean was the students in the general engineering department with a mean of 95.45, which was significant at the .01 level of confidence. The students in agricultural, architectural, civil, electrical, and mechanical engineering seemed to be very similar to the population mean since they did not vary significantly from it.

The population mean of the scores of the students on the Minnesota Paper Form Board Test of the 1955-56 group was 46.20 with a standard error of .52, which was comparable to the mean of the 1952-53 group. See Table XVII.

TABLE XVII

DEPARTMENTAL MEAN DIFFERENCES (MINNESOTA PAPER FORM BOARD TEST) GROUP II

Departments	N	ΣX	M
Agriculture	12	557	46.42
Architecture	35	1756	50.17**
Chemical	26	1219	46.88
Civil	37	1756	47.46*
Electrical	40	1790	44.75**
General	40	1770	44.25**
Mechanical	40	1777	44.43**
OIT-Total	230	10625	46.20

SD = 7.83
SE_m = .52
$\bar{x} \pm t_{.05} SE_m$ = 45.18---47.22
$\bar{x} \pm t_{.01} SE_m$ = 44.85---47.55
**Significant at the .01 level of confidence
*Significant at the .05 level of confidence

The mean of the students in architectural engineering was 50.17, which was significantly above the population mean at the .01 level of confidence. The mean of the students in civil engineering was 47.46, which was significantly above the population mean at the .05 level of confidence. There were three significantly below the population mean at the .01 level of confidence. These were electrical engineering students at 44.75, general engineering students at 44.25, and mechanical engineering students at 44.43. The students in agricultural and chemical engineering seemed to be homogeneous with the population mean.

The mean of the scores of all the students in the analysis of variance study of the year 1955-56 on the Pre-Engineering Ability Test was 33.23 with a standard error of .79, which was very similar to the mean of the 1952-53 group. See Table XVIII.

TABLE XVIII

DEPARTMENTAL MEAN DIFFERENCES
(PRE-ENGINEERING ABILITY TEST)
GROUP II

Departments	N	ΣX	M
Agriculture	12	415	34.58
Architecture	35	1196	34.17
Chemical	26	948	36.46**
Civil	37	1282	34.65
Electrical	40	1299	32.48
General	40	1220	30.50**
Mechanical	40	1283	32.08
OIT-Total	230	7643	33.23

SD = 12.00

SE_m = .79

$\bar{X} \pm t.05SE_m$ = 31.67---34.79

$\bar{X} \pm t.01SE_m$ = 31.18---35.28

**Significant at the .01 level of confidence

Again, the students in chemical engineering were significantly above the population mean at the .01 level of confidence with a mean value of 36.46. This further confirmed that those students who enrolled in chemical engineering possessed those qualities which were measured by the

Pre-Engineering Ability Test. The students in general engineering had a mean value of 30.50, which was significantly below the population mean at the .01 level of confidence. This was an indication that those students who major in general engineering had less of those qualities as measured by the Pre-Engineering Ability Test than the students who majored in the other departments. The scores of the students in agricultural, architectural, civil, electrical and mechanical engineering did not very significantly from the population mean.

The departmental mean differences computed from the scores on the Cooperative Algebra Test are given in Table XIX.

TABLE XIX

DEPARTMENTAL MEAN DIFFERENCES
(COOPERATIVE ALGEBRA TEST)
GROUP II

Departments	N	≤X	M
Agriculture	12	285	23.75**
Architecture	35	1062	30.34**
Chemical	26	786	30.23**
Civil	37	1076	29.08
Electrical	40	1074	26.85
General	40	972	24.30**
Mechanical	40	1063	26.58
OIT-Total	230	6318	27.48

SD = 12.72
SE_m = .84
$\bar{x} \pm t_{.05}SE_m$ = 25.83----29.13
$\bar{x} \pm t_{.01}SE_m$ = 25.30----29.66
**Significant at the .01 level of confidence

The investigation of the departmental differences in regards to the Cooperative Algebra Test on the 1955-56 group revealed that the students in agricultural engineering had a mean of 23.75, which was significantly below the population mean at the .01 level of confidence. The students in general engineering varied in a similar fashion with a mean value of 24.30. There were two departments whose students were significantly above the population mean at the .01 level of confidence. These were the students in architectural engineering with a mean value of 30.34 and those in chemical engineering with a mean value of 30.23. The results of the agricultural and chemical engineering students were similar to the results in the initial study in 1952-53. Students in the departments of civil, electrical and mechanical engineering seemed to be very similar to the population mean.

The cross-validation study gave similar results as were found on the initial study in determining the departmental mean differences on the Computational scale of the Kuder Preference record. See Table XX.

