AN EXAMINATION OF RELATIONSHIPS BETWEEN SELECTED STUDENT ENTRY PARAMETERS AND ACHIEVEMENT IN AN ELECTROMECHANICAL TECHNOLOGY PROGRAM

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CHAPTER I

INTRODUCTION

In ancient times the learned man was able to cope with wide areas of human knowledge. As science and technology become more advanced and sophosticated it becomes necessary for the individual man to become increasingly specialized in his occupational pursuit. For this reason, almost all areas of education have become interested in identifying potential students who possess those abilities which promise success in a given speciality. Technical education, that area which deals with the application of physical science at a level between engineering on the one hand and the skilled trades on the other, is in this respect little different from other areas of education.

While there have been relatively few formal studies which deal with the specific problem of how to identify promising students for technical education, there is some evidence that these students demonstrate different characteristics than do university students.

In recent years the rapid growth of technology has generated a need for technicians in areas in which the demand was not previously acute. Several of the newer technologies are characterized as being multidiciplinary

in that they incorporate principles previously found in a number of different single specialty areas. Among these new and emerging fields are biomedical equipment technology, electro-optical technology, and electromechanical technology.

Curriculum materials for one of these new areas (electromechanical technology) is currently being developed at Oklahoma State University. There would seem to be a possibility that other institutions will begin to offer similar programs. For this reason it would seem appropriate at this time to start developing methods for identifying promising students in this area.

Purpose of the Study

The purpose of this study was to take the first step toward establishing a basis from which promising students for the emerging technologies can be identified. Specifically, the purpose of this study is to investigate whether or not the factors which are appropriate for identifying promising potential students for the emerging technologies are the same ones that are appropriate in other areas of education.

Review of Literature

The technical nature of the weaponry used during World War II made the problem of identifying potentially good technical personnal take on an air of urgency. Technicians were immediately needed for both the Armed

Services and for the defense industries. The U. S. Navy, in particular, conducted a number of studies relative to the identification of promising technical trainees. As early as 1943 Lawshe and Thornton[1] reported on the correlation between selected examinations (Mechanical Aptitude, Arithmetic, English, Spelling, and others) and the grade point average earned by Navy trainees in an electricity course at the Purdue Naval Training School. The results varied from correlations of over 0.35 to over 0.65 for the various tests. The predictive value of the test battery was subsequently evaluated with a second group of trainees and found to produce a correlation of over 0.8.

A similar study was conducted by Frandsen and Hadley[2] at Utah State Agricultural College using mathematics and electricity tests with Naval Radio School trainees. In this case the correlations between test scores and average achievement varied from over 0.5 to over 0.7.

Other studies were conducted by the military services in the area of vocational technical education. While the exact coefficients of correlation varied depending on the

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[1] C. H. Lawshe and G. R. Thornton, "A Test Battery for Identifying Potentially Successful Naval Electrical Trainees", Journal of Applied Psychology, XXVII (1943), pp. 399-406.

[2] A. N. Frandsen and J. M. Hadley, "The Prediction of Achievement In a Radio Training School", Journal of Applied Psychology, XXVII (1943), pp. 303-310.

test instruments and other variables the general outcomes of the investigations were positive in virtually every case.

Substantially the same results have been achieved with engineering students in a variety of studies.

In 1946 Cohen[3] found a high correlation between high school grades and success in engineering programs. Two years later McClanahan and Morgan[4] conducted a similar investigation at Colorado Agricultural and Mechanical College using a variety of standardized tests together with high school rank. The results were a correlation of almost 0.85. As in the case of the military studies, many other examples of high predictive correlation between selective tests and achievement can be found. In the engineering college studies, high school achievement as well as standardized test scores in the areas of mathematics and English seem to be the most reliable predictors in the majority of instances.

In spite of the many studies indicating an ability to predict success in military specialist schools and in engineering colleges, there is some evidence that these

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

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

same techniques may not be appropriate for modern technician training programs. Wold[5] found that:

> 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.

It is possible that today's technical student is not motivated to achieve as highly as was the World War II military technician. On the other hand, some authorities seem to feel that technical students are not as academically capable as are engineering students. C. H. Patterson[6], for example, is one who holds this opinion. If this is indeed the case then there is at least one study which would seem to indicate that predicting the success of less academically capable students is somewhat uncertain. This study was carried out by Harley F. Garrett[7] in 1949. One of Garrett's conclusions was:

> There is a closer correlation between

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[5]Kenneth M. Wold, "Practices Employed in Selecting Students for Technical Curricula and Their Relation to the Student Completion Rate" (unpub. Ed. D. dissertation, University of Missouri, 1961), pp. 240-241.

[6]C. H. Patterson, "Predicting Success In Trade and Vocational School Courses", Educational Psychological Measurement, Vol. 16, No. 3, p. 353.

