# A COMPARATIVE STUDY OF MATHEMATICS COURSES FOR ENGINEERING TECHNOLOGY STUDENTS


By

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A COMPARATIVE STUDY OF MATHEMATICS
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## NOMENCLATURE

ACT-C - American College Testing Composite

ACT-M - American College Testing Mathematics

CMT-ALG - Cooperative Mathematics Test Algebra I

SEM-ALG - Semesters of High School Algebra

n - Sample Population

N - Total Population

# CHAPTER I

# INTRODUCTION

Technology has generated thousands of job opportunities for competent technical personnel. Technical education and, more specifically, engineering technology education is a major component in preparing persons for employment in technical occupations.

Educational institutions, industry, and government, concerned with engineering technology, are united in the common effort of attracting students to this area of education. Once attracted, the process of counseling and advisement of the entering student is an important first step. This process will yield a decision in the selection of courses applicable to his technical major and his "apparent" capability.

## Statement of Problem

At best, the evaluation of student entry parameters and subsequent recommendation of courses for the beginning college student is a difficult decision. This decision is even more difficult if a course is new to the curriculum. In this case, background information of student performance in the course and effectiveness of the course to the curriculum is limited, or not available.

Simply stated, the problem with which this study was concerned was the lack of information relative to the advisement of beginning engineering technology students in the selection of the appropriate mathematics courses.

## Purpose of Study

The specific purpose of this study was to evaluate selected variables as predictors of mathematics achievement and to determine if a difference exists among treatments of the mathematics courses available to engineering technology students.

Considered in this investigation were high school background, entrance examination scores, and post test results.

## Need for Study

With the introduction of the Bachelor of Science in Engineering Technology curricula at Oklahoma State University, certain course changes were made in the Associate Degree in Engineering Technology curricula of The Technical Institute, Stillwater campus. Among these course changes, effective the fall semester, 1969, were the elimination of the applied algebra and trigonometry courses for technology majors. This area of mathematical content was replaced by available courses in the Department of Mathematics and Statistics.

A concern now exists relative to the advisement of entering technology students as to the selection of the appropriate mathematics course. The unique requirements of technical education and the possibility of differing characteristics of the technology students compared to those in other areas of education gave rise to the need for this study.

## Scope of Study

This study was limited to students enrolled for the first time in engineering technology programs during the 1969-70 school year at the Oklahoma State University, Stillwater, campus.

The study was not designed to examine course content. Further, the evaluation of teaching methods and the grading system are beyond the scope of this study.

## Assumptions

The assumptions made for the purpose of this study are:

1. The students involved in this study are representative of future enrollees.
2. The treatment of the mathematics courses will remain unchanged.
3. Mathematics achievement can be measured by the conventional course grade system of A, B, C, D, F.
4. The Cooperative Mathematics Test, Algebra I, is valid as a determinant of algebra achievement

based on its use in the selection of or exemption from the freshman level algebra courses at Oklahoma State University.

5. The Cooperative Mathematics Test, Algebra I pre-test and post-test score is valid for statistical use to differentiate treatment among mathematics courses involved in this study.

## Definitions

Engineering Technician:

An engineering technician is one whose education and experience qualify him to work in the field of engineering technology. He differs from a craftsman in his knowledge of scientific and engineering theory and methods and from an engineer in his more specialized background and in his use of technical skills in support of engineering activities (1, p. 12).

Engineering Technology:

Engineering technology is that part of the engineering field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational area between the craftsman and the engineer (1, p. 11).

Engineering Technology Curriculum

An engineering technology curriculum is a planned sequence of college-level courses, usually leading to an associate degree, designed to prepare students to work in the field of engineering technology.

(a) The term college-level in the definition of a technology curriculum indicates the attitude with which the education is approached, the rigor, and the degree of achievement demanded, and not solely or even necessarily that the credits are transferable to baccalaureate programs.

(b) There are many specific branches of engineering technology in which curricula are offered. Commonly encountered are such curriculum titles as mechanical technology, electronic technology, chemical technology, and civil technology (1, p. 13).

## CHAPTER II

## REVIEW OF LITERATURE

The prediction of scholastic achievement has been the object of research studies many times over. Within the past two decades, the rapid increase in college enrollment has brought forth an attendant increased interest toward predicting academic success at the college level. However, this impetus has not been inclusive of all areas of college level programs.

### Prediction Studies

Patterson (2, p. 353), in a study of technical programs, observed predictive studies in this area have received relatively little attention; and, in particular, predictive studies in individual areas of learning are few in number.

Nevertheless, there are those who have given attention to this area of education. Brown (3, p. 28), in a study of technical institute students at Oklahoma State University, found useful predictors of academic success and reported:

> Of all tests or combinations of tests given, the composite of the ACT tests resulted in the highest correlation with grade-point average ($\rho = 0.410$), and the result of the t Test was sufficiently high for rejection of the null hypothesis at the one per cent level. The composite of the ACT tests, then, can be used as a predictor of success for technical institute students.

Greenwood (4, p. 22), in a study of technical students enrolled in three New York community colleges, found intelligence test scores, high school mathematics and English averages along with the number of years of high school mathematics likely to have a close relationship to academic success in the technical curriculums.

