# PREDICTING SUCCESS IN THE COLLEGE OF ENGINEERING

UNIVERSITY OF HOUSTON

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A Thesis

Presented to

the Faculty of the Department of Psychology

University of Houston

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In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

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by

B. Frank Johnson, Jr.

August 1956

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ABSTRACT

The purpose of this study was to determine how accurately academic success of engineering students at the University of Houston can be predicted from a knowledge of their High School grade point average, and their scores obtained on tests that make up the freshman guidance battery.

The battery of standardized tests considered in this study included (1) The American Council on Education Psychological Examination, 1947 College Edition; (2) Cooperative Inter-American Reading Test -- part 2 only; (3) Cooperative English Test Mechanics of Expression, forms Z & S; (4) Math. Screening Test, University of Houston; and (5) Kuder Preference Record, Form CM.

The criterion used was the grade point average for the first semester's work of the recent high school graduates that entered the University of Houston's Engineering College in the Fall of 1955. The Pearson product moment method was used to find the intercorrelation between the criterion and each variable and between each variable and all other variables.

The Wherry-Doolittle test selection method was used to determine the multiple correlation and the beta coefficients of the various tests. It was found that the maximum predictive value of variables is obtained with the high school grade point averages and the scores provided on two of the tests in the battery. Listed in the order of their relative contribution these are: High school grade point averages, Math. Screening and ACE Psychological Examination score. The beta coefficients, listed in the same order, were found to be .54, .03, and .02. The shrunken coefficient of multiple correlation was found to be .63.

It is obvious that no single variable is a very good means of predicting success in the college of engineering. However, when optimum weights are applied to three of the scores, a substantial reduction in errors of prediction is obtained.

# CHAPTER I

## THE PROBLEM

Statement of the problem. It was the purpose of this study to determine how accurately academic success of engineering students at the University of Houston can be predicted from a knowledge of their high school grade point average and their scores obtained on tests that make up the freshman guidance battery.

Importance of the study. The University of Houston began a new comprehensive freshman guidance program in the fall of 1955. But, without valid statistical information concerning the tools they are using to give the student objective information about his chances of success in the various colleges, the counselor's recommendations cannot be much better than chance.

The College of Engineering of the University of Houston has enrolled from eight hundred to one thousand freshmen engineering students each year since 1946. The greatest number to graduate from this school in any one year has been between one hundred seventy five to two hundred. What is happening to the seven or eight hundred that did not make the grade? It is quite inefficient to spend the time and money training students who will never complete the training, and it is both psychologically and economically unwise for the student to spend years training for something he will never be able to complete or utilize. The College of Engineering could turn out more graduates with perhaps even higher standards if it were able to predict more accurately the success of its applicants.

The shortage of trained engineers at present is estimated to

be nearly 65,000 and occupational market analysts have pointed out that this shortage is likely to remain for a number of years. In light of this situation, engineering educators have been engaging in an active campaign of informing and inviting able high school students to consider engineering as a profession. Since the training of engineers is an expensive program as well as a demanding one for the student, means for facilitating selection and guidance of prospective engineers are needed.[1]

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1. Coleman, W.; "Economical Test Battery for Predicting Freshman Engineering Course Grades", Journal of Applied Psychology, December 1953, pp. 465-467

## CHAPTER II

## REVIEW OF THE LITERATURE

It is beyond the scope of this investigation to review all the studies relating to the prediction of success in scholastic work in general, but some of the studies that deal with prediction of success in engineering colleges were considered in relation to this study.

As a means of predicting the grades of college engineering students a trial test battery was administered to entering freshman engineering students at the University of Tennessee in September, 1950. The battery used included the American Council on Education Psychological Examination, 1949 edition, the Cooperative English Test, Form OM, Form S of the Cooperative Algebra Test, the Minnesota Paper Form Board, and the Bennet Mechanical Comprehension Test. No interest inventory was included in this battery, otherwise it is similar to the one recommended by Stuit and his collaborators for use with engineers. The particular tests were selected because of their low cost and ease of administration.