TABLE XX

DEPARTMENTAL MEAN DIFFERENCES (KUDER PREFERENCE RECORD-COMPUTATIONAL SCALE). GROUP II

Departments	N	ΣX	M
Agriculture	12	334	27.83**
Architecture	35	932	26.63**
Chemical	26	856	32.92**
Civil	37	1197	32.35**
Electrical	40	1284	32.10**
General	40	1172	29.30
Mechanical	40	1169	29.23
OIT-Total	230	6944	30.19

SD = 8.29
SE_m = .55
$\bar{x} \pm t_{.05}SE_m$ = 29.11---31.27
$\bar{x} \pm t_{.01}SE_m$ = 28.76---31.62
**Significant at the .01 level of confidence

The population mean was 30.19 with a standard error of .55. There were two means which were significantly below the mean at the .01 level of confidence. These were the mean of 27.83 for agricultural engineering students and the mean of 26.63 for the architectural engineering students. There were three means which were significantly above the population mean at the .01 level of confidence. These were the mean of 32.10 of the electrical engineering students, the mean of 32.35 of the civil engineering students, and the mean of 32.92 of the chemical engineering students. The students in general and mechanical engineering seemed to be very similar to the population mean because their means did not vary significantly from the population mean. These results resemble the results of the initial study in this respect.

The departmental mean differences computed from the scores on the Scientific scale of the Kuder Preference Record are given in Table XXI.

TABLE XXI

DEPARTMENTAL MEAN DIFFERENCES (KUDER PREFERENCE RECORD-SCIENTIFIC SCALE)
GROUP II

Departments	N	ΣX	M
Agriculture	12	546	45.50*
Architecture	35	1169	33.40*
Chemical	26	1373	52.80*
Civil	37	1561	42.19
Electrical	40	1950	48.75*
General	40	1727	43.18
Mechanical	40	1708	42.70
OIT-Total	230	10034	43.63

SE = 11.33

$SE_m =$ .75

$\bar{x} \pm t_{.05} SE_m$ = 42.15---45.11

$\bar{x} \pm t_{.01} SE_m$ = 41.68---45.58

*Significant at the .05 level of confidence

The cross-validation study of the results on the Kuder Scientific scale revealed the population mean to be 43.63, which was similar to the mean obtained on the initial study. The architectural engineering students were significantly below the population mean with a mean value of 33.40, which was significant at the .05 level of confidence. There were three departmental means which were significantly above the population mean. These were the means of the agricultural engineering students of 45.50, the electrical engineering students of 48.75, and the chemical engineering students of 52.30. The means of the students in civil, general, and mechanical engineering seemed to be very similar to the population mean. These results are in the same general direction of the initial study except for the civil engineering students, which were significantly below the population mean in the first study.

In summarizing the cross-validation study of departmental differences in the Oklahoma Institute of Technology, some confirming evidence was found to substantiate the findings in the earlier study. As in the initial study, it seemed as though the most capable students were selecting chemical engineering as their major and that the tests seemed to bring out these facts. The chemical engineering students were significantly above the population mean in all seven of the comparisons, while on the first study they varied from the population means on six of the comparisons. On the first study the students in agricultural engineering were significantly below the population means in all seven of the comparisons. In the cross-validation study, the agricultural engineering students were significantly below the population means on the Cooperative algebra Test and the Kuder Computational scale. The students majoring in general engineering were significantly below the population mean in five categories on the second study. They were below the population mean on the six tests combined on the American Council on Education Psychological Examination, on the Minnesota Paper Form Board Test, on the Pre-Engineering Ability Test, and on the Cooperative Algebra Test. The fact that the majors in general engineering were doing more poorly in 1955-56 than in 1952-53 seemed to indicate that the population of the entering freshmen in the Oklahoma Institute of Technology had changed somewhat in the three years which had elapsed. It was true that many more students enrolled in 1955-56 than in 1952-53. In fact in 1952-53 there were 343 freshmen enrolled in the Oklahoma Institute of Technology. In 1955-56 there were 661 freshmen. It may well mean that many of these freshmen had not decided on which branch of engineering they would choose and consequently they chose general until they did decide. Also, it may have meant that many of those in general engineering were students who were lacking in those factors which made for success in the program. As was mentioned previously, these results could well have been caused by a small sample. The agricultural engineering sample was still not as large as one would like to have had since there were only twelve students enrolled in the program.

The students in architectural and civil engineering were significantly above the population means in the second study on the Minnesota Paper Form Board Test. This was a result which was expected for success in these fields. Another consistent result as was found on the first and second studies was that the electrical and chemical engineering students were significantly above the mean on the computational and scientific scales of the Kuder Preference Record. This seemed to be related to success in these areas.