Righthand (5, p. 72), in an investigation of the characteristics which differentiate the technical institute dropout from the persisting student, found the combination pattern of the mathematics portions of the Engineering Physical Science Aptitude Test and the score on the Survey of Study Habits and Attitudes to be the most effective discriminate. Based on this and other findings in the study, he stated:

> This study has substantiated the importance of the role of mathematics in technical education. Practical and research implications of these results indicate a need for investigation of the effectiveness of preinstitute mathematics courses, admission standards, teaching methods and curriculum.

It can hardly be expected all studies would concur in finding predictors with a significant relationship to academic achievement. Wold (6, p. 240) concluded from his study:

> There appears to be no statistically significant relationship between student completion rate in technical curricula and the following: entrance requirements, selection methods and devices, type of school control, and whether or not the school is accredited by the Engineering Council for Professional Development.

A sample of 834 students from six colleges was used by Hoyt (7, pp. 20-23) in an investigation of predicting grades in two-year terminal programs. The American College Testing Program (ACT) scores and high school grades were found about equally predictive. Combined, they were considered as valid predictors for these technically oriented students. However, the investigator considered the level of predictability reduced over that usually obtained from such data. Variation in predictor factors among different oriented groups was expressed by Tinnell (8, p. 26) in a study involving students in an electromechanical technical program. One of his conclusions was:

> Perhaps the greatest significance of the study lies in the fact that it demonstrates that factors which are useful in identifying promising potential students for the emerging technological areas may not be the same as those used in other areas of education.

The preceding review reflects considerable variance in the observations, results, and conclusions with respect to predictors of achievement. However, of particular pertinence to this study was a study by Siegle (9, pp. 115-117). In an investigation of predictors of success in college mathematics, eleven prognostic factors were compared with student achievement as measured by grades in mathematics. He found the best single predictor of success in college algebra were scores on a constructed mathematics test.

## Mathematics Treatment

With the exception of the ability to communicate, the ability to use mathematics is second to none in the world of technology. From the most elementary quantitative use to the abstract studies of science, mathematics is involved; hence, justification is not the question. The question is what mathematics will prepare the individual to perform his technical mission?

The importance of this question is in part reflected in the report of the President's Committee on Scientists and Engineers (10, pp. 44-46). This Committee reported that the scope of mathematics was the most critical determinant for both the level and the quality of technological curriculums. The results of their survey indicated the most common criticism among graduates and employers was directed at the mathematical content of such curriculums.

Of more specific concern to this study was the treatment of mathematics. A report by the Commission on Science Education (11, pp. 13-14) proposes that technical students and liberal arts students should not be taught mathematics in the same classes. Instead, technical students should have their own classes with content and presentation designed for their particular needs. It was their consensus, mathematics should be taught by mathematicians who maintain communication with the technology instructors and who have an understanding of the needs of technical students. Moreover, the Commission emphasized the mathematics course should not be of the "traditional" type oriented toward theory with limited emphasis on application. Instead, the course "should be inclined toward the applied." Roney (12, p. 133) expressed a similar opinion when he stated:

> Mathematics courses of a general nature would not be adequate for the needs of engineering technology curricula. Such courses would lack the proper emphasis on specific topics needed in technical courses. Mathematics courses designed to provide the prerequisites for advanced mathematics study would be inefficient and hence inappropriate for engineering technology curricula.

A study of national scope by a committee of the American Society for Engineering Education (1, p. 27) suggests an adequate program in mathematics can be provided in nine to twelve semester credit hours if the content is specifically designed for the engineering technology curriculum. The committee emphasized the selection of mathematical topics and the sequence of presentation must be determined "by coordinated effort of the mathematics and technical faculty". An expressed recommendation concerning mathematics in the curriculum was:

> Mathematics taught in the engineering technology curriculum should be of college level. This refers to the pace at which the course proceeds, the difficulty with which the material is approached, and the degree of achievement demanded of the students. While of college level, engineering technology mathematics programs are essentially applied in nature; that is, they emphasize problem solving rather than extensive mathematical proofs. The Committee believes such mathematics courses to be of college level, whether or not they are transferable to baccalaureate curricula.

## Summary

From the preceding review, it does seem technology students have educational needs that differ from those in other areas of education. Further, these needs are best served by technical education. Phillips (13, p. 30), following his review of the literature in a study concerning entering technician education students, stated:

> From a review of several studies it appeared that technician education students have characteristics which were different from the characteristics of students in several other fields. Characteristics of technician education students seem to justify the existence of specialized curriculums and institutions for meeting the educational needs of these students.

Further summary is reflected in a statement of the Commission on Science Education (11, p. 3):

> The education of technicians is based on science and mathematics. Technical education has unique requirements and characteristics - quite different in numerous ways from the education of scientists and engineers - and has an identity of its own.

## Statement of Hypotheses

Based upon the review of the literature and within the scope of this study and assumptions set forth, the following hypotheses are stated:

1. There is no significant correlation between one or a multiple of the American College Testing mathematics score, American College Testing composite score, Cooperative Mathematics Test algebra I score, semesters of

high school algebra, and achievement in mathematics.

2. There is no significant difference among mathematics treatment groups and the Cooperative Mathematics Test algebra I, before-after scores.

# CHAPTER III

# METHODOLOGY

The specific purpose of this study was to evaluate selected variables as predictors of mathematics achievement and to determine if a difference existed among treatments of the mathematics courses available to engineering technology students. The problem was concerned with the lack of information relative to the advisement of beginning engineering technology students in the selection of the appropriate mathematics course.

