THE RELATIONSHIP BETWEEN CERTAIN FACTORS AND ACADEMIC SUCCESS IN COLLEGE MATHEMATICS

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CHAPTER I

INTRODUCTION

The problem of who should go to college and in what special fields of endeavor the students who go should concentrate is not one of recent origin. For many years now most colleges have been concerned about the high mortality rate of their students, due often to the lack of capacity of some individuals for certain types of endeavor. Moreover, psychologists have long known (1) that different mental processes are required for different subject-matter fields and (2) that individuals differ within themselves as well as among others in utilizing the mental processes they possess. Educational growth, then, would seem to depend to a large extent on intelligent and adequate educational guidance.

The growing enthusiasm for higher education makes the problem of effective differential guidance, and consequent reduction of student mortality, ever more pressing.

According to the annual report of the Federal Security Agency, about 31 per cent of the 1950 high school graduates enrolled in college as compared to 25 per cent of the 1930 graduates. This comparison has more meaning when it is known that in 1930 about 51 per cent of the youth of high school age were enrolled in high school whereas 77 per cent were enrolled in 1950.[1]

Satz, who studied the relationship between certain variables and

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[1] Federal Security Agency, Annual Report, 1952 (Washington, D. C., 1953), p. 14.

academic performance, makes this interesting statement concerning interest in higher education:

> One of the significant phenomena of our time is the popular interest in higher education. This interest is revealed by the ever-increasing number of applications for admission to various colleges and universities; by expressions of parents respecting the desirability of higher education for their children; by the increasing search by employers for technically trained persons to fill strategic positions in office, laboratory, and plant; and, at the same time, by the growing demand for a greater variety of curricular offerings to meet the vastly expanding needs of individuals in a culture such as ours.[2]

The full impact of this enthusiasm for higher education probably will not be felt until the great flood of children now enrolled in the elementary schools reaches college age.

It is now and will be the duty of persons responsible for higher education, in institutions such as The Oklahoma Agricultural and Mechanical College, to help these students discover the fields of endeavor for which they are best fitted and from which they will derive the most benefit.

Problem To Be Investigated

The problem of this study was concerned with but one small area of the total problem, that of the field of college mathematics. The specific statement of the problem and the hypotheses to be tested follow:

> What is the relationship between certain factors (the background in high school mathematics, the level of mental ability, reading comprehension, general reasoning ability,

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[2]Martin A. Satz, "The Relationship Between Eleven Independent Variables and Academic Performance in Nine Social Science Areas at the University of Washington," Unpublished Doctoral Dissertation (Seattle, 1953), p. 1.

achievement in algebra) and academic success in college mathematics as the degree of abstract thinking demanded in mathematics increases?

Hypotheses To Be Tested

1. The background in high school mathematics, as represented by semesters of high school mathematics completed, and by the grade point average in these courses, is significantly related to academic success in college mathematics as the degree of abstract thinking demanded in mathematics increases.

2. The level of mental ability, as determined by a standardized intelligence test, is significantly related to academic success in college mathematics as the degree of abstract thinking demanded in mathematics increases.

3. Reading comprehension, as determined by a standardized reading instrument, is significantly related to academic success in college mathematics as the degree of abstract thinking demanded in mathematics increases.

4. General reasoning ability, as determined by a standardized test of quantitative reasoning, is significantly related to academic success in college mathematics as the degree of abstract thinking demanded in mathematics increases.

5. Achievement in algebra, as determined by a standardized test in algebra at the time of entrance into college is significantly related to academic success in college mathematics as the degree of abstract thinking demanded in mathematics increases.

Procedure

Information relative to the high school background in mathematics, grade point average in college algebra and in calculus, was available in the Registrar's office. Scores on the American Council on Education Psychological Examination, used as a measure of mental ability, were available from the Bureau of Tests and Measurements. Scores on the Co-operative algebra Test, the Nelson-Denny Reading Test, and the Guilford-Zimmerman Reasoning Test were made available by the Mathematics Department.

In order to test the hypotheses, intercorrelation between all of the factors involved in the study and necessary partial correlations were computed.

The predictive power of this combination of factors was determined by the construction of multiple regression equations and calculation of the multiple coefficient of correlation.

Tables were prepared to show the relationship between each factor and grades in calculus and in college algebra.

A prediction table and a chart for determining the most probable grade category in which a student's grade in calculus would fall were prepared from data obtained by utilizing the most promising multiple regression equation.

The Purpose Of The Study

The purpose of the study was to provide evidence showing the relationship of the factors mentioned in the hypotheses to academic success in college mathematics, and to report this evidence in such a manner that it might prove helpful to counselors and teachers of students who are contemplating enrollment in a college program involving considerable

mathematics.

Three questions were inherent in the problem statement and the purpose: (1) What was the relationship between each of the factors and success in college algebra? (2) What was the relationship between each of the factors and success in calculus? (3) What was the comparison of these relationships?

A final purpose was made mandatory by the nature of the problem if the study was to be useful to counselors and teachers of mathematics. This involved combining the most promising factors into a prediction team for marks in calculus.

The Need For This Study

There is a real need to determine, as early as possible, the student's potentialities and the probability of his success in a mathematics program. It is almost an unpardonable waste of human effort and financial resources to allow a student to continue in a program in which he has little or no chance of success without making him aware of those chances, so that he may if he wishes transfer into a field where there is a greater probability of satisfactory experience.

The report of the President's Commission on Higher Education contains a particularly pertinent statement in this regard:

> . . . to assume that only those looking to professional careers can profit from college experience is to misread and under-estimate the broad personal and social benefits to be gained.
>
> The danger is not that individuals may have too much education. It is rather that it may be either the wrong kinds for the particular individual, or education dominated by inadequate purposes.[3]

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[3]President's Commission on Higher Education, Higher Education For American Democracy (New York, 1948), p. 7.

The report further states that, even with the inflexibility of the college curriculum of today, a minimum of 49 per cent of the people of college age have the ability to profit from at least two years of college work and that at least 32 per cent could go beyond two years successfully.

The trend toward increased enrollment in college makes ever more pressing the responsibility of college personnel to study the significance of all possible factors which may influence academic performance and to make the student aware of as many of his deficiencies as can be determined in order that he may properly appraise himself. No one study will be able to involve all of these factors, but a good beginning may be made by investigating those factors which have commonly been considered of more than passing importance.

Frederiksen makes a plea from the counselor's point of view for this sort of study:

> The longer I have tried to counsel students, the more I have been impressed with the lack of adequate information on which to base interpretations of test scores. Even when dealing with prediction of <u>academic</u> success, which has been studied more thoroughly than any other prediction problem, I often feel the handicap of a lack of useful information to give to the student sitting across from my desk who wants to know his chances of being successful in some academic undertaking. To such problems as the choice of a college, the choice of a curriculum, the choice of a graduate school program, a client might legitimately expect me to make useful statements about probabilities of success in those academic programs which he is considering.
>
> What I am trying to say is that I, for one, feel frustrated by the lack of adequate information for the interpretation of a test score.
>
> What can I do about it? I believe that there are several things that can be done, and the first is to put my own house in order. I should at least be able to make reasonably accurate differential predictions of success

> in the various divisions of my own institution. My first recommendation, therefore, is that local validity studies should be made. Separate studies should be made of the major academic programs at one's own institution.[4]

The importance of helping students find the right place in the college program has been recognized by many advisers for a long time. These advisers recognize that this is not a problem which is likely to be resolved on enrollment day, when the student is helped to make his choice of curriculum. The problem goes farther back than that and continues through the entire college program.

MacRae, writing on the responsibility of the college for the welfare of the student, makes this statement:

> The college's concern for the welfare of the student should begin with the institution's recruitment program. Increasingly, tests, scales, formal and informal inventories, and other devices are being used to give prognoses of probable success in various kinds of colleges and different types of programs. A better use of these instruments and of other techniques which the college may devise should lessen the number of students who drop out of America's institutions of higher education. In some schools the mortality rate reaches the alarming proportion of 60%. In other institutions this proportion is below 5%. Although there are factors that impel some institutions to admit students whose needs they cannot meet, the lower mortality percentage above should be accepted as a challenge by the guidance forces of the high school and college.[5]

The problem of failure in mathematics at The Oklahoma Agricultural and Mechanical College is not at all new. It is quite interesting to find this statement by Harrington made in 1928:

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[4]Norman O. Frederiksen, "Making Test Scores More Useful For Prediction," Educational and Psychological Measurement, XI (Winter, 1951), 783-787.

[5]James Bonner MacRae, "Responsibility of the College for the Welfare of the Student," Current Issues in Higher Education, (1950), 51.

> The mathematics department of the Oklahoma Agricultural and Mechanical College has been troubled for many years by the extremely large percentage of failures in its courses. Figures from the President's Office for the year 1926-27 place this percentage at 46.[6]

There has been a constant effort through the years to find ways to lower this percentage of failure. Further evidence of the truth of this statement is found in a study by Clark in 1930:

> In the light of modern investigations, we have come to question the validity of the popular belief that our state furnishes to all individuals equal opportunity as an equal legal claim upon the institutions of learning supported by the state without considering the fitness of these institutions to meet equally well the needs of all individuals. That all individuals are not equally able to profit by the training of the traditional type of school has long been accepted as a fact . . .. Much waste of funds and effort, for the college and for the student concerned, could be avoided if some criteria could be developed for predicting, more accurately, success in college.[7]

The Report of the President's Commission on Higher Education considers the problem of equal opportunity in the opening statement:

> Equal educational opportunity for all persons, to the maximum of their individual abilities and without regard to economic status, race, creed, color, sex, national origin, or ancestry is a major goal of American Democracy. Only an informed, thoughtful, tolerant people can maintain and develop a free society.
>
> Equal opportunity for education does not mean equal or identical education for all individuals. It means, rather, that education at all levels shall be available equally to every qualified person (italics not in the original).[8]

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[6]Harold E. Harrington, "The Prediction of Success in Algebra by the Use of the Iowa Placement Examination and the Otis Mental Test," Unpublished Master's Thesis, (Stillwater, Oklahoma, 1928), p. 10.