Some of the related findings from the analysis of variance of the cross-validation group indicated again there was no significant F value from Groups times Departments interaction. The F value was .72 with 6 and 1080 d.f. Groups times Tests interaction gave an F value of 10.30 with 5 and 1080 d.f., which was significant at the .01 level of confidence. The Departments times Tests interaction was highly significant with an F value of 2.58 with 30 and 1080 d.f. Groups times Departments times Tests interaction was not significant. The F value was .91. These results were very similar to those obtained on the initial study. Again, the generalization which seemed appropriate here was that the interaction variation is that which comes about by one factor acting on another. Again, it should be mentioned that in human experimental work it was dangerous to generalize too widely on the interaction effects because there were too many reverberatory circuits and intervening variables which might affect the results. Interaction variation was that which was not accounted for in the groups, tests and departments alone but was variation due to the joint effects of the two or three acting together.

Summary of the Study of the Differences Between Groups and Departments

In summarizing this phase of the study, the evidence gained thus far seemed to be of value since the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record have served the purpose of separating those students who did well from those who did poorly in the first semester of the freshman program in the Oklahoma

Institute of Technology. By placing those students in one group who made a grade point average of 2.00 or above and those in another group who made a grade point average of 1.99 and below and then studying these two groups as to how they did on the six tests mentioned above, seemed to give conclusive evidence that these tests were adequate for studying prediction by means of regression or by means of a multiple cutoff technique. These problems were considered next in this study. The hypotheses have been tested and the facts gathered have refuted the hypotheses that there were no differences between groups and departments. Conclusive findings indicated that the two groups differed significantly according to the results of the tests and that some of the departments differed significantly.

Comparison of Prediction by Means of Regression with Prediction by Means of the Multiple Cutoff Technique

With college enrollments increasing steadily from year to year, a need has developed to find a predictive device which may be administered with the minimum amount of time but which will give the kind of information about an entering student a counselor needs in order that counseling and advising will be as accurate and adequate as possible. With this thought in mind, a comparison was made of prediction by means of regression with prediction by means of a multiple cutoff technique.

Thorndike[4] stated that prediction by means of regression could be compared more simply with prediction by means of a multiple cutoff tech-

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[4] R. L. Thorndike, Research Problems and Techniques. AAF Aviation Psychology Research Program, Report No. 3. Washington, D. C.: Government Printing Office, 1947, pp. 89-93.

nique if a case were taken in which only two test variables were used. It seems that a multiple cutoff technique is inappropriate if more than two tests are used. Thorndike further stated that if only three cutting scores were used on ten different tests that there would be a possibility of some 59,000 different comparisons to be made and analyzed. Therefore, it becomes a hopeless task. The logical course to pursue is to select through zero order correlations and multiple correlations, the tests which seem to have the highest correlations with the criteria and then develop regression equations and/or multiple cutoff scores for predictive purposes.

In order to activate the purposes stated above, the following hypotheses are to be tested:

(1) There is no difference between a regression and a multiple cutoff technique when predicting total grade point average in the first semester of the freshman program in the Oklahoma Institute of Technology.

(2) There is no difference between a regression and a multiple cutoff technique when predicting first semester grade point average in the following courses taken by freshmen in the Oklahoma Institute of Technology: English 115, Mathematics 165, Chemistry 114, and a combined grade point average of the three above courses.

An earlier part of the present study furnished evidence that six tests correlated well with grade point average and discriminated between those students who were successful in the first semester of the freshman program of the Oklahoma Institute of Technology. These six tests were the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test and the Computational and Scientific scales of the Kuder Preference Record. In order to compute multiple regression equations, multiple correlation coefficients were computed from the zero-order correlations of the fifteen possible combinations of the six tests named above. These multiple correlations are given in Table XXII.

TABLE XXII

CORRELATIONS OF COMBINATIONS OF TWO TESTS AND TOTAL GRADE POINT AVERAGE

N = 200

Test Combination	Criterion	R
Pre-Eng-MPFB	GPA	.623
Pre-Eng-Math Pl	GPA	.613
ACE-Math Pl	GPA	.594
Pre-Eng-Kuder Comput.	GPA	.587
Math Pl-Kuder Comput.	GPA	.585
ACE-Pre-Eng	GPA	.584
MPFB-Math Pl	GPA	.582
Math Pl-Kuder Scient.	GPA	.579
Pre-Eng-Kuder Scient.	GPA	.578
ACE-Kuder Comput.	GPA	.445
ACE-MPFB	GPA	.432
ACE-KUDER Scient.	GPA	.432
MPFB-Kuder Comput.	GPA	.333
MPFB-Kuder Scient.	GPA	.286
Kuder Comput.-Kuder Scient.	GPA	.231

