A STUDY OF PREDICTING ACHIEVEMENT IN ANALYTICAL GEOMETRY AND CALCULUS

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June 27, 1966

To the Graduate ~~Council~~ Committee:

I am submitting herewith a thesis written by John L. Howlett entitled "A Study of Predicting Achievement in Analytical Geometry and Calculus." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, in Education with a major in Mathematics.

William G. Stokes
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Abstract of Thesis

A Study of Predicting Achievement

in Analytical Geometry and Calculus

PURPOSE

The basic purpose of this study is that of finding a means of differentiating between those students prepared for college calculus and analytic geometry and those in need of further study below that level. It is generally agreed that some students entering college are better prepared in various fields than others; thus the purpose of this study is to attempt to find a means of classifying according to ability groups entering freshmen desiring to take mathematics. It is expected that students of high ability in mathematics should begin with a course in analytic geometry and calculus while those of the lower ability and training be required to begin with algebra and trigonometry.

LIMITATIONS

Since a workable method of predicting success of students in Mathematics 201, Analytic Geometry and Calculus was desired, it was decided that data sources should be those available for immediate use, and that the prediction equation be constructed as simply as possible without reducing the reliability of the prediction. The source of data was limited to that available in the student's personnel record file.

RELATED LITERATURE

There has been much study in regard to prediction of achievement in almost every field of study. In studying the many sources of information it was found that the authors did find a significant means of predicting success. The conclusions of the authors in general were that there was enough increase in correlation with the use of a multiple regression procedure to warrant its use for prediction of success. It was also a general concensus of opinion that further study in this area of success prediction was warranted.

DESIGN OF THE EXPERIMENT

The subjects of the experiment were freshmen college students who had never taken a college mathematics course prior to taking Mathematics 201, Analytic Geometry and Calculus at Austin Peay State College. The criterion variable used in the study was the final grade in the Mathematics 201 course. The predictor variables used were: high school mathematics grade point average, high school general grade point average, class percentile rank in high school, ACT English score, ACT mathematics score, ACT social science score, ACT natural science score, ACT composite score. The study was designed so as to derive the simple correlations of the predictors with the dependent variable, and also to derive a multiple regression equation using the best possible combination of predictors.

ANALYSIS OF THE DATA

The data was collected and submitted to a 1620 digital computer which computed the simple correlations and derived the best possible combination of predictors. The best single predictor of success proved to be the high school mathematics grade point average (.618). The multiple regression equation chosen for use of prediction was: Calculus grade = -4.735817 + .918036 (high school mathematics grade point average) + .156528 (ACT composite score).

CONCLUSION

This study shows that a method of placement can be derived using achievement type predictor variables which will allow students to perform adequately in calculus in their first year of college.

A STUDY OF PREDICTING ACHIEVEMENT

IN ANALYTICAL GEOMETRY AND CALCULUS

A Thesis

Presented to

the Graduate Council

Austin Peay State College

In Partial Fulfillment

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Master of Arts in Education

by

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CHAPTER I

INTRODUCTION

The great scientific advancement brought on by "sputnik" has caused the mathematician to take a serious look at the adequacy of the entire mathematics program from kindergarten through the doctoral level. Such studies as those made by The Committee on the Undergraduate Program in Mathematics (CUPM), The Cambridge Conference,[1] and the School Mathematics Study Group (SMSG) have inaugurated deliberate, well-planned programs to update mathematics education. Recommendations concerning the degree of training constituted just one phase of the studies by CUPM. Recommendations most emphatically emphasized were: "For all future high school teachers, the Recommendations plead for requirements of a bachelor's degree with a major in mathematics consisting of at least 33 semester hours of college mathematics courses";[2] and, "For those people who teach advanced mathematics programs in high school, for junior college teachers, and for people employed by universities to teach in the first one or two years, the Recommendations call for a master's degree in mathematics."[3]

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[1] Goals for School Mathematics, (Boston: Houghton Mifflin Company, 1963).

[2] Robert J. Wisner, "CUPM--Its Activities and Teacher Training Recommendations" Committee on the Undergraduate Program in Mathematics CUPM Report No. 1, Sept. 1961.