## Mathematics Courses

The specific mathematics courses involved in this study were MATH 1213, MATH 1513, MATH 1715, and ELME 1124. The course descriptions are provided in Appendix A.

## Population

Subjects involved in this study were first year engineering technology students. All had received instruction in one of the four mathematics courses during the 1969 fall semester and were enrolled in technology curricula during the 1970 spring semester. It should be further noted, enrollment in a particular mathematics course did not necessarily alter the students' study plan as compared to the other groups. The population was comprised of 104 male and 7 female students.

## Instrument

The instrument used to determine if a difference existed among treatment groups was the Cooperative Mathematics Test, Algebra I. The Cooperative Algebra Test was developed by the Educational Testing Service (14) to measure students' comprehension of the basic concepts, techniques, and unifying principles of elementary algebra. The ability to apply understanding of mathematical ideas to new situations and to reason with insight are emphasized while factual recall and computation are minimized. The test consists of forty-five choice items and the administration time is 40 minutes. Since the test is a measure of developed abilities, content validity is of primary importance; thus, the test was developed by subject-matter specialists who worked with test technicians.

The test has been in use for over twelve years at Oklahoma State University as a part of the entrance examination program. It is used as a mathematics placement test on the basis of raw score data as described in Appendix B.

## Data Collection

The American College Testing mathematics, composite, and Cooperative Mathematics Test entrance exam scores, mathematics course grade, and number of semesters of high school algebra were obtained from the students' official file.

The Cooperative Mathematics Test, post-test scores were obtained following the administration of the exam the second week of March, 1970. This time period was selected in the consideration of reducing the effect of reinforcement from the mathematics course final exam given during the third week of January, 1970. Further consideration in selecting the post-test schedule was the forthcoming mid-term exam week and the potential of current courses, particularly technical courses, contributing to further mathematics proficiency.

The preceding data are registered in groups according to the mathematics course in Tables I, II, III, and IV.

## Data Selection Rationale

The rationale used in determining the data to be evaluated in the study was:

1. The anticipated continuance of the presently required entrance data for entering students.
2. The present use as course placement criteria; in particular, the Cooperative Mathematics Test raw score and the number of semesters of high school algebra as a determinant of entry math course level.

TABLE I

STUDENT DATA - MATH 1213

| N = 25 Student Number | Entrance Criteria SEM-ALG | ACT-M | ACT-C | CMT-ALG | Criterion CMT-ALG | Course Grade |
|---|---|---|---|---|---|---|
| 1 | 4 | 16 | 16 | 17 | 23 | B |
| 2 | 2 | 18 | 19 | 12 | 31 | D |
| 3 | 2 | 26 | 23 | 24 | 29 | A |
| 4 | 3 | 23 | 17 | 21 | 25 | B |
| 5 | 3 | 20 | 17 | 20 | 29 | B |
| 6 | 4 | 19 | 17 | 18 | 21 | B |
| 7 | 2 | 16 | 16 | 14 | 24 | F |
| 8 | 2 | 8 | 18 | 12 | 23 | D |
| 9 | 2 | 17 | 18 | 12 | 24 | F |
| 10 | 2 | 20 | 20 | 26 | 31 | F |
| 11 | 4 | 16 | 20 | 23 | 32 | B |
| 12 | 2 | 16 | 14 | 24 | 22 | B |
| 13 | 4 | 28 | 23 | 20 | 31 | A |
| 14 | 4 | 23 | 22 | 33 | 37 | A |
| 15 | 2 | 18 | 14 | 22 | 32 | A |
| 16 | 2 | 13 | 13 | 18 | 22 | B |
| 17 | 2 | 25 | 25 | 30 | 33 | D |
| 18 | 6 | 19 | 22 | 20 | 30 | C |
| 19 | 4 | 26 | 25 | 26 | 30 | C |
| 20 | 2 | 17 | 18 | 18 | 30 | B |
| 21 | 6 | 24 | 22 | 15 | 27 | D |
| 22 | 4 | 21 | 23 | 22 | 29 | C |
| 23 | 2 | 22 | 20 | 14 | 25 | D |
| 24 | 4 | 25 | 24 | 23 | 32 | B |
| 25 | 2 | 19 | 21 | 13 | 22 | B |