Yule's three-variable correlation formula was used to calculate the correlations above. This formula and the one used to compute the multiple regression equations were taken from Guilford.[5]

All of the multiple correlations above were computed from zero-order correlations which were derived from scores on the above mentioned tests of freshmen entering the Oklahoma Institute of Technology in 1952-53. Using regression and the multiple cutoff scores derived from those

[5] J. P. Guilford, Fundamental Statistics in Psychology and Education, New York: McGraw-Hill Book Co., Inc. 1950, pp. 427-433.

results, predictions were done on the freshmen entering the Oklahoma Institute of Technology in 1955-56. In other words, the regression equations were developed on one group of freshmen and the predictions using the regression equations were tested on another similar group. The procedure was of the nature of cross-validating previous findings. The three variable type multiple correlation and regression fit in well in making comparisons with a multiple cutoff technique, because two of the variables are used as predictors and the other variable is the criterion of success. In using the multiple cutoff technique, cutting scores are selected for two of the tests used as predictors. Any score falling below these cutting scores simply infers that the probability of a person's succeeding in a task measured by the two tests would be rather slight. Any score falling above the cutting scores would mean the probability of a person's succeeding in a task measured by the two tests would be great. Guilford pointed out the difficulty found in determining the cutoff scores. Once the scores are determined, however, there is no difficulty in administering the technique. He pointed out further that a score falling below the minimal score on either test automatically rejects the applicant. In other words, if a student entering the Oklahoma Institute of Technology should score above the cutting score on the American Council on Education Psychological Examination but below the critical score on the Pre-Engineering Ability Test, he would be a poor risk in the program. The problem in this present study is to determine if prediction using regression is better than prediction using the multiple cutoff technique. A type of multiple cutoff score was developed for this study to fit in with the policy of grading in vogue at Oklahoma Agricultural and Mechanical

College. There are five possible grades a student may make, i.e., an A, B, C, D or F.

Rinsland[6] has worked out a technique whereby grades may be given to students in the various classes by computing the mean and standard deviation of the grades made in a class. In using this method, one-half a standard deviation, plus and minus from the mean comprises the C group, one half to one and one-half standard deviations above the mean comprises the B group, one and one-half standard deviations and above comprise the A group. Likewise, one-half to one and one-half standard deviations below the mean include the D group, and any grade below one and one-half standard deviations below the mean include the F group. For this present study the cutting score selected was one-half a standard deviation below the mean of the scores of the tests used for prediction. This would correspond approximately to the upper limits of the D group as explained above. Since it requires a C average to graduate, any student who scores below this cutting score on any of the tests used as predictors would be a poor risk in the program. It is assumed from this reasoning that a student who would make the equivalent of a D on one of the predictive tests would also make a D in his course grades.

With the above thoughts in mind, the six combinations of predictors with the highest correlations with total grade point average for the first semester of 1952-53 in the Oklahoma Institute of Technology were selected. Regression equations were derived for all of these. The standard error of estimate from multiple regression was also computed

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[6]Henry D. Rinsland, Elements of Educational Statistics, Part I, Mimeographed Bulletin, University of Oklahoma, p. 13.

using the formula given by Guilford[7] and confidence limits were set on the predictions at the .05 level of confidence. Then, thirty students were selected from the first semester freshmen of the school year 1955-56 from the Oklahoma Institute of Technology in order to test the predictions by using regression. A check was made to determine how many were within the confidence limits of prediction through regression.

To implement the multiple cutoff technique, the mean and standard deviation were obtained for each of the tests used. Then the cutting score was selected as that one occurring one-half a standard deviation below the mean. Any student scoring below this point on one or both of the tests used as predictors was considered as a poor risk in the program. The scores of the thirty students were checked with this device in order to determine how many students were predicted by this method.

A chi-square test of independence using contingency tables was made to test the hypothesis that there was no difference in prediction by regression and prediction by a multiple cutoff technique. Six comparisons were made to determine if regression was more effective in the prediction of total grade point average than a multiple cutoff technique. The results are found in Table XXIII. These six comparisons seemed to present evidence that prediction by means of regression was more effective in this study than prediction by means of a multiple cutoff technique. Multiple regression predicted accurately in 173 cases out of a possible 180 compared to an accurate prediction of 130 out of 180 for the multiple cutoff technique. Likewise, the X^2 test of independence was significant at the .05 level of confidence in four of the six tests,

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[7]Guilford, p. 77.