[3] Ibid.

When CUPM refers to the college mathematics curriculum it takes the stand that, "college mathematics begins with calculus."[4] In the introduction to the recommendations of the Committee are found the guidelines for the college and universities:

> It is desirable that all calculus prerequisites, including analytic geometry, be taught in high school. At present, it may be necessary to include some analytic geometry in the beginning analysis course, but all other deficiencies should be corrected on a noncredit basis.[5]

Even if it is an accepted principle that college mathematics should begin with calculus, there is always a question as to whether or not an entering college freshman should be permitted to begin his mathematics program in analytic geometry and calculus. If a student is not prepared to begin college mathematics at this level, he should be required to take courses in remedial mathematics in preparation for his college work.

The purpose of this study is basically finding a means of differentiating between those students prepared for college calculus and analytic geometry, and those in need of further study below that level. It is generally agreed that some students entering college are better prepared in various fields than others; thus it is the purpose of this study to attempt to find a means of classifying entering freshmen desiring to take mathematics according to ability groups. It

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[4] Ibid.

[5] Committed on the Undergraduate Program in Mathematics CUPM Report Number 5, Jan. 1962, p. 15.

is expected that students of high ability begin college mathematics with a course in analytic geometry and calculus while those of the lower ability and training be required to begin with algebra and/or trigonometry.

A realistic study of the problem requires the use of several variables as predictors of success of students in the Analytic Geometry and Calculus course at Austin Peay State College. It is generally found that variables do not do an equally good job in the prediction of any given criteria; thus it is desirable to determine the validity of each variable and to study the results of combining variables by a multiple regression procedure.

Since the purpose of this study was to find a workable method of predicting success of students in Analytic Geometry and Calculus, it was decided that data sources should be those available for immediate use, and that the prediction equation be constructed as simply as possible without reducing the reliability of the prediction. The source of data was reduced to that available in the students' personnel files. The criterion variable used in the study was the final grades of the students taking analytic geometry and calculus as their first college mathematics course. The data was programmed into a 1620 digital computer which computed both the intercorrelations and the best multiple regression combination. The best predictive combination of variables was reduced to a regression equation for computing the possible degree of success of an entering freshman taking analytic geometry and calculus.

CHAPTER II

RELATED LITERATURE

There has been much study in regard to prediction of achievement in almost every field of study. This author has found many sources of information on this subject and therefore will mention briefly only those which were closely related to the prediction of grades in Analytic Geometry and Calculus.

In studying the sources of information it was found that in each article there was a significant prediction of success. The conclusions of the author in general were that there was enough increase in correlation with the use of multiple regression procedure to warrant its use for prediction of success. It was also a general concensus of opinion that further study in this area of success prediction was warranted.

Wampler[1] attempted to select measures of aptitude which could be used effectively to predict performance in college mathematics. The study concerned only the selection of measures for a prediction scheme and not with a factor analysis of ability in mathematics. The subjects were chosen from a group of students who had completed ten semester hours of integrated courses in calculus and analytic geometry at Nebraska Wesleyan University. The tests used were taken from the

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[1] Joe F. Wampler, "Prediction of Achievement in College Mathematics," The Mathematics Teacher, LIX (April, 1966), pp. 364-369.

French, Ekstrom, and Price aptitude factors kit.[2] The actual tests chosen were:

X_1 = Location Test

X_2 = Addition Test

X_3 = Division Test

X_4 = Subtraction and Multiplication Test

X_5 = Mathematics Aptitude Test

X_6 = Necessary Arithmetic Operations Test

X_7 = Inference Test

X_8 = Wide Range Vocabulary Test

X_9 = Cube Comparison Test

X_{10} = Match Problems V

X_{11} = Surface Development Test

Each of the tests of aptitude was administered to the subject at the beginning of the school year. Upon completion of the course Mathematics 106, Calculus II, a standardized test in calculus was administered. The eleven aptitude measures were used as prediction variables and the calculus test score was used as the criterion variable. The entire set of scores was submitted to a linear regression analysis utilizing an IBM 1620 digital computer with a program written

