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A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

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Norman, Oklahoma

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PREDICTION OF SUCCESS AS A MATHEMATICS

MAJOR AT THE MINNESOTA STATE COLLEGES

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Statement of the problem. In 1954, Minnesota had 150,000 youths from age 18 to 21; today there are 232,000 and by 1975 an estimated 316,000 will be in this age group. In 1954, approximately one in four high school graduates went on to college; by 1975 the prediction is that nearly one in two will undertake advanced study in some form.

During the fall of 1966 about 24,000 young men and women enrolled in Minnesota's five State Colleges. Estimates are that by 1970 the enrollment will be 32,480 and by 1975 more than 42,000 students will enroll.

Enrollment in mathematics courses has more than kept pace with overall college growth. Mankato State College, for example, has grown in student body by a factor of four over the past ten years, but enrollment in mathematics courses has increased by a factor of five.

Students need to carefully select a college and the courses they study. With increased enrollments, along with a diversity of student interests, adequate advisement of students becomes mandatory.

This study was planned to provide information on how well the available test data and other information normally available for each student could be used to forecast success as a major in mathematics at the Minnesota State Colleges. In advising students interested in majoring in mathematics, such information should also be useful in placement of students in appropriate mathematics courses.

This study was made to find the best predictors of college success as a mathematics major in the Minnesota State Colleges. The predictor variables which were available for consideration consisted of high school and college test scores and grades. A study was made first to determine the predictive value of the high school variables using grade point averages received in Calculus I, Calculus I, II, and III, Abstract Algebra, and the courses in the college mathematics major as criterion respectively. This was followed using the high school variables, Calculus I grade point average, Calculus I, II, and III grade point averages, and Abstract Algebra grade point average as predictor variables with the college major grade point average as the criterion.[1]

Need for the study. The need for information useful for selection, placement, and retention of college students in general as well as specific fields has long been recognized. For example, R. E. Iffert found that about 43 per cent of the students who entered universities dropped out with no record of transfer to another university. He estimated that about 60 per cent of the entrants ultimately graduated either

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[1]The phrases predictor variable and criterion variable are used frequently throught this work. The predictor variables (or independent variables) are combined in this study to predict scores on another variable called the criterion.

from the university of first registration or from another institution.[2]

T. R. McConnell points out that not all who drop out along the way in American universities have unsatisfactory records or low ability. For example, in the Minnesota State Colleges, the average high school percentile rank of the men who had earned degrees or were still in school four years after admission in 1952 was only three points higher than that of the men who withdrew. (Those who had been officially dropped for low scholarship were excluded.)[3] A study, by R. F. Berdie, of the number of graduates in two undergraduate colleges of the University of Minnesota who would have been excluded had higher standards of admission been established for freshmen showed that it is possible to establish admission requirements that will exclude most poor students, but that the same requirements will also eliminate many who would be successful.[4] Lotus D. Coffman, a former president of the University of Minnesota, encouraged a widespread testing program at his university and in his state on the basis of which students could be counseled (before and after admission to the university) concerning their chances of academic success, the fields of study, and the vocations for which they were best fitted.[5]

Increased student enrollment in our colleges along with a desire

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[2]R. E. Iffert, Retention and Withdrawal of College Students, U. S. Office of Education Bulletin No. 1 (Washington: U. S. Government Printing Office, 1958), pp. 15-20.

[3]T. R. McConnell, A General Pattern for American Public Higher Education (Chicago: McGraw-Hill Book Co., 1962), p. 86.

[4]R. F. Berdie, "Some Principles and Problems of Selective College Admissions," Journal of Higher Education, XXXI (April, 1960), pp. 191-199.

[5]L. D. Coffman, The State University: Its Work and Problems (copyright 1934 by the University of Minnesota), pp. 205-206.

to properly advise students makes it important that the value of certain variables as related to success be determined by research. An entering freshman student needs advice concerning his beginning mathematics course and the possibility of majoring in mathematics. He will also need advice in later college years concerning the desirability of continuing as a mathematics major.

At Mankato State College, high school seniors accepted for fall admission are invited to the campus to pre-register during the summer. At this time, those students expressing a desire to major in mathematics are advised by a member of the mathematics department concerning the appropriate beginning mathematics course. Available to assist in advising are high school course grades in mathematics and the score received on the ACT mathematics subtest.[6] Students not planning to major in mathematics are furnished a description of possible beginning courses describing the background that is recommended for a particular beginning course. Local research has not been available to support use of particular data such as test scores and high school grades in the advising process.

The need for each college to do local research for use in advising college students is stated by S. H. Masten who wrote:

> It would seem naive at best, and unreasonable at worst, for any college to attempt to apply "outside" findings to the selection of its own students. What is needed, in the interest of both the college and the student population it serves, is local research into the question of what makes for academic success at that particular college.[7]

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[6]American College Testing program consists of subtests indicated hereafter by ACT mathematics, ACT English, ACT Natural Sciences, and ACT Composite.

[7]Sherman H. Masten, "The Value of Entrance Tests and Nine High

Frederickson has a similar comment: "My first recommendation (to colleges), therefore, is that local validity studies should be made."[8]

Lowry and Spraker, in describing the need for local research to improve the method of selecting engineering students, stated:

> While the amount of information concerning success in engineering study is extensive and of considerable value, it is important for at least two reasons that each school of engineering make a study of its own special problems dealing with the selection of its students. First, although there is considerable agreement among the findings of investigators, there are also notable disagreements. This fact indicates that the particular combination of factors most predictive of success in engineering school A is not necessarily the best combination for engineering school B. Engineering schools differ widely in their selection criteria, the quality of their programs, and the populations from which they draw their students. Second, each school must select students for admission and does so on the basis of some set of factors, whether or not these factors have been studied to determine their validity to predict success. Each school has a folder of information about each applicant. The kinds of information in these folders vary with the schools. One question, then, becomes that of how best to use the information available in a particular school.[9]

Duggan and Hazlett point out the need to modify weights assigned to predictors due to change in the quality and homogeniety of succeeding entering freshman classes.[10]

Advising the student concerning his major does not end after his

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School Variables in the Selection of Freshman at Hofstra College: A Study in Differential Prediction" (unpublished doctoral dissertation, New York University, N. Y., 1962), p. 6.

[8]Norman D. Frederickson, "Making Test Scores More Useful for Prediction," Journal of Educational and Psychological Measurement, XI, (Winter, 1951), p. 784.

[9]William C. Lowry and Harold S. Spraker, Predicting Success in the First Year of Engineering Study (Charlottesville, Virginia: Division of Educational Research, University of Virginia, 1959), p. 3.

[10]John M. Duggan and Paul H. Hazlett, Jr., Predicting College Grades, (College Entrance Examination Board, New York, 1963), p. 13.

first enrollment. Continual evaluation of student goals as related to desire and accomplishment is necessary. Students change majors throughout their undergraduate program--to mathematics as well as away from it. In the interest of the student, college, and society, the best advice possible must be continuously provided.

A longitudinal study deals with several points in time while a static design is concerned with performance at one point in time. Most studies using academic performance as a predictor are of a static rather than longitudinal design.[11] There is a need to assess the consistency of academic performance from the freshman through senior years of college. In this way variables can be found which may be useful predictors at one time but do not predict as well at a later time. There is, in other words, a real need to deal with the question of the stability of predictor variables. While there have been several studies predicting success for mathematics at a particular high school level or college freshman level and some longitudinal studies for areas other than mathematics on the college level, there have been few involving the prediction of success as a college mathematics major that extend throughout college.

Limitations of the study. There were no major limitations outside the stated definitions of the problem. Minor limitations of the study were:

1. Predictor variables were selected that are normally available for use in the advising procedure. It is recognized that other factors might have value for predicting success.

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[11] David E. Lavin, The Prediction of Academic Performance, (Russell Sage Foundation, New York, 1965), pp. 44-45.

2. The populations employed in this study were composed of individuals for whom all of the study variables were available. This was not a serious limitation since data were incomplete for no more than two students at any one of the colleges and for only six of one hundred seventy-five students in the study.

CHAPTER II

REVIEW OF RELATED LITERATURE

Considerable research has been reported that is concerned with predicting college success. The criteria, in most instances, being freshman-year grade average and lower classman grade average not focused on specific fields. The number of research studies which follow a student through college is limited. The predictors used in most instances are high school course averages and test scores.

There are several recent research studies which involve the correlation of ability tests with grade point averages. In his book, _The Prediction of Academic Performance_, Lavin reports on research findings through 1961. According to Lavin, research indicates that the correlations between ability tests and grade point averages have a mean of about .50 and a range of about .30 to .70. Some studies use one of the standard intelligence tests, others use tests intended specifically as predictors of school performance such as the Scholastic Aptitude Test developed by Educational Testing Service. A third index of ability involves course grades as predictors of future performance.[1]

Where a battery of predictors is used to predict an overall index of college performance, Lavin points out that the most recent research

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[1]Lavin, _op. cit._, pp. 50-55

shows an average correlation of .65.[2]

In surveys of over 200 studies made between 1929 and 1949, Pierson found that high school grades are usually the best indicator of college grades.[3] In arriving at his conclusion Pierson used surveys of the literature by Durflinger[4] in 1943 and Harley F. Garrett[5] in 1948.

Fishman and Pasanella, in a survey of research concerning prediction of college success, report:

> The most frequently encountered examples of criteria were freshman-year grade average, first semester grade average, and lower classman grade average not focused on specific fields. The most obvious intellective predictor is the high school record, usually expressed as total grade average or rank in class.[6]

Using freshman students in the College of Education at the University of Arkansas, Smith found the best single predictor of college grades to be high school grades. He reports a coefficient of correlation of .63 between cumulative high school grade point average and first year college grade point average.[7] Laughlin found the high school grade

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[2]Ibid., p. 52.

[3]Leroy R. Pierson, "High School Teacher Prediction of College Success," Personnel and Guidance Journal, XXXVII (October, 1958), pp. 142-145.

[4]Glenn W. Durflinger, "Prediction of College Success--A Summary of Recent Findings," American Association of Collegiate Registrars, XIX (October, 1943), pp. 68-78.

[5]Harley F. Garrett, "A Review and Interpretation of Investigations of Factors Related to Scholastic Success in College of Arts and Science and Teachers Colleges," Journal of Experimental Psychology, XVIII (December, 1948), pp. 91-138.

[6]J. A. Fishman and Ann I. Pasanella, "College Admission Selection Studies," Review of Educational Research, XXX (1960), pp. 298-310.

[7]Corbett Smith, "Achievement and Affiliation Motives as Factors in Predicting Scholastic Success in College" (unpublished doctoral dissertation, University of Arkansas, 1964).

average to be superior for prediction of the first semester college grade point average at Pennsylvania State University.[8]

The American College Testing Program is frequently used in predicting college success. The program reported a range of correlation coefficients' values from a low of .38 to a high of .78 for the relationship between grades for all colleges participating in the program and the composite score of the ACT battery.[9]

For a sample of 400 freshman students at the University of Oklahoma in 1960, John Keihlbauch found the best correlations with freshman grade point averages were .569 with the high school grade point average and .524 with the ACT Composite Scores. A low correlation of .399 was found with ACT Mathematics Scores.[10]

Dale Hassinger, in working with a sample of students at Oklahoma State University, concluded that the best predictors of success in calculus were mathematics aptitude tests and high school grades in mathematics.[11] A low correlation was found between achievement in calculus and the number of previous high school mathematics courses.[12]

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[8]James W. Laughlin, "College First Semester Academic Achievement as Related to Characteristics of a High School Graduating Class" (unpublished doctoral dissertation, Pennsylvania State University, 1961).

[9]D. P. Hoyt and E. F. Lindquist, "Summary Data for all Colleges" (Mimeographed, ACT Research Service, The American College Testing Program, Iowa City, 1962).

[10]John Keihlbauch, "Multivariate Analysis of Some Criteria of Academic Achievement and Aptitude as Predictors of College Performance" (M. S. Thesis, University of Oklahoma, 1962).

[11]Dale Eugene Hassinger, "The Relationship of Certain Measure of Scholastic Competency and Previous Scholarship Record to Achievement in Calculus in the Engineering School at Oklahoma State University, 1961).

[12]*Ibid.*

Joyce Shana'a used subsets of the freshman class of 1962 at the University of Oklahoma in an analysis to arrive at recommendations for placement in college mathematics.[13] Attention was focused mainly on the mathematics and composite scores of the American College Testing Program, the high school mathematics grade point average, and the number of semesters of high school mathematics as independent variables for the generated functions. The discriminant functions did not prove significantly better as placement guidelines than the scores on the mathematics subtest of the American College Testing Program. The data analyzed, however, did point out several pertinent facts which should influence the placement policy in mathematics at the University of Oklahoma.[14] Recommendations included: (1) Use of developed discriminant functions based on the ACT mathematics subtest, the ACT composite score, the high school mathematics grade point average, and the number of semesters of high school mathematics as a placement guideline in mathematics for some future freshman class at the University of Oklahoma. (2) Using test scores from the mathematics department Qualifying Examination as a predictive variable to discriminate more accurately correct placement in Mathematical Analysis I, an integrated course in college algebra and analytic trigonometry with introduction to analytic geometry, and Mathematical Analysis II, an integrated calculus and analytical geometry course. (3) Strongly advising students receiving D grades in any elementary mathematics course not to continue in the next level of course

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[13] Joyce Shana'a, "A Statistical Analysis of the Placement Program in Mathematics for Freshmen at the University of Oklahoma" (unpublished doctoral dissertation, University of Oklahoma, 1966).

[14] Ibid., pp. 84-89.

work in mathematics unless they first repeat and improve their work at the original course level.[15]

In a study of the factors associated with achievement in first-year college mathematics, Marshall Wick considered three questions: (1) Are the new experimental programs in secondary school mathematics effective in preparing students for first-year college mathematics? (2) What are the factors, from among the information normally available, which are most significanly associated with success in first-year college mathematics? (3) How effectively can success in first-year college mathematics be predicted with the information normally available?[16] These questions were investigated in terms of the achievements of 1692 students who were 1962 spring high school graduates enrolled in the first semester mathematics courses at six Minnesota and Wisconsin colleges and universities. The predictor variables included a measure of high school mathematics achievement, high school rank, mathematics placement test scores, and scores on mathematical and general scholastic aptitude tests. It was found that: (1) for the participants in this investigation there appears to be no significant difference in the quality of preparation for first-year college mathematics as between the experimental (SMSG) and the traditional programs in high school mathematics. (2) The high school record was consistently the source of the best predictors of success in first-year college mathematics. The average mathematics grade between grades ten and twelve gave the highest correlations with success in college algebra courses, whereas the average

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[15] *Ibid.*, pp. 84-89.