TABLE XXIII

SIX COMPARISONS OF PREDICTION BY REGRESSION WITH PREDICTION BY A MULTIPLE CUTOFF TECHNIQUE

Predictors	Cutting Scores	Prediction of Success or Failure by Multiple Cutoff: Number Predicted Yes	No	Prediction of Total Grade Point Average by Regression Within the Limits Set at the .05 Level of Confidence: R	Regression Equation	***$SE_{(Est. Y)} t_{.05}$	Number Predicted Yes	No	Chi-Square Test of Independence between Regression and Multiple Cutoff: d.f.	x^2
Pre-Eng MPFB	27.97 42.68	24	6	.623	$.60 + .036X_3 + .009X_4$	±1.18	28	2	1	2.30
Pre-Eng MPT	27.97 21.03	23	7	.613	$.55 + .022X_3 + .020X_5$	±1.24	29	1	1	5.20*
ACE MPT	92.02 21.03	20	10	.594	$.73 + .006X_2 + .030X_5$	±1.26	30	0	1	12.00**
Pre-Eng K C	27.97 26.35	23	7	.587	$.66 + .037X_3 + .011X_6$	±1.28	28	2	1	3.28
MPT K C	21.03 26.35	18	12	.585	$.93 + .034X_5 + .010X_6$	±1.28	30	0	1	15.00**
ACE Pre-Eng	92.02 27.97	22	8	.584	$.67 + .004X_2 + .034X_3$	±1.28	28	2	1	4.32*
		130	50				173	7	6	42.10**

*Significant at the .05 level of confidence.
**Significant at the .01 level of confidence.
***Confidence limits at the .05 level of confidence set on the regression equation.

which indicated the two methods differed significantly. In the four tests in which there were differences, prediction by regression was more accurate. In combining the six tests, X^2 was 42.10 with 6 d.f., which was significant at the .01 level of confidence. Furthermore, only two predictive variables were used in the regression equations in order that the proper comparisons might be made with the multiple cut-off technique. If several predictors could have been used, it is likely that regression would have been more accurate than it was in this present study. Related experimental evidence has indicated this. Therefore, the evidence thus gained seemed to refute the hypothesis that there is no difference in prediction by means of regression and prediction by means of multiple cutoff technique in predicting total grade point average in the first semester of the freshman program in the Oklahoma Institute of Technology. Prediction by means of regression seemed to give more consistent results throughout.

In order to test the hypothesis that there is no difference in prediction by means of regression and prediction by means of a multiple cutoff technique in predicting grade point average in English 115, Mathematics 165, Chemistry 114, and the combined grade point average of these three courses, a further analysis was made. The English Department at Oklahoma Agricultural and Mechanical College changed the basic freshman first semester English course from a three hour course, English 113, in 1952-53, to a five hour course, English 115, in 1955-56. This was the only curriculum change which affected this study. The regression equation and the multiple cutoff score were developed on the English 113 course, and the predictions were made on the English 115 course. Four tests and several combinations of them were selected as predictors in this phase of the study. These tests were the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, and the Cooperative Algebra Test. The tests were selected which had the highest correlations with the various grade point averages in English 113, Mathematics 165, Chemistry 114, and the combined grade point average of the three courses. These correlations are summarized in Table XXIV. The scales of the Kuder were rejected because the results with them seemed to vary and to be inconsistent from time to time. The subjects for this part of the study were selected randomly from those students who had taken all three of the above courses. There were fifty-nine students selected from the 1952-53 freshman class in the Oklahoma Institute of Technology whose scores on the four tests and whose grades in the three courses served as the basis of developing the regression equations and the multiple cutoff scores. Thirty students were selected from the 1955-56 freshman class on whom the predictions were made and tested.

TABLE XXIV

CORRELATIONS BETWEEN THE TESTS AND CRITERIA USED IN PREDICTING GRADE POINT AVERAGE IN SPECIFIC COURSES IN ENGLISH, MATHEMATICS AND CHEMISTRY BY MEANS OF REGRESSION.