The criteria for the study consisted of grades tabulated for this group from the fall quarter, 1950, through the fall quarter, 1951. Freshman year grades usually take care of most of the screening of engineering candidates at the University of Tennessee, as failures are more unlikely after the first few quarters in the engineering curriculum. No selection procedures, other than a minimum mathematics requirement of four high school units are used; therefore, the entering class is a relatively heterogeneous group.[2]

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2. Coleman, William; "An Economical Test Battery for Predicting Freshman Engineering Course Grades", The Journal of Applied Psychology, Vol. 37, No. 6 (1953), p. 466

Though the coefficients found in Coleman's study are not specially high, several of them are sufficiently so to be regarded as meaningful in selection or for guidance purposes. With a population consisting of high school students, a higher correlation would be hypothesized for this more heterogeneous group.

The Cooperative Algebra Test seemed to be the best predictive instrument in the battery, followed by the Cooperative English Test which ranked second. Better correlations with grades were obtained from the Mechanical Comprehension Tests than with either of the ACE scores. In an unpublished master's thesis at the University of Tennessee, Tarvin found that the algebra and English tests yielded higher correlations than either ACE score among freshman students. From these data and other studies, the predictive value of so-called scholastic aptitude tests such as the ACE must be questioned in comparison to outright achievement tests.

This same study reveals that in different courses different instruments may be the most effective predictors. The English test, for example, is best for predicting English grades and the algebra test in a similar fashion for mathematics grades. The Bennett is clearly the best predictor in engineering drawing instead of the Minnesota Paper Form Board as might have been expected. No test emerges as a good predictor for civil engineering. This may reflect to some extent the unreliability of grades in this course though further evidence is needed. The English grade stands out as the best predictor in mechanical engineering. The algebra test and Q score seem to be the best predictors in engineering problems, though the Bennet provides a moderate correlation coefficient.

To be noted with interest is the fact that the "Q" score is more valuable than the "L" for this engineering group in the courses

considered. This, of course, is contrary to the usual findings with the ACE in other curricula. The lowest correlation coefficients were yielded by the Minnesota Paper Form Board.

Multiple correlations were then computed for four of the criterion variables, grades in English, engineering drawing, engineering problems, and mathematics.

The addition of further tests does not add much in the case of English and mathematics where the zero order correlations were moderately high in the first place. In engineering drawing and engineering problems the extra tests appreciably contribute in improving the correlation coefficients, from .496 to .612 for the problems course, and from .453 to .541 for the drawing course. Additional tests seem warranted for more reliable prediction in the case of these two courses.

Johnson[3] found that the mathematical score on the College Board Scholastic Aptitude test provides a most effective prediction of engineering college grades. It is, of course, merely an indication of ability. It provides no clue as to motivation or to achievement. There is no evidence that it is a measure of talent for making money, or of persuasive skill in dealing with people, or of the ability to invent useful things. In addition to scholastic ability, it would be good to learn whether an applicant has learned to study or to discipline himself to do the day to day work which will be assigned to him in engineering school, for often an exceptionally able freshman has not learned these things. Achievement test scores are partial clues in this connection as are grades in secondary school.

It is becoming widely known that the verbal score on the Scholastic Aptitude Test can be an important aid in evaluating the qualifications

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3. Johnson, A. Pemberton; "The Prediction of Engineering Potentiality in High School Students", The Journal of Engineering Education; October, 1955, Pp.136-9

of a high school senior who is an applicant to an engineering college. Johnson recommends the use of a combined scholastic aptitude test score along with consideration of rank in high school class for predicting success in engineering college. This combined score may be either an average of the mathematics and verbal scores of the College Board Scholastic Aptitude Test or a total obtained by doubling the mathematics score and adding the verbal score so that in effect twice as much weight is given to the mathematics score. In this way, if the verbal score is low it will serve to depress either the average or the total composite score. Ideally, of course, the proper weighting should be worked out by each institution.

For those institutions which receive the College Board Test Reports the comparison of achievement tests scores against corresponding aptitude test scores may give a rather good clue as to whether a particular man has performed up to the level of his ability as measured by the aptitude test.

Some engineering colleges are faced with a problem of high school students dropping in and asking for an immediate evaluation of their potential for the study of engineering. In such situations, the Pre-Engineering Ability Test can be a very useful substitute for the College Board test scores. Some comparative data are available for the direct comparison on an approximate basis of the Pre-Engineering Ability Test scores to College Board Scholastic Aptitude Test mathematics scores.