[16] Marshall Wick, "A Study of the Factors Associated with Achievement in First-Year College Mathematics" (unpublished doctoral dissertation, University of Minnesota, 1963).

in grade twelve appeared to be slightly more indicative of success in beginning calculus. All correlations between the factors analyzed and college mathematics grades are best described as being low.[17]

Ralph Scott attempted to determine the relationship between achievement in high school science and mathematics and achievement in college science and mathematics.[18] Successful high school achievement was measured by the number of units completed and the grades received, while college achievement was measured by grades received. The high school courses used in this study were general science, biology, chemistry, physics, general mathematics, Algebra I, Algebra II, geometry, and advanced mathematics. The college areas of study used were biology, chemistry, physics, geology, and mathematics. One thousand ninety-five graduates of the College of Arts and Science at the University of Arkansas from 1960 to 1964 were used in the sample. It was found that the number of units of mathematics taken in high school has little or no predictive value for determining future achievement in college mathematics. The grades received in high school general mathematics, Algebra I, Algebra II, geometry, and advanced mathematics are good predictors of success in college mathematics. The average grade received in all mathematics taken in high school is a good predictor of success in college mathematics. In general, students who have made an "A" average in all high school mathematics tend to make an "A" or a "B" average in college mathematics, while those making a "B" or "C" average in high

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[17] Ibid.

[18] Ralph L. Scott, "The Relationship between Achievement in High School and Success in College with Reference to Science and Mathematics," (unpublished doctoral dissertation, University of Arkansas, 1966).

school mathematics tend to make a "C" average in college mathematics.[19]

A survey of the literature indicates continued use of high school achievement as a predictor of success in college. The number of studies using high school scores to make predictions in specific subject areas is comparatively limited. The need for additional research on the prediction of success as a college mathematics major is indicated by the limited amount of information on the topic available in the literature.

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[19] *Ibid.*

CHAPTER III

DEVELOPMENT OF THE STUDY

The purpose of this study was to determine how well the information normally available for each student could be used to forecast success as a major in mathematics as the Minnesota State Colleges. Multiple regression equations, as related to prior predictor variables, were calculated for several points in the four college years of a mathematics major. These equations were calculated for each college and for the five Minnesota State Colleges combined.

Factors studied. This investigation was designed to find the predictive value of those variables which are normally available for use in forecasting success as a mathematics major in the Minnesota State Colleges. The independent variables are rank in high school graduating class, number of semesters of high school mathematics, high school grade point average in mathematics, overall high school grade point average, ACT standard score in mathematics, ACT standard score in English, ACT standard score in natural science, and the ACT composite score.

Selection of the sample. One hundred sixty-nine (of one hundred seventy-five) students who graduated with a major in mathematics from the Minnesota State Colleges during the academic year 1966-67 were used as the sample. Complete data were not available for six graduating mathematics majors; consequently, they were not included in the study.

The dependent variables used successively were the grade received in Calculus I, grade point average in Calculus I, II, and III, grade received in Abstract Algebra, and the over-all grade point average received in the college mathematics major.

An analysis was also made using for independent variables the high school battery of scores mentioned above, number of quarter hours of pre-calculus mathematics, grade point average in college pre-calculus mathematics and Calculus I, grade point average in Calculus I, grade point average in Calculus II, grade point average in Calculus III, grade point average in Calculus I, II, and III, and the grade point average in Abstract Algebra. For this analysis, the dependent variable was the grade point average received in the college mathematics major.

Dependent and independent variables. In this study, the predicted value of a grade in Calculus I depends upon the values of the high school variables mentioned above. We shall refer to the Calculus I grade as the dependent variable and the High school variables as independent variables. Similarly, the variables Calculus I, II, and III grade point average, Abstract Algebra grade point average, and the over-all college major grade point average, respectively, will be used as dependent variables with the high school variables as independent variables.

Collection of the data. After the variables were determined, each of the colleges was visited in order to obtain the data. Most of the data were in the students cumulative folder in the College Registrar's office of the particular college. Some data were located in the College Personnel office, and for some it was necessary to write the high school of the student concerned in order to obtain his high school record. The number of graduating mathematics majors from each college for which complete data were available and which were included in the study are: Moorhead State College--25, Winona State College--22, St. Cloud State College--39, Bemidji State College--26, and Mankato State College--57; a total sample of 169 students.

For each of the 169 cases included in the study, 20 discrete factors were obtained; Table I describes those 20 factors. There are 4 items which were included primarily for purposes of identification.

An account of the procedure for computing high school and college grade point averages is given below.

1. High school grade point average (high school GPA). Grades in physical education, band, and chorus were not used in computing the high school grade point average. All grade point averages were recorded for this study based on 4 grade points for "A," 3 points for "B," 2 points for "C," 1 point for "D," and no grade points for an "F" grade. Some schools reported grades using the percent system. Where this was the case, the transcript provided an interval scale relating the percent to the grade of A, B, C, D, and F; the grade was then converted to the 4-point system described above.

2. College grade point average for college courses (college GPA). All of the colleges involved in the study are organized on the quarter system and all assign grades of A, B, C, D, or F. To compute averages an "A" is weighted as 4 points, a "B" as 3, a "C" as 2, and a "D" as 1; no grade points are assigned for "F" grades.

Recording of the data. The data were recorded on forms especially designed (see Appendix B) for the information needed and then punched on

TABLE I

ITEM-CODE FOR TABULATION OF SAMPLE DATA

ITEM	DESCRIPTION
	Situational
A	Student identification number
B	Number of college from which student graduated
C	Sex
D	Type of college degree (B. A. or B. S.)
	Predictor
E	Rank in high school graduating class
F	Number of semesters of high school mathematics
G	High school grade point average in mathematics
H	Over-all high school grade point average
I	ACT mathematics subtest, standard score
J	ACT English subtest, standard score
K	ACT natural science subtest, standard score
L	ACT composite, standard score
M	Number of quarter hours of college pre-calculus mathematics
N	Grade point average in college pre-calculus mathematics and Calculus I
O	Grade point average in Calculus I
P	Grade point average in Calculus II
Q	Grade point average in Calculus III
R	Grade point average in Calculus I, II, and III
S	Grade point average in Abstract Algebra or comparable course
	Criteria
O	Grade point average in Calculus I
R	Grade point average in Calculus I, II, and III
S	Grade point average in Abstract Algebra or comparable course
X	Grade point average in college mathematics major. In this study, included are the required mathematics courses, excluding college algebra and trigonometry, plus the first elective courses taken to total a minimum of 40 quarter hours (or nearest 40 quarter hours). The requirements for a major in mathematics at each of the Minnesota State Colleges are stated in Appendix A.

IBM cards for use in the computer.

Treatment of data. The sample consisted of 169 students who graduated with a major in mathematics from the Minnesota State Colleges during the academic year 1966-67 and for whom complete data were available for the study.

1. Complete data were available for each of the following 20 items: student identification number, college from which student graduated, sex, type of college degree (B. A. or B. S.), rank in high school graduating class, number of semesters of high school mathematics, high school grade point average in mathematics, high school grade point average, ACT mathematics subtest score, ACT English subtest score, ACT natural science subtest score, ACT composite score, number of quarter hours of college pre-calculus mathematics, grade point average in college pre-calculus mathematics and Calculus I, grade point average in Calculus I, grade point average in Calculus II, grade point average in Calculus III, grade point average in Calculus I, II, and III, grade point average in Abstract Algebra or comparable course, and grade point average in the college mathematics major. The first four items were not used in the analysis of the data.

2. In order to determine how well the information normally available for each student could be used to forecast success as a major in mathematics at the Minnesota State Colleges, the following factors were studied:

a. the mean score for each of the 16 items mentioned in (1) above for each college and for the colleges combined.

b. the standard deviation score for each of the 16 items for each college and for the colleges combined.

c. the predictive value of the 8 variables E, F, G, H, I, J, K, and L, with the criteria being the Calculus I grade point average, Calculus I, II, and III grade point average, Abstract Algebra grade point average, and the over-all college mathematics major grade point average. This factor was considered for each State College and for the colleges combined. The 8 predictor variables were the rank in high school graduating class, number of semesters of high school mathematics, high school grade point average in mathematics, over-all high school grade point average, ACT mathematics subtest, ACT English subtest, ACT natural science subtest, and ACT composite score.

d. predictive value of 15 variables consisting of the 8 variables listed in (c) above plus the following variables: number of quarter hours of college pre-calculus mathematics, grade point average in college pre-calculus mathematics and Calculus I, grade point average in Calculus I, grade point average in Calculus II, grade point average in Calculus III, grade point average in Calculus I, II, and III, and grade point average in Abstract Algebra. The criteria in this case being the over-all college mathematics major grade point average.

e. continued value of certain high school predictor scores as related to academic performance from the freshman through senior years of college for each state college and for the colleges combined.

3. In order to make a study of the factors under consideration, the following procedure was used:

a. The IBM 1620 computer at the Computer Center of Mankato State College was used to analyze the data.

b. A program was used which would allow the computer to analyze the data relative to those factors mentioned in (2) above. A program was needed to provide product-moment correlations for 9 variables and 16 variables. The program also needed to provide the necessary information to write prediction equations using the best single variable, the best 2 predictor variables, the best 3 predictor variables, and so on up to the number of predictor variables available. The program selected for use with the computer in analyzing the data was the multiple regression package MRP31.[1]

4. The computer program was set up to provide the following information for each college and for the colleges combined:

a. A mean and the variance for each variable. The mean $\bar{x}$ and the standard deviation s of a variable x in a set of size n were determined by the equations:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad s = \sqrt{\frac{n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2}{n(n-1)}}$$

b. A simple correlation for each variable with every other variable using sets of 9 variables as follows: {E, F, G, H, I, J, K, L, O}, {E, F, G, H, I, J, K, L, R}, {E, F, G, H, I, J, K, L, S}, and {E, F, G, H, I, J, K, L, X}. The coefficient of correlation between two variables x_i and y_i in a set of size n is:

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[1]"Multiple Regression Package MRP31," (General Foods Research Center, Tarrytown, New York). This package is a multi-processor which will perform a multiple-regression analysis for at most 31 variables without the need for intermediate input and/or output. The inputs are (1) the data deck, which consists of a punched card for each student in the sample (the card contains information for each variable selected for the study); (2) header deck, which consists of a set of cards for instructing the computer relative to the computations necessary in order to obtain the desired outputs. The outputs are the definitions of the variable, their means and variances, all simple pairwise correlations, and the regression analysis itself.

$$r_{xy} = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{\left[n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2\right]\left[n\sum_{i=1}^{n} y_i^2 - (\sum_{i=1}^{n} y_i)^2\right]}}$$

c. A simple correlation for each variable with every other variable using a set of 16 variables as follows: {E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, X}.

d. The regression analysis using variables E, F, G, H, I, J, K, and L as predictor variables and variables O, R, S, and X as criteria respectively. The procedure followed by the program consisted first of computing a partial regression coefficient and a one degree of freedom F ratio for each of the 8 variables. In addition, the constant term, multiple-correlation coefficient, and standard error of estimate were computed for the set of 8 variables. This information enabled the investigator to write a regression equation of the form:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8$$

where B_0 is the constant term computed in the analysis, and B_1, B_2, . . ., B_8 represent the partial regression coefficients computed in the analysis.[2] The program continued the procedure by automatically deleting that variable having the smallest F ratio. Thus, a multiple regression equation was provided using all 8 variables, 7 variables, on down to the best 2 predictor variables and the best single predictor variable. Data for developing all of the regression equations are included in Appendix C.

e. The regression analysis using variables E, F, G, H, I, J, K, L, M, N, O, P, Q, R, and S as predictor variables and variable X as the criterion. The procedure involved the use of 15 variables as independent

---

[2]Helen M. Walker and Joseph Lev, Statistical Inference (New York: Henry Holt and Company, 1953), pp.315-347.

variables with one dependent variable. As described in (d) above, a multiple regression equation was obtained using all 15 variables followed by automatically deleting the variables one at a time until the equation using the best single predictor variable was obtained. Data for development of all the regression equations is included in Appendix D.

CHAPTER IV

ANALYSIS OF THE DATA

Data for this study were obtained from the records of students graduated with a major in mathematics from the Minnesota State Colleges during the academic year 1966-67. The purpose of this study was to determine information that would be useful in forecasting success for future mathematics majors. Regression equations were developed for use with mathematics majors at each college to predict college grade point averages in Calculus I, Calculus I, II, and III, Abstract Algebra, and the mathematics major.

Twenty basic measures were included in the study of which four were used for purposes of identification. The predictor variables are labeled E, F, G, H, I, J, K, L, M, N, O, P, Q, R, and S. Variables serving as criteria are labeled O, R, S, and X. The variables are specifically described as follows:

Predictor variables:

Variable E. Percentile rank in high school graduating class.

Variable F. The number of semesters of high school mathematics.

Variable G. A high school grade point average in mathematics was computed specifically for this study. The grade point averages were weighted from 4 to 0 as follows: A = 4, B = 3, C = 2, D = 1, and F = 0.

Variable H. An over-all high school grade point average was computed using weights from 4 to 0 as for variable G.

Variable I. The standard score made on the ACT mathematics subtest.

Variable J. The standard score made on the ACT English subtest.

Variable K. The standard score made on the ACT natural science subtest.

Variable L. The standard score made on the ACT composite.

Variable M. The number of quarter hours of college pre-calculus mathematics. Courses included were college algebra, trigonometry, and introductory courses in mathematics of a general education nature.

Variable N. Grade point average in college pre-calculus mathematics and Calculus I.

Variable O. Grade point average in Calculus I.

Variable P. Grade point average in Calculus II.

Variable Q. Grade point average in Calculus III.

Variable R. Grade point average in Calculus I, II, and III.

Variable S. Grade point average in Abstract Algebra or a comparable course. Most students had taken a course in Abstract Algebra. All had taken a course that would be comparable such as a course in foundations of mathematics.

Criteria or dependent variables:

Variables O_1, O_2, O_3, O_4, O_5, O_6. The college grade point average in Calculus I earned by students graduating respectively from Moorhead State College, St. Cloud State College, Winona State College, Bemidji State College, Mankato State College, and the State Colleges combined, with a major in mathematics during the academic year 1966-67.

Variables R_1, R_2, R_3, R_4, R_5, R_6. The college grade point average in Calculus I, II, and III earned by students graduating respectively from Moorhead State College, St. Cloud State College, Winona State College, Bemidji State College, Mankato State College, and the State Colleges combined, with a major in mathematics during the academic year 1966-67.

Variables S_1, S_2, S_3, S_4, S_5, S_6. The college grade point average in Abstract Algebra or comparable course earned by students graduating respectively from Moorhead State College, St. Cloud State College, Winona State College, Bemidji State College, Mankato State College, and the State Colleges combined, with a major in mathematics during the academic year 1966-67.

Variables X_1, X_2, X_3, X_4, X_5, X_6. The college grade point average in the college mathematics major earned by students graduating respectively from Moorhead State College, St. Cloud State College, Winona State College, Bemidji State College, Mankato State College, and the State Colleges combined, during the academic year 1966-67.