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[2] Ibid., p. 365, J. W. French, R. B. Ekstrom, and L. A. Price, Kit of Reference Tests for Cognitive Factors, Educational Testing Service, Princeton, New Jersey, 1963.

by Griffith.[3] The best combination of variables proved to be: Location Test, Division Test, Inference Test, Wide Range Vocabulary Test and Cube Comparison Test. The multiple correlation coefficient for this combination had the value .9502 which differed significantly from zero at the 1 per cent level and the regression equation for the best combination of these five variables was Calculus Test score equals $.4209X_1 - (.1498X_3) + .8930X_7 + .8238X_8 - .1601X_9 + 4.496$. Prediction of performance on the standardized calculus test using the aforementioned regression equation should not be wrong by more than 3.176 points in approximately two-thirds of the predictions one might make.

The results of this study indicated that measures of aptitude can be used effectively to predict achievement in college mathematics.

The purpose of the test conducted by Hulser and Smith[4] was to find some means of predicting general grade point average of freshmen after one quarter of college work at Central Missouri State College. The experiment served a twofold purpose: The first step was to determine the validity of each of the tests of the freshman battery for predicting first quarter grade point average. The second aspect

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[3]Joe F. Wampler, Op. Cit., p. 366, E. V. Griffith, "Linear Regression Analysis of All Combinations of Variables," IBM 1620 General Program Library, No. 6.0.057, 1963.

[4]Lyle D. Hulser, Gary Smith, "A Study of the Validities of the Tests in Central Missouri State College Freshman Battery." Central Missouri State College, Warrensburg, Missouri, 1963, p. 1.

of the study was to determine whether a combination of two or more variables would produce a sufficient increase in validity to justify the use of multiple regression procedures.

The procedure began with the administration of the freshman battery consisting of the School and College Aptitude Test (SCAT) and the Missouri English Placement Test (MEPT). The high school percentile rank was also used in this combination. College grade point average computed from the first quarter grades served as the criterion measure. All possible intercorrelations were computed between predictors as well as the criterion variables. The best single predictor of grade point average proved to be the high school rank, with a correlation of .6000.

In the second phase of the study, use was made of all possible combinations of tests. The best possible combination using linear regression procedures proved to be the use of the SCAT, verbal, and Quantitative MEPT and high school rank with a correlation of (.686). But since the combination of the SCAT total score and the high school rank was .671, only .015 less than the best possible combination, and the addition of each predictor does add a source of error, it was decided to use the regression equation:

$$Y = .017133X_1 + .013829X_2 - .110 \text{ where}$$

Y = Predicted grade point average

X_1 = Total SCAT score

X_2 = High school rank

The experiment did show that multiple regression procedures can improve prediction of grade point averages using SCAT, MEPT and high school grade point averages. Stiles and Williams[5] at Vanderbilt University School of Engineering wished to find a means to select from among the applicants, those students having the best chance of success in college. Eight prediction variables were selected.

I. $CEEB_1$ - College Entrance Examination Board Scholastic Aptitude Tests Verbal Battery Score

II. $CEEB_M$ - College Entrance Examination Board Scholastic Aptitude Tests Mathematics Battery Score

III. $CEEB_T$ - College Entrance Examination Board Scholastic Aptitude Tests - total score - $CEEB_T + CEEB_M$

IV. IQ - Intelligence Quotient high school age levels, based on a mean of 100 and standard deviation of 15

V. HS_{GP} - High School grade point average based on a 3.0 system

VI. HS_{RA} - High School percentile rank in class

VII. Age - The age of applicant as of September 1959

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[5]Raeburn Stiles, H. E. Williams, "A Multivariate Analysis of Admissions Criteria at Vanderbilt Engineering School." Journal of the Tennessee Academy of Science. Vol. 38, No. 1, Jan. 1963, pp. 37-39.

VIII. HS_{RE} - High school Recommendations

The high school principal or counselor was required to write a recommendation for each applicant. Means of prediction were:

+1 - Student was given a positive recommentation by the high school

0 - student given neutral recommendation or no recommendation

-1 - student given a negative recommendation

IX. G.P.A. - Criterion variable grades were computed from college grades using the same basis as that for high school G.P.A.