[7]H. F. Garrett, "A Review and Interpretation of Investigations of Factors Related to Scholastic Success in Colleges of Arts and Sciences and Teachers Colleges". The Journal of Experimental Education, XVIII (February, 1949), pp. 91-138.

> intelligence test scores and later college grades for those scoring high in intelligence than for those scoring average or low in intelligence. This would indicate that students with high intelligence tend to succeed in college in spite of all other factors operating. With students of lesser mental ability, however, some may put other factors into operation to bring them scholastic success, and some may not. This uncertainty makes it more difficult to predict scholastic success in college for this group.

In summary, there have been a number of studies directed toward identifying promising students for the engineering and vocational-trade levels of education. There is also some evidence which would seem to indicate that parameters used to identify potential students at these levels are not necessarily appropriate for use in the new and emerging multidiciplinary technologies.

CHAPTER II

METHODS OF INVESTIGATION

Many studies have been conducted at both the engineering level and at the military technician level that would seem to indicate that mathematics ability is one of the important factors contributing to student achievement.

As regards this study, the specific problem was to examine the strength of the relationship between mathematics ability and student achievement in the first year of electromechanical technology at Oklahoma State University.

Data Collection

In September of 1968 a class of 28 freshman students were admitted to the electromechanical technology program at Oklahoma State University. Prior to admission each student completed the American College Testing Program (ACT) tests in the areas of mathematics, English, social science, and natural science. Each student also completed the Algebra portion of the Cooperative Mathematics Tests and supplied an offical copy of his high school transcript. During September the General Aptitude Test Battery (GATB) was administered to the beginning electromechanical

students.

Of the 28 students admitted to the electromechanical program in September, 22 completed the first year of the program. Six of the initial 28 students withdrew from the program during the first year.

Accurate records of the semester grades for the 22 completing students' were kept during the first year and their over-all grade point averages were determined.

Variables

Appropriate variables for the purposes of this study were identified as follows:

(a) Each student's Composite ACT Score, ACT math score, Cooperative Mathematics Test - Algebra score, GATB numerical score, GATB Learning Ability score, and the highest level high school mathematics course successfully completed were selected as independent variables.

(b) Each student's achievement at the end of one year was chosen as the dependent variable.

(c) The length and content of the electromechanical technology program were controlled variables.

(d) Among the many possible intervening variables are maturation, motivation, and other student personality characteristics.

Definitions

For the purposes of this study the following functional definitions are useful:

(a) Achievement in electromechanical technology is understood to be defined in terms of first year grade point average. That is, a student's achievement score in this study is numerically equal to his grade point average for the first year of the electro-mechanical technology program.

(b) High School Mathematics background is to be understood to mean the highest level high school mathematics course satisfactorily completed by the student. For the purposes of this study high school mathematics levels were quantified as follows:

Algebra I	level 1
Geometry	level 2
Algebra II	level 3
Trigonometry	level 4
Trigonometry with matrix algebra	level 4
Trigonometry with Analytics	level 4
Math Analysis	level 5

Therefore, a student who had successfully completed trigonometry with matrix algebra would have a high school mathematics background

score of 4.

Hypotheses

Utilizing the variables and definitions cited above the following null hypotheses were set forth:

1. There is no statistically significant correlation between student composite ACT Scores and achievement in electromechanical technology.
2. There is no statistically significant correlation between student ACT Math scores and achievement in electromechanical technology.
3. There is no statistically significant correlation between student cooperative mathematics test Algebra scores and achievement in electromechanical technology.
4. There is no statistically significant correlation between student GATB numerical scores and achievement in electromechanical technology.
5. There is no statistically significant correlation between student GATB learning ability scores and achievement in electromechanical technology.
6. There is no statistically significant correlation between student high school mathematics background and achievement in electromechanical technology.

Statistical Procedures

There were a variety of ways in which the statistical significance of the six null hypotheses could have been tested. The Pearson Product Moment correlation coupled with the Fisher t-test have been widely used in studies of this type. It should, however, be noted that the high school mathematics background variable would probably not be considered an interval scale. It is probably ordinal in nature and may therefore be correlated with the dependent variable on a rank basis.

The Kendall rank correlation coefficient, τ (tau), may be used effectively with ordinal measures[8]. Establishing the level of statistical significance for the Kendall rank correlation coefficient may be readily accomplished using the familiar z-test.

Since it was desirable to be able to compare results of one hypothesis with those of the others, the Kendall rank correlation coefficient and z-test were used for all of the hypotheses in this study.

If a given correlation in this study was statistically significant at the one percent level ($z \geq 2.326$) then that null hypothesis was rejected. If the correlation coefficient was significant at the five percent level $z \geq 1.645$ but not at the one percent level then that null hypothesis

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[8]Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences, (New York, 1956). pp. 213-223.

was or was not rejected depending on the value of the correlation coefficient and the significance level. For example, if a correlation coefficient was relatively small and statistically significant at or just below the 0.05 level, then that hypothesis was not rejected because the relationship would have little value for selecting promising potential students. If the correlation coefficient was significant at a level greater than five percent ($z < 1.645$) then that null hypothesis was not rejected.