TABLE II

STUDENT DATA - MATH 1513

| N = 45 | Entrance Criteria | | | | Criterion | |
|---|---|---|---|---|---|---|
| Student Number | SEM-ALG | ACT-M | ACT-C | CMT-ALG | CMT-ALG | Course Grade |
| 26 | 3 | 19 | 18 | 28 | 33 | C |
| 27 | 2 | 25 | 22 | 26 | 24 | D |
| 28 | 2 | 24 | 22 | 33 | 38 | C |
| 29 | 2 | 21 | 15 | 12 | 11 | F |
| 30 | 2 | 24 | 25 | 25 | 31 | D |
| 31 | 4 | 21 | 22 | 19 | 24 | F |
| 32 | 4 | 18 | 17 | 15 | 23 | D |
| 33 | 4 | 21 | 18 | 27 | 31 | D |
| 34 | 2 | 11 | 14 | 14 | 24 | F |
| 35 | 4 | 17 | 19 | 16 | 23 | D |
| 36 | 4 | 24 | 20 | 28 | 35 | C |
| 37 | 3 | 20 | 19 | 19 | 22 | D |
| 38 | 5 | 20 | 19 | 23 | 29 | C |
| 39 | 2 | 11 | 15 | 11 | 19 | D |
| 40 | 4 | 29 | 25 | 31 | 32 | B |
| 41 | 2 | 16 | 20 | 13 | 22 | F |
| 42 | 4 | 21 | 22 | 25 | 29 | F |
| 43 | 2 | 22 | 24 | 22 | 32 | F |
| 44 | 4 | 20 | 17 | 26 | 31 | D |
| 45 | 4 | 27 | 20 | 28 | 33 | D |
| 46 | 4 | 26 | 24 | 28 | 32 | C |
| 47 | 4 | 17 | 14 | 30 | 36 | C |
| 48 | 4 | 32 | 23 | 39 | 40 | B |
| 49 | 4 | 18 | 17 | 23 | 24 | F |
| 50 | 2 | 12 | 8 | 15 | 14 | C |
| 51 | 4 | 17 | 14 | 22 | 31 | C |
| 52 | 4 | 28 | 29 | 34 | 37 | A |
| 53 | 4 | 20 | 21 | 26 | 33 | D |
| 54 | 4 | 14 | 13 | 22 | 23 | F |
| 55 | 4 | 24 | 23 | 23 | 35 | D |

TABLE II (Continued)

| N = 45 | Entrance Criteria | | | | Criterion | |
|---|---|---|---|---|---|---|
| Student Number | SEM-ALG | ACT-M | ACT-C | CMT-ALG | CMT-ALG | Course Grade |
| 56 | 4 | 23 | 21 | 31 | 33 | D |
| 57 | 4 | 18 | 17 | 21 | 23 | D |
| 58 | 4 | 29 | 27 | 25 | 32 | C |
| 59 | 2 | 17 | 20 | 22 | 19 | D |
| 60 | 2 | 10 | 19 | 17 | 21 | F |
| 61 | 4 | 22 | 19 | 24 | 31 | C |
| 62 | 2 | 16 | 16 | 14 | 19 | F |
| 63 | 6 | 32 | 25 | 31 | 36 | F |
| 64 | 4 | 18 | 17 | 22 | 31 | D |
| 65 | 2 | 23 | 21 | 21 | 36 | C |
| 66 | 4 | 24 | 21 | 31 | 35 | D |
| 67 | 4 | 21 | 20 | 28 | 37 | A |
| 68 | 2 | 24 | 24 | 27 | 32 | B |
| 69 | 4 | 27 | 27 | 27 | 34 | C |
| 70 | 4 | 18 | 16 | 38 | 37 | A |

TABLE III

STUDENT DATA – MATH 1715

| N = 19 | Entrance Criteria | | | | Criterion | |
|---|---|---|---|---|---|---|
| Student Number | SEM-ALG | ACT-M | ACT-C | CMT-ALG | CMT-ALG | Course Grade |
| 71 | 5 | 26 | 24 | 32 | 33 | C |
| 72 | 2 | 23 | 19 | 28 | 27 | D |
| 73 | 4 | 18 | 22 | 23 | 35 | C |
| 74 | 6 | 22 | 16 | 25 | 33 | C |
| 75 | 4 | 23 | 19 | 31 | 32 | B |
| 76 | 4 | 26 | 19 | 27 | 31 | F |
| 77 | 4 | 28 | 26 | 30 | 35 | C |
| 78 | 2 | 24 | 24 | 24 | 28 | D |
| 79 | 4 | 16 | 15 | 28 | 34 | B |
| 80 | 2 | 15 | 18 | 22 | 30 | F |
| 81 | 4 | 24 | 24 | 34 | 38 | B |
| 82 | 4 | 16 | 17 | 24 | 26 | C |
| 83 | 4 | 21 | 24 | 32 | 27 | F |
| 84 | 6 | 22 | 20 | 25 | 26 | D |
| 85 | 4 | 21 | 24 | 30 | 36 | C |
| 86 | 4 | 30 | 23 | 32 | 33 | B |
| 87 | 5 | 24 | 18 | 22 | 29 | B |
| 88 | 4 | 22 | 21 | 31 | 31 | D |
| 89 | 3 | 27 | 21 | 33 | 31 | C |

TABLE IV

STUDENT DATA – ELME 1124

| N = 22 | Entrance Criteria | | | | Criterion | |
|---|---|---|---|---|---|---|
| Student Number | SEM-ALG | ACT-M | ACT-C | CMT-ALG | CMT-ALG | Course Grade |
| 90 | 3 | 22 | 23 | 26 | 37 | A |
| 91 | 3 | 23 | 23 | 28 | 35 | A |
| 92 | 3 | 14 | 19 | 20 | 29 | B |
| 93 | 4 | 21 | 24 | 28 | 31 | A |
| 94 | 2 | 10 | 14 | 14 | 28 | C |
| 95 | 2 | 17 | 21 | 9 | 17 | D |
| 96 | 4 | 17 | 13 | 24 | 34 | C |
| 97 | 3 | 18 | 18 | 19 | 30 | C |
| 98 | 3 | 14 | 20 | 13 | 15 | D |
| 99 | 4 | 16 | 13 | 17 | 14 | D |
| 100 | 2 | 16 | 18 | 13 | 22 | D |
| 101 | 2 | 20 | 17 | 19 | 30 | D |
| 102 | 4 | 23 | 19 | 32 | 38 | A |
| 103 | 2 | 22 | 23 | 23 | 31 | B |
| 104 | 2 | 17 | 24 | 16 | 27 | C |
| 105 | 2 | 27 | 28 | 30 | 36 | A |
| 106 | 2 | 16 | 16 | 10 | 22 | D |
| 107 | 4 | 33 | 30 | 38 | 40 | A |
| 108 | 3 | 20 | 22 | 16 | 27 | B |
| 109 | 4 | 26 | 24 | 30 | 34 | C |
| 110 | 4 | 30 | 26 | 31 | 37 | A |
| 111 | 4 | 18 | 16 | 29 | 33 | A |