The data collected was entered into a computer programmed to compute the intercorrelation of the nine variables, the means, and standard deviations of the variables. A multiple regression procedure by the Fisher - Doolittle method was employed to give the best prediction combination of the variables. The prediction equation was G.P.A. (predicted) - 2.4816 + .0011 $CEEB_V$ + .0027 $CEEB_M$ + .4774 $HS_{G.P.}$ + 1.1207 HS_{RE}

The authors were quite interested in the fact that the high school ratings by the principal or counselor proved to be of significant value. In fact, the authors recommended an improvement on the rating scale to increase the predictability. This scale would use the ratings: 5, superior college student; 4, good student material; 3, student has minimum qualifications for college; 2, there is doubt of success of the student in college work; 1, student is not qualified to do college work.

The purpose of a study by Ivanoff and DeWane[6] was to determine whether on the basis of certain available criteria, it was possible to discriminate between students who successfully completed ninth-grade algebra and those who completed the general mathematics program. This study differed from previous investigations of the problem not only with regard to the variable under scrutiny but also with the design. The subjects were taken from a large midwestern suburban non tax supported high school open to male students. The group was divided into 286 algebra students and 162 general mathematics students. The variables selected were: I. Q. rating, reading, arithmetic, language, and composite scores from the High School Placement Test (HSPT) and eighth grade mathematics marks. Grades were based on A-5, B-4, C-3, D-2, F-1. The hypothesis tested was that there is no significant relationship between the two groups and the prediction variables adopted.

The design of the experiment was set up as a regression scheme using a dichotomous variable rather than the usual numerical variable. Thus because the usual regression procedure was not appropriate an adaptation of the Fisher[7] discriminant analysis was made. Data was

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[6]John M. Ivanoff and Evermode T. DeWane OPraem. "Use of Discriminant Analysis for Selecting Students for Ninth-grade Algebra or General Mathematics." The Mathematics Teacher, (May, 1965), pp. 412-416.

[7]Ibid., p. 413, R. A. Fisher, "The Use of Multiple Measurement in Taxonomic Problems," Annals of Eugenics, VII (1936), pp. 179-188.

processed by an IBM 1620 digital computer using a two group multiple variable stepwise discriminant analysis.

The result of the experiment indicated that there was a significant difference between the two groups and that prediction could be made as to the success of students in the two groups. The prediction equation was $Z_{AM} + -.01255X_2 - .02333X_3 - .00250X_5 - .09246X_6 + 1.75442$ where Z_{AM} = The algebra general mathematics prediction score

X_2 = (HSPT) Reading

X_3 = (HSPT) Arithmetic

X_5 = (HSPT) Composite

X_6 = 8th grade class work

In prediction, if the Z score was negative it predicted achievement in Algebra whereas a positive score predicted achievement in General Mathematics. It was further pointed out the students found to be on the border line could be counselled in such a way that they would understand and be encouraged to "beat the odds" through diligent study and work habits.

In the present study, however, The American College Test (ACT) test scores were chosen as part of the criteria of prediction; thus it was necessary to understand the relation of the ACT program and limitations. The official booklet "Using ACT on the Campus" was the best source of information on using ACT scores as predictors. The booklet itself states, "Although the ACT battery is not designed to perform an advanced placement function, the tests can contribute to an effective program in this area."[8] The booklet also gives support for the use of high school grades in combination with ACT in prediction of success. "Perhaps the most reliable research finding in education is that high school grades are predictive of college grades; further that academic aptitude tests and high school grades combined are a better prediction of college grades than either alone."[9] The reliability and usefulness of the ACT scores in selecting beginning college mathematics students is thoroughly discussed in <u>The Sixth Mental Measurements Yearbook</u>. Englebert states in reference to the mathematics test, "This test should be very useful in screening beginning college mathematics classes and in placement or counseling of students."[10] But he also states that "The test is not designed for differential prediction or advanced placement."[11] Later he again emphasizes caution in using ACT test scores for prediction of academic achievement when he himself quotes the ACT booklet, <u>Using the ACT on Your Campus</u>, "Those responsible for the ACT program wisely emphasize this in the section on student counseling in <u>Using the ACT Scores on Your Campus</u>. 'The question of the relative suitability of a student for various curriculums or majors

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[8] <u>Using ACT on the Campus</u>, (The American College Testing Program, Inc., 1965), p. 36.