The Correlation Matrices

The procedure for obtaining the correlation matrices was described in Chapter III. The mean and the standard deviation were computed by this program for each Minnesota State College and for the colleges combined. The results are shown in Tables 2 through 7. A comparison of the mean and standard deviation scores for each of the colleges and the colleges combined is shown in Table 8. All calculations in the accompanying tables were carried to 4 decimals but were rounded to 3 decimal places to conserve space. The number was rounded upward if the digit in the fourth decimal place was 5 or more. These statistics were obtained primarily for descriptions of the group and for use in determining regression equations.

TABLE 2

NUMBER OF CASES, MEAN, AND STANDARD DEVIATION FOR EACH VARIABLE
MOORHEAD STATE COLLEGE

Variable	Name of Variable	Number of Cases	Mean	Standard Deviation
E	Percentile rank in high school graduating class	25	78.724	15.987
F	Number semesters h. s. math	25	6.880	1.395
G	High school GPA (math)	25	3.300	.589
H	Over-all high school GPA	25	3.075	.500
I	ACT mathematics subtest	25	26.400	4.454
J	ACT English subtest	25	20.360	3.740
K	ACT natural science subtest	25	25.040	5.553
L	ACT composite	25	23.640	3.910
M	Number quarter hours college pre-calculus mathematics	25	8.560	3.395
N	GPA in college pre-calculus mathematics and Calculus I	25	3.244	.656
O	GPA in Calculus I	25	3.200	.800
P	GPA in Calculus II	25	3.040	.824
Q	GPA in Calculus III	25	2.960	.916
R	GPA in Calculus I, II, and III	25	3.026	.783
S	GPA in Abstract Algebra	25	3.080	.688
X_1	GPA in college mathematics courses comprising major	25	2.998	.627

TABLE 3

NUMBER OF CASES, MEAN, AND STANDARD DEVIATION FOR EACH VARIABLE
ST. CLOUD STATE COLLEGE

Variable	Name of Variable	Number of Cases	Mean	Standard Deviation
E	Percentile rank in high school graduating class	39	75.538	16.010
F	Number semesters h. s. math	39	7.538	.996
G	High school GPA (math)	39	3.153	.554
H	Over-all high school GPA	39	2.956	.492
I	ACT mathematics subtest	39	26.897	3.868
J	ACT English subtest	39	21.026	3.324
K	ACT natural science subtest	39	25.128	4.570
L	ACT composite	39	24.256	3.200
M	Number quarter hours college pre-calculus mathematics	39	5.885	3.928
N	GPA in college pre-calculus mathematics and Calculus I	39	2.758	.668
O	GPA in Calculus I	39	2.718	.783
P	GPA in Calculus II	39	2.744	.953
Q	GPA in Calculus III	39	2.769	.890
R	GPA in Calculus I, II, and III	39	2.734	.658
S	GPA in Abstract Algebra	39	2.385	.625
X_2	GPA in college mathematics courses comprising major	39	2.651	.468

TABLE 4

NUMBER OF CASES, MEAN, AND STANDARD DEVIATION FOR EACH VARIABLE
WINONA STATE COLLEGE

Variable	Name of Variable	Number of Cases	Mean	Standard Deviation
E	Percentile rank in high school graduating class	22	68.432	21.199
F	Number semesters h. s. math	22	7.636	.979
G	High school GPA (math)	22	2.832	.540
H	Over-all high school GPA	22	2.715	.560
I	ACT mathematics subtest	22	26.682	3.153
J	ACT English subtest	22	19.364	5.032
K	ACT natural science subtest	22	23.591	4.355
L	ACT composite	22	23.182	2.741
M	Number quarter hours college pre-calculus mathematics	22	6.636	2.496
N	GPA in college pre-calculus mathematics and Calculus I	22	2.573	.511
O	GPA in Calculus I	22	2.273	.538
P	GPA in Calculus II	22	2.773	.598
Q	GPA in Calculus III	22	2.410	.717
R	GPA in Calculus I, II, and III	22	2.477	.439
S	GPA in Abstract Algebra	22	2.364	.771
X_3	GPA in college mathematics courses comprising major	22	2.390	.338

TABLE 5

NUMBER OF CASES, MEAN, AND STANDARD DEVIATION FOR EACH VARIABLE
BEMIDJI STATE COLLEGE

Variable	Name of Variable	Number of Cases	Mean	Standard Deviation
E	Percentile rank in high school graduating class	26	76.031	15.115
F	Number semesters h. s. math	26	7.823	.968
G	High school GPA (math)	26	3.159	.647
H	Over-all high school GPA	26	2.983	.542
I	ACT mathematics subtest	26	26.577	3.733
J	ACT English subtest	26	19.923	4.141
K	ACT natural science subtest	26	23.154	4.007
L	ACT composite	26	22.846	3.348
M	Number quarter hours college pre-calculus mathematics	26	7.481	3.499
N	GPA in college pre-calculus mathematics and Calculus I	26	2.794	.647
O	GPA in Calculus I	26	2.654	.731
P	GPA in Calculus II	26	2.885	.698
Q	GPA in Calculus III	26	2.654	.731
R	GPA in Calculus I, II, and III	26	2.743	.573
S	GPA in Abstract Algebra	26	2.731	.857
X_4	GPA in college mathematics courses comprising major	26	2.741	.382

TABLE 6

NUMBER OF CASES, MEAN, AND STANDARD DEVIATION FOR EACH VARIABLE
MANKATO STATE COLLEGE

Variable	Name of Variable	Number of Cases	Mean	Standard Deviation
E	Percentile rank in high school graduating class	57	74.258	18.851
F	Number semesters h. s. math	57	8.281	.886
G	High school GPA (math)	57	3.071	.687
H	Over-all high school GPA	57	3.101	.592
I	ACT mathematics subtest	57	27.123	3.765
J	ACT English subtest	57	21.018	3.586
K	ACT natural science subtest	57	24.140	3.431
L	ACT composite	57	23.211	4.663
M	Number quarter hours college pre-calculus mathematics	57	7.711	4.254
N	GPA in college pre-calculus mathematics and Calculus I	57	3.111	.706
O	GPA in Calculus I	57	3.000	.749
P	GPA in Calculus II	57	3.070	.769
Q	GPA in Calculus III	57	3.175	.797
R	GPA in Calculus I, II, and III	57	3.143	.814
S	GPA in Abstract Algebra	57	2.509	.976
X_5	GPA in college mathematics courses comprising major	57	2.969	.486

TABLE 7

NUMBER OF CASES, MEAN, AND STANDARD DEVIATION FOR EACH VARIABLE
MINNESOTA STATE COLLEGES COMBINED

Variable	Name of Variable	Number of Cases	Mean	Standard Deviation
E	Percentile rank in high school graduating class	169	74.728	17.846
F	Number semesters h. s. math	169	7.748	1.105
G	High school GPA (math)	169	3.106	.633
H	Over-all high school GPA	169	2.995	.559
I	ACT mathematics subtest	169	26.822	3.831
J	ACT English subtest	169	20.669	3.645
K	ACT natural science subtest	169	24.278	4.336
L	ACT composite	169	23.580	3.487
M	Number quarter hours college pre-calculus mathematics	169	7.240	3.857
N	GPA in college pre-calculus mathematics and Calculus I	169	2.931	.697
O	GPA in Calculus I	169	2.817	.789
P	GPA in Calculus II	169	2.923	.807
Q	GPA in Calculus III	169	2.870	.860
R	GPA in Calculus I, II, and III	169	2.882	.739
S	GPA in Abstract Algebra	169	2.580	.854
X_6	GPA in college mathematics courses comprising major	169	2.789	.518

TABLE 8

COMPARISON OF MEAN AND STANDARD DEVIATION
FOR EACH VARIABLE WITH EACH COLLEGE
AND THE COLLEGES COMBINED

Variable	Moorhead $\bar{X}$	Moorhead s	St. Cloud $\bar{X}$	St. Cloud s	Winona $\bar{X}$	Winona s	Bemidji $\bar{X}$	Bemidji s	Mankato $\bar{X}$	Mankato s	Combined $\bar{X}$	Combined s
E	78.724	15.987	75.538	16.010	68.432	21.199	76.031	15.115	74.258	18.851	74.728	17.846
F	6.880	1.395	7.538	.996	7.636	.979	7.823	.968	8.281	.886	7.748	1.105
G	3.300	.589	3.153	.554	2.832	.540	3.159	.647	3.071	.687	3.106	.633
H	3.075	.500	2.956	.492	2.715	.560	2.983	.542	3.101	.592	2.995	.559
I	26.400	4.454	26.897	3.868	26.682	3.153	26.577	3.733	27.123	3.765	26.822	3.831
J	20.360	3.740	21.026	3.324	19.364	5.032	19.923	4.141	21.018	3.586	20.669	3.645
K	25.040	5.553	25.128	4.570	23.591	4.355	23.154	4.007	24.140	3.431	24.278	4.336
L	23.640	3.910	24.256	3.200	23.182	2.741	22.846	3.348	23.221	4.663	23.580	3.487
M	8.560	3.395	5.885	3.928	6.636	2.496	7.481	3.499	7.711	4.252	7.240	3.857
N	3.244	.656	2.758	.668	2.573	.511	2.794	.647	3.111	.706	2.931	.697
O	3.200	.800	2.718	.783	2.273	.538	2.654	.731	3.000	.749	2.817	.789
P	3.040	.824	2.744	.953	2.773	.598	2.885	.698	3.070	.769	2.923	.807
Q	2.960	.916	2.769	.890	2.410	.717	2.654	.731	3.175	.797	2.870	.860
R	3.026	.783	2.730	.658	2.477	.439	2.743	.573	3.143	.814	2.882	.739
S	3.080	.688	2.385	.665	2.364	.771	2.731	.857	2.509	.976	2.580	.854
X	2.998	.627	2.651	.468	2.390	.338	2.742	.382	2.969	.486	2.789	.518

The r matrix. A total of 20 basic measures was determined for each of the 169 students included in the study. Of these basic measures, 4 were simple indentifiers not further analyzed.

The investigation was designed to first find the predictive value of 8 variables normally available for beginning college students. These variables were designated by E, F, G, H, I, J, K, and L. Variables then used successively as dependent variables were designated by O, R, S, and X. The information thus obtained is an indication of how the high school battery of 8 variables contribute to a prediction of success in Calculus I, to a prediction of success in Calculus I, II, and III, to a prediction of success in Abstract Algebra, and to the over-all grade point average in the college mathematics major.

The investigation was also designed to find the predictive value of 15 variables consisting of the 8 variables E, F, G, H, I, J, K, and L which constitute the high school battery, and variables M, N, O, P, Q, R, and S. The dependent variable in this case being the over-all grade point average in college mathematics.

Table 9 gives the matrix of product-moment correlations for 9 variables for the graduates of Moorhead State College. The first row contains the correlations of each of the predictor variables with the criterion O (grade point average in Calculus I). Row two contains the correlations of each of the predictor variables with the criterion R (grade point average received in Calculus I, II, and III). Row three contains the correlations of each of the predictor variables with the criterion S (grade point average in Abstract Algebra). Row four contains the correlations of each of the predictor variables with the criterion X (grade point average in the college mathematics major). The remainder of the matrix gives the product-moment correlations among the predictor variables. Tables 10 through 14 are similarly organized for the remaining State Colleges and for the colleges combined. The correlation necessary for significance at the .05 level or .01 level is indicated on each table. Garrett's table of levels of significance was used to determine significance.[1]

Table 15 gives the matrix of product-moment correlations for 16 variables for the graduates of Moorhead State College. The first row contains the correlations of each of the predictor variables with the criterion X (grade point average in the college mathematics major). The remainder of the matrix gives the product-moment correlations among the predictor variables. In a similar way, Tables 16 through 20 present the matrix of product-moment correlations respectively for the remaining state colleges and for the colleges combined. Garrett's table of levels of significance was used to determine significance at the .05 and .01 level.[2]

Analysis of R

There were four dependent variables involved in the study. Predictive equations were computed for each variable for the five State Colleges and for the colleges combined. These were derived by use of the computer program described in Chapter III.

The coefficient of multiple correlation, standard error of estimate, constant, and partial regression coefficients were tabulated and are shown in Appendix C for the set of nine variables and in Appendix D

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[1]Henry E. Garrett, Statistics in Psychology and Education (6th ed.; New York: David McKay Company, Inc., 1966), p. 201.

[2]Ibid.

TABLE 9

PRODUCT-MOMENT CORRELATIONS FOR NINE VARIABLES FOR MOORHEAD STATE COLLEGE

	E	F	G	H	I	J	K	L
O_1	.40	.34	.61	.59	.46	.26	.61	.60
R_1	.38	.30	.50	.54	.27	.21	.47	.51
S_1	.61	.43	.49	.54	.45	.28	.68	.65
X_1	.49	.37	.56	.62	.41	.33	.54	.60
E		.17	.44	.70	.24	.33	.61	.55
F			.25	.02	.30	.03	.14	.18
G				.84	.70	.32	.61	.69
H					.52	.55	.68	.76
I						.44	.52	.73
J							.53	.71
K								.90
L								

N = 25

.39 or more significant at the .05 level

. 50 or more significant at the .01 level

TABLE 10

PRODUCT-MOMENT CORRELATIONS FOR NINE VARIABLES FOR ST. CLOUD STATE COLLEGE

	E	F	G	H	I	J	K	L
O_2	.29	-.12	.31	.27	.18	.43	.27	.34
R_2	.21	.11	.21	.18	.02	.15	-.05	-.01
S_2	.34	-.02	.38	.34	.18	.12	.42	.43
X_2	.44	.15	.29	.35	.16	.04	.12	.15
E		.09	.71	.90	.29	.20	.38	.41
F			.14	.11	.20	-.33	-.40	-.29
G				.77	.56	.39	.47	.66
H					.33	.22	.38	.51
I						.28	.37	.63
J							.54	.64
K								.84
L								

N = 39

.32 or more significant at .05 level

.41 or more significant at .01 level

TABLE 11

PRODUCT-MOMENT CORRELATIONS FOR NINE VARIABLES FOR WINONA STATE COLLEGE

	E	F	G	H	I	J	K	L
O_3	.10	-.16	.04	.26	.21	-.08	.28	.18
R_3	.27	.05	.38	.48	.19	.29	.42	.47
S_3	.23	.18	.27	.35	-.08	-.14	.02	-.12
X_3	.16	-.03	.30	.41	.25	.08	.31	.32
E		.47	.87	.90	.47	.37	.07	.28
F			.46	.25	-.04	.04	.05	.06
G				.86	.56	.41	.21	.39
H					.47	.31	.24	.34
I						.32	.14	.46
J							.34	.76
K								.77
L								