[7]Alice Beuls Clark, "An Analytical Study of Good and Poor Students Among College Freshmen," Unpublished Master's Thesis, (Stillwater, Oklahoma, 1930), p. 7.

[8]President's Commission, Higher Education for American Democracy, p. 1.

How, then, are college personnel to determine who the qualified persons are and in which areas they are best qualified to study?

With the outlook for increased college enrollment and the emphasis on equal educational opportunity, colleges will need to be on guard against a dilution of standards. The Commission Report makes clear in this further statement that no such intention is implied, " . . . nor does it believe that a broadening of opportunity means a dilution of standards either of admission or of scholarly attainment in college work."[9]

College entrance requirements have not always been based on the philosophy of education which emphasizes the importance of the individual student above the importance of the subject matter. Early colleges were quite limited in space, equipment, and instructional staff. Their objective was also very different. They were concerned almost entirely with the production of a small number of scholars who could master the great body of knowledge of the past, our cultural heritage. This meant an almost equal ability to master work involved in many subject areas. It was, therefore, only natural and common practice to demand of those who entered college that they be equipped with high intelligence, adequate knowledge, and superior ability.

It is easy to see why the traditional entrance requirements came into being, and probably adherence to that tradition explains why colleges have not adjusted these requirements to meet the changing times and conditions.

Perhaps the two most popular present-day methods of determining whether or not a person is qualified to enter college are the satisfactory

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[9] Ibid, p. 1.

completion of a prescribed number of units of high school work resulting in a high school diploma, and entrance examinations.

Considerable thought has been given in recent years to the inadequacy of these admission requirements. Douglass, in a study of the relation of high school preparation and certain other factors to academic performance in college, is emphatic on this point:

> Not only do the results of this study indicate that such entrance requirements contribute practically nothing to the differentiation of good from poor student college risks, but all other studies of similar nature agree in this respect. In fact, no record can be found by any thorough-going objective investigation ever conducted which affords any rational support for the practice of conditioning general admission to the University upon the completion of prescribed units of certain favored fields.[10]

One of the objectives of a study by Black[11] was to determine the relationship between the number of units of high-school work and university grades. He found that the relationship between the number of units completed in a particular high school subject area and successful performance in any given subject matter area was very slight. Correlations ranged from -.247 to +.291. His conclusion was that the relationships were not high enough to justify placing much emphasis on subjects completed in high school as guides for admission to and enrollment in corresponding subject-matter areas in college.

The entrance examinations commonly used for the purpose of determining the ability to do college work have not proved very satisfactory

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[10]Harl R. Douglass, "The Relation of High School Preparation and Certain Other Factors to Academic Success at the University of Oregon," University of Oregon Publications, XXX (September, 1931), 56.

[11]Donald B. Black, "Prediction of Academic Success in the University of Washington," Unpublished Doctoral Dissertation, (Seattle, 1951).

as indicators of success in college. They have proved to be of even less value in helping to determine what the probability is that a student may be successful in a particular curriculum area such as mathematics.

Wallace, University of Michigan, in a study of the value of the American Council on Education Psychological Examination in this respect, makes the following comment:

> The freshman testing program has become an established practice among most colleges and universities in this country. Its content and extent varies as to the examinations administered, but, typically includes one or more instruments designed to estimate the incoming student's aptitude for college-level study with the possible addition of an appraisal of his competence in particular areas.
>
> The proposed and actual uses of the results of these tests include placement of students in appropriate sections or courses; educational, vocational, and personal guidance; selection of students for particular areas of concentration or pre-professional training; and research of various sorts. All too often no application is made of the results at all.
>
> Although it was believed that scores on these tests would be an aid in determining the suitability of individual students for electing particular courses or fields of concentration, insufficient evidence was available on which to base such determinations. The only clues counselors could use in the application of test results were knowledge of the content of the tests, subjective judgement, and to some extent, information from investigations made at other institutions on the predictive value of a few of the tests used.[12]

The use of entrance examination covers a relatively long period in the history of higher education in the United States. Douglass, writing more than twenty years ago, points out the historical significance

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[12] N. L. Wallace, "Differential Predictive Value of the A. C. E. Psychological Examination," School and Society, LXX (July 9, 1949), 23-25.

of the entrance examination:

> Until the early seventies the method uniformly employed was that of the entrance examination. First employed at the University of Michigan in 1871, the accrediting system has spread until at the present time it is now the prevailing means. The accrediting method is the principal avenue of entrance to practically every state supported institution and to the very large majority of privately supported colleges and universities. It is still possible to enter practically all institutions of higher learning by the college entrance examination route and several institutions, principally colleges for women in New England and the Middle Atlantic states, receive students only on that basis. Because of the confusion occasioned from varying standards resulting naturally from the setting at each individual institution a different examination, there was formed in 1900 the College Entrance Examination Board for the purpose of standardizing the examination given for the purpose of selecting college entrants.
>
> With the development of group mental, or, as they are often called, psychological or intelligence, tests or examinations, this type of criterion has been urged as a means of determining the capacity to do college work. For reasons which we cannot pause to discuss here, mental tests are employed in but a small minority of institutions for the purpose of selecting college entrants and then only to furnish supplementary data. Perhaps in no institution are they employed as the sole criterion for determining the acceptance or rejection of applicants for entrance.[13]

It is quite interesting to note that Douglass, writing at a much later date, was still interested in ways and means of discovering just what it is which determines how successful a student may expect to be in an area of college work. Reviewing the results of scholastic success studies at the University of Minnesota, Douglass concluded:

> It would therefore seem that there is no simple, uniform threshold of ability to succeed in a university having several schools and colleges. The abilities required for success in the various schools and colleges vary both in nature and in degree.[14]

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[13]Douglass, op. cit., p. 5.

[14]Harl R. Douglass, "Different Levels and Patterns of Ability Necessary for Success in College," Occupations, XXII (December, 1943), 182-186.

Early educational literature, as well as that of more recent date, abounds with reports of studies made in an attempt to shed some light on the factors influencing success in algebra. Yet the problem remains as one of the most important in our time. One might be inclined to agree with Summers,[15] who feels that a point of no progress in the use of examinations for prognosis has been reached. But an attitude of defeatism will not solve the problem. If the problem is to be solved, continuous study must be made of all factors, intellectual and others, which are suspected of bearing a relationship to academic success in any curriculum area. Whether or not the factors used in a particular study are found to bear a significant relationship to academic success seems to the writer to be not quite so important as is the constant effort to find such factors. If enough studies are done and enough factors are considered, the long-term result will be the discovery of the factors most valuable in helping to determine whether a student has the qualities, both academic and otherwise, which are necessary for success in his chosen college program. It would seem to be just as significant, in the long-term picture, to discover that a certain factor bears no significant relationship to academic success in a program such as mathematics, as it is to discover that a factor bears a significant relationship.

Overview of Remainder of Thesis

An account of the procedure, the sources of data, the scope, and the limitations of this study are found in Chapter II. A description of the test instruments and what they purport to measure will be

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[15] R. E. Summers, "Some Thoughts on Prediction of Academic Achievement," College and University, XXVI (January, 1951), 229-235.

included. The nature of the criterion grades and the weaknesses of such criteria will be discussed.

Chapter III will be a report of selected related studies. Although no studies were found which attempted to do quite the same thing as attempted in this study, certain studies were related in one or more ways to the present study. Only those studies were selected which involved the relationship between the same variables used in this study, or similar ones, and academic success in some portion of the college mathematics program. Some attention will be given to the techniques used and the results obtained. No effort was made to confine the account of related studies to those with results in agreement with the present study. Consequently, some very interesting contrasts in results will be observed.

Chapter IV will describe in detail the procedure used in this study, present the data, and analyze the results obtained. The relationship of each factor to grades in calculus and to grades in algebra will be compared. Finally, through partial and multiple correlation and the formulation of a regression equation involving the factors most closely related to academic success in calculus, the evidence from the study will be put into useable form. As a part of this final step, an analysis of the two factors most closely related to success in calculus will be made, and the results will be presented in chart form for the convenience of those who want a quick estimate of the most probable category in which a student's grade in calculus may be expected to fall.

Chapter V will summarize the objectives, the findings, and conclusions of this study.

CHAPTER II

SOURCES OF DATA, SCOPE, AND LIMITATIONS

The purpose of this chapter is to describe briefly the procedure used in selection of factors and subjects for the study, give the sources of data, describe the test instruments used, and call attention to some of the important limitations of the study.

Selection of Factors For Study

After the decision was made to study the relationship of certain factors to academic performance in college algebra and in calculus, the next step was to choose factors for study which would most likely be related to such performance. A survey of the literature furnished many clues as to what factors would most likely bear a significant relationship to academic performance in college algebra, but not many clues could be found with regard to calculus. Of the factors examined and considered, the following seemed to hold the most promise: mental ability, reading comprehension, reasoning ability, achievement in algebra at the time of entrance into college, the number of semesters of high school mathematics completed, and the grade point average in high school mathematics.

Selection of Subjects For Study

The subjects chosen were the students enrolled in calculus at The Oklahoma Agricultural and Mechanical College during the fall semester of the school year 1953-54. About two hundred students constituted the

original group. It was found that complete data were not available for students who transferred from foreign countries and other institutions. After discarding these subjects, 160 cases remained on which complete data were available.