[9] <u>Ibid</u>., p. 5.

[10] Oscar Krisen Buros, (Ed.), <u>The Sixth Mental Measurements Yearbook</u>, (New Jersey, The Gryphon Press, 1965), p. 5.

[11] <u>Ibid</u>., p. 6.

is an extremely complex one, and involves considerations beyond ACT information such as the students' goals, interests, values, personalities, characteristics, occupational opportunities: The College's education and training requirements and philosophies.'"[12]

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[12] Ibid., p. 6.

CHAPTER III

DESIGN OF THE EXPERIMENT

The primary purpose of the experiment was to find a means of predicting success of entering college freshmen taking analytic geometry and calculus at Austin Peay State College. The subjects therefore were seventy-six freshmen students who had never taken a college mathematics course prior to taking analytic geometry and calculus. The selection was taken from classes conducted over a two year period from 1964 through 1965. The criterion or dependent variable used in the study was defined in terms of the final grade in the course Mathematics 201, Analytic Geometry and Calculus. The degree of success of each student was recorded on a four point system (A = 4). Other means of measuring degree of success such as an achievement test administered at the end of the course could have been used; but since the final grades were the measure of success in the eyes of the College and the experiment was designed to be used as a measure of success at Austin Peay State College it was decided to use the final grades as the criterion measure.

The design of the experiment required that the data used in the procedure be readily available, thus it was decided to use only those sources of data available in the student's personnel record file at Austin Peay State College. The personnel record file contained the student's application, the high school transcript, and his ACT test scores. Because of the lack of uniformity in high school transcripts, it was necessary to eliminate some variables from the experiment. Prediction variables chosen were:

X_1 = high school mathematics gradepoint average based on a 4 point system. Only students taking four years of mathematics in high school were selected for the experiment.

X_2 = high school general gradepoint average based on a 4 point system.

X_3 = high school class standing based on percentile rank.

X_4 = ACT English score.

X_5 = ACT mathematics score.

X_6 = ACT social studies score.

X_7 = ACT science score.

X_8 = ACT composite score.

It would have been desirable to use variables which measured emotional adjustment and interests but the personnel record files did not contain such information. The prediction results were therefore based entirely on measures of achievement.

The basic design of the experiment included a two phase study. The first phase was the study of predictability of the calculus grades by use of each individual predictor variable. The second phase combined the independent variables by means of a multiple regression procedure. Since most of the information obtained in the first phase was needed in the second phase, the procedure was so set up to give intercorrelations of all the variables at once. The data was accumulated and then processed by an IBM 1620 digital computer using a program written by Dykstra.[1] The use of this program proved to be a significant aid in the choice of the best possible predictors. The author so devised the procedure as to eliminate the predictors according to the amount of weight each carried in relation to the other predictors. Thus a stepwise elimination procedure eliminated the need of computing the entire two hundred and fifty-six possible combinations in the regression analysis.

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[1] Otto Dykstra, Jr., "Multiple Regression Procedure," IBM 1620 General Program Library, No. 06.043, 1963.

CHAPTER IV

ANALYSIS OF DATA

The data was submitted to the computer which converted it to the format needed in the 1620 digital computer program .06.043.[1] (Table I). Computations were then performed which gave arithmetic averages, the variances, and correlations of the independent variables with the dependent variable. (Table II). Table III indicates the intercorrelations among all the variables. Note that all correlations between the dependent variable and each independent variable were significant at the five per cent level of confidence except the ACT natural science variable. Upon analysis of the correlation of each independent variable with the calculus grade, it is noted in Table II that the variable with highest correlation value was the high school mathematics grade point average, and the class percentile rank in high school was second. The correlation between the ACT mathematics score and the calculus grade proved to be a strong third, and its correlation with the ACT composite score ranked fourth. While the intercorrelation of the high school general grade point average with the high school mathematics grade point average was the highest of all correlations, the high school general grade point average ranked only fifth in correlation with the dependent variable. Natural science, English, and social studies proved to

[1]Otto Dykstra, Jr., "Multiple Regression Procedure," IBM 1620 General Program Library, No. 06.043, 1963.

correlate to a lesser degree with class grades in college calculus. A very surprising factor in the results of the experiment was that the correlation ratio of 0.374 of the English ACT score and the dependent variable proved to be barely significant at the one per cent level of confidence.