Neither the College Entrance Examination Board Scholastic Aptitude Test nor the Pre-Engineering Ability Test is available for use by secondary schools. However, as Johnson points out, the Cooperative Intermediate Algebra Test which is available for secondary school use, and

which takes only forty minutes of testing time in addition to some time for handing out and collecting the test papers, answer sheets, and electrographic pencils, has been found to be a very effective predictor of grades at two institutions, Purdue and Cornell, when given to incoming new high school graduates.

Johnson in his study refers to an unpublished study made by Dr. W. B. Schrader, based upon data from 721 enrolled engineering freshmen tested in the Fall of 1948 at Carnegie Institute of Technology, Cornell University, Lehigh University, Rutgers University, and the University of Pennsylvania, in which Schrader found that the weighted average correlation coefficient of high school grades against first-term engineering grades at these five institutions was .46. The weighted average correlation coefficient of the Scholastic Aptitude Test (Mathematical Section) scores combined with high school grades against first-term engineering grades for these five institutions was .66.

The present evidence suggests that for almost all engineering schools the Scholastic Aptitude Test, mathematics score, is a somewhat better single predictor of engineering grades than is rank in high school graduating class. A slight improvement results when, in addition to these, the Intermediate or the Advanced Mathematics Test score of the College Board is added into the composite of the mathematics Scholastic Aptitude Test score and rank in high school class. Many engineering schools have concluded that the additional advantage from use of the achievement test is not worth the additional cost in terms of time and money to the applicant.[4]

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4. Pierson, G. A. & Jex, F. B.;"Using the Cooperative General Achievement Tests to Predict Success in Engineering," Educational and Psychological Measurement, 1951, pp.397-402

## CHAPTER III

## SOURCE OF DATA

Group Studied. The group used in this study consisted of students selected from the entering engineering freshmen of the University of Houston in the Fall of 1955.[5] Only those students meeting the following requirements were included: (1) recent high school graduate, (2)taking twelve or more semester hours of accredited college work, (3) had no three hour remedial course included in his schedule, (4) had taken all tests of the freshman guidance battery, and (5) were still enrolled at the end of the Fall Semester. A total of eighty-nine students comprised the study group on this basis.

In order to justify the comparison of this group with other engineering schools through-out the nation it was necessary that the sample be restricted in the above manner. Only students having the above qualifications would meet the minimum entrance requirements of most colleges.

Variables. The Counseling and Testing Service of the University of Houston selected the following battery of tests which was administered to all entering freshmen in the fall of 1955 by the testing staff.

American Council on Education Psychological Examination for College Freshmen, 1947 Edition. This is a test of general scholastic aptitude which has been found to predict, fairly well, success in college work in general. The test yields in addition to the total score two sub-scores, quantitative and linguistic. The "Q" score (quantitative) is based on problems in arithmetic, figure analogies, and number series. The "L" score

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5. Students enrolled as freshmen at the University of Houston who designate engineering as a major do not in reality take any courses in engineering as such until the sophomore year.

(linguistic) is based on same-opposites, completion problems, and verbal analogies.

Cooperative English Test A: Mechanics of Expression, forms S and Z. This test was designed to measure the student's knowledge of English grammar. Though the test is divided into three parts, only one score is obtained. Part I attempts to measure a knowledge of the use of the right word in syntax. Part II atempts to measure knowledge of punctuation and capitalization, and Part III attempts to measure the ability to spell. Two different forms of this test were used and the scaled scores which were used were found not to be equated. Therefore, the use of this test in the study could not be justified.

Cooperative Inter-American Test, Advanced Level. The tests consist of two parts: I, Vocabulary; and II, Comprehension. The words included in the vocabulary section, and the paragraphs on which the comprehension questions are based represent a variety of materials and are designed to give a measure of general reading ability. The scores on Part II only were used in this study.

Mathematical Screening Test, University of Houston. This test was constructed by the mathematics department of the University of Houston. It attempts to measure achievement in the basic concepts of algebra.

Kuder Preference Record, Form CM. This test is designed to measure a person's relative interests in ten different areas: outdoor, mechanical, computational, scientific, persuasive, artistic, literary, musical, social service, and clerical.

High School Grade Point Averages, these were computed from high school transcripts. All grades obtained in the four major subject areas -- English, mathematics, natural sciences, and social studies -- for four years

of high school work were used. The averages were computed in the following way: each term grade earned equaled 1; grade of F when not repeated = 0, grade of D = 1, grade of C = 2, grade of B = 3, and grade of A = 4.