Sources of Data

As measures of mental ability, the scores on the American Council on Education Psychological Examination[1] were used. All entering freshmen students at The Oklahoma Agricultural and Mechanical College are required to take this examination. The scores were made available through the Bureau of Tests and Measurements. The mathematics department administers the American Council on Education Cooperative Algebra Test[2] to all freshmen students enrolling in mathematics. These results were made available by the mathematics department and used as a measure of achievement in algebra at the time of entering college. With the cooperation of the personnel of the mathematics department, the Nelson-Denny Reading Test[3] and the Guilford-Zimmerman Test in Reasoning[4] were administered to the subjects of this study at the beginning of the semester. Records of high school mathematics courses and grades, and records of grades made in college algebra and calculus, were obtained from the registrar's office.

These data were recorded on especially prepared five by eight individual data cards. The data were later transferred to International Business Machine punch cards to facilitate calculations necessary for

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[1] Hereafter called the "A.C.E."
[2] Hereafter called the "cooperative algebra test."
[3] Hereafter called the "reading test."
[4] Hereafter called the "reasoning test."

the study.

Description of Test Instruments

At this point a description of the test instruments involved in this study seems to be in order.

The American Council on Education Psychological Examination.[5] The psychological examination consists of six tests. Factorial analyses have justified grouping the six tests into two general classes as follows: (1) Quantitative tests yielding the Q-score include arithmetical reasoning, number series, and figure analogies, and (2) Language aptitude tests yielding the L-score include same-opposite, completion, and verbal analogies. The test has a reliability coefficient of .94 with a standard error of .01.

The purpose of the A. C. E. examination is to appraise what has been called scholastic aptitude or general intelligence, with special reference to the requirements of most college curricula. It has been found that, in general, language aptitude tests give higher correlations with scholarship in the liberal arts colleges than do quantitative tests. This higher correlation is probably, in part, due to the fact that most of the freshman courses in the liberal arts programs depend more upon language abilities than upon the abilities involved in quantitative thinking. For the scientific and technical curricula the quantitative tests may be more significant. Those who have become convinced of the merits of psychological tests sometimes over-estimate the significance of the test scores. While the scores do show roughly the mental alertness of

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[5]Published by Cooperative Test Division, Educational Testing Service, Princeton, New Jersey.

the student, they should not be thought of as measuring capacity for learning with high accuracy. The scores are indicative of the mental alertness of the student and reflect his previous education, but they should not be taken so seriously as to exclude other evidences of intelligence and talent in individual cases. Generally, the best usefulness of the tests is in combination with other evidences of ability.

The Guilford-Zimmerman Test of General Reasoning.[6] According to its authors, the Guilford-Zimmerman Test of General Reasoning is designed to measure the ability to diagnose problems. They point out that this is only one of several types of reasoning. The reasoning test is one of seven parts in what is known as the Guilford-Zimmerman Aptitude Survey. The survey was developed with the conviction that the aptitudes required for doing successfully the many kinds of tasks in a complex society are much more numerous and varied than has generally been supposed. The authors also believe that aptitudes of individuals can be evaluated most adequately, economically, and meaningfully by using a series of tests, each of which measures a unique ability. The internal-consistency reliability of the General Reasoning Test is .89 with a standard error of .01.

The Nelson-Denny Reading Test.[7] The Nelson-Denny Reading Test is designed to serve the following purposes: (1) To predict probable success in college; (2) to section incoming college or high school classes; and (3) to aid in the diagnosis of students' difficulties. The test consists of two parts: (1) A test of vocabulary; and (2) a test of ability to read and understend paragraphs. Studies indicate that for

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[6]Published by Sheridan Supply, Beverley Hills, California.
[7]Published by Houghton-Mifflin Company, Dallas, Texas.

college students the test predicts general scholastic success about as well or better than the better intelligence tests. The reliability coefficient for the test is .91 with a standard error of .01.

The Nelson-Denny Reading Test was used in this study for the primary purpose of obtaining a measure of reading comprehension.

The American Council on Education Cooperative Algebra Test.[8] The American Council on Education Cooperative Algebra Test is designed to measure achievement in elementary algebra through quadratics. The test is composed of 63 problems covering the very elementary items as well as items of relatively more difficult nature that are usually included in a high school algebra course of one year's duration. The mathematics department at The Oklahoma Agricultural and Mechanical College has, for many years, used this test to determine as well as possible the proper placement of students enrolling in their first college mathematics course. The reliability coefficient for the test is .90 with a standard error of .02.

The purpose of this test, so far as this study was concerned, was to measure the achievement in algebra at the time of entrance into college.

Mathematics Background

Semesters of Mathematics Completed in High School. The inclusion of the number of semesters of mathematics completed in high school was deemed valuable by the writer for two reasons: (1) Interest in the subject of mathematics may be revealed, at least to some extent, by the quantity of mathematics taken, particularly if this quantity exceeds the minimum requirement; and (2) Ability in mathematics may be somewhat

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[8]Published by Cooperative Test Division, Educational Testing Service, Princeton, New Jersey.

closely related to the election by students to take a considerable quantity of mathematics, for individuals do not ordinarily continue long in areas where they cannot do fairly well.

Grades Made in High School and College Mathematics. The decision to use grades made in high school mathematics as an independent variable and grades in college algebra and calculus as criterion data was made after consideration had been given to the problem of the reliability of these grades. Most educators would probably agree that school marks are notoriously unreliable, whether they are awarded in high schools or in colleges. A large number of studies have been made regarding the bases on which school grades are awarded, and recommendations have been made for proper practices. If educators would follow the recommendations of Ross in one such study, school grades might be more reliable:

> In determining any mark, only those factors should be considered which afford evidence of the degree to which the pupil has attained the objectives set up for that particular course.[9]

It is true, of course, that not all educators agree that achievement of the objectives of the course is the only factor upon which grades should depend. Some believe that effort, amount of improvement in abilities and skills, development of certain understandings apart from achievement, and many other factors should influence the grade awarded. Ross has this further comment:

> It seems too bad that the marks received by certain individuals are conditioned more by the contours of the face than by the contents of the head. . . . studies have shown that the pupil's handwriting, conduct, language ability, seating position in class, and ratings on such

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[9]C. C. Ross, Measurement in Today's Schools, (New York, 1947), p. 405.

> personality traits as respect for authority and cooperativeness are significant factors in determining his mark, as well as the condition of fatigue or boredom the teacher happens to be in when it is awarded.[10]

Grades are not completely satisfactory measures of success in college in general nor in any specific subject, for success seems to connote much more than achievement in a given subject. For studies like the present one, a measure of a particular type of success is desired. In spite of the many criticisms of grades, they are still used in most high schools and colleges for the purpose of recording the measure of academic success in his curricular program on a student's transcript.

Wallace makes a comment in this connection in his study of the differential predictive value of the A. C. E. Psychological Examination:

> In reporting previous studies on the predictive value of test results some authors have argued that grades were an unsatisfactory criterion of achievement and have sought to use a different one, such as achievement test scores. However, scholastic success continues to be judged entirely on the basis of grades, and it is the accuracy of the prediction of this type of success that the study is designed to investigate.[11]

The Oklahoma Agricultural and Mechanical College Mathematics Grades. The following statement concerning grades given to students in mathematics courses at The Oklahoma Agricultural and Mechanical College was made by Dr. Zant. The statement should prove helpful in interpreting the results of this study:

> This statement is based on opinion and convictions acquired over a long period of years in the teaching and administration of mathematics at this college. Analyses of grades assigned by individual teachers and of the total grades assigned to mathematics students during particular semesters or periods have been made from time to

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[10] Ibid., p. 404.
[11] Wallace, op. cit., p. 24.

time. Although these analyses have not been made consistently or for the same purposes, their results have had their effect on the opinions here expressed.

1. Whenever we have tabulated all of the mathematics grades given by the entire department in any one semester the distribution has been reasonably close to a normal one. This would probably be true for any semester since the enrollment is large, from 2000 to 2750 individual students taking courses in mathematics.

2. When we look at individual teachers and classes the chief characteristic is their variability. This is also to be expected since there are required courses which every student in a particular curriculum must take, there are terminal courses and graduate courses in which the enrollments are small and in which the students are highly selected. There is also some evidence that predominantly low grades are given to students in some sections because they are filled with students who are taking a curriculum for which they are not prepared and for which they have no ability, or both. For example, an entire class in Mathematics 103, Plane Geometry, may make extremely low grades, probably because they are enrolled in the Division of Engineering, for which the course is required as a non-credit course. Their ability or interest in any sort of mathematics is usually very low.

3. An examination of the distribution of grades given in individual classes indicates that few, if any, of the mathematics staff assign grades on the basis of the normal curve or normal distribution. However, there is evidence that the very existence of the normal curve or distribution does have a definite effect on the teachers' grades. This evidence is highly subjective and the opinion expressed is subject to the same limitation and may not be justified.[12]

Scope and Limitations of the Study

The use of grades either as criteria of performance or as independent variables is a limitation in any study which attempts to seek out relationships such as those sought in this study. The limited reliability of the grades will necessarily limit the reliability of any relationships obtained. However, many studies point out the value of grades in both

[12] James H. Zant, "Brief Statement Concerning Grades Given to Students in Mathematics Courses at The Oklahoma A. & M. College," Unpublished Document by Professor of Mathematics, the College, May, 1954.

high school and college subjects in determining such relationships.

The tendency of students to compensate for differences in native ability by expending more effort in order to perform satisfactorily will tend to reduce the difference that might otherwise occur in grades.

There is also an important limitation inherent in any study which attempts to study relationships or forecast the probable success of an individual in a particular course. Probabilities are based on the group in the same way that actuarial predictions are made in the field of insurance. Some investigators argue that the individual case is lost in the group for which forecasts are made. This is not true in educational studies any more than it is in insurance problems. The probability that a student's grade will fall within a certain range is just as valid a prediction as to state that there is a certain probability that a person will live to a specified age.