N = 22

.42 or more significant at .05 level

.54 or more significant at .01 level

TABLE 12

PRODUCT-MOMENT CORRELATIONS FOR NINE VARIABLES FOR BEMIDJI STATE COLLEGE

	E	F	G	H	I	J	K	L
O_4	.36	-.20	.60	.64	.41	-.01	.23	.23
R_4	.25	-.33	.49	.47	.15	-.03	.17	.00
S_4	.33	-.29	.30	.34	.00	-.24	.41	.04
X_4	.30	-.40	.46	.51	.27	.10	.26	.23
E		-.20	.65	.79	.36	.13	.35	.33
F			-.13	-.35	-.13	.01	-.06	-.05
G				.79	.43	.07	.31	.24
H					.54	.24	.41	.45
I						.43	.62	.76
J							.52	.76
K								.83
L								

N = 26

.39 or more significant at .05 level

.50 or more significant at .01 level

TABLE 13

PRODUCT-MOMENT CORRELATIONS FOR NINE VARIABLES FOR MANKATO STATE COLLEGE

	E	F	G	H	I	J	K	L
O_5	.33	.00	.33	.26	.11	.25	.16	.21
R_5	.14	.63	-.11	.47	-.11	.11	.07	-.15
S_5	.31	.23	.14	.34	.27	.23	.02	.08
X_5	.40	.00	.42	.34	.29	.28	.26	.27
E		-.09	.67	.63	.54	.44	.37	.52
F			-.55	.45	-.25	-.06	-.23	-.47
G				.30	.64	.42	.49	.69
H					.26	.36	.22	.19
I						.47	.43	.68
J							.36	.72
K								.67
L								

N = 57

.27 or more significant at .05 level

.34 or more significant at .01 level

TABLE 14

PRODUCT-MOMENT CORRELATIONS FOR NINE VARIABLES
FOR THE MINNESOTA STATE COLLEGES COMBINED

	E	F	G	H	I	J	K	L
O_6	.32	.00	.40	.41	.23	.21	.30	.30
R_6	.22	.42	.18	.45	.05	.13	.17	.06
S_6	.35	.14	.29	.37	.17	.07	.21	.17
X_6	.38	.03	.42	.46	.26	.18	.28	.29
E		-.04	.67	.75	.39	.31	.36	.44
F			-.33	.28	-.11	-.04	-.13	-.30
G				.60	.57	.32	.44	.58
H					.37	.33	.36	.38
I						.40	.42	.67
J							.46	.71
K								.78
L								

N = 169

.15 or more significant at .05 level

.20 or more significant at .01 level

TABLE 15

PRODUCT-MOMENT CORRELATIONS FOR SIXTEEN VARIABLES FOR MOORHEAD STATE COLLEGE

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
X_1	.49	.37	.56	.62	.41	.33	.54	.60	-.24	.91	.86	.75	.83	.88	.67
E		.17	.44	.70	.24	.33	.61	.55	-.48	.39	.40	.26	.52	.38	.61
F			.25	.02	.30	.03	.14	.18	-.07	.46	.34	.18	.22	.30	.43
G				.84	.70	.32	.61	.69	-.47	.62	.61	.46	.35	.50	.49
H					.52	.55	.68	.76	-.56	.59	.59	.46	.46	.54	.54
I						.44	.52	.73	-.31	.47	.46	.16	.16	.27	.45
J							.53	.71	-.51	.30	.26	.09	.12	.21	.28
K								.90	-.47	.52	.61	.20	.43	.47	.68
L									-.52	.58	.60	.27	.42	.51	.65
M										-.24	-.28	-.17	-.22	-.25	-.12
N											.88	.77	.75	.88	.61
O												.59	.67	.82	.62
P													.80	.87	.21
Q														.89	.39
R															.44
S															

N = 25

.39 or more significant at .05 level

.50 or more significant at .01 level

TABLE 16

PRODUCT-MOMENT CORRELATIONS FOR SIXTEEN VARIABLES FOR ST. CLOUD STATE COLLEGE

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
X_2	.44	.15	.29	.35	.16	.04	.12	.15	-.45	.49	.60	.49	.56	.75	.60
E		.09	.71	.90	.29	.20	.38	.41	-.28	.29	.29	.15	.03	.21	.34
F			.14	.11	.20	-.33	-.40	-.29	.01	-.17	-.12	.10	.26	.11	-.02
G				.77	.56	.39	.47	.66	-.29	.33	.31	.11	.10	.21	.38
H					.33	.22	.38	.51	-.32	.27	.27	.17	.03	.18	.34
I						.28	.37	.63	-.00	.03	.18	-.19	.13	.02	.18
J							.54	.64	.04	.38	.43	-.10	.09	.15	.12
K								.84	.07	.20	.27	-.11	-.21	-.05	.42
L									-.01	.26	.34	-.19	-.06	-.01	.43
M										-.21	-.06	-.22	-.34	-.30	-.36
N											.74	.09	.43	.53	.34
O												.21	.46	.73	.22
P													.29	.69	.12
Q														.77	.11
R															.17
S															

N = 39

.32 or more significant at .05 level

.41 or more significant at .01 level

TABLE 17

PRODUCT-MOMENT CORRELATIONS FOR SIXTEEN VARIABLES FOR WINONA STATE COLLEGE

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
X_3	.16	-.03	.30	.41	.25	.08	.31	.22	-.47	.32	.35	.63	.71	.84	.36
E		.47	.87	.90	.47	.37	.07	.28	-.65	.23	.10	-.13	.33	.27	.23
F			.46	.25	-.04	.04	.05	.06	-.43	.18	-.16	-.14	.08	.05	.18
G				.86	.56	.41	.21	.39	-.70	.21	.04	.06	.40	.38	.27
H					.47	.31	.24	.34	-.67	.24	.26	.06	.47	.48	.35
I						.32	.41	.46	-.31	.03	.21	.18	.02	.19	-.08
J							.34	.76	-.53	-.01	-.08	.20	.39	.29	-.14
K								.77	-.47	.03	.28	.47	.16	.42	.02
L									-.63	.00	.18	.47	.31	.47	-.12
M										-.15	-.20	-.33	-.60	-.65	-.17
N											.76	.01	.11	.42	-.36
O												.19	.06	.51	-.35
P													.32	.70	-.02
Q														.78	.22
R															.03
S															

N = 22

.42 or more significant at .05 level

.54 or more significant at .01 level

TABLE 18

PRODUCT-MOMENT CORRELATIONS FOR SIXTEEN VARIABLES FOR BEMIDJI STATE COLLEGE

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
X_4	.30	-.40	.46	.51	.27	.10	.26	.23	-.20	.60	.72	.62	.66	.84	.64
E		-.20	.65	.79	.36	.13	.35	.33	-.19	.47	.36	.25	-.03	.25	.33
F			-.13	-.35	-.13	.01	-.06	-.05	.04	-.23	-.20	-.28	-.33	-.33	-.29
G				.79	.43	.07	.31	.24	-.19	.70	.60	.47	.11	.49	.30
H					.54	.24	.41	.45	-.34	.69	.64	.37	.12	.47	.34
I						.43	.62	.76	-.34	.51	.41	.01	-.04	.15	.00
J							.52	.76	.19	.07	-.01	-.12	.00	-.03	-.24
K								.83	-.22	.17	.23	.12	.02	.17	.14
L									-.16	.23	.23	-.17	-.12	-.00	.04
M										-.27	-.29	-.10	-.05	-.18	-.39
N											.86	.42	.36	.69	.33
O												.45	.35	.74	.47
P													.60	.82	.33
Q														.83	.40
R															.51
S															

N = 26

.39 or more significant at .05 level

.50 or more significant at .01 level

TABLE 19

PRODUCT-MOMENT CORRELATIONS FOR SIXTEEN VARIABLES FOR MANKATO STATE COLLEGE

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
X_5	.40	.00	.42	.34	.29	.28	.26	.27	-.40	.54	.64	.63	.61	.61	.47
E		-.09	.67	.63	.54	.44	.37	.52	-.37	.30	.33	.20	-.00	.14	.31
F			-.55	.45	-.25	-.06	-.23	-.47	-.20	-.54	.00	-.21	.45	.63	.23
G				.30	.64	.42	.49	.69	-.28	.52	.33	.38	-.08	-.11	.14
H					.26	.36	.22	.19	-.37	-.07	.26	.12	.28	.47	.34
I						.47	.43	.68	-.23	.30	.11	.20	-.14	-.11	.27
J							.36	.72	-.36	.30	.25	.18	.05	.11	.23
K								.67	.01	.21	.16	.38	.11	.07	.02
L									-.12	.47	.21	.34	-.14	-.15	.08
M										-.14	-.39	-.08	-.20	-.32	-.34
N											.65	.41	.08	.06	.10
O												.43	.44	.60	.22
P													.47	.49	-.00
Q														.88	.07
R															.20
S															

N = 57

.27 or more significant at .05 level

.34 or more significant at .01 level

TABLE 20

PRODUCT-MOMENT CORRELATIONS FOR SIXTEEN VARIABLES FOR MINNESOTA STATE COLLEGES

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
X_6	.03	.42	.46	.26	.18	.28	.29	-.25	.63	.71	.61	.68	.76	.53
E	-.04	.67	.75	.39	.31	.36	.44	-.33	.33	.32	.16	.14	.22	.35
F		-.33	.28	-.11	-.04	-.13	-.30	-.14	-.30	-.00	-.10	.27	.42	.14
G			.60	.57	.32	.44	.58	-.29	.49	.40	.30	.12	.18	.29
H				.37	.33	.36	.38	-.35	.28	.41	.23	.29	.45	.37
I					.40	.42	.67	-.20	.26	.23	.06	.03	.05	.17
J						.46	.71	-.21	.24	.21	.05	.11	.13	.07
K							.78	-.13	.24	.30	.16	.10	.17	.21
L								-.20	.35	.30	.12	.04	.06	.17
M									-.11	-.18	-.11	-.19	-.23	-.23
N										.77	.37	.38	.45	.24
O											.40	.49	.70	.29
P												.49	.66	.12
Q													.85	.18
R														.26
S														

N = 169

.15 or more significant at .05 level

.20 or more significant at .01 level

for the set of sixteen variables.

Partial regression coefficients. The predictive equations were of the form

$$Y = B_0 + B_1X_1 + B_2X_2 + - - - + B_nX_n$$

where Y represents the criterion, B_0 represents the constant computed from the sample data, B_1 represents the partial regression coefficient of the first independent variable and X_1 represents the observed score for the variable, B_2 represents the partial regression coefficient of the second independent variable and X_2 represents its observed score, and so on through n independent variables.

The standard error of estimate. The standard error of estimate was used to provide the range within which the predicted grade would fall for a given degree of confidence. For example, if a student received a predicted grade equivalent of 2.50 in Calculus I at Moorhead State College, one could state that the odds are about two to one that such a student would get a grade-value of $2.50 \pm .628$--the predicted grade-value plus or minus the standard error of estimate .628 (see Appendix C, Table 32).

The multiple regression equations using the best three predictor variables are presented for each college and for the colleges combined in Tables 21 through 26. Equations were first derived using variables E, F, G, H, I, J, K, or L as predictor variables with variables O, R, S, and $\acute{X}$ as criteria respectively. An equation was also obtained using variables E, F, G, H, I, J, K, L, M, N, O, P, Q, R, or S as predictor variables with variable X as the criterion. Appendix C contains the necessary data for the equations involving up to all eight predictor variables, while Appendix D contains the data for writing the multiple regression equations using up to all fifteen predictor variables.

Table 21 gives the multiple regression equations for Moorhead State College using the best three predictor variables. The prediction equation for Calculus I (O) is O_1 = .591 (H) + .168 (F) + .046 (K) - .919. The terms are listed in order of their contribution to the coefficient of multiple correlation, high school grade point average (H), the number of semesters of high school mathematics (F), and ACT natural sciences subtest (K). These three in combination yielded an R of .716 as compared with .778 using all eight variables (see Appendix C, Table 32). Best of the predictors was the factor of high school grade point average (H), displaying an R of .591 with the criterion (see Appendix C, Table 32). Second in order was the variable number of semesters of high school mathematics (F) which increased the R to .679 (see Appendix C, Table 32).

In a similar way, one can interpret the regression equations for the remaining criteria R, S, and X respectively.

Tables 22 through 26 contain the multiple regression equations for St. Cloud State College, Winona State College, Bemidji State College, Mankato State College, and the colleges combined, using the best three predictor variables. Complete data for the multiple regression equation is contained in Appendix C and Appendix D.

Overview

One of the purposes of this study was to determine the continued value of certain high school predictor scores as related to academic performance from the freshman through senior years of college. Table 27 indicates the number of state colleges at which the high school predictor variables correlated significantly at the 5% level with the dependent variables Calculus I GPA (O), Calculus I, II, and III GPA (R),

TABLE 21

MOORHEAD STATE COLLEGE
MULTIPLE REGRESSION EQUATIONS

A--Using Best Three of Eight Predictor Variables
B--Using Best Three of Fifteen Predictor Variables

	Regression Equation	Multiple Correlation	Standard Error of Estimate
A			
	$C_1 = .591 (H) + .168 (F) + .046 (K) - .919$	.716	.609
	$R_1 = .955 (H) + .186 (F) - .026 (I) - .497$	.621	.670
	$S_1 = .144 (L) + .144 (F) - .057 (J) - .167$	.755	.493
	$X_1 = .602 (H) + .149 (F) + .029 (L) - .570$	.730	.468
B			
	$X_1 = .351 (F) + .310 (S) + .296 (O) + .031$	.949	.215

TABLE 22

ST. CLOUD STATE COLLEGE
MULTIPLE REGRESSION EQUATIONS

A--Using Best Three of Eight Predictor Variables
B--Using Best Three of Fifteen Predictor Variables

Regression Equation	Multiple Correlation	Standard Error of Estimate
A		
O_2 = .095 (J) + .001 (E) - .006 (K) + .069	.473	.728
R_2 = .474 (G) - .092 (L) + .055 (J) + 2.332	.360	.648
S_2 = .098 (L) - .044 (J) + .001 (E) + .409	.496	.573
X_2 = .002 (E) + .058 (F) - .239 (H) + 1.473	.468	.436
B		
X_2 = .452 (R) + .328 (S) + .001 (E) + .283	.899	.216

TABLE 23

WINONA STATE COLLEGE
MULTIPLE REGRESSION EQUATIONS

A--Using Best Three of Eight Predictor Variables
B--Using Best Three of Fifteen Predictor Variables

Regression Equations	Multiple Correlation	Standard Error of Estimate
A		
O_3 = .844 (H) - .880 (G) + .051 (I) + 1.115	.501	.515
R_3 = .838 (H) - .002 (E) + .052 (L) + .099	.674	.358
S_3 = 1.212 (H) - .080 (L) - .002 (E) + 2.120	.479	.748
X_3 = .930 (H) - .002 (E) + .069 (F) + .772	.641	.287
B		
X_3 = .234 (Q) + .270 (P) + .112 (S) + .812	.864	.188

TABLE 24

BEMIDJI STATE COLLEGE
MULTIPLE REGRESSION EQUATIONS

A--Using Best Three of Eight Predictor Variables
B--Using Best Three of Fifteen Predictor Variables

	Regression Equation	Multiple Correlation	Standard Error of Estimate
A			
	O_4 = 1.348 (H) - .002 (E) - .034 (J) + .786	.706	.563
	R_4 = .599 (H) - .112 (L) + .069 (K) + 1.911	.594	.501
	S_4 = -.123 (J) + .111 (L) + .312 (G) + 1.644	.483	.816
	X_4 = .180 (G) - .134 (G) + .154 (H) + 2.793	.582	.386
B			
	X_4 = .660 (R) + .032 (L) - .090 (N) + .636	.899	.213

TABLE 25

MANKATO STATE COLLEGE
MULTIPLE REGRESSION EQUATIONS

A--Using Best Three of Eight Predictor Variables
B--Using Best Three of Fifteen Predictor Variables

	Regression Equation	Multiple Correlation	Standard Error of Estimate
A			
	$O_5 = .684\ (G) + .030\ (F) - .042\ (I) + 1.804$	.428	.702
	$R_5 = .094\ (F) + .590\ (G) - .045\ (I) + 1.767$	.715	.590
	$S_5 = .112\ (I) - .132\ (L) + .107\ (J) + .332$	.413	.921
	$X_5 = .404\ (G) + .021\ (F) + .009\ (J) + 1.371$	.509	.434
B			
	$X_5 = .584\ (R) - .047\ (F) + .218\ (S) + .976$	.896	.223

TABLE 26

MINNESOTA STATE COLLEGES COMBINED
MULTIPLE REGRESSION EQUATIONS

A--Using Best Three of Eight Predictor Variables
B--Using Best Three of Fifteen Predictor Variables

Regression Equation	Multiple Correlation	Standard Error of Estimate
A		
O_6 = .332 (H) + .257 (G) + .024 (K) + .450	.467	.706
R_6 = .306 (H) + .069 (F) + .204 (G) + .798	.556	.621
S_6 = .001 (E) + .042 (F) + .289 (G) + .596	.407	.789
X_6 = .288 (H) + .164 (G) + .010 (K) + 1.179	.496	.461
B		
X_6 = .269 (O) + .256 (Q) + .204 (S) + .772	.865	.266

Abstract Algebra GPA (S), and the college major GPA (X).