Criterion. Grade point averages appeared to be a logical criterion for they are an important means by which the University of Houston determines the success or failure of its students. The use of the first semester's grade point averages as a criterion rather than the first year or any other combination of grade point averages, can be justified statistically in that the sample is rapidly skewed towards the high end of the curve after the first semester, due to the fact that a large percentage of the dropouts and failures come from the first quarter of the distribution.

The first semester grade point averages were computed in the following manner: each semester hour attempted is equal to 1; grades of F & W = 0, grade of "D" = 1.0, grade of "C" = 2.0, grade of "B" = 3.0, and grade of "A" = 4.0 for each semester hour. To compute grade point average divide number of semester hours attempted into quality points earned.

## CHAPTER IV

## TECHNIQUES AND ANALYSIS OF THE DATA

Pearson's product-moment coefficients of correlation were computed between each of the variables and the criterion. These coefficients are presented in Table I. The means and standard deviation for the criterion and each variable are also shown in this table.

The Wherry-Doolittle test selection method was applied to the data given in Table I. This revealed that the maximum predictive value of the variables is obtained with three of the scores. They are listed in the order of their relative contribution: High School grade point average, Mathematical Screening Test, and the quantitative score of the American Council on Education Psychological Examination. The beta coefficients, listed in the same order, were found to be .54, .03, and .02. The regression equation would be $\overline{Y} = .54B + .03G + .02D - 3.06$ when all of the scores are in terms of raw scores. The shrunken[6] coefficient of multiple correlation was found to be .63, significant at the .01 level of confidence. The American Council on Education Psychological Examination quantitative score made very little contribution to the battery, increasing the multiple correlation only from .61 to .63.

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6. A multiple correlation coefficient is subject to positive bias, that is, the multiple correlation coefficient obtained from a sample always tends to be larger than the correlation in the total population. The Wherry shrinkage formula has been applied to all multiple correlation coefficients given in this study in an attempt to remove the chance error.

TABLE I

INTERCORRELATIONS BETWEEN CRITERION TEST AND HIGH SCHOOL GRADE POINT AVERAGE

| V's = | B | C | D | E | F | G | MEANS | S.D. |
|---|---|---|---|---|---|---|---|---|
| A | .54 | 32 | .41 | .31 | 41 | .43 | 1.8 | .88 |
| B | | 45 | .29 | .45 | .45 | .26 | 2.7 | .68 |
| C | | | 48 | .76 | 76 | .23 | 34.9 | 6.6 |
| D | | | | .43 | 77 | .38 | 47.4 | 9.0 |
| E | | | | | 91 | .26 | 58.6 | 13.6 |
| F | | | | | | .36 | 106.0 | 19.3 |
| G | | | | | | | 21.6 | 5.4 |

Legend

A = 1st Semester Col. Grade Point Average

B = 4 year High School Grade Point Average

C = Cooperative Inter-American Test Raw Score Part II

D = ACE "Q" Raw Score

E = ACE "L" Raw Score

F = ACE Total Raw Score

G = Math Screening Test U of H. Raw Score

It was found that 80 percent of the sample group made a grade point average of 1.3 or better for their first semester's college work. This is the minimum passing mark set by the University of Houston, therefore the investigator felt justified in making the assumption that all students making a grade point average of 1.3 or better should be classified as satisfactory students. Assuming that 80 percent of the engineering students are successful by chance selection, Tables II, III, IV, and V were computed from Taylor and Russel Tables[7] to show the improvement over chance that can be made by using various cutting scores. As an example of how these tables can be used, let us assume that the College of Engineering wanted to select the best 80 percent of their applicants for admission. By entering column 2 of Table II at the 20 percent equivalent they could expect 88 students out of each 100 to succeed if only those students who earned a 1.1 computed grade point average were admitted. This would be an 8 percent improvement over chance selection. In other words, by entering column 1 of Tables II, III, IV and V with an obtained score, column 2 will show the percent that should be rejected, column 3 the percent of students that could be expected to succeed of the ones accepted, and column 4 the percentage of imporvement over chance selection.