Finally a scatter diagram was plotted for each correlation to assist in gaining insight into the value of the correlation for predicting individual student achievement in electromechanical technology.

CHAPTER III

RESULTS

Twenty eight freshman students were admitted to the electromechanical technology program at Oklahoma State University in September of 1968. Of these 28 freshman, 22 remained in the program at the end of the first two semesters. Prior to (or immediately after) admission selected standardized tests were administered to these entering students. From the test results five scores were selected for examination. In addition, the highest level of high school mathematics successfully completed by each student was determined from official high school transcripts. At the end of two semesters the over-all grade point average of each student was compiled. These data, for the 22 students who completed the first two semesters, are shown in Table I.

From these data the standard deviation (S), Kendall rank correlation coefficient (τ), and the significance level z-score (z) was determined for each of the independent variables (T_A) paired with the dependent variable (T_B) using the following equations[9]:

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[9] Ibid. p 11

TABLE I

TABLE OF STUDENT SCORES AND GRADE POINT AVERAGE

Student Number	ACT Math.	ACT Comp.	GATB Num.	GATB Learn Ab.	HS Math.	Coop. Alg.	Gr. Pt. Ave.
01	21	13	125	114	03	22	2.45
02	24	20	090	096	03	13	1.37
03	26	20	103	115	04	35	2.31
04	18	21	127	143	01	25	0.91
05	22	18	101	107	03	19	2.05
06	19	16	097	120	04	26	2.62
07	17	20	120	124	04	13	2.45
08	15	13	100	094	04	00	3.34
09	26	22	134	132	04	33	3.85
10	19	20	113	111	05	29	3.71
11	26	23	135	125	03	30	2.88
12	29	24	122	118	05	36	3.94
13	21	19	095	108	03	21	1.60
14	27	24	107	123	04	28	1.91
15	19	17	111	101	03	18	2.66
16	25	21	149	129	03	25	2.17
17	17	18	113	110	04	30	3.40
18	24	24	105	123	03	31	3.00
19	11	12	102	089	03	07	2.37
20	14	19	121	105	04	34	2.44
21	16	18	093	086	02	08	2.09
22	25	24	115	121	03	32	2.40

1. $S = \frac{2(2N+5)}{9N(N-1)}$

2. $\tau = \frac{X}{\sqrt{0.5N(N-1)-T_A}\ \sqrt{0.5N(N-1)-T_B}}$

3. $z = \frac{\tau}{S}$

Where: N = number of ranks

X = total score calculated for ranks of the dependent variable by selecting each rank in turn, adding 1 for each larger rank to its right, subtracting 1 for each smaller rank to its right.

The level of significance was then determined for each correlation using a z-test table.

The results of these calculations are given in Table II. The disposition of each of the hypotheses is also given in Table II. A given null hypothesis was rejected if the significance level was equal to or less than 0.01. If the significance level was over 0.05 for a given hypothesis, it was not rejected. Between the significance levels of 0.01 and 0.05 (including 0.05) a given hypothesis was either rejected or not rejected depending on the strength of the correlation coefficient (τ) and on the significance level.

It is worth noting that the last hypothesis (cooperative mathematics, Algebra) was handled slightly differently

TABLE II

CORRELATION WITH THE DEPENDENT VARIABLE, SIGNIFICANCE, AND HYPOTHESIS

Variable	τ	S	z	Signif. level	Hypothesis Disposition
ACT Math.	.071	.154	.462	.323	Not rejected
ACT Comp.	.063	.154	.412	.341	Not rejected
GATB Num.	.252	.154	1.643	.050	Not rejected
GATB Learn Ability	.078	.154	.510	.305	Not rejected
HS Math.	.600	.154	3.908	.00005	Rejected
Coop. Alg.	.361	.158	2.287	.011	Rejected

than the others. In Table I it will be seen that student number 8 had a cooperative mathematics score of zero. In actuality there is no score available for this student. Consequently student number 8 was not included in the calculations dealing with the cooperative mathematics variable. Had the zero score been included the results for this variable would have been $\tau = 0.271$, $S = 0.154$, and $z = 1.764$ resulting in a significance level of 0.038. Under these circumstances the cooperative mathematics hypothesis may not have been rejected.

While correlation coefficients and significance levels are invaluable for determining whether or not a null hypothesis may be rejected, they provide only limited insight into the usefulness of the variables in selecting promising students. For this reason the results of this study are also presented in the form of scatter (or correlation) diagrams. Figures 1 through 6 are the diagrams of the results.