In order to find the best possible combination of all the variables the equations were computed in a stepwise manner. The computer selected the best possible combination of all eight independent variables and then eliminated, one at a time, the variables which added the least amount to the overall regression equation. It can be noted here that the general high school grade point average variable was eliminated from the regression equation because of the high degree of intercorrelation it had with the high school mathematics grade point average, and therefore did not add significantly to the overall regression equation.[2] Table IV shows the best combinations of predictors, their multiple correlation, the multiple correlation F scores, the degrees of freedom of the numerator, (DF1), the degrees of freedom of the denominator and the standard error of estimate. Correlation did increase with the use of multiple regression analysis. The best single predictor showed a correlation of .618, and the addition of just one variable increased the correlation value by .081 to a value of .699. The highest multiple correlation resulted from

[2]George W. Snedecor, Statistical Methods, (Ames: The Iowa State University Press, 1956), p. 438.

the use of all eight variables (.745). At this point it must be noted that the addition of independent variables does decrease the reliability of the correlation factor.[3] Since the design of the experiment called for the best combination of variables with a workable method of predicting the success of students in Analytic Geometry and Calculus, it was decided that the use of the linear regression equation employing high school mathematics grade point average and ACT composite score would be the most feasible method of prediction. The regression equation for the best combination of the two variables is:

$$Y = -4.735817 + .918036\ X_1 + .156528\ X_8$$

The standard error of estimate using this regression equation was .952.

Upon analysis of the raw data one finds that if a student had a minimum mathematics grade point average in high school of 2.5 based on a 4 point system, and a minimum composite ACT score of 20, he would in forty-two cases out of the forty-eight make a C or better in Mathematics, Analytic Geometry and Calculus. An interesting aspect was that only one case in the entire population of fifty-six cases did better than one would expect using such a cut off point in analysis.

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[3] Ibid.

CHAPTER V

SUMMARY AND CONCLUSIONS

The basic purpose of the study was to select a means of placing entering college freshman students in the course Mathematics 201, Analytic Geometry and Calculus. Selection of predictor variables was entirely from the student's personnel record file at Austin Peay State College. This procedure was adopted since a readily available and simple means of prediction was desired. Selection of the sample for analysis was taken from the personnel record file of all entering freshmen at Austin Peay State College who had taken Mathematics 201, Analytic Geometry and Calculus as their first college mathematics course. Data was taken from the student records during the period 1964 through 1965. The eight independent variables selected as test criteria were all submitted to a multiple linear regression procedure to find the best possible combination of predictors of success in Mathematics 201, Analytic Geometry and Calculus. Data was collected and analyzed by a 1620 digital computer. It was found that the best possible single predictor was the high school mathematics grade point average. The use of multiple regression procedures did increase the correlation significantly. The final choice of predictors was the use of the high school mathematics grade point average and the ACT composite score in a linear regression equation.

Upon analysis of the data it was discovered that a minimum high school mathematics grade point average of 2.5 on a 4 point system combined with a minimum of 20 on the ACT composite score proved to be a very reliable predictor of a grade of C or better in the course Analytic Geometry and Calculus. The correlations of the various predictors combined with the dependent variable did not prove to be of an extremely high value, but they did compare favorably with the results of other work in this area of study.

This study raises some belief that some method of correlation of study habits in combination with achievement type predictors would increase the value of the results substantially. It is also realized that the first grade in college mathematics is not necessarily a predictor of overall ability and success in mathematics.