What must be kept in mind, however, is that there is no way to tell whether a particular student will fall in the successful or the unsuccessful portion of the group. The proportion of the students who will fall in each group can be predicted with a high degree of accuracy. The individual student can then determine his chances of success or failure and hence the risk of enrolling in a specified subject.

Subjects included in this study form another important limitation. The cases included only students enrolled in calculus at The Oklahoma Agricultural and Mechanical College during the fall semester of the school year 1953-54. In order to minimize this limitation two other groups of calculus students, those enrolled in the fall of 1949 and those enrolled in the fall of 1951, were compared with the present group on their mental ability as measured by the A. C. E. Psychological Examination and on their performance in calculus. This was an attempt to

establish the fact that the present group is typical of those students who enroll in a mathematics program and persist through calculus.

The study is further limited in the choice of the mathematics courses to represent the different degrees of abstract thinking demanded. The courses chosen were college algebra and calculus. College algebra was chosen because it is the first course in which students contemplating a program of mathematics are required to enroll. Students may enroll in elementary algebra at their own request or as a result of a low score on the Cooperative Algebra Test, but for the most part, those who continue very far in college mathematics enroll in college algebra as their first course. Calculus is the last of what are normally considered elementary mathematics courses. Calculus is usually considered by mathematics teachers to require a considerably greater degree of abstract thinking for satisfactory performance than college algebra does.

The number of cases may constitute a slight limitation. A total of 160 cases was included in the study. This many cases is usually considered sufficient to give fairly reliable results, particularly if compared to other similar groups to determine if the groups differ significantly or if they appear to be samples drawn from the same population.

CHAPTER III

RELATED STUDIES

In Chapter I an attempt was made to make clear that this study is primarily concerned with relationships between certain factors and grades received in the specific subjects, college algebra and calculus, with one of the possible outcomes being the formulation of a regression equation for the purpose of predicting grades in calculus. However, the study is not primarily one of prediction of academic success.

Types and Extent of Related Studies

In surveying the literature for studies with similar objectives it was discovered that about the only place relationships of this nature were found was in studies, the chief purpose of which was prediction of academic success. The great majority of these studies had as their aim either the prediction of over-all college success for the full four-year program or for some part of the program. Others were concerned with the prediction of over-all success in some subject-matter field or for some smaller part of the total program such as success in freshman mathematics.

The writer has been unable to find many studies which were concerned with the relationship between factors such as those studied here, and academic success in a specific subject coming late in the program, such as calculus. However, many of the studies present interesting and valuable information concerning some of the factors involved in this study and their correlation or relationship to academic success in

certain phases of the mathematics program. Bruce,[1] in a study conducted at the University of Washington, reports on the number of studies that have been conducted with prediction of academic success as the objective. Bruce quotes Angell, et al, on this point:

> Since the early twenties well over 1000 studies have been made in an attempt better to understand and cope with the problems of university admissions and failures. About ninety per cent of these studies used one variable and calculated zero order coefficients of correlation to determine evidence of predictive value of these variables. Approximately five per cent of the studies combined two variables and computed multiple coefficients of correlation. Some increase in the multiple coefficient of correlation was achieved by investigators using three-variable combinations but only some twenty of such studies have been completed. About eight studies attempted four or more variables with limited success but rarely does anyone attempt as many as eight independent variables as did the Angell study. Currently a study is contemplated in which twenty-six independent variables will be combined. The present study successfully handles the relatively large number of eleven independent variables.[2]

Recently, particularly since the development of applicable International Business Machine techniques, a few investigations have been conducted which utilized a large number of factors. A good example of one such study is that which was done at the United States Coast Guard Academy and reported by French.[3] The objective of the study was to identify factors which were, in a large part, responsible for the variations in psychological test scores and grades in subject matter.

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[1]John William Bruce, "The Contribution of Eleven Variables to the Prognosis of Academic Success in Eight Areas at the University of Washington," Unpublished Doctoral Dissertation (Seattle, 1952), p. 10.

[2]Melvin A. Angell, Richard C. Langton, George A. Meyer, and Maurice L. Pettit, "An Evaluation of General and Specific Admission Requirements at the University of Washington," Unpublished Doctoral Dissertation (Seattle, 1950), p. 10.

[3]J. W. French, et al., "Factor Analysis and Achievement Entrance Tests and Course Grades at the U. S. Coast Guard Academy," Educational Psychology, XLIII (February, 1952), 65-80.

Twenty-three tests were administered to 100 freshman cadets. The test data, along with the 14 grades made by each cadet, were compiled. A factor analysis isolated nine factors responsible for the variation. The four most important factors discovered, in order of their importance, were mathematical ability, verbal ability, reading ability, and spatial ability.

The following comment was made about a most fascinating factor which the author called "Grade Aptitude":

> There is also some factor which greatly affects course grades, termed "Grade Aptitude," but which is not measured by the actual or experimental entrance tests used in this study. This factor results from the similarity of grades received by cadets in every subject. This could be some factor like interest or effort, or could arise from the present grading system. The development of tests to measure this factor would be desirable.[4]

Studies Involving College Entrance Requirements

At the present time, as in the past, a number of colleges require only the presentation of evidence of graduation from high school as an entrance requirement. The assumption seems to be that the course of study in high school leading to graduation automatically prepares the student to enter college.

In speaking of "college-preparatory course" programs, Seyfert remarks, "The courses themselves may be very much worthwhile, but as true and valid preparation for college they are notorious for shooting rather wide of the mark."[5] Although this statement is recognized as being true, Seyfert, like so many others, does not make recommendations for

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[4] Ibid., p. 71.

[5] W. C. Seyfert, "Do You Recommend This Student For College?" School Review, LX (March, 1952), 129-133.

a curriculum revision to alleviate the situation which he recognizes.

Wolfenden,[6] Vice-Chancellor of the University of Reading, in writing along the same line, says in regard to college entrance requirements that the first criterion must be academic performance and promise. He says further that the evidence on which this selection has to be made is not very satisfactory and that there is still considerable information that the selectors inevitably lack.

That this lack of information is felt and recoghized by the colleges is brought out in this comment by Carter:

> The colleges themselves by adopting such entrance requirements as the Scholastic Aptitude Test have indicated that meeting the conventional unit requirement for college fails to disclose satisfactorily the fitness of many students for college.[7]

Dr. F. H. Bowles,[8] Director of the College Entrance Board, in a speech having to do with college admissions, delivered to the Fifteenth Educational Conference of the Educational Records Bureau, implied that within the next five years college entrance requirements will change greatly, and that many more applicants will be admitted without specific subject requirements, and emphasis in tests will be placed increasingly, not on what an applicant has had but on how he uses information and materials.

This forecast is of particular interest at the present time, since this statement was made four years ago and no marked change has been

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[6] J. F. Wolfenden, "Selection for Universities," Universities Quarterly, VI (November, 1951), 16-39.

[7] M. H. Carter, "Modern Secondary School Looks at College Admission," College and University, XXVI (April, 1951), 349-361.

[8] F. H. Bowles, "Crystal Ball and College Admission," Measurement and Evaluation in the Improvement of Education, 15th Educational Conference, New York, 1950, pp. 8-16.

evident in entrance requirements. The problem of selection and guidance into a field of endeavor where at least some degree of academic success may be reasonably expected seems to be no nearer to a solution than it was when this forecast was made.

The Steering Committee of the Illinois Secondary School Curriculum Program, a committee of secondary school and college representatives under the chairmanship of Dr. Ralph W. Tyler of the University of Chicago, made a thorough study of college admissions policies and came forth with a number of recommendations. Among these recommendations are found the following statements:

> . . ., it is recommended that the college adopt admissions policies which do not specify the courses the students are to take in high school, but specify the kinds of competence to be required of entering students. There has been extensive research on the kinds of competence which are good predictors of college success. The following five criteria can be used by a college or university to provide the best prediction of the probable success of the student in college: 1. Score on a scholastic aptitude test; 2. Score on a test of critical reading; 3. Score on a test of writing skill; 4. Score on a simple mathematics test; 5. Evidence that the student has an intellectual interest and some effective study habits as shown by his having taken at least two years of work in one field in high school in which his grades were better than average. It is recommended that the foregoing criteria be used for admission to general college work in place of any other set of entrance requirements.[9]

For evidence that the concern about the high mortality rate of students in institutions of higher learning is well founded we have only to look around us. The record at the University of Washington as reported by Black is typical:

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[9]Steering Committee, Illinois Secondary School Curriculum Program, New College Admission Requirements Recommended, Bulletin No. 9, Circular Series A, No. 51, (Springfield, Illinois, February, 1950), p. 14.

> It seems highly questionable, wasteful of human resources, inefficient, and costly for a university to determine the eligibility of students by admission requirements which admit 2868 students of whom 45% withdraw from the University before the end of their second year with records primarily of low grades, few credits completed, and many credits "failed," "withdrawn" and "incomplete." (The percentage of students withdrawing with such records were: after one quarter-7.04%; two quarters-7.85%; three quarters-16.28%; four quarters-6.17%; five quarters-7.81%. A total of 1295 of the 2868 freshmen withdrew before completing six quarters at the University of Washington.)[10]

This concern is not of local origin, nor is it confined to our country. The British are disturbed by this relatively good record reported by Baker:

> In the Faculty of Science at Bristol 80 per cent of those entering the honors school were allowed to continue after their first year, 2 to 3 per cent were required to leave, and the rest were directed to ordinary degree courses or made to repeat the year's work.[11]

Baker emphasized that lack of advice or wrong advice is a crucial factor in student failure by commenting that, "It did not matter so much which university candidates went to; what they required was advice on what courses of study to follow."[12]

Studies Predicting Grades in College Mathematics

Barrett, in a study of entering freshmen at Hunter College, reports on the relationships of scores on the A. C. E. to grades in trigonometry, college algebra, and analytic geometry:

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[10] Donald B. Black, "Prediction of Academic Success in the University of Washington," Unpublished Doctoral Dissertation, (Seattle, 1951), p. 81.