TABLE 27

EIGHT HIGH SCHOOL INDEPENDENT VARIABLES

Dependent Variables	E	F	G	H	I	J	K	L	Sum
O	3	0	4	3	3	2	2	2	19
R	1	2	3	4	0	0	2	1	13
S	4	1	3	4	3	0	4	3	22
X	4	1	4	5	3	2	2	3	24
Sum	12	4	14	16	9	4	10	9	

Table 27 indicates that a significant correlation existed between the high school grade point average (H) and the college major grade point average (X) for all of the colleges. The table indicates that the number of semesters of high school mathematics (F) and ACT English subtest (J) correlate significantly with fewer of the variables at the five State Colleges than any other variable. As shown by the table, the high school variables E, F, G, H, I, J, K, and L do continue to correlate significantly with college dependent variables.

Table 28 indicates which of the three high school predictor variables are of most use in predicting success in Calculus I (O), Calculus I, II, and III (R), Abstract Algebra (S), and in the college major (X). The independent variables are listed in order of their contribution to the predictor equation.

TABLE 28

DEPENDENT VARIABLE

College	O	R	S	X
Moorhead	HFK	HFI	LFJ	HFL
St. Cloud	JEK	GLJ	LJE	EFH
Winona	HGI	HEL	HLE	HEF
Bemidji	HEJ	HLK	JLG	GFH
Mankato	GFI	FGI	ILJ	GFJ
Colleges Combined	HGK	HFG	EFG	HGK

The table indicates that the over-all high school grade point average (H) and the high school mathematics grade point average (G) serve as the two best predictors of success in Calculus I (O), Calculus I, II, and III (R), and college mathematics major (X). The best two predictors of success in Abstract Algebra (S) were the ACT composite score (L) and the ACT English subtest (J).

Table 29 lists, by college, the three high school predictor variables contributing the most to success in Calculus I (O), Calculus I, II, and III (R), Abstract Algebra (S), and the college major GPA (X).

Table 29 indicates that the over-all high school grade point average (H) plays a strong role as a predictor for college success at Moorhead and Winona, a lesser role at Bemidji, and a comparatively minor role at St. Cloud and Mankato. This type of information supports the theory that it is not desirable for any college to apply "outside" findings to the advising of its own students. Geographic location, selection procedure, type of programs, and the populations from which they draw their students contribute to the need for local research into the question of what makes for academic success at that particular college.

TABLE 29

STATE COLLEGE

Variable	Moorhead	St. Cloud	Winona	Bemidji	Mankato	Combined Colleges
O	HFK	JEK	HGI	HEJ	GFI	HGK
R	HFI	GLJ	HEL	HLK	FGI	HFG
S	LFJ	LJE	HLE	JLG	ILG	EFG
X	HFL	EFH	HEF	GFH	GFJ	HGK

Using the fifteen variables as independent variables and the college mathematics major GPA (X) as the dependent variable, Table 30 indicates the number of state colleges at which the independent variables correlated significantly at the 5% level with the dependent variable.

TABLE 30

FIFTEEN INDEPENDENT VARIABLES

Dependent Variable	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
X	3	1	3	4	1	1	1	2	3*	4	4	5	5	5	4

*There was a negative correlation between the number of quarter hours of college pre-calculus mathematics (M) and the over-all college major grade point average (X) at all of the state colleges (significantly at the 5% level at three of the state colleges). One would expect that the better students would be able to by-pass more course work at the pre-calculus level. Hopefully, the advising of freshmen mathematics students would be such that the calculus-capable students would take calculus as their beginning college course and continue to do satisfactory work in later mathematics courses. On the other hand, less capable students would be advised to take pre-calculus mathematics in preparation for calculus. Apparently, when this is done, the less able student successfully completes the mathematics major but does not reach the level of the person who did not need pre-calculus mathematics. A useful study related to a placement program in freshmen mathematics was recently conducted by Joyce Shana'a at the University of Oklahoma.[3]

Table 30 indicates that the variables Calculus II GPA (P), Calculus III GPA (Q) and Calculus I, II, and III GPA (R) correlated significantly at the 5% level with the college major GPA (X) at all of the state colleges. This information is not surprising since these courses constitute a good percentage of the major.

Using fifteen variables as independent variables and the college major GPA (X) as the dependent variable, Table 31 indicates those three variables most prominent in predicting success as a mathematics major at each of the state colleges and for the state colleges combined.

TABLE 31

STATE COLLEGE

Variable	Moorhead	St. Cloud	Winona	Bemidji	Mankato	Combined Colleges
X	PSO	RSE	QPS	RLN	RFS	OQS

The best single variable is the Calculus I, II, and III GPA (R), while the Abstract Algebra GPA (S) appears the most often as a predictor

[3]Shana'a, *op cit.*

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Purpose of the study. The purpose of this study was:

1. To determine the predictive value of a battery of tests, number of semesters of high school mathematics, high school achievement, number of semesters of pre-calculus mathematics, and college achievement for college success as a mathematics major as measured by the grade point average of the students used in the study. These predictor variables included:

Variable (High School)	Code
Rank in high school graduating class	E
Number semesters of high school mathematics	F
High school mathematics grade point average	G
Over-all high school grade point average	H
ACT mathematics subtest	I
ACT English subtest	J
ACT natural science subtest	K
ACT composite score	L
Variable (College)	
Number quarter hours of college pre-calculus mathematics	M
Grade point average in college pre-calculus and Calculus I	N

Calculus I grade point average	O
Calculus II grade point average	P
Calculus III grade point average	Q
Calculus I, II, and III grade point average	R
Abstract Algebra grade point average	S

2. To choose from among the set of high school variables a subset for each criterion which yielded a good prediction of college academic success. Criteria selected included Calculus I GPA (O), Calculus I, II, and III GPA (R), Abstract Algebra GPA (S), and the college mathematics GPA (X).

3. To choose from among the set of high school and college variables a subset which yields a good prediction of college academic success, as a mathematics major which would be determined by using the college major GPA (X) as the criterion.

Procedure. The population used for the study consisted of all those who graduated from the Minnesota State Colleges during the 1966-67 academic year who had a mathematics major and for whom all sixteen variables were available. The group number 169 students.

The study group was considered according to each State College and by combining the State Colleges. An analysis was made using the eight high school variables as independent variables with Calculus I GPA, Calculus I, II, and III GPA, Abstract Algebra GPA, and the college mathematics GPA as dependent variables respectively. An analysis was also made using fifteen variables as independent variables with the college mathematics major GPA as the dependent variable.

For each of the groups, coefficients of correlation were derived among the predictor variables and between these predictors and the criteria. Means and standard deviations of each of the variables were calculated.

The multiple regression package MRP31 was used with an IBM 1620 computer in order to identify, for each criterion group, that combination of predictor variables which predicted the criterion using the desired number of predictor variables.

Findings. 1. Discriminant functions for predicting success in Calculus I were computed using from one to eight variables (see Appendix C). The functions calculated using the best three predictors were:

Moorhead: $O_1 = .591\ (H) + .168\ (F) + .046\ (K) - .919$; $R = .716$

St. Cloud: $O_2 = .095\ (J) + .001\ (E) - .006\ (K) + .069$; $R = .473$

Winona: $O_3 = .844\ (H) - .880\ (G) + .051\ (I) + 1.115$; $R = .501$

Bemidji: $O_4 = 1.348\ (H) - .002\ (E) - .034\ (J) + .786$; $R = .706$

Mankato: $O_5 = .684\ (G) + .030\ (F) - .042\ (I) + 1.804$; $R = .428$

Colleges Combined: $O_6 = .332\ (H) + .257\ (G) + .024\ (K) + .450$; $R = .467$

2. The discriminant functions determined for predicting success in Calculus I, II, and III using the best three of eight predictor variables were:

Moorhead: $R_1 = .955\ (H) + .186\ (F) - .026\ (I) - .497$; $R = .621$

St. Cloud: $R_2 = .474\ (G) - .092\ (L) + .055\ (J) + 2.332$; $R = .360$

Winona: $R_3 = .838\ (H) - .002\ (E) + .052\ (L) + .099$; $R = .674$

Bemidji: $R_4 = .599\ (H) - .112\ (L) + .069\ (K) + 1.911$; $R = .594$

Mankato: $R_5 = .094\ (F) + .590\ (G) - .045\ (I) + 1.767$; $R = .715$

Colleges Combined: $R_6 = .306\ (H) + .069\ (F) + .204\ (G) + .798$; $R = .556$

3. The functions computed for predicting success in Abstract Algebra were:

Moorhead: $S_1 = .144\ (L) + .144\ (F) - .057\ (J) - .167$; $R = .755$

St. Cloud: $S_2 = .098 (L) - .044 (J) + .001 (E) + .409$; $R = .496$

Winona: $S_3 = 1.212 (H) - .080 (L) - .002 (E) + 2.120$; $R = .479$

Bemidji: $S_4 = - .123 (J) + .111 (L) + .312 (G) + 1.644$; $R = .483$

Mankato: $S_5 = .112 (I) - .132 (L) + .107 (J) + .332$; $R = .413$

Colleges Combined: $S_6 = .001 (E) + .042 (F) + .289 (G) + .596$; $R = .407$

4. The equations determined for predicting success in the college mathematics major using the variables were:

Moorhead: $X_1 = .602 (H) + .149 (F) + .029 (L) - .507$; $R = .730$

St. Cloud: $X_2 = .002 (E) + .058 (F) - .239 (H) + 1.473$; $R = .468$

Winona: $X_3 = .930 (H) - .002 (E) + .069 (F) + .772$; $R = .641$

Bemidji: $X_4 = .180 (G) - .134 (F) + .154 (H) + 2.793$; $R = .582$

Mankato: $X_5 = .404 (G) - .021 (F) + .009 (J) + 1.371$; $R = .509$

Colleges Combined: $X_6 = .288 (H) + .164 (G) + .010 (K) + 1.179$; $R = .496$

5. Discriminant functions for predicting success in college mathematics major were computed using from one to fifteen variables (see Appendix D). The functions calculated using the best three predictors were:

Moorhead: $X_1 = .351 (P) + .310 (S) + .296 (O) + .031$; $R = .949$

St. Cloud: $X_2 = .452 (R) + .328 (S) + .001 (E) + .283$; $R = .899$

Winona: $X_3 = .234 (Q) + .270 (P) + .112 (S) + .812$; $R = .864$

Bemidji: $X_4 = .660 (R) + .032 (L) - .090 (N) + .636$; $R = .899$

Mankato: $X_5 = .584 (R) - .047 (F) + .218 (S) + .976$; $R = .896$

Colleges Combined: $X_6 = .269 (O) + .256 (Q) + .204 (S) + .772$; $R = .865$

6. Following is a list of the eight predictor variables from the high school record with the number in parentheses indicating the number of state colleges at which the variable correlated significantly at the 5% level with dependent variables Calculus I, Calculus I, II, and III,

Abstract Algebra, and the college mathematics major respectively:

rank in high school graduating class:	(3), (1), (4), (4)
number semesters of high school mathematics:	(0), (2), (1), (1)
high school mathematics grade point average:	(4), (3), (3), (4)
over-all high school grade point average:	(3), (4), (4), (5)
ACT mathematics subtest:	(3), (0), (3), (3)
ACT English subtest:	(2), (0), (0), (2)
ACT natural science subtest:	(2), (2), (4), (2)
ACT composite score:	(2), (1), (3), (3)

7. Using the fifteen variables as independent variables and the college mathematics major grade point average as the dependent variable, a correlation significant at the 5% level was found at all five of the state colleges for variables P, Q, and R; at four of the state colleges for variables H, N, O, and S; at three of the state colleges for variables E, G, and M; at two of the state colleges for the variable L; and at one of the state colleges for variables F, I, J, and K.

Conclusions

Several conclusions followed from the nature of the groups studied. These conclusions should not be considered as necessarily applicable to colleges other than the Minnesota State Colleges.[1]

1. A number of the eight predictor variables made a small contribution in predicting success in the criteria selected for the study.

a. In predicting success in Calculus I, small contribution was made by the ACT composite score, while the over-all high school grade point

[1]The Minnesota State Colleges include Moorhead State College, St. Cloud State College, Bemidji State College, Winona State College, and Mankato State College.

average was the best single predictor.

b. With the Calculus I, II, and III GPA as the criterion, small contribution to success was made by the ACT English subtest, while the over-all high school grade point average was again the best single predictor.

c. When the Abstract Algebra GPA was used as the criterion, small contribution to success was made by the ACT natural science subtest, while the best single predictor was the ACT composite score. The nature of the content of an Abstract Algebra course requires a broad ability of reasoning such as tested by the ACT composite score, therefore it is reasonable to expect the composite score to do well as a predictor.

d. In predicting success in the over-all college mathematics major, small contribution was made by the ACT natural science subtest and the ACT English subtest, while the best predictors were the over-all high school grade point average and the high school mathematics grade point average.