Since an important purpose of Austin Peay State College is the preparation of future teachers of elementary and high schools, one must realize that a high school teacher of mathematics will be primarily interested in algebra and geometry. Therefore a question can be raised as to the feasibility of dropping algebra entirely in order to take calculus in the first year. Thus it is recommended that further study be made comparing graduates who began their mathematics with freshman algebra with those who began with freshman calculus.

This study shows that the proper placement of students in mathematics courses can be aided by using achievement type predictor variables, and with proper guidance and motivation students can perform adequately in calculus in their first year of college.

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TABLE 1

DATA CONVERSION FOR MULTIPLE REGRESSION PROCEDURE

MATH GPA	GEN GPA	CLASS RANK	ACT ENG	ACT MATH	ACT SOC	ACT N.S.	ACT COMP	CAL GRADE
3.00	3.22	92.68	20	24	21	22	22	1.00
2.50	3.00	38.46	10	20	15	20	16	0.00
2.75	2.59	45.70	24	28	25	27	26	0.00
3.75	3.00	84.42	25	27	25	23	25	2.00
1.75	2.31	39.05	19	25	22	26	23	0.00
4.00	3.86	97.74	23	26	28	20	24	2.00
3.75	3.00	77.16	22	26	26	31	26	2.00
3.75	3.50	85.06	19	25	29	25	22	2.00
3.50	3.95	96.95	29	28	29	27	28	3.00
1.75	1.95	31.46	17	21	18	26	21	1.00
2.50	2.42	49.63	19	24	22	31	24	0.00
4.00	3.68	98.00	26	28	23	29	27	4.00
4.00	4.00	98.87	29	29	26	30	29	4.00
2.75	3.00	60.00	20	27	25	31	26	2.00
4.00	4.00	99.99	28	35	31	29	31	4.00
3.75	3.87	95.18	21	29	23	23	24	3.00
2.25	3.00	82.12	21	30	33	27	28	2.00
3.75	3.62	95.54	23	26	22	26	24	2.00
2.75	2.24	50.34	09	21	12	14	14	2.00
3.75	3.63	89.66	19	21	24	28	23	0.00
3.50	3.31	89.00	25	25	29	25	26	2.00
3.25	3.09	83.33	24	31	23	24	26	3.00
3.25	3.21	89.19	12	28	25	28	23	1.00
3.75	3.82	99.24	26	26	25	30	27	4.00
3.50	3.05	89.16	25	31	29	27	28	2.00
3.00	2.80	71.57	17	24	16	22	20	1.00
4.00	3.25	97.56	26	27	22	24	25	2.00
3.25	2.78	74.97	23	35	25	26	27	2.00
4.00	3.89	82.96	22	25	20	27	24	3.00
3.75	3.35	87.06	24	33	28	28	28	3.00
1.75	2.00	50.83	17	15	18	20	18	0.00
4.00	3.74	94.07	21	23	27	23	24	2.00
4.00	3.43	92.55	18	32	29	29	27	3.00
3.25	3.19	86.00	22	25	27	30	26	3.00
3.50	2.84	56.83	18	27	26	28	25	3.00
3.00	3.24	90.10	21	28	20	25	24	2.00
3.75	3.22	90.97	17	32	25	28	26	3.00
3.25	3.35	93.68	24	26	17	26	23	1.00
4.00	3.39	93.00	20	28	28	23	25	4.00
3.25	2.89	62.98	16	24	23	19	21	2.00
4.00	3.89	91.93	23	26	25	20	24	3.00
3.25	3.21	88.49	21	29	21	28	25	4.00
4.00	3.75	94.67	21	27	28	28	26	2.00
3.75	3.00	90.85	23	32	25	23	26	4.00
2.50	2.94	80.71	20	19	20	26	21	2.00
3.50	2.84	68.85	10	33	29	26	25	3.00
3.50	3.11	85.00	17	27	21	28	23	0.00
3.50	2.53	63.92	19	24	18	23	21	0.00
2.75	2.72	64.47	24	26	28	27	26	2.00
3.75	3.46	95.24	21	30	26	26	26	4.00
3.75	3.63	91.37	24	31	30	29	29	4.00
3.00	3.53	70.56	23	31	23	21	25	1.00
4.00	3.66	97.97	24	34	25	26	27	4.00
4.00	4.00	98.65	24	34	31	31	30	4.00
3.50	3.25	86.58	18	29	26	32	26	2.00
4.00	3.44	95.69	15	29	25	28	24	4.00