[11] William Baker, "Who Should Go to the University? Machinery of Selection Discussed," Times Education Supplement, MCMXLI (December 21, 1951), 984.

[12] Ibid., 984.

> The quantitative scores obtained on the 1947 and 1948 editions of the ACE did not correlate significantly better than the linguistic scores with grades in analytic geometry, college algebra, and trigonometry. In fact in the case of trigonometry, the quantitative scores correlated less well with grades than did linguistic scores.[13]

She concluded that these data are interpreted to mean that quantitative scores should not be used as a differential predictor of achievement in college mathematics courses.

In a study conducted at the University of Washington by Newhall and Snoddy, the relationship of five independent variables, high school average, reading comprehension, A. C. E. Q-score, A. C. E. L-score, and reading aptitude, to academic success in the various subject-matter areas was studied. Because of the similarity of that study to the present study, it was considered of value to quote extensively from the section dealing with prediction of success in the over-all area of mathematics:

> The seventy-nine students in this study who had taken mathematics courses earned an average grade point of 22.9 (2.29) in that subject. The zero order correlation coefficients between University mathematics and each of the predictive criteria is shown in Table XV (reproduced in this study as Table I). The highest correlation was between university mathematics and the A. C. E. (Q) score. This finding is not surprising as this is the quantitative section of the A. C. E., the mathematical part of the test. The obtained coefficient $r_{15} = .3982$ yields a coefficient of forecasting efficiency $E = .0835$ or 8.35 percent better than chance. As this was the highest zero order correlation of all the independent variables with the criterion, it may be said that none were high enough to be significantly predictive of success in university mathematics.
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> . . .. When partial coefficients of correlation had been computed, the highest coefficient was still that

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[13]Dorothy M. Barrett, "Differential Value of Q and L Scores on the A. C. E. Psychological Examination for Prediction Achievement in College Mathematics," Journal of Psychology, XXXIII (April, 1952), 205-207.

between A. C. E. (Q) average and university mathematics, though it had decreased from .3982 to .2403. The coefficient for reading aptitude changed from $r_{13} = .1801$ to a negative $r_{13.2456} = -.0512$, indicating that reading speed and good general vocabulary are by no means essential to success in university mathematics.

The multiple coefficient of correlation $R_{1.23456} = .4519$ yields a coefficient of forecasting efficienty $E = .1070$, an increase over any single variable of .0235 or 2.35 per cent better than chance . . ..

The regression equation gives the predicted grade point in university mathematics multiplied by ten. The sigma error of the predicted grade is 8.83 (.883). This indicates that if the university grade point be predicted from the five variables used in this study, sixty-eight percent of the achieved grades would be within .883 grade points of the predicted grade points.[14]

TABLE I*

MEANS, SIGMAS, AND INTERCORRELATIONS BETWEEN AVERAGE IN UNIVERSITY MATHEMATICS AND THE FIVE PREDICTIVE CRITERIA

Variables	H. S. Average	Reading Apt.	Reading Comp.	A. C. E. Q	A. C. E. L
Univ. Math.	.32	.18	.27	.40	.28
H. S. Av.		.16	.33	.39	.25
Reading Apt.			.78	.28	.62
Reading Comp.				.33	.52
A. C. E. (Q)					.57
A. C. E. (L)					
Means	2.60	42.68	51.13	52.71	56.57
Sigmas	.53	7.00	6.51	27.68	27.46

*From Master's Thesis by W. S. Newhall and C. D. Snoddy, University of Washington, 1950, p. 81. (Coefficients of correlations have been rounded to two places.

[14] W. S. Newhall and C. D. Snoddy, "The Relation of Reading and Other Criteria to University Success," Unpublished Master's Thesis, (Seattle, 1950), pp. 80-103.

Shirley conducted a study at The Oklahoma Agricultural and Mechanical College in which an attempt was made to determine the value of certain placement tests given to students entering the mathematics program at the freshman level. An attempt was also made to determine the best time to give the tests:

> All students who enrolled at the Oklahoma Agricultural and Mechanical College for the fall term of 1948 and who were entering a school where mathematics is required, were required to take two mathematics placement tests previous to enrolling. They were the Cooperative Algebra Test, Revised Series Form S, and the Cooperative General Mathematic test, Revised Series Form O, distributed by the American Council on Education. The tests will hereafter be known as T_1 and T_2 respectively.
>
> . . .. During the third week of school the Cooperative Algebra Test, Revised Series, Form T, hereafter known as T_3, was given . . ..[15]

Shirley summarized his findings as follows:

> 1. In predicting mathematics grades for students who enrolled in Elementary and Business Arithmetic, none of the placement tests given are of any value.
>
> 2. In predicting grades for students who enrolled in Intermediate Algebra, College Algebra, Trigonometry, and College Algebra-Trigonometry, each of the three tests is of value, although the grades for students enrolled in Intermediate Algebra are not predicted as well by any test as the grades of students enrolled in more advanced courses.
>
> 3. In view of the fact that T_1 and T_3 have higher correlation coefficients and lower standard errors of estimate and that T_2 does not assist by predicting grades above that which can be done by T_1 and T_3, it seems that T_2 can be omitted with no loss of information.
>
> 4. By observing the test means, it may be noticed that the students who made higher scores on T_1 showed a greater gain in knowledge during the review than those who made the lower scores.

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[15] Walter Warren Shirley, "The Use of Placement Tests in Freshman Mathematics," Unpublished Master's Report, The Oklahoma Agricultural and Mechanical College, 1949, pp. 5-6.

5. Students who have had four semesters of high school algebra can be expected to handle College Algebra and need not be required to take the placement tests.

6. Students who are qualified to take College Algebra are equally qualified to take Trigonometry.[16]

Hannah[17] compared the value of high school grades in subject-matter areas with cooperative test scores in the same areas. The Cooperative General Mathematics Test scores were more closely related to success in college mathematics than were high school grades in mathematics. This was also found to be true in other subject areas. Hannah concluded that his study offered evidence to refute the commonly held assumption that high school grades are better predictors of college success than are achievement tests.

Symonds, in a study of the achievement of high school students in algebra in relation to their intelligence, concludes that, in general, a high rating in intelligence means high achievement in algebra and a low rating in intelligence means low performance in algebra.

Although this study concerned high school students, there is no reason to believe that these findings would not be equally true for college algebra students. There is no evidence in the study, however, to support such an inference. Symonds makes this interesting comment:

> Mathematicians plead for a compulsory first year high school course; mathematicians also plead for a maintenance of past standards. The two are incompatible. If the values of algebra are achieved only by those who acquire a certain ability, as the writer believes, then an elective course comparable in its standards of difficulty with the course of the past is the solution. If it is believed that certain values are important for all,

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[16] Ibid., p. 45.

[17] Joseph V. Hannah, "A Comparison of Cooperative Test Scores and High School Grades as Measures for Predicting Achievement in College," The Journal of Applied Psychology, XXIII (April, 1939), 289-297.

> then different courses must be planned to accommodate individual differences and to allow all who can to profit by a more rigorous course.
>
> We favor raising the current passing standard. It is absurd to allow pupils to take algebra for a year when the final result is so meagre and the final ability so low as at the present. If this passing standard is raised, a more thorough and substantial course could be given with greater value to those taking it and less waste for those now taking algebra but not meeting this standard . . .. A standard corresponding to an alpha score of 100 (I. Q. of 110) would mean that approximately one half of the secondary school population of the country could not come up to this standard in a year's time . . .. By and large, high intelligence means high ability in algebra, and low intelligence means poor ability in algebra. Of the twenty-two brightest pupils out of the 100, seventeen will be above the average in algebra and of the twenty-two stupidest pupils, seventeen will be below the average in algebra.[18]

Newhall and Snoddy report a study by Stright dealing with the relation of Reading Comprehension to the solution of algebraic problems:

> A high school Freshman class, seventy in number, took ninth grade algebra from Stright. He divided the class into two groups to which he refers as groups A and B. The two groups were evenly divided as to size. No particular factor influenced the grouping of the class. Group A was used as the experimental group and Group B became the control group. At the beginning of the school year the Iowa Silent Reading Test, Form A, was administered to both groups. The results of this test showed a difference of .92 between the mean scores of the two groups in favor of Group B. This difference fell within the probable error of the test and had, therefore, little significance.
>
> Stright had Group A for an activity hour once a week. During the first week this hour was spent studying The Student's Guide to Efficient Study.[19] The students were also given material on efficient study habits taken from courses in educational psychology. This material was

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[18] Percival M. Symonds, "Special Disability in Algebra," Columbia University Contributions to Education, No. 132, (New York, 1923), p. 70.

[19] Luella Cole and Jessie Mary Ferguson, The Student's Guide to Efficient Study, (New York, 1935), p. 38.

taught as a subject in itself with class recitation, drill, and tests. The pupils were taught how to read and how to study.[20]

In January the Henmon-Nelson Test of Mental Ability was administered to both groups. The results favored Group A with a difference of .42 between the mean scores. Little significance could be attached to this difference as it was within the probable error of the test. The remedial class was continued for Group A throughout the second semester. At the end of the school year a battery of the tests was given to both groups. The results of the experiment were as follows:

1. The experimental group, which received the specific training in reading, advanced from an average score in reading comprehension of 77.08 to 107.86, an increase of 30.78, whereas the control group progressed from 78 to 89.3, an increase of only 11.3. In other words the experimental group increased from a reading grade level of 9.5 to 11.8 whereas the control group increased from a reading grade of 9.6 to only 10.6. The latter of course, should be the normal development as revealed by the Iowa Silent Reading Test.