3. The availability of this data to advisers of entering students.

## Statistical Procedure

Toward testing of the null hypothesis regards significance of the relationship of selected variables and mathematics achievement, the technique of multiple regression analysis was chosen. In addition, this technique has practical application in providing the best possible estimate of a criterion measure from the combination of variables.

The multiple regression equation in standard score form with k variables as given by Ferguson (15, p. 396) is:

$$z_1' = \beta_2 z_2 + \beta_3 z_3 + \ldots + \beta_k z_k$$

where:

$z_1'$ is the estimated standard score.

$z_2$, $z_3$, and $z_k$ are observed standard scores.

$\beta_2$, $\beta_3$, and $\beta_k$ are multiple regression weights for standard scores.

The raw score form of this equation may be shown as:

$$X_1' = \beta_2 \frac{s_1}{s_2} X_2 + \beta_3 \frac{s_1}{s_3} X_3 + \ldots \beta_k \frac{s_1}{s_k} X_k + A$$

where A, the intercept, is given by:

$$A = \bar{X}_1 - \beta_2 \frac{s_1}{s_2} \bar{X}_2 - \beta_3 \frac{s_1}{s_3} \bar{X}_3 - \ldots - \beta_k \frac{s_1}{s_k} \bar{X}_k$$

and:

$s_1$, $s_2$, $s_3$, and $s_k$ are the standard deviation of the variable.

$X_1'$ is the predicted raw score.

$X_1$, $X_2$, $X_3$, and $X_k$ are raw scores.

$\bar{X}_1$, $\bar{X}_2$, $\bar{X}_3$, and $X_k$ are sample means.

The multiple correlation coefficient is given by:

$$R = \sqrt{\beta_2 r_{12} + \beta_3 r_{13} + \ldots \beta_k r_{1k}}$$

where:

$r_{12}$, $r_{13}$, and $r_{1k}$ are sample values of the correlation coefficient with subscript denoting variables correlated.

The multiple R in the regression analysis is inclined toward inflation. This is particularly so when the variables are increased and the sample is small. Garrett (16, pp. 416-417) provides a formula for shrinking the multiple R under these conditions as follows:

$$\bar{R}_c^2 = 1 - k^2 \frac{(N-1)}{(N-m)}$$

where:

$N$ = size of the sample

$m$ = number of variables in the problem

$(N - m)$ = degrees of freedom

$k^2$ = $(1 - R^2)$.

For purposes of statistical inference, the F-value for analysis of variance and subsequent t value are obtained by Walker and Lev (17, p. 251).

$$F = \frac{r^2(N - 2)}{1 - r^2}$$

where:

r = coefficient of correlation

N = size of sample

and:

$$t = \sqrt{F}.$$

The variables of the A.C.T. mathematics, composite, and the C.M.T. scores and the number of semesters of high school algebra for the population of each group were investigated by the multiple regression analysis technique. The results of this analysis are reported in Chapter IV.

The analysis of covariance was selected to discern if a difference existed among treatments of the mathematics courses. This statistical method may be used to adjust for the effects of one or more uncontrolled variables and thereby provide a valid measure of the treatment variable.

A step-by-step procedure of the analysis of covariance as a method to test for significance of treatment is provided by Ferguson (15, p. 334). The test of significance is applicable to the "adjusted means" with reference to a table of F.

A further explanation of the "adjusted means is given by Walker and Lev (17, p. 397):

> To ascertain what the differences among Y means are because of differences among teaching methods alone, the effects of differences among X means should be eliminated. This elimination is achieved by adjusting all the means to a common X value, which, for convenience, may be taken as the mean of all X values, $\bar{X}$.

The results of this process are in Chapter IV.

# CHAPTER IV

# RESULTS

This study was concerned with an evaluation of variables as predictors of mathematics achievement and of determining if a difference existed among treatments of the mathematics courses. The terminal results and the more important incremental results of the statistical procedure are reported herein.

## Predictors

The results of the multiple regression analysis of the variables are recorded in Tables V, VI, VII, and VIII.

The criterion was achievement in the mathematics course and was defined by the course grade with a numerical value of A = 1, B = 2, C = 3, D = 4, and F = 5. This arbitrary assignment accounts for the negative value; hence, the results could appear contradictory to the casual observer.