2. The high school predictor variables do have continued value as related to academic performance in mathematics from the freshman through senior years of college. Seven of the eight predictor variables correlated significantly at the 5% level with the Calculus I GPA at two or more of the Minnesota State Colleges; four of the eight correlated significantly with the Calculus I, II, and III GPA at two or more of the Minnesota State Colleges; six of the eight correlated significantly with the Abstract Algebra GPA at two or more of the colleges; and seven of the eight variables correlated significantly with the over-all GPA at two or more of the Minnesota State Colleges.

3. The discriminant functions determined would be useful for the respective Minnesota State Colleges to advise freshmen mathematics majors

relative to taking Calculus I. An example of how the equations can be used follows: Suppose a student at Mankato State College has a high school mathematics grade point average (G) of 3.0, seven semesters of high school mathematics (F), and an ACT mathematics subtest score (I) of 26. Using Table 48 in Appendix C, the equation Calculus I GPA = .684 (G) + .030 (F) - .042 (I) + 1.804 is obtained. Upon substitution, we obtain Calculus I GPA = .684 (3.0) + .030 (7) - .042 (26) + 1.804 = 2.974, which is approximately a "B" grade. Using the standard error of estimate for the best combination of three variables, the prediction of performance in Calculus I, using this regression equation, will not vary by more than .702 grade points in approximately two-thirds of the predictions one might make.

4. Prediction equations were derived that would be useful in advising prospective mathematics majors relative to their continuing with a major in mathematics. For example, if the best three combinations of three variables are used in regression equations to predict the grade point average for Calculus I, Calculus I, II, and III, Abstract Algebra, and the college mathematics major respectively at Mankato State College, scores for five variables are needed. The scores needed are high school mathematics grade point average (G), number semesters of high school mathematics (F), ACT mathematics subtest (K), ACT composite score (L), and ACT English subtest (J). Thus, if a student at Mankato State College has a high school mathematics grade point average of 3.0, seven semesters of high school mathematics, an ACT mathematics subtest score of 26, and ACT composite score of 22, and an ACT English subtest score of 21, the following grade points are predicted with the corresponding error of estimate given:

a. Calculus I GPA = 2.974 $\pm$ .702 (see 3 above for method of arriving at this score). Since this score represents about a "B" grade, the student would be advised to take Calculus I if he so desired.

b. Calculus I, II, and III GPA = .094 (7) + .590 (3.0) - .045 (26) + 1.767 = 3.025 (see Table 49 for the equation). Using the standard error of estimate for this equation, the predicted grade would be 3.025 $\pm$ .590. This is approximately a "B" grade.

c. Abstract Algebra GPA = .112 (26) - .132 (22) + .107 (21) + .332 = 2.587 (see Table 50 for the equation). Using the standard error of estimate, we obtain a predicted grade of 2.587 $\pm$ .921. This represents a low "B" grade with a range down to a low "C". The large standard error of estimate is probably due in part to the nature of the material covered in the Abstract Algebra course. Also, apparently a greater range exists in the ability of today's students to understand the material.

d. Mathematics major GPA = .404 (3.0) + .021 (7) + .009 (21) + 1.371 = 2.919 (see Table 51 for the equation). The standard error of estimate for this equation is .434; therefore, the predicted grade would be 2.919 $\pm$ .434. This represents a grade of approximately "B".

Looking at the results of a, b, c, and d above, it would be reasonable to advise this student to major in mathematics at Mankato State College.

5. The results of this study indicate that those variables most useful in predicting success in mathematics at any one of the Minnesota State Colleges were not necessarily of prime importance at another state college. This is probably due to the local college situation determined by such factors as geographic location, selection procedure,

type of program, and the population from which the students are drawn. Considering further the role of type of program, some schools may emphasize a strong pre-calculus sequence of mathematics for general education and thereby interest students in majoring in mathematics that might not have done so. By doing this, the school is attracting a different kind of student for a mathematics major and thus a particular set of predictor variables are useful to them that may not be as useful at another college which does not offer such a program.

6. Those variables most useful in predicting success in Abstract Algebra differ from those of most importance in forecasting success in Calculus I, Calculus I, II, and III, and the college mathematics major. This is probably due to the fact that Abstract Algebra requires a reasoning ability different from many of the other mathematics courses which are more computational in nature.

Recommendations for Use of Findings

1. The prediction equations developed in this study are recommended for use by the respective Minnesota State Colleges. Furthermore, constant research should be maintained at each of the colleges in order to evaluate the equations. This appears necessary since students, faculties, and subject matter are constantly changing.

2. Since the results of this study support the need for local research in the development of prediction equations, it would seem advisable for colleges outside of this study to develop equations for their individual use.

Recommendations for further Research

The mathematics curriculum is expected to continue to change, reflecting perhaps the recommendations of such groups as the Committee on the Undergraduate Program in Mathematics and the Cambridge Conference on Mathematics. Also, as more varied applications are found for mathematics, we can expect the student majoring in mathematics to change. In view of this, the study should be replicated in a few years to determine the most useful predictor variables.

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APPENDIX A

1966-67 CATALOG DESCRIPTION OF THE MATHEMATICS MAJOR FOR EACH OF THE MINNESOTA STATE COLLEGES

1966-67 CATALOG DESCRIPTION OF THE MATHEMATICS MAJOR FOR EACH OF THE MINNESOTA STATE COLLEGES

Listed below are the requirements for the mathematics major at each of the Minnesota State Colleges. Course credit is expressed in quarter hours.

Moorhead State College

B. A. Degree Requirements

Mathematics 230, 232, 233, Analytic Geometry and Calculus I, II, and III	15 hrs.
Mathematics 322, Differential Equations and Calculus IV	5 hrs.
Mathematics 420, Foundations of Geometry	4 hrs.
Mathematics 421, Modern Algebra	4 hrs.
Mathematics 422, Linear Algebra	4 hrs.
Mathematics 474, Probability and Statistics	4 hrs.
Mathematics 475, Mathematics Statistics I	3 hrs.
Electives in mathematics (two or more courses numbered 300 or above)	9 hrs.
	48 hrs.

B. S. Degree Requirements

B. A. degree in mathematics except mathematics 322, Differential Equations, and mathematics 420, Foundations of Geometry	39 hrs.
Mathematics 401, Foundations of Mathematics	3 hrs.
Mathematics 419, Modern Geometry	4 hrs.

Mathematics 440, Mathematics in the Secondary School	3 hrs.
Additional electives in mathematics	2 hrs.
	51 hrs.

St. Cloud State College

B. A. Degree Requirements

Mathematics 241, 242, 243, 244, Analysis I, II, III, and IV	16 hrs.
Mathematics 356, Modern Algebra	4 hrs.
Mathematics 429, Probability and Statistics	4 hrs.
Mathematics 432, Intermediate Calculus	4 hrs.
Mathematics 433, Advanced Calculus	4 hrs.
Mathematics 434, Differential Equations	4 hrs.
Mathematics 457, Linear Algebra	4 hrs.
Electives in Senior College Mathematics	20 hrs.
	60 hrs.

B. S. Degree Requirements

Mathematics 241, 242, 243, 244, Analysis I, II, III, and IV	16 hrs.
Mathematics 354, Foundations of Algebra	4 hrs.
Mathematics 356, Modern Algebra	4 hrs.
Mathematics 424, Elements of Geometry	4 hrs.
Mathematics 429, Probability and Statistics	4 hrs.
Mathematics 451, Professional subject matter for Junior and Senior High School Mathematics	4 hrs.
Mathematics 422, Modern Algebra II or Mathematics 457, Linear Algebra	4 hrs.
Electives in Senior College Mathematics	8 hrs.
	48 hrs.

Winona State College

B. A. Degree Requirements

*Mathematics 220, College Algebra and Trigonometry	5 hrs.
Mathematics 225, 226, 227, Analytic Geometry and Calculus I, II, and III	15 hrs.
Mathematics 329, Calculus IV	5 hrs.
Electives from mathematics courses 300 or above	20 hrs.
	45 hrs.

B. S. Degree Requirements

*Mathematics 220, College Algebra and Trigonometry	5 hrs.
Mathematics 225, 226, 227, Geometry and Calculus I, II, and III	15 hrs.
Mathematics 316, Introduction to Modern Mathematics	3 hrs.
Mathematics 317, Abstract Algebra	3 hrs.
Mathematics 318, Probability or Mathematics 319, Statistical Methods	4 hrs.
Mathematics 322, Modern Geometry	3 hrs.
Mathematics 417, Linear Algebra	4 hrs.
Electives from mathematics courses numbered 300 or above	8 hrs.
	45 hrs.

Bemidji State College

B. A. or B. S. Degree Requirements

Mathematics 121, 122, Elementary Analysis I and II	10 hrs.
or	
Mathematics 129, 129b, Accelerated Elementary Analysis	7 hrs.

*Mathematics 215, College Algebra, and Mathematics 216, Trigonometry may be substituted for Mathematics 220.

Mathematics 221, 222, 223, Anaytic Geometry and
Calculus I, II, III .... 15 hrs.

Mathematics 324, Calculus and Differential
Equations .... 5 hrs.

Mathematics 341, Introduction to Modern Mathematics
or Mathematics 422, Foundations of Mathematics .... 4 hrs.

One of: Mathematics 431, Algebraic Theory
Mathematics 432, Introduction to Linear Algebra
Mathematics 433, Matrix Algebra
Mathematics 435, Modern Algebra .... 4 hrs.

One of: Mathematics 351, College Geometry
Mathematics 452, Elementary Geometry from an Advanced Standpoint
Mathematics 455, Foundations of Modern Geometry .... 4 hrs.

Electives in mathematics courses numbered 300
or above .... 6 hrs.

45-48 hrs.

Mankato State College

B. A. or B. S. Degree Requirements

A major in mathematics in any curriculum requires at least forty quarter hours in courses numbered 2000 and above. Mathematics 2244, Intermediate Calculus, and at least one course in the area of Abstract Algebra and one in the area of Foundations of Mathematics must be included. Astronomy 4104, Celestial Mechanics, may be used as an elective course in the mathematics major.

Note: The calculus sequence begins with the 2000 numbered sequence.

APPENDIX B

FORM FOR RECORDING DATA

Data for a Study of Mathematics Majors at the Minnesota State Colleges

1. Student ID Number: ____________

2. Sex: ___Male, ___Female. 3. Type of Degree: ___B. A. ___B. S.

4. Rank in high school graduating class: ____________

5. Standard ACT Scores:
   a. Mathematics Subtest ______ b. English Subtest ______
   c. Natural Sciences Subtest ______ d. Composite ______

6. High school mathematics grades. List courses by title for grades 9-12 (Units Credit will be 1 unit for one year).

	Course Title	Units Credit	Course Grade		Course Title	Units Credit	Course Grade
Grade 9				Grade 11			
Grade 10				Grade 12			

7. Over-all high school grade average if available on transcript: ______

8. If the high school grade average is not on transcript--list all courses other than mathematics taken in grades 9, 10, 11, and 12.

Grade 9			Grade 10			Grade 11			Grade 12		
Course Title	Units	Grade	Course Title	Units	Grade	Course Title	Units	Grade	Course Title	Units	Grade

9. College mathematics grades--list all college courses in mathematics. List in the order taken.

Course No.	Title	Hrs. Credit	Grade	Course No.	Title	Hrs. Credit	Grade

APPENDIX C

Multiple Regression Program Listing the Predictor Combinations of From One to Eight Predictor Variables with their Partial Regression Coefficient, Multiple Correlation Coefficient, Constant, and the Standard Error of Estimate of Dependent Variable. (Instructions for interpretation are given in Table 32.)

TABLE 32

MOORHEAD STATE COLLEGE--PREDICTOR COMBINATIONS--CALCULUS I GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
H	.591	.945	.295	.673
H,F	.679	.936,.192	-.999	.626
H,F,K	.716	.591,.168,.046	-.919	.609
H,F,K,E	.733	.795,.186,.053,-.001	-.936	.608
H,F,K,E,J	.757	.976,.188,.064,-.001,-.051	-.557	.600
H,F,K,E,J,G	.774	1.912,.269,.079,-.003,-.083,-.668	-.586	.597
H,F,K,E,J,G,I	.778	2.099,.270,.078.-.003,-.097,-.882,.024	-.715	.609
H,F,K,E,J,G,I,L	.778	2.101,.271,.079,-.003,-.097,-.883,.024,-.001	-.715	.628

Interpretation. In the above table, the variable coefficients are listed in the order corresponding to the variables. Thus, the regression equation for the best combinations of four variables is

$$O_1 = .795\ (H) + .186\ (F) + .053\ (K) - .001\ (E) - .936.$$

On the basis of this sample, prediction of the grade point average in Calculus I at Moorhead State College using this regression equation will not be wrong by more than .608 grade points (Standard Error of Estimate) in approximately two-thirds of the predictions one might make. In a similar way, equations using from one to eight variables can be determined.