TABLE II

TABLE OF AVERAGES VARIANCES AND CORRELATION WITH Y

	Average	Variance	Correlation with Y
X_1	3.388393	.381635	.618056
X_2	3.225714	.257178	.575028
X_3	81.214464	324.889450	.615712
X_4	20.857143	19.215582	.373960
X_5	27.250000	16.918182	.590930
X_6	24.321429	18.731164	.481490
X_7	25.875000	13.093182	.256101
X_8	24.642857	9.833764	.588329
Y	2.232143	1.708766	

Note: r at 1 per cent level of confidence is .342
r at 5 per cent level of confidence is .264

TABLE III

INTERCORRELATION OF ALL VARIABLES

		X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
H.S. math GPA	X_1	.790635	.797740	.366636	.497749	.445483	.194955	.490555	.618056
H.S. gen GPA	X_2		.836521	.506238	.415169	.473239	.242753	.539345	.575028
H.S. % rank	X_3			.513625	.471478	.470576	.249519	.561216	.615712
ACT English	X_4				.358991	.427975	.315225	.715752	.373960
ACT math	X_5					.600048	.390615	.780927	.590930
ACT social S.	X_6						.484426	.812408	.481490
ACT natural S.	X_7							.681796	.256101
ACT composite	X_8								.588329

Note: r at 1 per cent level of confidence is .342

r at 5 per cent level of confidence is .264

TABLE IV

BEST PREDICTOR COMBINATIONS

Variable	Multiple Correlation	Multiple F	Degrees of Freedom DF1	DF2	Standard Error of Estimate
X_1	.618	33.377739	1	54	1.037
$X_1\ X_8$	.699	25.365517	2	53	.952
$X_1\ X_7\ X_8$	.709	17.547875	3	52	.946
$X_1\ X_4\ X_7\ X_8$	.720	13.741056	4	51	.940
$X_1\ X_3\ X_4\ X_7\ X_8$	.731	11.488321	5	50	.925
$X_1\ X_3\ X_4\ X_6\ X_7\ X_8$	.742	9.989625	6	49	.929
$X_1\ X_3\ X_4\ X_5\ X_6\ X_7\ X_8$	.744	8.522220	7	48	.934
$X_1\ X_2\ X_3\ X_4\ X_5\ X_6\ X_7\ X_8$	.745	7.329985	8	47	.942

Note: F values are significant at the 5 per cent level of confidence on all combinations
r at 1 per cent level of confidence is .342
r at 5 per cent level of confidence is .264

TABLE V

LINEAR REGRESSION EQUATIONS USING BEST PREDICTOR COMBINATIONS

$$Y = -2.199235 + 1.307811\,X_1$$

$$Y = -4.735817 + .918036\,X_1 + .156528\,X_8$$

$$Y = -4.282212 + .853571\,X_1 - .059908\,X_7 + .209888\,X_8$$

$$Y = -4.332532 + .837114\,X_1 - .056807\,X_4 - .082859\,X_7 + .286371\,X_8$$

$$Y = -4.083929 + .506621\,X_1 + .016584\,X_3 - .070877\,X_4 - .082521\,X_7 + .278626\,X_8$$

$$Y = -4.295557 + .502476\,X_1 + .017400\,X_3 - .101277\,X_4 - .074160\,X_6 - .105099\,X_7 + .407724\,X_8$$

$$Y = -4.242815 + .537461\,X_1 + .017571\,X_3 - .145713\,X_4 - .058615\,X_5 - .107400\,X_6 - .143528\,X_7 + .575790\,X_8$$

$$Y = -4.380966 + .488136\,X_1 + .162696\,X_2 + .015348\,X_3 - .147327\,X_4 - .056177\,X_5 - .108445\,X_6 - .143211\,X_7$$
$$+ .573578\,X_8$$