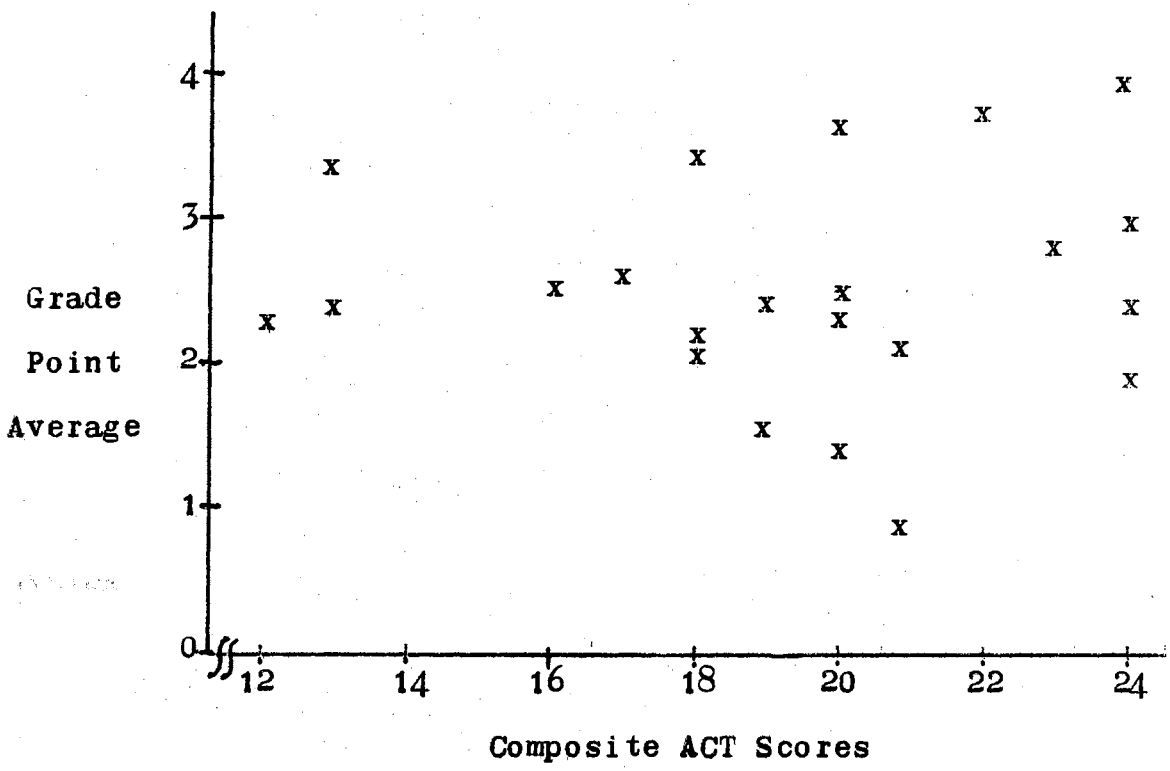

Figure 1. Scatter Diagram of Achievement vs ACT Composite Scores

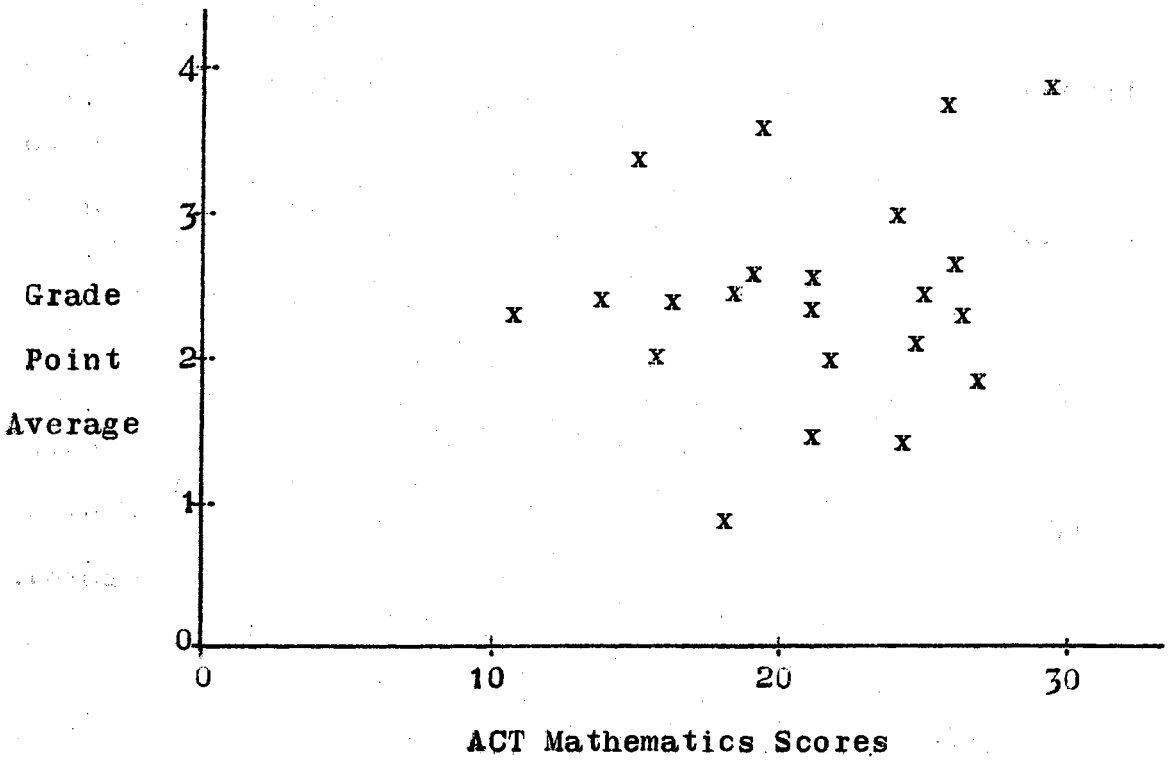

Figure 2. Scatter Diagram of Achievement vs ACT Math Scores

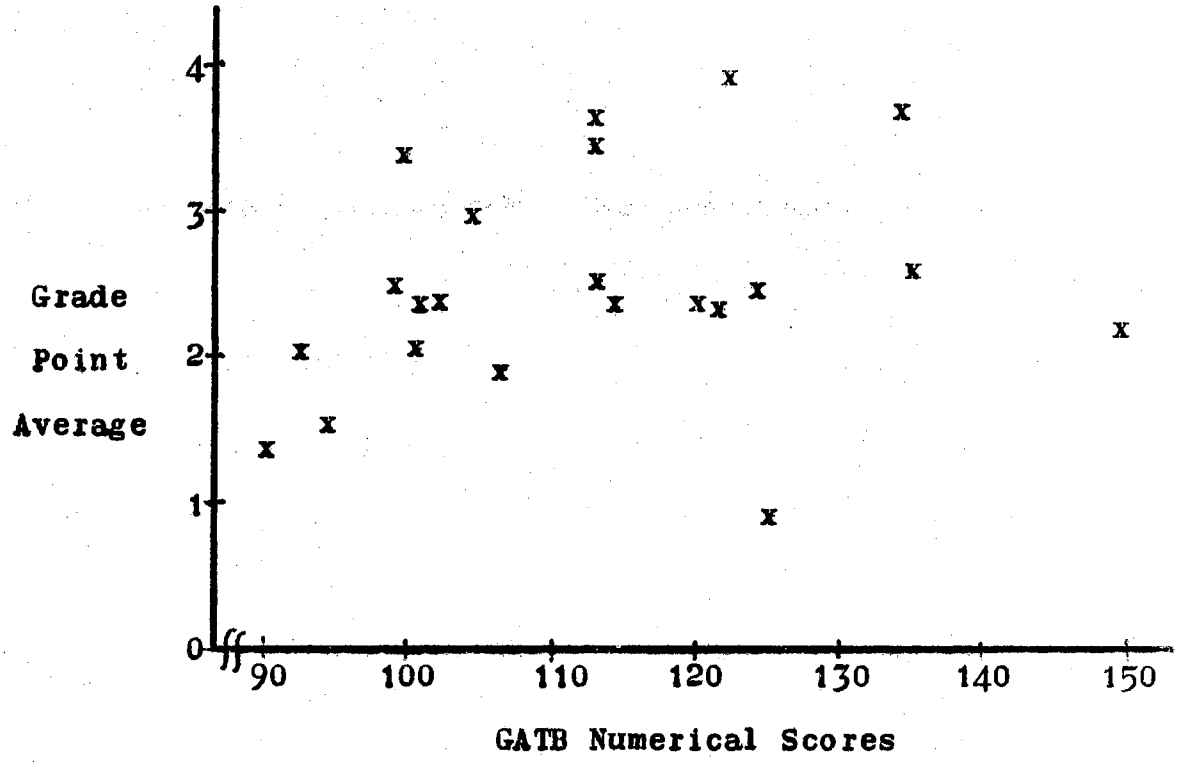

Figure 3. Scatter Diagram of Achievement vs GATB Numerical Scores

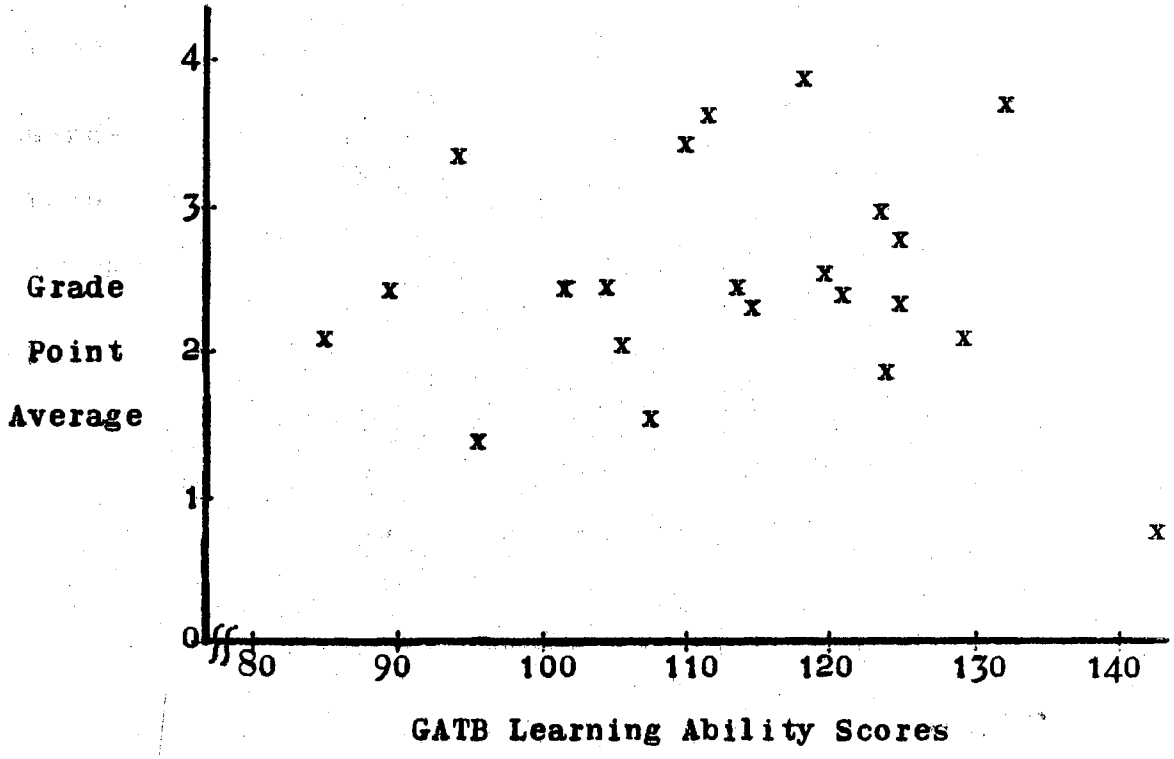

Figure 4. Scatter Diagram of Achievement vs GATB Learning Ability Scores

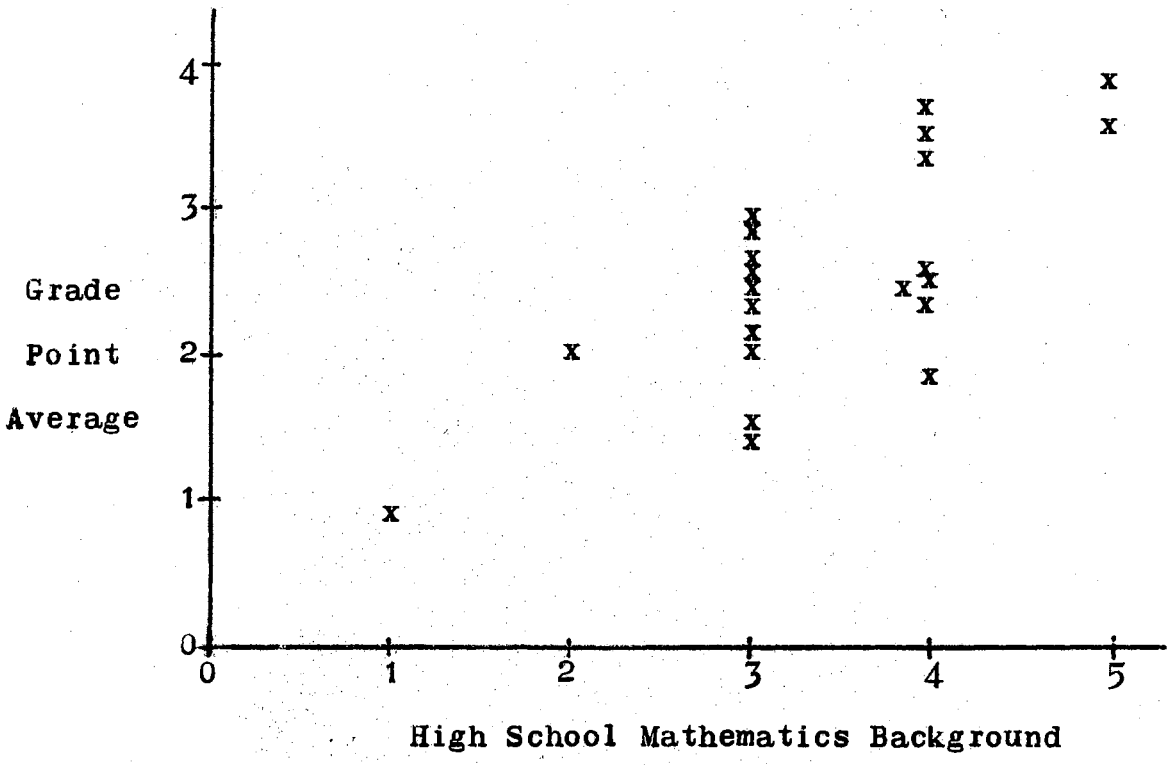