The multiple regression analysis used the forced step procedure; thus, the variable with the highest correlation to the criterion is recorded in step 1 of the table. The succeeding steps 2, 3, and 4 order the remaining variables according to highest correlation with the criterion and the lowest correlation with the preceding variable(s). For a

TABLE V

MULTIPLE REGRESSION ANALYSIS DATA - MATH 1213

| Sample<br>N = 25 | Forced Step Sequence<br>I | <br>II | <br>III | <br>IV |
|---|---|---|---|---|
| Forced Variable | CMT-ALG | ACT-C | SEM-ALG | ACT-M |
| Multiple Correlation Coefficient (r) | 0.379 | 0.442 | 0.540 | 0.581 |
| Adjusted r | 0.379 | 0.400 | 0.476 | 0.493 |
| F-Value | 3.853 | 2.671 | 2.875 | 2.554 |
| t-Value(s) of | | | | |
| CMT-ALG | -1.963 | -2.284 | -2.310 | -1.793 |
| ACT-C | | 1.191 | 1.851 | 2.212 |
| SEM-ALG | | | -1.684 | -1.515 |
| ACT-M | | | | -1.191 |
| Regression Coeff.(s) of | | | | |
| CMT-ALG | -0.0881 | -0.1098 | -0.1067 | -0.0872 |
| ACT-C | | 0.0922 | 0.1531 | 0.2250 |
| SEM-ALG | | | -0.3629 | -0.3264 |
| ACT-M | | | | -0.0941 |
| Std. Error of Reg. Coeff.(s) | | | | |
| CMT-ALG | 0.0449 | 0.0481 | 0.0462 | 0.0486 |
| ACT-C | | 0.0774 | 0.0827 | 0.1017 |
| SEM-ALG | | | 0.2154 | 0.2155 |
| ACT-M | | | | 0.0797 |
| Intercept | 4.4715 | 3.1062 | 2.9909 | 2.9681 |

TABLE VI

MULTIPLE REGRESSION ANALYSIS DATA - MATH 1513

| Sample N = 45 | Forced Step Sequence I | II | III | IV |
|---|---|---|---|---|
| Forced Variable | CMT-ALG | SEM-ALG | ACT-C | ACT-M |
| Multiple Correlation Coefficient (r) | 0.607 | 0.617 | 0.621 | 0.621 |
| Adjusted r | 0.607 | 0.605 | 0.598 | 0.584 |
| F-Value | 25.024 | 12.913 | 8.600 | 6.293 |
| t-Value(s) of | | | | |
| CMT-ALG | -5.002 | -4.843 | -4.553 | -4.015 |
| SEM-ALG | | 0.936 | 0.961 | 0.914 |
| ACT-C | | | 0.604 | 0.390 |
| ACT-M | | | | 0.011 |
| Regression Coeff.(s) of | | | | |
| CMT-ALG | -0.1029 | -0.1133 | -0.1206 | -0.1207 |
| SEM-ALG | | 0.1415 | 0.1466 | 0.1462 |
| ACT-C | | | 0.0227 | 0.0223 |
| ACT-M | | | | 0.0006 |
| Std. Error of Reg. Coeff.(s) of | | | | |
| CMT-ALG | -0.0206 | 0.0234 | 0.0265 | 0.0301 |
| SEM-ALG | | 0.1512 | 0.1526 | 0.1599 |
| ACT-C | | | 0.0376 | 0.0571 |
| ACT-M | | | | 0.0551 |
| Intercept | 6.1189 | 5.8870 | 5.5958 | 5.5975 |

TABLE VII

MULTIPLE REGRESSION ANALYSIS DATA – MATH 1715

| Sample N = 19 | Forced Step Sequence I | II | III | IV |
|---|---|---|---|---|
| Forced Variable | SEM-ALG | CMT-ALG | ACT-C | ACT-M |
| Multiple Correlation Coefficient (r) | 0.317 | 0.390 | 0.419 | 0.433 |
| Adjusted r | 0.317 | 0.320 | 0.270 | 0.157 |
| F-Value | 1.899 | 1.435 | 1.066 | 0.807 |
| t-Value(s) of | | | | |
| SEM-ALG | -1.378 | -1.364 | -1.220 | -1.075 |
| CMT-ALG | | -0.987 | -1.169 | -0.914 |
| ACT-C | | | 0.656 | 0.762 |
| ACT-M | | | | -0.446 |
| Regression Coeff.(s) of | | | | |
| SEM-ALG | -0.2936 | -0.2908 | -0.2683 | -0.2479 |
| CMT-ALG | | -0.0599 | -0.0842 | -0.0721 |
| ACT-C | | | 0.0595 | 0.0771 |
| ACT-M | | | | -0.0353 |
| Std. Error of Reg. Coeff.(s) of | | | | |
| SEM-ALG | 0.2130 | 0.2132 | 0.2198 | 0.2305 |
| CMT-ALG | | 0.0607 | 0.0721 | 0.0789 |
| ACT-C | | | 0.0907 | 0.1013 |
| ACT-M | | | | 0.0790 |
| Intercept | 4.4220 | 6.0924 | 5.4518 | 5.4601 |