TABLE 33

MOORHEAD STATE COLLEGE--PREDICTOR COMBINATIONS--CALCULUS I, II, AND III GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
H	.538	.842	0.436	.688
H,F	.610	.835,.161	-.649	.661
H,F,I	.621	.955,.186,-.026	-.497	.669
H,F,I,L	.650	.653,.180,-.056,.074	-.499	.665
H,F,I,L,J	.687	.654,.167,-.064,.128,-.068	-.085	.652
H,F,I,L,J,K	.717	.647,.173,-.101,.288,-.102,-.083	-.150	.643
H,F,I,L,J,K,E	.735	.931,.203,-.113,.283,-.106,-.069,-.001	-.043	.644
H,F,I,L,J,K,E,G	.744	1.647,.253,-.089,.262,-.131,-.053,-.002,-.563	-.167	.654

TABLE 34

MOORHEAD STATE COLLEGE--PREDICTOR COMBINATIONS--ABSTRACT ALGEBRA GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
L	.650	.115	.373	.545
L,F	.724	.105,.159	-.486	.506
L,F,J	.755	.144,.144,-.057	-.167	.493
L,F,J,H	.767	.115,.157,-.057,.290	-.460	.494
L,F,J,H,G	.813	.146,.217,-.096,.984,-.730	-.537	.459
L,F,J,H,G,K	.820	.094,.217,-.081,.920,-.665,.033	-.437	.464
L,F,J,H,G,K,I	.822	.065,.217,-.080,1.020,-.764,.043,.019	-.507	.475
L,F,J,H,G,K,I,E	.822	.066,.215,-.079,.997,-.751,.042,.018,.000	-.506	.490

TABLE 35

MOORHEAD STATE COLLEGE--PREDICTOR COMBINATIONS--COLLEGE MAJOR GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
H	.624	.782	.593	.511
H,F,	.721	.775,.162	-.501	.464
H,F,L	.730	.602,.149,.029	-.570	.468
H,F,L,J	.737	.604,.142,.047,-.025	-.428	.474
H,F,L,J,G	.756	.991,.176,.064,-.047,-.408	-.472	.471
H,F,L,J,G,E	.774	1.650,.229,.084,-.074,-.786,-.001	-.504	.468
H,F,L,J,G,E,I	.776	1.583,.229,.091,-.072,-.719,-.001,-.011	-.447	.480
H,F,L,J,G,E,I,K	.779	1.452,.221,.135,-.077,-.633,-.001,-.023,-.024	-.451	.492

TABLE 36

ST. CLOUD STATE COLLEGE--PREDICTOR COMBINATIONS--CALCULUS I GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
J	.426	.100	..606	.727
J, E	.473	.091,.001	.041	.718
J, E, K	.473	.095,.001,-.006	.069	.727
J, E, K, L	.475	.090,.001,-.015,.020	-.049	.738
J, E, K, L, H	.477	.088,.001,-.020,.031,-.170	.009	.748
J, E, K, L, H, I	.478	.086,.002,-.023,.042-.194,-.006	.065	.759
J, E, K, L, H, I, G	.478	.085,.002,-.022,.040,-.212,-.008,.042	.093	.771
J, E, K, L, H, I, G, F	.478	.085,.001,-.023,.035,-.201,-.005,.053,-.016	..224	.784

TABLE 37

ST. CLOUD STATE COLLEGE--PREDICTOR COMBINATIONS--CALCULUS I, II, AND III GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
G	.210	.250	1.941	.661
G,L	.290	.459,-.055	2.611	.656
G,L,J	.360	.474,-.092,.055	2.332	.648
G,L,J,E	.368	.373,-.091,.056,.001	2.246	.656
G,L,J,E,K	.371	.340,-.074,.057,.001,-.013	2.185	.665
G,L,J,E,K,F	.371	.325,-.073,.057,.001,-.012,.015	2.046	.675
G,L,J,E,K,F,H	.371	.329,-.071,.057,.001,-.013,.015,-.036	2.058	.686
G,L,J,E,K,F,H,I	.371	.331,-.069,.057,.001,-.013,.017,-.042,-.001	2.054	.697

TABLE 38

ST. CLOUD STATE COLLEGE--PREDICTOR COMBINATIONS--ABSTRACT ALGEBRA GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
L	.425	.083	.371	.581
L, J	.468	.115,-.048	.611	.575
L,J,E	.496	.098,-.044,.001	.409	.573
L,J,E,I	.524	.130,-.053,.001,-.035	.746	.570
L,J,E,I,F	.540	.152,-.050,.001,-.052,.105	-.123	.572
L,J,E,I,F,H	.552	.173,-.054,.002,-.058,.132,-.376	-.145	.575
L,J,E,I,F,H,G	.557	.165,-.057,.001,-.061,.116,-.441,.159	.084	.582
L,J,E,I,F,H,G,K	.559	.141,-.055,.001,-.057,.118,-.376,.171,.015	.062	.591

TABLE 39

ST. CLOUD STATE COLLEGE--PREDICTOR COMBINATIONS--COLLEGE MAJOR GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
E	.440	.001	1.680	.431
E,F	.455	.001,.055	1.290	.434
E,F,H	.468	.002,.058,-.239	1.473	.436
E,F,H,L	.471	.002,.069,-.291,.010	1.257	.442
E,F,H,L,K	.473	.002,.062,-.328,.002,-.010	1.295	.448
E,F,H,L,K,J	.474	.002,.059,-.339,.026,-.011,-.066	1.354	.454
E,F,H,L,K,J,I	.475	.002,.070,-.370,.038,-.013,-.007,-.007	1.322	.462
E,F,H,L,K,J,I,G	.477	.002,.075,-.352,.042,-.014,-.006,-.007,-.054	1.247	.469

TABLE 40

WINONA STATE COLLEGE--PREDICTOR COMBINATIONS--
CALCULUS I GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con- stant	Standard Error of Estimate
H	.256	.246	1.605	.545
H,G	.436	.824,-.695	2.004	.521
H,G,I	.501	.844,-.880,.051	1.115	.515
H,G,I,K	.547	.795,-.878,.049,.028	.626	.512
H,G,I,K,J	.572	.755,-.786,.053,.035,-.030	.846	.517
H,G,I,K,J,E	.573	.810,-.758,.053,.033,-.029,-.000	.795	.534
H,G,I,K,J,E,F	.575	.924,-.831,.058,.030,-.025,-.001,.045	.366	.552
H,G,I,K,J,E,F,L	.575	.910,-.814,.055,.026,-.031,-.001,.039,.012	.404	.572

TABLE 41

WINONA STATE COLLEGE--PREDICTOR COMBINATIONS--
CALCULUS I, II, AND III GPA DEPENDENT
VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
H	.479	.375	1.458	.404
H,E	.601	.959,-.002	1.048	.377
H,E,L	.674	.838,-.002,.052	.099	.358
H,E,L,F	.694	.984,-.002,.052,.094	-.632	.359
H,E,L,F,K	.704	.1.112,-.003,.077,.119,-.021	-.971	.366
H,E,L,F,K,I	.711	1.117,-.002,.091,.103,-.026,-.018	-.644	.374
H,E,L,F,K,I,J	.713	1.090,-.002,.116,.092,-.033,-.024,-.015	-.534	.386
H,E,L,F,K,I,J,C	.713	1.106,-.002,.114,.097,-.033,-.023,-.014,-.022	-.573	.401

TABLE 42

WINONA STATE COLLEGE--PREDICTOR COMBINATIONS--
ABSTRACT ALGEBRA GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
H	.349	.481	1.057	.758
H,L	.430	.607,-.075	2.460	.749
H,L,E	.479	1.212,-.080,-.002	2.120	.748
H,L,E,F	.540	1.597,-.080,-.003,.248	.192	.738
H,L,E,F,I	.548	1.559,-.069,-.003,.216,-.028	.810	.757
H,L,E,F,I,G	.549	1.483,-.070,-.003,.196,-.033,.128	.979	.781
H,L,E,F,I,G,J	.549	1.508,-.074,-.003,.203,-.032,.114,.004	.917	.808
H,L,E,F,I,G,J,K	.549	1.509.-.072,-.003,.202.-.032,.116,.003.-.001	.919	.839

TABLE 43

WINONA STATE COLLEGE--PREDICTOR COMBINATIONS--
COLLEGE MAJOR GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
H	.409	.247	1.718	.323
H,E	.621	.823,-.002	1.313	.285
H,E,F	.641	.930,-.002,.069	.772	.287
H,E,F,L	.659	.881,-.002,.068,.020	.407	.289
H,E,F,L,K	.677	1.014,-.002,.094,.047,-.022	.056	.292
H,E,F,L,K,J	.696	.959,-.002,.081,.089,-.033,-.031	.074	.294
H,E,F,L,K,J,I	.696	.963,-.002,.086,.082,-.031,-.028,.005	-.008	.304
H,E,F,L,K,J,I,G	.696	.974,-.002,.089,.081,-.031,-.027,.005,-.015	-.035	.315

TABLE 44

BEMIDJI STATE COLLEGE--PREDICTOR COMBINATIONS--
CALCULUS I GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
H	.641	.863	.079	.584
H,E	.680	1.253,-.002	.269	.570
H,E,J	.706	1.348,-.002,-.035	.786	.562
H,E,J,G	.719	1.117,-.002,-.030,.250	.633	.566
H,E,J,G,L	.729	1.036,-.002,-.056,.266,.046	.334	.571
H,E,J,G,L,I	.730	1.017,-.002,-.051,.249,.030,.015	.265	.584
H,E,J,G,L,I,F	.731	1.071,-.002,-.051,.226,.028,.016,.035	-.034	.599
H,E,J,G,L,I,F,K	.732	1.057,-.002,-.054,.239,.041,.014,.033,-.009	-.019	.616

TABLE 45

BEMIDJI STATE COLLEGE--PREDICTOR COMBINATIONS--
CALCULUS I, II, AND III GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
H	.473	.499	1.255	.525
H,L	.528	.624,-.045	1.915	.517
H,L,K	.594	.599,-.112,.069	1.911	.501
H,L,K,E	.641	.927,-.121,.077,-.001	2.091	.489
H,L,K,E,F	.651	.852,-.118,.077,-.001,-.073	2.746	.496
H,L,K,E,F,G	.666	.615,-.103,.068,-.001,-.099,.219	2.826	.500
H,L,K,E,F,G,J	.675	.620,-.137,.077,-.001,-.101,.223,.026	2.840	.508
H,L,K,E,F,G,J,I	.677	.610,-.156,.080,-.001,-.098,.201,.031,.015	2.753	.521

TABLE 46

BEMIDJI STATE COLLEGE--PREDICTOR COMBINATIONS--
ABSTRACT ALGEBRA GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
J	.244	-.051	3.738	.865
J,L	.427	-.137,.139	2.270	.824
J,L,G	.483	-.123,.111,.312	1.644	.816
J,L,G,I	.575	-.157,.244,.475,-.127	2.158	.781
J,L,G,I,F	.634	-.156,.250,.446,-.137,-.239	4.248	.756
J,L,G,I,F,H	.640	-.155,.237,.282,-.138,-.201,.286	3.898	.771
J,L,G,I,F,H,K	.641	-.159,.258,.303,-.141,-.204,.268,-.015	3.924	.791
J,L,G,I,F,H,K,E	.642	-.158,.257,.300,-.139,-.207,.207,-.015,.000	3.915	.813

TABLE 47

BEMIDJI STATE COLLEGE--PREDICTOR COMBINATIONS--
COLLEGE MAJOR GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
G	.458	.309	1.797	.404
G,F	.572	.278,-.156	3.113	.381
G,F,H	.582	.180,-.134,.154	2.793	.386
G,F,H,E	.596	.186,-.127,.288,-.001	2.783	.390
G,F,H,E,K	.604	.191,-.131,.251,-.001,.011	2.667	.396
G,F,H,E,K,I	.608	.194,-.130,.289,-.001,.017,-.012	2.765	.405
G,F,H,E,K,I,L	.608	.205,-.132,.277,-.001,.014,-.014,.007	2.767	.416
G,F,H,E,K,I,L,J	.610	.209,-.133,.278,-.001,.011,-.018,.021,-.008	2.784	.428

TABLE 48

MANKATO STATE COLLEGE--PREDICTOR COMBINATIONS--
CALCULUS I GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
G	.330	.360	1.895	.720
G,F	.396	.518,.027	1.190	.707
G,F,I	.428	.684,.030,-.042	1.804	.702
G,F,I,J	.447	.629,.027,-.052,.031	1.587	.702
G,F,I,J,E	.451	.544,.023,-.053,.030,.000	1.672	.707
G,F,I,J,E,H	.457	.609,.032,-.056,.032,.001,-.165	1.775	.712
G,F,I,J,E,H,K	.457	.611,.032,-.056,.032,.001,-.164,-.001	1.793	.719
G,F,I,J,E,H,K,L	.457	.612,.033,-.057,.030,.001,-.164,-.003,.004	1.793	.726

TABLE 49

MANKATO STATE COLLEGE--PREDICTOR COMBINATIONS--
CALCULUS I, II, AND III GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
F	.634	.070	2.564	.641
F,G	.698	.091,.414	1.117	.600
F,G,I	.715	.094,.590,-.045	1.767	.590
F,G,I,K	.727	.094,.522,-.051,.035	1.292	.586
F,G,I,K,H	.727	.100,.576,-.051,.036,-.079	1.320	.591
F,G,I,K,H,J	.729	.100,.571,-.054,.034,-.094,.011	1.274	.596
F,G,I,K,H,J,E	.729	.100,.577,-.054,.034,-.085,.011,.000	1.258	.602
F,G,I,K,H,J,E,L	.729	.100,.576,-1053,.035,-.085,.012,.000,-.003	1.258	.608

TABLE 50

MANKATO STATE COLLEGE--PREDICTOR COMBINATIONS--
ABSTRACT ALGEBRA GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
I	.274	.071	.581	.955
I,L	.312	.107,-.054	.868	.952
I,L,J	.413	.112,-.132,.107	.332	.921
I,L,J,E	.461	.090,-.154,.098,.001	.465	.906
I,L,J,E,F	.479	.085,-.098,.071,.001,.022	-.024	.905
I,L,J,E,F,G	.482	.079,-.100,.070,.001,.028,.141	-.110	.913
I,L,J,E,F,G,K	.482	.078,-.090,.066,.001,.029,.154,-.009	-.036	.922
I,L,J,E,F,G,K,H	.482	.078,-.090,.066,.001,.029,.149,-.009,.013	-.043	.931

TABLE 51

MANKATO STATE COLLEGE--PREDICTOR COMBINATIONS--
COLLEGE MAJOR GPA DEPENDENT VARIABLE--
EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
G	.419	.296	2.058	.449
G,F	.505	.429,.022	1.467	.431
G,F,J	.509	.404,.021,.009	1.371	.434
G,F,J,L	.510	.421,.020,.015,-.011	1.449	.437
G,F,J,L,K	.515	.412,.018,.021,-.025,.015	1.342	.440
G,F,J,L,K,E	.517	.375,.016,.021,-.027,.016,.000	1.377	.444
G,F,J,L,K,E,H	.518	.390,.018,.022,-.028,.015,.000,-.043	1.393	.448
G,F,J,L,K,E,H,I	.518	.391,.018,.022,-.027,.016,.000,-.044,-.001	1.397	.453

TABLE 52

MINNESOTA STATE COLLEGES COMBINED--PREDICTOR COMBINATIONS--CALCULUS I GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
H	.406	.573	1.101	.726
H,G	.452	.359,.313	.767	.710
H,G,K	.467	.332,.257,.024	.450	.706
H,G,K,E	.472	.417,.305,.024,-.000	.410	.707
H,G,K,E,I	.473	.419,.331,.026,-.001,-.009	.530	.708
H,G,K,E,I,J	.474	.414,.333,.024,-.001,-.010,.005	.497	.710
H,G,K,E,I,J,F	.474	.385,.356,.024,.000,-.011,.006,.004	.469	.712
H,G,K,E,I,J,F,L	.474	.385,.356,.026,.000,-.010,.007,.004,-.004	.473	.714

TABLE 53

MINNESOTA STATE COLLEGES COMBINED--PREDICTOR COMBINATIONS--CALCULUS I, II, AND III GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con- stant	Standard Error of Estimate
H	.452	.597	1.095	.663
H,F	.545	.479,.053	1.032	.625
H,F,G	.556	.306,.069,.204	.798	.621
H,F,G,I	.565	.303,.071,.294,-.024	1.169	.618
H,F,G,I,E	.573	.443,.067,.342,-.025,-.001	1.146	.616
H,F,G,I,E,K	.581	.411,.070,.328,-.030,-.001,.019	.967	.614
H,F,G,I,E,K,J	.582	.404,.070,.332,-.031,-.001,.017,.006	.931	.615
H,F,G,I,E,K,J,L	.583	.408,.066,.332,-.025,-.001,.025,.014,-.023	.949	.617

TABLE 54

MINNESOTA STATE COLLEGES COMBINED--PREDICTOR COMBINATIONS--ABSTRACT ALGEBRA GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Constant	Standard Error of Estimate
E	.349	.002	1.334	.805
E,F	.381	.002,.030	1.083	.796
E,F,G	.407	.001,.042,.289	.596	.789
E,F,G,K	.415	.001,.042,.248,.017	.349	.789
E,F,G,K,J	.426	.001,.043,.262,.025,-.026	.591	.787
E,F,G,K,J,H	.427	.001,.037,.226,.025,-.027,.108	.583	.788
E,F,G,K,J,H,L	.428	.001,.039,.215,.020,-.032,108,.012	.540	.791
E,F,G,K,J,H,L,I	.428	.001,.040,.227,.018,-.033,.104,.018,-.005	.574	.793

TABLE 55

MINNESOTA STATE COLLEGES COMBINED--PREDICTOR COMBINATIONS--COLLEGE MAJOR GPA DEPENDENT VARIABLE--EIGHT PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
H	.456	.428	1.513	.469
H,G	.490	.300,.187	1.313	.461
H,G,K	.496	.288,.164,.010	1.179	.461
H,G,K,J	.496	.292,.165,.011,-.003	1.210	.462
H,G,K,J,F	.497	.273,.182,.011,-.003,.003	1.184	.463
H,G,K,J,F,E	.497	.287,.186,.011,-.003,.003,.000	1.181	.464
H,G,K,J,F,E,I	.497	.287,.183,.011,-.004,.003,.000,.001	1.171	.466
H,G,K,J,F,E,I,L	.497	.287,.183,.011,-.003,.003,.000,.001,-.001	1.172	.468

APPENDIX D

Multiple Regression Program Using Fifteen Predictor Variables Listing Predictor Combinations With Their Multiple Correlation Coefficient, Partial Correlation Coefficients, Constant, and Standard Error of Estimate for the Dependent Variable (Tables interpreted same as those in Appendix C).