2. The average score on the cooperative Algebra Test made by the experimental group was 26.63 whereas the mean score of the control group was only 18.76.

3. The difference between the mean scores on the total reading comprehension and the algebra tests were proved statistically to favor the experimental group 98 times in 100 among groups similarly selected.[21]

Stright stated the conclusions of his study as follows:

First, it is obvious that a definite relation does exist between a student's ability to read with comprehension and his skill in solving algebraic problems. The Cooperative Algebra Test, Elementary Algebra Through Quadratics, Form 1936, is composed largely of statement problems. The experimental group in this investigation who received the special training in reading made a noteworthy gain over the control group in this test.

Second, a better knowledge of reading mechanics does increase a student's reading comprehension.

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[20] Newhall and Snoddy, op. cit., p. 21.

[21] Isaac L. Stright, "The Relation of Reading Comprehension and Efficient Study Methods of Study to Skill in Solving Algebraic Problems," Mathematics Teacher, XXXI (December, 1938), 368-372.

> Third, this increase in reading comprehension does carry over into the student's ability to solve algebraic problems.
>
> Fourth, word meaning should be stressed in the teaching of algebra.
>
> In the writer's opinion a number of inferences can also be made as a result of this investigation. First, if this increase in reading comprehension carries over to an increase in the student's ability to solve algebraic problems, it would seem likely that it would also carry over toward an increase in the ability to master other academic subjects. Of course, the experiment does not prove this inference. Further investigation is necessary.[22]

Bruce,[23] after a rather comprehensive review of correlation studies, summarized his findings regarding the correlation coefficients between university mathematics average and various standard tests. The summary is presented in Table II.

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[22] Ibid., p. 372.
[23] Bruce, op. cit., p. 47.

TABLE II*

SUMMARY OF ZERO ORDER CORRELATION COEFFICIENTS BETWEEN UNIVERSITY MATHEMATICS AVERAGE AND STANDARDIZED TESTS

Investigator	Number of r's	Range of r	Median r	Test
Black**	6	-.16 - .64	.30	A.C.E.
	4	-.10 - .41	.23	Mental tests other than A.C.E.
	6	.09 - .74	.42	General Achievement tests
Lanigan**		.19		Minnesota Speed of Reading
Odell**		.31		Otis Quick Scoring Group (Algebra)
Stoddard**		.43		Iowa Comprehension Test
Wallace**		.276		A.C.E. (Q)
		.176		A.C.E. (L)
		.258		A.C.E. (T)
		.116		Cooperative English Vocabulary
		.217		Cooperative Reading Comprehension
		.191		Social Studies Vocabulary
		.234		Science Vocabulary
		.377		Iowa Foreign Language
		.421		Mathematics Placement
		.242		Visualization
Newhall and Snoddy**		.40		A.C.E. (Q)
		.28		A.C.E. (L)
		.27		Reading Comprehension
		.18		Reading Aptitude
Jex**	2	.23, .25		Cooperative General Achievement (English)
	2	.25, .30		Cooperative General Achievement (Social Studies)
	2	.28, .44		Cooperative General Achievement (Natural Science)
	5	.43 - .56		Cooperative General Achievement (Mathematics)

*From a Doctoral Dissertation by John William Bruce, University of Washington, 1952, p. 47.
**See Bibliography, p. 85.

Kinzer and Kinzer[24] studied 1244 students at Ohio State University who took college algebra and subsequent mathematics courses. Students were compared on performance on the Ohio State Psychological Examination and on grades made in mathematics courses.

For the 326 persons who finished the calculus course at Ohio State University which corresponds in content to the calculus course involved in the present study, a correlation coefficient of .13 was found between O. S. P. E. scores and grades in calculus, and a correlation of .18 was found between O. S. P. E. scores and grades in college algebra. The grades in college algebra and the grades in calculus were related by a correlation coefficient of .34; trigonometry and calculus grades, .47; and elementary calculus and calculus grades, .45.

The mean grade point for the 326 cases was 2.9 in college algebra and 2.4 in calculus. The standard deviation was .9 in college algebra and 1.1 in calculus.

When all grades in courses prerequisite to calculus and O. S. P. E. scores were combined into a prediction team, a multiple correlation coefficient of .61 was obtained with a standard error of .03.

Studies in General Prediction, Including Mathematics

In a number of studies an attempt was made to predict academic success in the total college program or in several areas, including mathematics. Some of these studies used prediction factors common to the present study and hence were of considerable interest.

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[24]John R. Kinzer and Lydia Green Kinzer, "Predicting Grades in Advanced College Mathematics," The Journal of Applied Psychology, XXXVII (June, 1953), 182-184.

Brown studied entering freshmen at Long Beach City College, California. The study compared scores on the A. C. E. Psychological Examination and grades made in what he called quantitative subjects and linguistic subjects.

Some pertinent information from Brown's study follows:

> Since counselors and admission officers in colleges make extensive use of tests to decide the academic future of many students, it is important that there should be regular evaluations of the measuring instruments in use. Very little published evidence is available to indicate that the Q and L scores given by the A. C. E. have sufficient validity to use as the basis for differential predictions in the college field. A summary of the relationships between A. C. E. scores and grade point averages found by Brown is presented in Table III.

TABLE III

CORRELATION BETWEEN THE A. C. E. SCORES AND GRADE POINT AVERAGES

A. C. E. Scores	Grade Point Averages		
	Quantitative	Linguistic	Total Subjects
Q.	.33	.18	.34
L.	.30	.54	.32
T.	.40	.44	.40

> A second phase of the problem was concerned with the answer to the individual student's request for information on the meaning of his score in terms of the possibility of securing a satisfactory grade point average in a specific course of study.
>
> Here the counselor deals with the individual who is no longer a member of the entire group for which the correlations have been completed. It becomes necessary to have some knowledge of a critical score below which it is unwise to suggest the possibility of successful work in the desired curriculum. Good counseling would seem to make this approach desirable.
>
> . . . the inadequacy of the Q-score for predicting the probability of an <u>individual</u> achieving a C average in quantitative subjects is illustrated by the fact that, while 82% of those making a Q-score at the 80th p. c. or

> higher, achieve at least a C average, so do 74% of those rating below the 20th p. c.
>
> In general there appears to be some basis for the conclusion that as a group the higher the scores the lower the possibility of failing to maintain a C average but to set critical scores on which to advise an individual to enter or not to enter specific curricula does not appear possible in this student body.[25]

Carter and McGennis[26] selected, at Western Michigan College of Education in 1949, the one hundred freshmen having the highest grade point average and the one hundred having the lowest average. The mean differences between these two groups were then compared on 46 factors in an effort to determine the effectiveness of each factor in differentiating between the two groups. A summary of the results of this study is presented in Table IV. It is interesting to note that the first fourteen factors differentiate at the .01 level of confidence.

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[25]Hugh S. Brown, "Differential Prediction by the A. C. E.," Journal of Educational Research, XLIV (October, 1950), 116-121.

[26]Homer L. J.Carter and Dorothy J. McGennis, "Some Factors Which Differentiate College Freshmen Having Lowest and Highest Point - Hour - Ratios," Journal of Educational Research, XLVI (November, 1952), 219-226.

TABLE IV[1]

COMPARATIVE SIGNIFICANCE OF CERTAIN SELECTED FACTORS AS PREDICTORS OF SUCCESS IN COLLEGE

	Factor	S. E.$_d$	"t"*
1.	Point-hour-ratio (high school)	.07	16.71
2.	Ohio State Psychological Examination	2.78	16.05
3.	Test III (reading) O.S.P.E.	1.10	15.05
4.	Test II (grammar) O.S.P.E.	1.33	14.47
5.	Estimate of high school principal	.08	13.14
6.	Test I (vocabulary) O.S.P.E.	.74	12.45
7.	Number of books reported as read	.32	6.61
8.	Terms of acceptance by college	5.81	6.02
9.	Re-entrance for second semester	4.26	4.93
10.	Number of units failed in high school	4.05	4.69
11.	Number of periodicals reported as read	.23	4.39
12.	Definite vocational choice	5.29	3.97
13.	Physical education curriculum	3.83	3.39**
14.	Units of high school credit in mathematics	.13	2.69
15.	Mother did not graduate from high school	6.67	2.10**
16.	Employed more than four hours per day in school	1.70	1.77**
17.	Graduation from class A high school	6.84	1.75
18.	Graduation from class C high school	6.16	1.62**
19.	Mother attended college	5.40	1.48
20.	Employed less than two hours per day in college	5.40	1.48
21.	Pre-professional curriculum	4.57	1.31**
22.	Residence in dormitory	7.04	1.28**
23.	Residence in rooming house	6.25	1.28
24.	Employed 2-4 hours per day in college	5.60	1.25**
25.	Graduation from class B high school	6.14	1.14
26.	Secondary education curriculum	4.66	1.07
27.	Hours studied per day senior year in high school	.14	1.03
28.	Father attended college	4.97	1.00**
29.	Age	.30	.96
30.	Two languages spoken in home	3.94	.77**
31.	Mother graduated from high school	6.67	.75
32.	Father not a high school graduate	7.06	.71
33.	Residence in own home	4.97	.60
34.	Father graduated from college	5.24	.57
35.	Father graduated from high school	5.59	.45**
36.	No outside employment in college	6.90	.29
37.	Mother graduated from college	4.83	.21
38.	Number of children in family	.25	.12

[1]This table taken from article in Journal of Educational Research, November, 1952, p. 223.