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7. Taylor, H. C., & Russell, J. T., "The Relationship of Validity Coefficients to the Practical Effectiveness of Test in Selection: Discussion & Tables", Journal of Applied Psychology, 1939, 23, pp.565-578

TABLE II

PREDICTING SUCCESS (FIRST SEMESTER COLLEGE OF ENGINEERING) BY COMPUTING COLLEGE GRADE POINT AVERAGE FROM MULTIPLE REGRESSION EQUATION: R = .63

| Computed Grade Point Average | Percentile Equiv. | Percent Success | Improvement Over Chance |
|---|---|---|---|
| 3.2 | 95 | 100 | 20% |
| 2.9 | 90 | 99 | 19% |
| 2.5 | 80 | 98 | 18% |
| 2.4 | 70 | 97 | 17% |
| 2.0 | 60 | 96 | 16% |
| 1.8 | 50 | 95 | 15% |
| 1.6 | 40 | 93 | 13% |
| 1.3 | 30 | 91 | 11% |
| 1.1 | 20 | 88 | 8% |
| 0.8 | 10 | 85 | 5% |
| 0.4 | 5 | 83 | 3% |

TABLE III

PREDICTING SUCCESS (FIRST SEMESTER COLLEGE OF ENGINEERING) FROM FOUR YEAR HIGH SCHOOL GRADE POINT AVERAGE: r = .54

| High School Grade Point Average | Percentile Equv. | Percent Success | Improvement Over Chance |
|---|---|---|---|
| 3.8 | 95 | 99 | 19 |
| 3.6 | 90 | 98 | 18 |
| 3.3 | 80 | 97 | 17 |
| 3.1 | 70 | 95 | 15 |
| 2.9 | 60 | 94 | 14 |
| 2.7 | 50 | 92 | 12 |
| 2.5 | 40 | 91 | 11 |
| 2.3 | 30 | 89 | 9 |
| 2.1 | 20 | 87 | 7 |
| 1.8 | 10 | 84 | 4 |
| 1.6 | 5 | 82 | 2 |

TABLE IV

PREDICTING SUCCESS (FIRST SEMESTER COLLEGE OF ENGINEERING) FROM SCORE ON MATHEMATIC SCREENING TEST: $r = .43$

| Math. Screening Score | Percentile Equv. | Percent Success | Improvement Over Chance |
|---|---|---|---|
| 30 | 95 | 97 | 17 |
| 28 | 90 | 96 | 16 |
| 26 | 80 | 95 | 15 |
| 24 | 70 | 93 | 13 |
| 23 | 60 | 92 | 12 |
| 22 | 50 | 90 | 10 |
| 21 | 40 | 89 | 9 |
| 19 | 30 | 87 | 7 |
| 18 | 20 | 85 | 5 |
| 16 | 10 | 83 | 3 |
| 14 | 5 | 82 | 2 |

TABLE V

PREDICTING SUCCESS (FIRST SEMESTER COLLEGE OF ENGINEERING) FROM ACE "Q" SCORE: $r = .41$

| "Q" Score | Percentile Equv. | Percent Success | Improvement Over Chance |
|---|---|---|---|
| 62 | 95 | 96 | 16 |
| 58 | 90 | 95 | 15 |
| 55 | 80 | 93 | 13 |
| 52 | 70 | 92 | 12 |
| 49 | 60 | 90 | 10 |
| 47 | 50 | 89 | 9 |
| 44 | 40 | 88 | 8 |
| 42 | 30 | 86 | 6 |
| 40 | 20 | 85 | 5 |
| 36 | 10 | 83 | 3 |
| 33 | 5 | 82 | 2 |

Table VI provides percentile equivalents for raw scores obtained on the following variables:

Column (A) First semester college grade point averages

Column (B) High School grade point averages

Column (C) Cooperative Inter-American Reading Test (part 2 only)

Column (D) American Council on Education Psychological Examination, quantitative score "Q"

Column (E) American Council on Education Psychological Examination, linguistic score "L"

Column (F) American Council on Education Psychological Examination, total score "T"

Column (G) University of Houston Mathematical Screening Test scores

These percentiles were computed from the distribution of the scores obtained by the eighty-nine students in this group.