Figure 5. Scatter Diagram of Achievement vs High School Mathematics Background

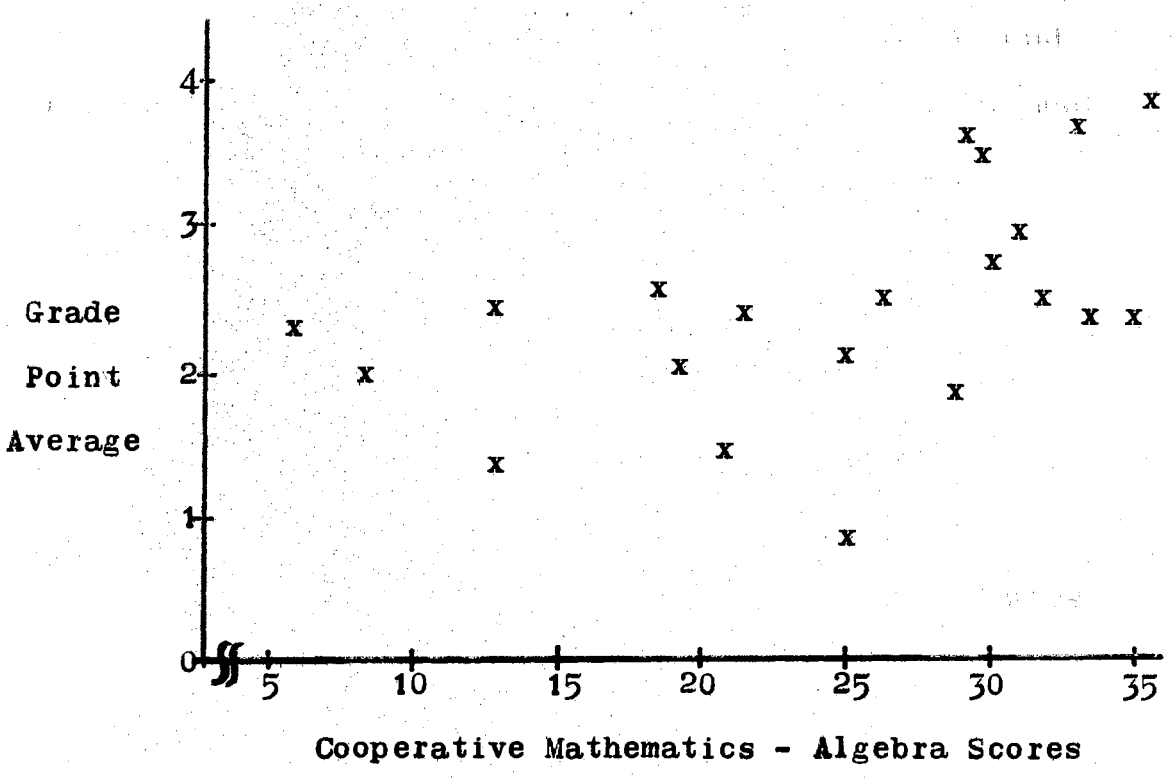

Figure 6. Scatter Diagram of Achievement vs Cooperative Mathematics Algebra Scores

CHAPTER IV

SUMMARY AND CONCLUSIONS

Twenty two students completed the electromechanical technology program at Oklahoma State University in May of 1969. The grade point averages of these students were determined and were used as the dependent variable in this study.

All of these students had entered the program in September of 1968. Prior to (or immediately after) admission to the program the following data were collected for each student;

1. The Composite ACT Score.
2. The ACT math score.
3. The GATB Learning Ability score.
4. The GATB numerical score.
5. The Cooperative Mathematics Test - Algebra score.
6. The highest level of high school mathematics satisfactorily completed by the student.

These quantities are the independent variables in the study.

The statistic used in examining correlations between the independent variables and the dependent variable was the Kendall rank correlation coefficient. The confidence levels of the various coefficients of correlation were

determined using a table of the probabilities associated with values as extreme as the observed values in a normal distribution. This procedure is commonly referred to as the z-test for statistical significance.