TABLE VIII

MULTIPLE REGRESSION ANALYSIS DATA - ELME 1124

| Sample N = 22 | Forced Step Sequence I | II | III | IV |
|---|---|---|---|---|
| Forced Variable | CMT-ALG | SEM-ALG | ACT-M | ACT-C |
| Multiple Correlation Coefficient (r) | 0.401 | 0.487 | 0.543 | 0.596 |
| Adjusted r | 0.401 | 0.446 | 0.470 | 0.498 |
| F-Value | 3.824 | 2.956 | 2.508 | 2.345 |
| t-Value(s) of | | | | |
| CMT-ALG | -1.955 | -2.421 | -2.436 | -2.477 |
| SEM-ALG | | 1.384 | 1.706 | 1.124 |
| ACT-M | | | 1.211 | 1.764 |
| ACT-C | | | | -1.267 |
| Regression Coeff.(s) of | | | | |
| CMT-ALG | -0.0600 | -0.0948 | -0.1575 | -0.1576 |
| SEM-ALG | | 0.5004 | 0.6407 | 0.4489 |
| ACT-M | | | 0.0952 | 0.1860 |
| ACT-C | | | | -0.1174 |
| Std. Error of Reg. Coeff.(s) of | | | | |
| CMT-ALG | 0.0307 | 0.0392 | 0.0647 | 0.0636 |
| SEM-ALG | | 0.3617 | 0.3756 | 0.3993 |
| ACT-M | | | 0.0787 | 0.1055 |
| ACT-C | | | | 0.0926 |
| Intercept | 4.1858 | 3.4524 | 2.5094 | 3.6757 |

discussion of this rationale see Ferguson (15, pp. 401-402).

The sample size for each course is noted on the subheading of the tables. The size ranged from a low of n = 19 for MATH 1715 to a high of n = 45 in MATH 1513. The results indicate the MATH 1715 sample was below the critical point for a multiple regression analysis. This point is emphasized by the decline in the Adjusted R values from Steps II through IV. The Adjusted R values in the other samples maintained a relatively high value.

It is notable, the CMT-ALG commanded the highest correlation as evidenced by its position in Step I with the exception of MATH 1715. Step II positions were shared with ACT-C, SEM-ALG, and CMT-ALG. With the exception of ELME 1124, the ACT-M took the Step IV position; hence, the least correlation in the forced step sequence.

Reference to the F-value, for an analysis of variance, reveals a significantly high value for MATH 1513 as compared to the remaining three courses. This significance, as might be expected, is further reflected in the associated t-values.

For the purpose of determining the level of significance of the t-values, the Fisher t table was employed. Two important factors were established by this test. First, the variables analyzed were significant only in the case of MATH 1513. That is to say, there is no statistically significant correlation at the one per cent level, between one or a multiple of the independent variables and achievement in mathematics in the case of MATH 1213, MATH 1715, or

ELME 1124. The second important factor was the minimal contribution of the variables beyond the one chosen for Step I. It is the intention of the multiple regression analysis to analyze beyond the Step I variable to determine if other variables will increase the predictive power. In this analysis, it appears that the remaining variables were operating in much the same predictive region as the first one chosen. Garrett (16, pp. 419-421) considers this effect and provides a graphical explanation.

Only the t-value of the first step of MATH 1513 was significant at the one per cent level. Thus, only the first step analysis is considered appropriate in reporting the disposition of the first hypothesis. This disposition is reported in Table IX.

With the establishment of the Cooperative Mathematics Test Algebra I score as a predictor of achievement for MATH 1513, the following example is appropriate:

From Table VI, p. 27 -

| | |
|---|---|
| CMT-ALG Regression Coefficient | = -0.1029 |
| Standard Deviation of Regression Coefficient | = ±0.0206 |
| Intercept | = 6.1189 |
| Assume C.M.T. Algebra Entrance Score | = 26 |

then,

Course Grade = (26)(-0.1029 ±0.0206) + 6.1189

Course Grade = 3.6 ± 0.4 on the basis of:

TABLE IX

MULTIPLE REGRESSION ANALYSIS RESULTS
(DISPOSITION OF FIRST HYPOTHESIS)

| Mathematics Course | Step I Variable | Adjusted r | t-Test | Rejection Level | Hypothesis Disposition |
|---|---|---|---|---|---|
| MATH 1213 | CMT-ALG | 0.379 | -1.963 | .01 | Not rejected |
| MATH 1513 | CMT-ALG | 0.607 | -5.002 | .01 | Rejected |
| MATH 1715 | SEM-ALG | 0.317 | -1.378 | .01 | Not rejected |
| ELME 1124 | CMT-ALG | 0.401 | -1.955 | .01 | Not rejected |

A = 1, B = 2, C = 3, D = 4, F = 5.

It can be shown that the highest grade attainable, based on the above predictor factors and a C.M.T. algebra maximum raw score of 40, is a 1.178+.

## Mathematics Treatment

An analysis of covariance was chosen to determine if a statistically significant difference between mathematics treatment groups and the Cooperative Mathematics Test Algebra I, before-after scores existed. The more important data of this analysis is given in Table X. With reference to a table of F, the F value of 2.593 at 106 and 3 degrees of freedom is not statistically significant at the five per cent level of significance. The disposition of the second hypothesis is cited in Table XI.

TABLE X

ANALYSIS OF COVARIANCE DATA - MATHEMATICS TREATMENT

| Analysis Factors | Mathematics Treatment Groups N = 111 | | | |
|---|---|---|---|---|
| | MATH 1213 | MATH 1513 | MATH 1715 | ELME 1124 |
| CMT Before Mean | 19.880 | 24.044 | 28.053 | 22.045 |
| CMT After Mean | 27.760 | 29.044 | 31.316 | 29.409 |
| CMT Adjusted Mean | 30.391 | 28.560 | 27.833 | 30.420 |

TABLE XI

ANALYSIS OF COVARIANCE RESULTS (DISPOSITION OF SECOND HYPOTHESIS)

| D. of F. Numerator | D. of F. Denominator | F-Value | Rejection Level | Hypothesis Disposition |
|---|---|---|---|---|
| 3 | 106 | 2.593 | .05 | Not Rejected |

# CHAPTER V

# SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The problem with which this study was concerned was the lack of information relative to the advisement of beginning engineering technology students. In particular, the concern was focused on the available mathematics courses.