TABLE VI

PERCENTILE EQUIVALENTS FOR ALL VARIABLES

| Percentile | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 99 | 3.8 | 4.3 | 50. | 68. | 90. | 150. | 34. |
| 98 | 3.6 | 4.1 | 48. | 66. | 87. | 145. | 33. |
| 96 | 3.3 | 3.9 | 46. | 63. | 84. | 139. | 31. |
| 95 | 3.2 | 3.8 | 45. | 62. | 80. | 136. | 30. |
| 92 | 3.0 | 3.7 | 44. | 59. | 79. | 133. | 29. |
| 85 | 2.7 | 3.4 | 42. | 56. | 73. | 125. | 27. |
| 80 | 2.5 | 3.3 | 41. | 55. | 70. | 122. | 26. |
| 75 | 2.4 | 3.2 | 39. | 53. | 69. | 119. | 25. |
| 70 | 2.3 | 3.1 | 38. | 52. | 66. | 117. | 24. |
| 60 | 2.0 | 2.9 | 36. | 49. | 64. | 111. | 23. |
| 50 | 1.8 | 2.7 | 35. | 47. | 59. | 106. | 22. |
| 40 | 1.6 | 2.5 | 34. | 44. | 54. | 101. | 21. |
| 30 | 1.3 | 2.3 | 32. | 42. | 52. | 95. | 19. |
| 25 | 1.2 | 2.2 | 31. | 41. | 49. | 93. | 18. |
| 20 | 1.1 | 2.1 | 29. | 40. | 47. | 90. | 18. |
| 15 | 0.9 | 2.0 | 28. | 38. | 45. | 87. | 17. |
| 8 | 0.6 | 1.7 | 26. | 35. | 39. | 79. | 15. |
| 5 | 0.4 | 1.6 | 23. | 33. | 38. | 76. | 14. |
| 4 | 0.3 | 1.5 | 22. | 31. | 34. | 73. | 13. |
| 2 | 0.2 | 1.3 | 21. | 28. | 31. | 67. | 11. |
| 1 | 0.0 | 1.1 | 20. | 26. | 29. | 62. | 10. |

# CHAPTER V

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary. The purpose of this investigation was to determine how accurately the first semester's grade point average of recent high school graduates enrolled in the College of Engineering of the University of Houston could be predicted from a knowledge of their high school. grade point average and scores obtained from the Freshman Guidance Battery, and to provide local norms for this group.

Pearson's product-moment correlations were computed between the criterion, high school grade point average, and the scores obtained from the Freshman Guidance Battery. The Wherry-Doolittle method of test selection was used to determine the multiple correlation coefficient and beta coefficients. The multiple correlation was found to be .63. This multiple "R" compares favorably with those found in other studies on this subject reviewed by the investigator. The largest multiple correlation reported in the literature was .66.

The maximum predictive value was obtained by using the following variables; high school grade point average, Mathematic Screening Test, and American Council on Education Psychological Examination, quantitative score. Regression equations were provided for the prediction of the criterion by means of the above variables. Percentile equivalents were computed for the variables used in the study.

Conclusions. The following conclusions are based on the findings of this study.

1. No single variable nor the multiple regression equation can be justifiably used to predict individual success or failure in the College of Engineering of the University of Houston. But, if the College of Engineering accepted only those students whose predicted first semester grade point average was say 1.3 or above, then they could expect 910 out of 1000 admitted to obtain a grade point average of 1.3 or better. Under the present system they can expect only 800 out of each 1000 students admitted to make the required grade point average.

2. As a screening device for the College of Engineering the Freshman Guidance Battery could be greatly reduced as only the high school grade point average, scores on the mathematic test, and the "Q" score on the ACE Psychological Examination add to the value of the multiple regression "r".

3. Since most of the tests in the freshman guidance battery show rather high intercorrelation with each other, it is very likely that the battery could be improved.

Recommendations. Due to the difficulty of obtaining high school grade point averages at the time of counseling the investigator believes that further research should be done to try to replace this variable with some test score that would yield as high or higher multiple regression "r". From studying the literature on the research that has been made in this area it would seem that one of the standardized achievement test in English could, perhaps, replace the high school grade point average.[8]

The findings of this study should be verified by applying the regression equation to another sample of engineering students in order to compare the predicted success with their actual success.

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8. Drake, L. E. & Thomas, W. F., "Forecasting Academic Achievement in the College of Engineering", Journal of Engineering Education, December 1953, pp. 276-7

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