N = 59

Test	Combined Grade Point Average of the three courses	GPA in English 113	GPA in Math 165	GPA in Chem 114
ACE	.426	.315	.350	.362
Pre-Eng	.538	.260	.469	.520
MPFB	.284	.136	.183	.394
MPT	.526	.324	.508	.365

Four comparisons were made to determine if regression were more effective in the prediction of grade point average in specific English, Chemistry and Mathematic courses than a multiple cutoff technique. The results are found in Table XXV. In combining the results of these four comparisons in specific subject matter courses rather than with total grade point average, ninety-two were predicted correctly out of a possible one hundred and twenty by using regression while seventy-eight were predicted by using the multiple cutoff technique. The X^2 test of independence was significant at the .05 level of confidence in one out of four tests, which indicated the two methods differed significantly. In the one test in which there were differences, prediction by regression seemed to be more accurate. In combining the four tests, X^2 was 13.16 with 4 d.f., which was significant at the .05 level of confidence. In view of this evidence, the hypothesis was refuted; namely, that there is no difference in prediction by means of regression and prediction by means of a multiple cutoff technique in predicting grade point average in English 115, Chemistry 114, Mathematics 165, and the combined grade point average of the three courses. In combining all ten tests, X^2 was 55.26 with 10 d.f. and was significant at the .01 level of confidence. It seemed that regression was more consistent throughout. Regression did well in predicting in courses basic to engineering and in predicting total grade point average.

TABLE XXV

FOUR COMPARISONS OF PREDICTION BY REGRESSION WITH PREDICTION WITH PREDICTION BY A MULTIPLE CUTOFF TECHNIQUE USING GRADE POINT AVERAGE IN SPECIFIC COURSES AS A CRITERION

	Prediction of Success or Failure by Multiple Cutoff			Prediction of Total Grade Point Average by Regression Within the Limits Set at the .05 Level of Confidence						Chi-Square Test of Independence between Regression and Multiple Cutoff	
		Number Predicted						Number Predicted			
Predictors	Cutting Scores	Yes	No	Criterion	R	Regression Equation	SE(Est. Y)t.05	Yes	No	d.f.	χ^2
Pre-Eng MPT	33.62 35.58	20	10	Combined GPA ***	.601	$-.40+.035X_3+.034X_5$	± 1.30	26	4	1	3.36
Pre-Eng MPFS	33.62 43.92	16	14	GPA in Chem 114	.573	$-.56+.044X_3+.027X_4$	$\pm .98$	22	8	1	2.58
Pre-Eng MPT	33.62 31.69	21	9	GPA in Math 165	.553	$-1.43+.039X_3+.056X_5$	± 2.04	28	2	1	5.46*
ACE MPT	97.77 31.69	21	9	GPA in Engl 113	.387	$-.23+.011X_2+.028X_5$	$\pm .68$	16	14	1	1.76
		78	42					92	26	4	13.16*

*Significant at the .05 level of confidence.
**Confidence limits at the .05 level of confidence set on the regression equation.
***Combined Grade Point Average of Chemistry 114, Mathematics 165 and English 113

CHAPTER V

SUMMARY AND CONCLUSIONS

The search for the best predictors of success in engineering schools has become more intense as the enrollments have climbed. This present study was conducted for the purpose of selecting the best predictors from those used in the counseling program of the Oklahoma Institute of Technology. After correlating all of the tests, six tests of the eighteen used appeared to be useful enough for further study. These tests were the total score of the American Council on Education Psychological Examination, the total score on the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record. On Group I, which consisted of 343 first semester freshmen in the Oklahoma Institute of Technology for the year 1952-53, the scores on the above tests correlated with total grade point average as follows: American Council on Education Psychological Examination, .42; Pre-Engineering Ability Test, .53; the Minnesota Paper Form Board Test, .26; the Cooperative Algebra Test, .53; the Computational scale of the Kuder, .21; and the Scientific scale of the Kuder, .14. On Group II for the year 1955-56, which consisted of 492 freshmen engineering students, the correlations were as follows, respectively: .50; .60; .17; .55; .22; and 13. All of the <u>r's</u> were significant at the .05 level of confidence for Groups I and II. This was evidence that these tests were more effective in predicting success in the engineering program than the twelve tests and sub-tests which correlated somewhat lower with the criterion. This was the first step in selecting the optimal combination of predictors from those being employed to predict success more effectively in the first semester of the first-year program of the Oklahoma Institute of Technology.