*A "t" value of 2.63 is significant at the 1% level.

**This factor is characteristic of poor students.

Satz,[27] in a study of the relationship of eleven variables to academic performance at the University of Washington, reports a study of the relationship between intelligence and academic success which uses quite a different and interesting technique:

> Sappenfeld[28] used a rather unique approach to determine the relationship between intelligence and scholastic performance. He first derived what he termed the "effort index" (E. I.) by dividing the high-school marks of each student by his intelligence score. He did this by first changing the E. I.'s and intelligence scores into standard scores. Next, by correlating the intelligence scores of students within certain E. I. ranges with college grades, he was able to arrive at higher zero-order coefficients of correlation (r). For students in the upper E. I. levels, he obtained an r of .816 between intelligence and college performance. In other words, students with high E. I.'s were found to achieve more closely to their measured aptitude for scholastic work.

Humber[29] conducted a study of the relationship of reading efficiency and achievement at the University of Minnesota in 1942. Subjects of the study were seniors in college and several major subject-matter fields were studied. The Humber study was of particular interest here because reading was one of the factors of the present study and students well along in their major field of mathematics were studied. The following subject-matter areas were considered: Five Year Nursing, Three Year Nursing, Science Specialization in Agriculture, English Education, Music Education, Social Work, Social Science Education, and Science Education. Humber lists the following five conclusions:

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[27]Satz, op. cit., 31-32.

[28]Bert R. Sappenfeld, "Prediction of College Scholarship for Groups Having Effort Indices of Restricted Range," Journal of Applied Psychology, XXVII (October, 1943), 448-450.

[29]W. J. Humber, "The Relationship Between Reading Efficiency and Academic Success in Selected University Curricula," Journal of Educational Psychology, XXXIV (January, 1944), 17-26.

1. This study presents evidence which shows that the zero order correlations between honor-point ratio and measured scholastic aptitude are not as high among Seniors as might be expected from knowledge of prediction studies in the Freshman year.

2. In all of the curriculum groups, with the exception of Dietetics, at least one factor other than scholastic aptitude, such as certain reading test scores, are correlated as high or higher with H. P. R. than is A. C. E.

3. Scores on the reading tests used in this investigation are shown to be frequently related to achievement in the humanities groups (English Education and Music Education), but infrequently related to achievement in those curricula emphasizing science material.

4. It is shown to be impossible, for the Five-Year Nursing and English Groups, to develop a significant regression, based upon scholastic aptitude and the scores on reading tests used in this investigation, to predict honor-point ratio in the fields.

5. This study has certain practical implications for reading clinicians operating in situations comparable to the University of Minnesota. In this study it becomes clear that when a student at the University of Minnesota reaches the Senior year of a certain curriculum he finds that the difference between an A and a C grade is less dependent upon scholastic aptitude than upon other factors such as reading efficiency. This should not be taken to signify that intelligence is less important than reading skills. If the senior year is attained the students within a curriculum are so homogeneous with reference to scholastic aptitude that other factors such as reading efficiency may make the difference between high and low scholarship. In those cases where reading efficiency is apparently essential for scholastic success, as this study shows it to be in English Education and Music Education, it seems desirable that students be encouraged to develop the reading skills which have been demonstrated to be significantly related to academic success in their major field.

Summary

An attempt was made in the chapter (1) to call attention to the various types of studies and the extensiveness of the work done in the area of prediction of academic success in college, (2) to select and describe studies of college entrance requirements as related to high school background, entrance examinations, achievement and placement

tests, (3) to summarize selected studies in prediction of college mathematics grades, and (4) to summarize selected studies in prediction of general academic success in college, including the area of college mathematics.

CHAPTER IV

PRESENTATION OF DATA AND ANALYSIS OF RESULTS

The purposes of this chapter are to (1) present evidence to show that the present sample was representative, (2) present the data and analyze the results from the present study, (3) present procedure for prediction of grades in calculus at this institution, and (4) present scatter diagrams as an aid in analyzing correlation data.

The Present Sample and Others Compared

A consideration fundamental to any interpretation or conclusions drawn from this study was whether or not the subjects chosen were representative of the population who enroll in a program of mathematics and persist through calculus at this institution.

Consequently, the students enrolled in calculus in the fall of 1949 and in the fall of 1951 were chosen for comparison with the subjects of the present study. It was thought best to choose groups which represented a period of time at a considerable distance from the present but not so far back as to include classes which were largely made up of veterans of World War II.

Data obtained for these two groups of calculus students included the grades made in calculus, the Q-score, the L-score, and the total score on the A. C. E. Psychological Examination.

Data in Table V were presented to show the comparison between the 1951 and 1953 calculus groups on mean performance in the A. C. E. Psychological Examination, variability, correlation between Q-score and grade

made in calculus, and correlation between L-score and grade made in calculus.

TABLE V

COMPARISON OF PERFORMANCE ON A. C. E. PSYCHOLOGICAL EXAMINATION OF 1951 and 1953 CALCULUS GROUPS

Statistics	Year 1951	1953	t value
Number	132	160	
Mean Total Score	111.78	111.00	.33*
Standard Deviation	20.93	18.66	1.43*
r for Q-score and calculus grade	.20	.16	
Corresponding Fisher's z-function	.20	.16	.34*
r for L-score and calculus grade	.13	.10	
Corresponding Fisher's z-function	.13	.10	.25*

*Differences not significant at the .01 level of confidence.

In Table VI the same comparisons were made between 1949 and 1953 calculus groups.

TABLE VI

COMPARISON OF PERFORMANCE ON A. C. E. PSYCHOLOGICAL EXAMINATION OF 1949 and 1953 CALCULUS GROUPS

Statistics	Year 1949	1953	t value
Number	214	160	
Mean Total Score	109.41	111.00	.85*
Standard Deviation	19.83	18.66	.82*
r for Q-score and Calculus Grade	.17	.16	
Corresponding Fisher's z-function	.17	.16	.10*
r for L-score and Calculus Grade	.09	.10	
Corresponding Fisher's z-function	.09	.10	.10*

*Differences not significant at .01 level of confidence.

Appropriate formulas[1] were used to compute the reliability of the difference in mean performance, variability, and correlations.

No differences in either of the groups were found to be significant at either the .01 or the .05 level of confidence.

These results furnish strong evidence that the samples were drawn from the same population and that the 1953 group is representative of that population which enrolls in a mathematics program at this institution and persists through calculus.

The Intercorrelation Matrix

After the data on the subjects of this study were obtained as discussed in Chapter II, the next step in the procedure was to have these data punched on International Business Machine cards, as it was contemplated that all calculations which would lend themselves readily to International Business Machine procedures would be handled in this manner. The decision to use International Business Machine procedures was based on the premise that the calculations could be made much more rapidly and that there would be no doubt about their accuracy. The amount of computational work, if manually computed, would make a study of this nature prohibitive.

Basic to all future calculations and comparisons in the study was the intercorrelation matrix. The first step in obtaining this intercorrelation matrix was to compute (by I. B. M.) the summations, the summations of the squares, and the summations of the cross products for each of the factors involved in the study. Utilizing this information, zero order correlations were computed[2] between all factors involved in the study. All machine and manual calculations were made twice. The intercorrelation data are presented in Table VII.

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[1]Henry E. Garrett, Statistics in Psychology and Education, (New York, 1953), pp. 212-240.

[2]Garrett, op. cit., p. 142.

TABLE VII

BASIC INTERCORRELATION TABLE DERIVED FROM DATA ON THE 1953 CALCULUS GROUP

Factors	1	2	3	4	5	6	7	8	9
Means	6.02	3.08	47.26	63.74	35.24	82.84	14.64	2.62	2.09
Sigmas	1.66	.61	7.92	12.72	10.37	24.06	5.02	0.89	1.16
1. Sem. of H. S. M.		.24**	.18*	.11	.32**	.05	.05	-.06	.03
2. G. P. A. H. S. M.			.31**	.19*	.21**	.23**	.21**	.28**	.11
3. A. C. E. Q-score				.61**	.40**	.43**	.38**	.38**	.16*
4. A. C. E. L-score					.26**	.74**	.25**	.29**	.10
5. Cooperative Algebra Score						.16*	.27**	.16*	.02
6. Reading Score							.19*	.23**	.10
7. Reasoning Test								.23**	.02
8. Grade in College Algebra									.34**
9. G. P. in Calculus									

*Significant at 5% level of confidence.
**Significant at 1% level of confidence.

Analysis of Correlation Data

A correlation of .203 was significant at the .01 level of confidence, and a correlation of .157 was significant at the .05 level for the number of cases considered in this study. In the intercorrelation table, involving 36 correlations, 20 were significant at the .01 level, and 6 were significant at the .05 level of confidence. Ten correlations were not sufficiently large to be significant at the .05 level of confidence. The majority of the intercorrelations between the independent factors were about what would be expected. It was of particular value to note that the correlation between the A. C. E. L-scores and the reading test scores was .74. The relatively high correlation indicated that these two tests measured essentially the same thing. Hence, if one of these tests was used as a predictor, the other would add very little to the accuracy of the prediction. The correlation between the A. C. E. L-scores and the A. C. E. Q-scores was .61. There was some question as to the value of using both of these factors as predictors.

The number of semesters of high school mathematics completed and the scores on the reasoning test had a correlation coefficient of .05 which represented very little relationship. On the basis of this study it appeared that the ability to reason mathematically was not one of the outcomes of taking a large quantity of mathematics in high school.

Three major questions were posed in Chapter I: (1) What was the relationship between each of the factors and success in college algebra? (2) What was the relationship between each of the factors and success in calculus? (3) What was the comparison of these relationships? In order to show these relationships more clearly the information was presented separately in Table VIII. Data in Table VIII indicates that all

of the factors, except the number of semesters of high school mathematics completed, were significantly related to the grades made in college algebra.