## Summary

The purpose of this study was to evaluate selected variables as predictors of mathematics achievement and to determine if a difference existed among treatments of the mathematics courses available to engineering technology students. The students' high school background, entrance exam scores, and post test results were included in the study.

The two hypotheses cited were:

1. There is no statistically significant correlation between one or a multiple of the A.C.T. mathematics score, A.C.T. composite score, C.M.T. algebra score, semesters of high school algebra and achievement in mathematics.
2. There is no statistically significant difference between mathematics treatment groups and

the C.M.T. algebra, before-after scores.

The data used for testing of the hypotheses were applicable to 111 students who were enrolled in engineering technology curricula. All students had received treatment in one of the following math courses: MATH 1213, MATH 1513, MATH 1715, or ELME 1124 the semester prior to testing.

The instrument used was the Cooperative Mathematics Test, Algebra I. This test provided a before-after measure since it was used previously as a part of the entrance exam battery. The Cooperative Mathematics Test Algebra I, before-after scores were the variables used for the analysis of covariance in the investigation of mathematics treatment. The multiple regression analysis technique was used to evaluate selected variables for predictors of achievement in mathematics.

## Conclusions

1. Only the Cooperative Mathematics Test, Algebra I was found to be a valid predictor of mathematics achievement and only in MATH 1513.
2. The qualification of only one predictor might well indicate that factors apparently appropriate to students in other areas of education may not be appropriate to engineering technology students.
3. The rigor of MATH 1513, with respect to

engineering technology students, is attested by application of the C.M.T. predictor. This predictor projects the highest attainable course grade as a B. Reference of the student data in this study indicates three of forty-five students achieved an A in this course. Further examination of the data reveals, two of the three achieving an A held entrance credentials exemptive of college algebra.

4. The null hypothesis regarding difference in mathematics course treatment was not rejected. However, the highest adjusted mean value was achieved by ELME 1124 followed closely by MATH 1213. These two groups held the lowest mean scores before the course treatment.

## Recommendations

1. This study should be considered as only the first step in determining the most appropriate mathematics treatment for engineering technology students.
2. Since the variables selected were of minimal predictive value, other entry factors should be considered. Further consideration of high school background, to include

mathematics level and grade average may be worthwhile.

3. The subjects of this study should be followed through their terminal mathematics course. For many, the applied, technical calculus will be terminal.

4. Over-all, further consideration of an entry level, technology oriented, mathematics course is recommended.

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## APPENDIX A

## MATHEMATICS COURSE DESCRIPTIONS

Mathematics (18):

1213 INTERMEDIATE ALGEBRA. Prerequisite: one unit of high school algebra. Fundamental operations of algebra, exponents and radicals, simple equations, graphs, systems of simultaneous equations, quadratic equations, and logarithms.

1513 COLLEGE ALGEBRA. Prerequisite: at least one and one-half units of high school algebra or 1213 or 1115. Quadratic equations, progressions, the binomial theorem, mathematical induction, theory of equations, logarithms and determinants.

1715 COLLEGE ALGEBRA AND TRIGONOMETRY. Prerequisites: one unit of high school plane geometry and 1115 or 1213 or high school equivalent. An integrated course in college algebra and trigonometry.

Electromechanical (19):

1124*PHYSICAL MATHEMATICS. A review of intermediate algebra and an intensive study of those trigonometric topics appropriate for electromechanical technology. Also included is an introduction to vector algebra and analytical geometry stressing applications. Mathematics is one of the basic tools of the practicing electromechanical technician and must therefore be closely related to the other technical subjects. This course is directly supported by a physical mathematics laboratory. The laboratory contributes directly to the mathematics course and to the course in unified physics.

*As a result of a change in curriculum emphasis, the laboratory associated with this course was devoted to a study of fluid flow and was not designed to support the study of mathematics. Consequently, the mathematics course was a three credit course.

## APPENDIX B

## MATHEMATICS PLACEMENT TEST INFORMATION FOR ADVISORS

ALGEBRA PLACEMENT TEST. Cooperative Mathematics Test - Algebra I.

The raw score on this test and the number of semesters of high school algebra determine what course the student should take.

| Test Score (raw) | Course to be taken |
|---|---|
| 0 - 20 (inclusive) | Math 1115 |
| 21 - 25 (inclusive) | Math 1115 if the student has completed less than 2 semesters of algebra. |
| | Math 1213 if the student has completed 2 or more semesters of algebra. |
| 26 - 32 (inclusive) | Math 1213 if the student has completed less than 3 semesters of algebra. |
| | Math 1715 or Math 1513 if the student has completed 3 or more semesters of algebra. |
| 33 - 40 (Engineering Students) | Math 1813 if the student has completed a course in trigonometry and also has a raw score of 18 or more on the trigonometry placement test. (If the raw score is less than 18, Math 1813 and 1613 may be taken concurrently.) |
| (Non-engineering Students) | Math 2215 if the student has completed a course in |

trigonometry and also has a raw score of 18 or above on the trigonometry placement test.

# VITA

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