The six tests selected were used in testing the hypothesis that differences in scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology (a) who make a grade point average of 2.00 and above, and (b) those who make a grade point average of 1.99 and below, are no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling. These differences were tested by analysis of variance on the entering freshmen of the year 1952-53 and repeated on those of the year 1955-56. There were significant differences at the .01 level of confidence between the means of the upper and lower groups using scores of all the tests to determine the differences. Therefore, the hypothesis was refuted that there were no differences between the upper and lower groups. This indicated that the six tests selected were valuable instruments in discriminating between those students who did passing work and those students who did failing work in their first semester freshman program in the Engineering School

Another hypothesis tested by means of the analysis of variance was that differences in scores on the American Council on Education Psychological Examination, the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, the Cooperative Algebra Test, and the Computational and Scientific scales of the Kuder Preference Record between those students in the first semester of the freshman program in the Oklahoma Institute of Technology who are enrolled in the department of (a) agricultural engineering, (b) architectural engineering, (c) chemical engineering, (d) civil engineering, (e) electrical engineering (f) general engineering, (g) and mechanical engineering, are no greater than differences which could be expected to occur as a result of chance fluctuations in random sampling. The results indicated there were significant differences at the .01 level of confidence between departments on the 1952-53 freshmen and significant differences at the .05 level of confidence on the 1955-56 class. Therefore, the hypothesis was refuted that there were no departmental differences based on the scores on the six tests used in the study. This phase of the study revealed that chemical engineering students were significantly above the mean on most of the tests indicating that the students whose abilities, achievements, and interests are high as measured by the tests, had a tendency to select chemical engineering as their major. This was true for both years, 1952-53 and 1955-56. The results indicated that in the class of 1952-53 that those students who scored low on the tests had a tendency to select agricultural engineering and that in the class of 1955-56 those students who scored low on the tests had a tendency to select general engineering as their major. These were significant at the .05 level of confidence. This was further evidence that the six tests selected were giving results indicating they were very effective in separating those students who would succeed from those who would fail in the program. The analysis further revealed that students majoring in architectural engineering and chemical engineering were significantly above the mean on the Minnesota Paper Form Board Test. This seemed to indicate that this test might have value in screening those students who desired to enter these two branches of engineering. The civil and electrical engineering students were significantly above the mean on the Computational scale of the Kuder. The chemical and electrical engineering students were significantly above the mean on the Scientific scale of the Kuder. The results indicated that the agricultural and architectural engineering students were significantly below the mean on the Kuder Computational and Scientific scales. This seemed to indicate that the people in these fields may be more oriented toward the arts than the sciences as far as interests were concerned. These results were consistent on the 1952-53 class as well as the 1955-56 class.

Now, the real evaluation of a measuring device comes about by determining how well it will predict. With this in mind, the following hypotheses were assumed: first, that there is no difference in prediction by means of regression and prediction by means of a multiple cutoff technique in predicting total grade point average in the first semester of the freshman program in the Oklahoma Institute of Technology; and, second, that there is no difference in predicting by means of regression and prediction by means of a multiple cutoff technique in predicting grade point average in the following courses taken by first semester freshmen in the Oklahoma Institute of Technology: English 115, Mathematics 165, Chemistry 114, and a combined grade point average of the three grades. The regression equations and cutoff scores were computed on the classes of 1952-53 and the predictions made on those of 1955-56.

The two hypotheses were refuted. The results seemed to indicate that regression was more consistent in prediction throughout, both in predicting total grade point average as well as predicting grade point average in specific courses. Regression did well in the prediction of courses basic to engineering in the prediction of total grade point average.

The final question is what are the optimal combinations of predictors of those now being used to predict success more effectively in the first semester of the first-year program of the Oklahoma Institute of Technology. The study of the comparisons between prediction by using regression and the multiple cutoff technique gave some information which indicated some tests might be more efficient than others. In predicting total grade point average, the two tests used in combination with the largest R's were selected. For the six comparisons made in this category, the Pre-Engineering Ability Test figured in four of the highest multiple correlations. It combined with the Minnesota Paper Form Board Test in an R of .623 with total grade point average. The Pre-Engineering Ability Test and the Cooperative Algebra Test correlated .613 for the second highest R with total grade point average. The Pre-Engineering Agility Test and the Kuder Computational scales correlated .587 and the Pre-Engineering Ability Test and the American Council on Education Psychological Examination correlated .584 with total grade point average for the fourth and sixth highest correlations respectively. The Cooperative Algebra Test figured in the second, third, and fifth highest multiple correlations. The Kuder Computational scale was one of the variables in the fourth and fifth highest correlations.

In predicting success in English 115, the Cooperative Algebra Test and the American Council on Education Psychological Examination correlated .387. The Cooperative Algebra Test and the Pre-Engineering Ability Test correlated .553 with grade point average in Mathematics 165. The Pre-Engineering Ability Test and the Minnesota Paper Form Board Test correlated .578 with grade point average in Chemistry 114. The Pre-Engineering Ability Test and the Cooperative Algebra Test correlated .601 with grade point average in the three courses combined.