TABLE 56

MOORHEAD STATE COLLEGE--PREDICTOR COMBINATIONS--
COLLEGE MAJOR GPA DEPENDENT VARIABLE--
FIFTEEN PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
P	.755	.575	1.250	.429
P,S	.920	.491,.490	-.003	.262
P,S,O	.976	.348,.268,.297	-.558	.160
P,S,O,H	.980	.325,.228,.269,.157	-.856	.153
P,S,O,H,E	.981	.326,.254,.251,.229,-.000	-.907	.153
P,S,O,H,E,O	.983	.237,.274,.209,.281,-.001,.127	-.730	.148
P,S,O,H,E,Q,F	.984	.218,.250,.196,.327,-.001,.144,.028	-.861	.147
P,S,O,H,E,Q,F,N	.987	.313,.308,.308,.393,-.001,.160,.056,-.334	-1.000	.140
P,S,O,H,E,Q,F,N, K	.989	.260,.340,.322,.460,-.001,.203,.053,-.331, -.013	-.920	.134
P,S,O,H,E,Q,F,N, K,J	.990	.259,.362,.335,.393,-.001,.221,.048,-.342, -.017,.012	-.876	.134
P,S,O,H,E,Q,F,N, K,J,R	.991	.300,.383,.392,.388,-.001,.330,.051,-.343, -.019,.017,-.200	-.810	.132
P,S,O,H,E,Q,F,N, K,J,R,G	.991	.301,.364,.380,.511,-.001,.319,.062,-.309, -.015,.012,-.211,-.080	-.849	.138
P,S,O,H,E,Q,F,N, K,J,R,G,L	.991	.312,.366,.397,.481,-.001,.329,.061,-.326, -.019,.011,-.231,-.080,.008	-.828	.146
P,S,O,H,E,Q,F,N, K,J,R,G,L,I	.991	.312,.363,.401,.470,-.001,.337,.061,-.307, -.021,.011,-.258,-.072,.014,-.003	-.806	.156
P,S,O,H,E,Q,F,N, K,J,R,G,L,I,M	.991	.312,.358,.403,.470,-.001,.335,.061,.306, -.021,.011,-.258,-.070,.015,.004,.001	-.836	.169

TABLE 57

ST. CLOUD STATE COLLEGE--PREDICTOR COMBINATIONS--
COLLEGE MAJOR GPA DEPENDENT VARIABLE--
FIFTEEN PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con- stant	Standard Error of Estimate
R	.745	.529	1.206	.320
R,S	.887	.469,.365	.887	.225
R,S,E	.899	.452,.328,.000	.899	.200
R,S,E,G	.916	.461,.358,.001,-.219	.916	.193
R,S,E,G,J	.928	.492,.369,.001,-.223,-.012	.928	.192
R,S,E,G,J,O	.933	.418,.366,.001,-.227,-.019,.102	.678	.189
R,S,E,G,J,O,M	.938	.377,.342,.001,-.244,-.019,.133,-.013	.920	.185
R,S,E,G,J,O,M,F	.940	.354,.343,.001,-.267,-.014,.144,-.015,.038	.648	.184
R,S,E,G,J,O,M,F, L	.943	.381,.317,.001,-.335,-.019,.127,-.018,.053, .020	.394	.181
R,S,E,G,J,O,M,F, L,H	.943	.378,.302,.001,-.307,-.021,.123,-.021,.063, .024,-.229	.443	.180
R,S,E,G,J,O,M,F, L,H,K	.949	.382,.317,.002,-.321,-.021,.118,-.019,.051, .046,-.266,-.015	.480	.177
R,S,E,G,J,O,M,F, L,H,K,P	.954	.204,.296,.002,-.370,-.021,.208,-.025,.078, .065,-.423,-.023,.095	.333	.179
R,S,E,G,J,O,M,F, L,H,K,P,I	.954	.203,.304,.002,-.370,-.019,.206,-.024,.068, .054,-.386,-.020,.095,.007	.302	.182
R,S,E,G,J,O,M,F, L,H,K,P,I,N	.954	.201,.302,.002,-.372,-.019,.203,-.025,.068, .054,-.386,-.020,.097,.007,.007	.351	.186
R,S,E,G,J,O,M,F, L,H,K,P,I,N,Q	.954	.249,.305,.002,-.375,-.019,.184,-.024,.068 .053,-.372,-.020,.092,.007,.010,-.017	.331	.190

TABLE 58

WINONA STATE COLLEGE--PREDICTOR COMBINATIONS--
COLLEGE MAJOR GPA DEPENDENT VARIABLE--
FIFTEEN PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
Q	.708	.333	1.506	.250
Q,P	.828	.265,.256	.828	.204
Q,P,S	.864	.202,.282,.165	.812	.188
Q,P,S,N	.905	.208,.282,.165,.195	.230	.100
Q,P,S,N,I	.923	.205,.262,.171,.195,.020	-.268	.089
Q,P,S,N,I,G	.961	.271,.224,.235,.275,.048,-.270	-.664	.083
Q,P,S,N,I,G,J	.972	.299,.231,.201,.240,.048,-.219,.018	-.363	.080
Q,P,S,N,I,G,J,L	.984	.344,.186,.193,.223,.057,-.267,-.030,.021	-.721	.077
Q,P,S,N,I,G,J,L, R	.986	.452,.280,.198,.313,.059,-.269,-.037,.031, -.295	-.892	.078
Q,P,S,N,I,G,J,L, R,O	.988	.574,.402,.198,.292,.054,-.211,-.036,.029, -.665,.149	-.894	.082
Q,P,S,N,I,G,J,L, R,O,F	.991	.705,.623,.317,.438,.056,-.366,-.047,.050, -1.267,.305,.061	-1.456	.080
Q,P,S,N,I,G,J,L, R,O,F,E	.994	.689,.644,.370,.453,.056,-.322,-.043,.049, -1.330,.376,.091,-.000	-1.723	.073
Q,P,S,N,I,G,J,L, R,O,F,E,M	.994	.706,.675,.388,.504,.058,-.363,-.046,.051 -1.438,.372,.091,-.000,-.012	-1.539	.077
Q,P,S,N,I,G,J,L, R,O,F,E,M,K	.995	.699,.645,.417,.567,.065,-.429,-.040,.032, -1.475,.348,.101,-.000,-.018,.010	-1.537	.081
Q,P,S,N,I,G,J,L, R,O,F,E,M,K,H	.995	.725,.772,.496,.619,.063,-.427,-.044,.037, -1.666,.438,.118,-.000,-.017,.014,-.131	-1.645	.093

TABLE 59

BEMIDJI STATE COLLEGE--PREDICTOR COMBINATIONS
COLLEGE MAJOR GPA DEPENDENT VARIABLE--
FIFTEEN PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
R	.837	.638	1.023	.248
R,L	.894	.595,.029	.638	.212
R,L,N	.899	.660,.032,-.090	.636	.213
R,L,N,K	.905	.724,.058,-.127,-.024	.518	.211
R,L,N,K,J	.918	.782,.103,-.186,-.040,-.028	.421	.202
R,L,N,K,J,O	.929	.744,.091,-.309,-.035,-.020,.146	.610	.200
R,L,N,K,J,O,H	.934	.742,.093,-.262,-.030,-.021,.154,-.135	.748	.199
R,L,N,K,J,O,H,M	.937	.762,.104,-.272,-.031,-.029,.150,-.119,.012	.562	.201
R,L,N,K,J,O,H,M, E	.938	.768,.104,-.289,-.033,-.026,.174,-.195,.010, .000	.546	.205
R,L,N,K,J,O,H,M, E,G	.939	.772,.106,-.304,-.305,-.026,.178,-.213,.009, .000,.026	.530	.213
R,L,N,K,J,O,H,M, E,G,F	.939	.752,.103,-.313,-.036,-.022,.196,-.249,.007, .000,.047,-.020	.728	.221
R,L,N,K,J,O,H,M, E,G,F,S	.940	.716,.096,-.298,-.036,-.018,.187,-.205,.009, .000,.054,-.020,.039	.635	.230
R,L,N,K,J,O,H,M, E,G,F,S,I	.940	.716,.104,-.284,-.037,-.020,.183,-.201,.007 .000,.053,-.023,.038,-.007	.702	.253
R,L,N,K,J,O,H,M, E,G,F,S,I,P	.940	.737,.102,-.292,-.036,-.020,.182,-.205,.007, .000,.055,-.022,.033,-.006,-.015	.709	.286
R,L,N,K,J,O,H,M, E,G,F,S,I,P,Q	.940	.778,.101,-.295,-.036,-.020,.171,-.205,.008 .000,.054,-.022,.034,-.005,-.026,-.016	.708	.287

TABLE 60

MANKATO STATE COLLEGE--PREDICTOR COMBINATIONS--
COLLEGE MAJOR GPA DEPEDENT VARIABLE--
FIFTEEN PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con-stant	Standard Error of Estimate
R	.613	.265	1.819	.391
R,F	.789	.608,-.042	1.406	.307
R,F,S	.896	.584,-.047,.218	.976	.223
R,F,S,N	.900	.536,-.039,.206,.084	.829	.222
R,F,S,N,O	.908	.628,-.041,.214,.173,-.157	.731	.215
R,F,S,N,O,M	.916	.636,-.043,.198,.180,-.197,-.016	.979	.208
R,F,S,N,O,M,E	.928	.675,-.046,.183,.160,-.230,-.016,.000	.947	.199
R,F,S,N,O,M,E,L	.929	.678,-.047,.183,.170,-.236,-.017,.000,-.006	1.034	.200
R,F,S,N,O,M,E,L, I	.930	.680,-.047,.176,.166,-.227,-.016,.000,-.013, .011	.910	.200
R,F,S,N,O,M,E,L, I,Q	.931	.585,-.044,.177,.160,-.194,-.015,.000,-.012, .011,.068	.840	.201
R,F,S,N,O,M,E,L, I,Q,G	.932	.585,-.042,.176,.169,-.200,-.014,.000,-.013, .009,.062,.040	.806	.203
R,F,S,N,O,M,E,L, I,Q,G,J	.932	.595,.043,.175,.166,-.202,-.013,.000,-.018, .010,.057,.041,.005	.802	.205
R,F,S,N,O,M,E,L, I,Q,G,J,K	.932	.585,-.043,.175,.172,-.207,-.013,.000,-.019, .010,.067,.052,.007,-.002	.752	.210
R,F,S,N,O,M,E,L, I,Q,G,J,K,P	.932	.520,-.039,.175,.172,-.185,-.013,.000,-.020, .101,.089,.052,.008,-.002,.024	.730	.213
R,F,S,N,O,M,E,L, I,Q,G,J,K,P,H	.932	.516,-.039,.174,.173,-.184,-.013,.000,-.020, .010,.091,.050,.007,-.002,.025,.008	.721	.216

TABLE 61

MINNESOTA STATE COLLEGES COMBINED--PREDICTOR COMBINATIONS--COLLEGE MAJOR GPA DEPENDENT VARIABLE--FIFTEEN PREDICTOR VARIABLES

Variable	Multiple Correlation Coefficient	Variable Coefficients	Con- stant	Standard Error of Estimate
0	.707	.470	1.471	.373
0,Q	.804	.327,.268	1.104	.314
0,Q,S	.865	.269,.256,.204	.772	.266
0,Q,S,P	.899	.229,.189,.207,.186	.528	.233
0,Q,S,P,I	.905	.211,.196,.199,.186,.015	.182	.227
0,Q,S,P,I,N	.909	.147,.199,.199,.179,.013,.100	.129	.224
0,Q,S,P,I,N,F	.915	.169,.202,.211,.173,.011,.068,-.007	.136	.219
0,Q,S,P,I,N,F,E	.915	.167,.203,.203,.172,.009,.063,-.007,.000	.122	.219
0,Q,S,P,I,N,F,E, G	.916	.168,.202,.205,.177,.011,.068,-.009,.000, -.048	.127	.219
0,Q,S,P,I,N,F,E, G,R	.916	.124,.159,.206,.137,.012,.071,-.016,.000, -.048,.123	.169	.220
0,Q,S,P,I,N,F,E, G,R,H	.916	.125,.163,.205,.140,.012,.072,-.017,.000, -.059,.113,.033	.161	.220
0,Q,S,P,I,N,F,E, G,R,H,K	.916	.126,.161,.206,.138,.013,.070,-.018,.000, -.058,.118,.036,-.002	.187	.221
0,Q,S,P,I,N,F,E, G,R,H,K,J	.916	.124,.161,.205,.137,.013,.071,-.018,.000, -.059,.121,.038,-.002,-.002	.196	.221
0,Q,S,P,I,N,F,E, G,R,H,K,J,L	.916	.124,.161,.205,.137,.011,.070,-.017,.000, -.058,.121,.036,-.005,-.004,.008	.189	.221
0,Q,S,P,I,N,F,E, G,R,H,K,J,L,M	.916	.124,.161,.204,.137,.001,.071,-.017,.000, -.060,.120,.036,-.004,-.005,.008,-.002	.215	.222