In abbreviated form the results of the study were:

1. The ACT scores and the GATB Learning Ability score were found to have insignificant statistical correlations with achievement in electromechanical technology.
2. The GATB Numerical score and the cooperative mathematics - Algebra score were found to have statistically significent correlations with achievement in electromechanical technology, but the correlations were so small as to promise little value in identifying potentially successful students.
3. The high school mathematics background of the students was found to have the highest correlation coefficient (0.600) and the strongest confidence level (0.00005) of any of the variables considered.

On the basis of these results one could conclude that high school background in mathematics would offer the most promise as a tool for identifying potentially successful students for electromechanical technology.

Discussion of Results

The use of statistical correlations to select potentially successful students for an educational program can be argued at great length. Some authorities contend that correlations are descriptive statistics functioning only to describe the existing state of relationship between two sets of scores. If this view is taken then a correlation may not be used as a predictor. This being the case, correlation coefficients may not be employed in selecting potentially successful students.

Other authorities[10], perhaps a majority, hold that when correlation coefficients are coupled with an evaluation of the level of statistical significance they become inferential quantities and may be used as predictors. Based on this attitude correlation coefficients may be used in identifying promising potential students.

Based on the view that correlation coefficients may be considered predictors when they are statistically significant, the following interpretations of the results of this study can be made.

The Kendall rank correlation coefficients representing the relationships between the ACT mathematics score, ACT Composite scores, as well as the GATB Learning Ability

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[10]W. James Popham, Educational Statistics, Use and Interpretation, (New York, 1967) p. 76.

scores and student achievement in electromechanical technology were all below 0.1 and were not statistically significant. The actual correlation coefficients for these three tests were 0.071, 0.063, and 0.078 respectively. The levels of significance for the three coefficients were 0.323, 0.341, and 0.305 respectively. The low value of correlation coefficient would seem to indicate that these variables could not be used effectively in identifying promising potential students for electromechanical technology. The scatter diagrams given in Figures 1, 2, and 4 tend to confirm this contention. Moreover, the significance levels indicate that there was a possibility of over 30 percent that the correlation coefficients observed were due to chance alone. On this basis the null hypotheses dealing with these three variables could not be rejected.

The observed coefficient of correlation for the relationship between the GATB Numerical scores and achievement in electromechanical technology was 0.252. The level of statistical significance of this correlation was 0.050. In many instances the null hypothesis concerning this relationship would be rejected. However for the purpose of this study the null hypothesis was not rejected because the coefficient was relatively low and the level of significance was 0.050. The scatter diagram, Figure 3, would seem to indicate that this variable would have very limited value as a means of identifying promising potential students for electromechanical technology.

In the case of the cooperative mathematics Algebra test, the test scores correlated with achievement in electromechanical technology to the extent of producing a Kendall rank correlation coefficient of 0.361 at the 0.011 confidence level. On the basis of these values, the null hypothesis associated with this variable could be rejected. An examination of the scatter diagram, Figure 6, for this variable reveals a relatively wide spread among the test scores for a given achievement level. For this reason, the variable would probably have only limited value in identifying promising potential students for electromechanical technology.

The Kendall rank correlation coefficient for the relationship between high school mathematics background and achievement in electromechanical technology was the highest revealed by this study. The coefficient value of 0.600 was significant at the 0.00005 level. Consequently, the null hypothesis associated with this variable could be rejected. Of the six variables considered in this study, this one (high school mathematics background) would seem to provide the strongest basis for selecting promising potential students for electromechanical technology. The distribution of the data points in the scatter diagram for this variable (Figure 5) tends to confirm this conclusion in that there is less spread in the independent variable values for a given dependent variable value than is observed for any of the other correlations.

Conclusions

The results of this study should be of some value in selecting entry students for a program in electromechanical technology. It should not, however, be implied that the variables considered herein are the only factors to be considered in identifying promising potential students. Nor is it necessary that identical results are to be expected if the study is repeated under different conditions.

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.

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Publications:

Author:	Experiments in Circuit Analysis, The Technical Education Research Center, Oklahoma State University, 1969.
Author:	Transmission Lines and Wave Guides and Instructional Manual, Government Polytechnic Institute, Rawalpindi, West Pakistan, 1967.
Author:	Experiments in Electricity, Direct Current, McGraw-Hill Book Company, New York, New York, 1966.
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Author:	Introductory Microwave Techniques, Holt, Rinehart, and Winston, Inc., New York, New York, 1965.
Co-author:	Experiments In Electricity and Electronics, Direct Current, Alternating Current Hickok Teaching Systems, Inc., Cambridge, Massachusetts, 1967.
Staff Contributor:	Several contract documents produced by Oklahoma State University. Among these are several U. S. Department of Labor Man Power Training Guides and the current U. S. Office of Education Curriculum Guides in Electronics Technology and Radio and Television Repair.