In the ten various categories predicted, the Pre-Engineering Ability Test was used seven times as one of the predictive variables. It was picked each time because of high zero order correlations with the criteria. The Cooperative Algebra Test was second in that it was one of the predictive variables six out of the ten times. The number of times the other tests were used was as follows: The American Council on Education Psychological Examination, three times; the Minnesota Paper Form Board Test, two times; and the Kuder Computational scale, two times. These results seemed to indicate that the Pre-Engineering Ability Test was the most effective predictor used in the program and that the Cooperative Algebra Test was a close second. The authors of the Pre-Engineering Ability Test have developed an outstanding instrument for screening and placing students in engineering schools. This test as has been previously pointed out was the outgrowth of the Pre-Engineering Inventory which required many hours to administer. The Pre-Engineering Ability Test has proved its worth and requires only ninety minutes to administer.

Four tests were selected to use in the study of the effectiveness of the multiple regression method in prediction versus prediction by means of the multiple cutoff technique in predicting success in English

115, Chemistry 114, Mathematics 165, and the grade point average of the three courses combined. The tests selected had the highest correlations with the criteria. The total score on the American Council on Education Psychological Examination correlated .42 with total grade point average of the first semester freshmen in the Oklahoma Institute of Technology, .315 with the grade point average in English 113, .350 in Mathematics 165, .362 in Chemistry 114, and .426 with the grade point average in the three courses combined. The combined grade point average in the three courses and total grade point average seemed to correlate much better with the total score on the American Council on Education Psychological Examination than grade point averages in specific basic freshman courses. The total score on the Pre-Engineering Ability Test correlated .58 with total grade point average, .260 with the grade point average in English 113, .469 in Mathematics 165, .520 in Chemistry 114, and .538 with the combined grade point average of the three courses. The results were very similar to those obtained in using the American Council on Education Psychological Examination. The Minnesota Paper Form Board Test correlated .26 with the total grade point average, .136 with the grade point average in English 113, .133 in Mathematics 165, .394 in Chemistry 114, and .284 with the combined grade point average of the three courses. These results indicated that the Minnesota Paper Form Board Test may be of value in predicting success in chemistry because it correlated higher with grade point average in Chemistry 114 than it did with total grade point average and the grade point average of the three courses combined. The Cooperative Algebra Test correlated .58 with total grade point average, .324 with grade point average in English 113, .508 in Mathematics 165, .365 in Chemistry 114, and .526 with the combined grade point average of the three courses. These results indicated that total grade point average correlated better with the tests than grade point average in any of the specific courses.

The evidence thus gained seemed to infer that total grade point average was a more satisfactory criterion than grade point average in some specific course. The Minnesota Paper Form Board Test was the only test which correlated higher with the grade point average in a specific course than with the total grade point average. It seemed to have value in predicting success in Chemistry 114.

The Pre-Engineering Ability Test and the Minnesota Paper Form Board Test used in combination correlated .623 with the total grade point average compared to .578 with the grade point average in Chemistry 114. The Pre-Engineering Ability and the Cooperative Algebra Test used in combination correlated .613 with the total grade point average, .601 with the combined grade point average of the three specific courses, and .553 with the grade point average in Mathematics 165. The total score of the American Council on Education Psychological Examination and the Cooperative Algebra Test used in combination correlated .594 with total grade point average and .387 with the grade point average in English 115. These results indicated that the tests used seemed to be a little better for predicting total grade point average than the grade point average in some specific course.

The Minnesota Paper Form Board Test was the only one which correlated higher with the grade point average in some specific course than it did with total grade point average. The Cooperative Algebra Test correlated very high with the grade point average in Mathematics 165, but its highest correlation was with the total grade point average.

Recommendations

This present study seemed to indicate that regression was more effective for predicting success in the freshman program in the engineering school. Regression is, therefore, recommended as the technique for the prediction of success. The most optimal tests which are recommended to be included in a multiple regression equation to predict success in the engineering school are the Pre-Engineering Ability Test, the Cooperative Algebra Test, the American Council on Education Psychological Examination, and the Minnesota Paper Form Board Test. The Computational and Scientific scales of the Kuder might be used in some cases and especially in screening students for the departments of chemical, civil, and electrical engineering. Much more study should be given to this problem. The evidence gained here seemed to indicate that the Pre-Engineering Ability Test, the Minnesota Paper Form Board Test, Cooperative Algebra Test, and the American Council on Education Psychological Examination had value in predicting grade point averages in Chemistry 114, Mathematics 165 and English 115. There may be other tests which would be of use here or perhaps tests will have to be developed for this purpose. It is hoped that these results will be of value in selecting and placing engineering students that they may realize the most out of their training as well as rendering a service for society and that they may be doubly blessed in the process.

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