TABLE VIII

CORRELATION BETWEEN EACH FACTOR AND GRADES IN COLLEGE ALGEBRA AND CALCULUS

Factors	Correlation Between Grade In College Algebra And Each Factor	Correlation Between Grade In Calculus And Each Factor
Sem. H. S. M.	-.06	.03
G. P. A. in H. S. M.	.28**	.11
A. C. E. Q-Score	.38**	.16*
A. C. E. L-Score	.29**	.10
Cooperative Algebra Test Score .	.16*	.02
Reading Test Score	.23*	.10
Reasoning Test	.23**	.02
Grade in College Algebra		.34**

*Significant at the .05 level.
**Significant at the .01 level.

Factors significant at the .01 level of confidence and their correlation coefficients were: A. C. E. Q-score, .38; A. C. E. L-score, .29; grade point average in High school mathematics, .28; scores on the reasoning test, .23; and scores on the reading test, .23. The correlation coefficient between the Cooperative Algebra Test scores and grades in college algebra was .16 which was significant at the .05 level of confidence. The results of the Cooperative Algebra Test are used for the purpose of placing mathematics students in their first algebra courses at this institution.

The coefficient of correlation between the number of semesters of high school mathematics completed and grades in college algebra was -.06.

Although this was a very small coefficient of correlation, it was of considerable interest that it was negative. For the students of this study, it was evident that the quantity of mathematics completed in high school had very little to do with the quality of work done in college algebra. This was in direct contrast to one of the conclusions reached by Shirley[3] in which he stated that, "Students who have had four semesters of high school algebra can be expected to handle college algebra and need not be required to take the placement tests."

There are, however, several studies which lend support to the results of the present study in this respect. Seyfert,[4] in speaking of college-preparatory courses, said, "The courses themselves may be very much worthwhile, but as true and valid preparation for college they are notorious for shooting rather wide of their mark." Carter[5] remarked that, "Meeting the conventional unit requirement for college fails to disclose satisfactorily the fitness of many students for college."

In regard to the second question concerning relationship between the factors and grades in calculus, it was found that the coefficient of correlation between A. C. E. Q-scores and grades in calculus was .16. This correlation was significant at the .05 level of confidence. Grades in college algebra and grades in calculus were related by a coefficient of correlation of .34 which was significant at the .01 level of confidence. This was an especially interesting result as .34 was also the coefficient of correlation between college algebra grades and calculus grades obtained by Kinzer and Kinzer[6] at Ohio State University. They

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[3]Shirley, op. cit., p. 45.
[4]Seyfert, op. cit., p. 129.
[5]Carter, op. cit., p. 349.
[6]Kinzer and Kinzer, op. cit., p. 183.

found a coefficient of correlation of .13 between the Ohio State Psychological Examination scores and grades in calculus compared to the .16 correlation between Q-scores and grades in calculus in the present study.

There is some support from other investigators for the belief that such correlations might be expected to be low. One of the concluding statements made by Humber[7] was:

> This study presents evidence which shows that the zero order correlations between honor-point ratio and measured scholastic aptitude are not as high among Seniors as might be expected from knowledge of the prediction studies in the Freshman year.

This remark was made concerning over-all average in subject-matter fields, not in specific subjects.

In answer to the third question concerning the comparison of the relationships between each factor and grades in college algebra and grades in calculus, it may be said that all factors except one, semesters of high school mathematics completed, were more closely related to grades in college algebra than to grades in calculus. In regard to semesters of high school mathematics completed, the correlation so nearly approached zero that a comparison was not feasible.

A possible explanation for these low correlations is that the subjects of the study form a more homogeneous group than, for example, a group of college freshmen. Considerable natural selection took place between the time of enrollment in college algebra and enrollment in calculus. No one who was not capable of passing the sequence of courses leading to the study of calculus was represented in the sample used for this study. It is a well known fact that the more homogeneous the

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[7]Humber, op. cit., p. 25.

the group, the smaller the coefficients of correlations tend to be.

The relationship between the factors of this study and success in calculus, although indirect, may be much greater than the coefficients of correlation indicate. It may well be that success in calculus depends to a very great extent on successful performance in the sequence of courses prerequisite to calculus and that academic performance in these prerequisite courses is closely related to the factors considered in this study. A very interesting and profitable study would be to compare the relationship between academic success in each of the courses in the sequence and the prerequisite course.

Prediction of Grades in Calculus

The fourth major task was to combine the most promising factors into a prediction team for grades in calculus.

The best single factor for prediction of grades in calculus was the grade in college algebra. The next best factor was the Q-score. These were the only two factors having a correlation with the criterion grade significant at either the .05 level or .01 level of confidence. Regression equations were formulated and standard errors of estimate were calculated by the use of appropriate formulas:[8] (1) for predicting the calculus grade from grades made in college algebra and (2) for predicting the grade in calculus from a combination of the two factors, grade in college algebra and Q-score.

In order to demonstrate that factors not having a correlation with the criterion significant at the .05 level of confidence would add little

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[8]Garrett, op. cit., pp. 373-396.

or nothing to the accuracy of the prediction, the grade point average in high school mathematics, which had the next highest correlation with criterion grades, was used in combination with Q-score and grade in college algebra to form a third regression equation and standard error of estimate. Appropriate formulas were chosen from Garrett.[9]

Brief summaries of these three prediction problems follow:

(X_1) Calculus Grade	(X_2) College Algebra Grade
$M_1 = 2.09$	$M_2 = 2.62$
$\sigma_1 = 1.16$	$\sigma_2 = .89$

$$r_{X_1X_2} = .34$$

The regression equation in score form was $\bar{X}_1 = .45\ X_2 + .91$, from which the most probable grade in calculus could be predicted if the grade in college algebra was known. The standard error of estimate was 1.16 grade points, which meant that in two-thirds of the cases the actual grade received in calculus at this institution would fall within 1.16 points of the predicted grade.

Using the Q-score in combination with grade in college algebra as predictors of grade in calculus, the following calculations were necessary:

(X_1) Calculus Grade	(X_2) Q-Score	(X_3) College Algebra Score
$M_1 = 2.09$	$M_2 = 47.26$	$M_3 = 2.62$
$\sigma_1 = 1.16$	$\sigma_2 = 7.92$	$\sigma_3 = .89$
$r_{12} = .16$	$r_{13} = .34$	$r_{23} = .38$

$r_{12.3} = .04$ $\quad$ $S_{E(12.3)} = 1.08$

$r_{13.2} = .31$ $\quad$ $S_{E(13.2)} = 7.21$

$r_{23.1} = .35$ $\quad$ $S_{E(23.1)} = .77$

$R_{1(23)} = .37$

$b_{12.3} = .006$ $\quad$ $\beta_{1.23} = .04$

$b_{13.2} = .44$ $\quad$ $\beta_{13.2} = .34$

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[9] Ibid., pp. 388-395.

The multiple regression equation in score form was $\bar{X}_1 = .006\ X_2 + .44\ X_3 + .66$, and the standard error of estimate was 1.08, meaning that if the Q-score and the college algebra grade were known the calculus grade could be predicted in at least two-thirds of the cases within 1.08 grade points of the actual grade received at the institution.

The standard error of estimate for the second equation was .08 less than for the first. This was enough improvement to make it desirable to use the second equation.

The beta weights provided a measure of the comparative importance of the independent factors in predicting the criterion grade. Thus, a beta weight of .34 for college algebra grade was almost nine times as important as the beta weight of .04 for Q-score.

The addition of the factor, grade point average in high school mathematics, made very little difference in the accuracy of the prediction as illustrated in the following summary:

(X_1) Calculus	(X_2) Q-Score	(X_3) Col. Alg.	(X_4) G.P.A. in H.S.M.
$M_1 = 2.09$	$M_2 = 47.26$	$M_3 = 2.62$	$M_4 = 3.08$
$\sigma_1 = 1.16$	$\sigma_2 = 7.92$	$\sigma_3 = .89$	$\sigma_4 = .61$

$r_{12} = .16$ $r_{23} = .38$ $r_{34} = .28$

$r_{13} = .34$ $r_{24} = .31$ $r_{14} = .11$

$r_{12.3} = .04$ $r_{13.2} = .31$

$r_{14.3} = .02$ $r_{14.2} = .06$

$r_{24.3} = .23$ $r_{34.2} = .19$

$r_{12.34} = .04$ $r_{13.24} = .31$ $r_{14.23} = .01$

$R_{1(234)} = .37$

$\sigma_{1.234} = 1.08$ $\sigma_{2.134} = 7.05$

$\sigma_{3.124} = .76$ $\sigma_{4.123} = .57$

$b_{12.34} = .01$ $b_{13.24} = .44$ $b_{14.23} = .02$

$\beta_{12.34} = .04$ $\beta_{13.24} = .34$ $\beta_{14.23} = .01$

The multiple regression equation involving these three independent variables was $\bar{X}_1 = .006\ X_2 + .44\ X_3 + .02\ X_4 + .60$. The standard error of estimate was 1.08, representing no improvement over the prediction obtained by the use of the two independent factors, Q-score and grade in college algebra. There was no improvement in the multiple R. The beta weights for Q-score and college algebra remained the same, .04 and .34 respectively. The beta weight for grade point average in high school mathematics was .01, indicating that this factor accounted for only a very small portion of the variance in calculus grades.

In view of the above analysis it would appear that the regression equation involving the Q-score and college algebra grade is most desirable for predicting the most probable grade that a student will make in calculus.

Prediction of Grades in Calculus

Table IX, which can be used for predicting calculus grades, was constructed, using this equation, $\bar{X}_1 = .006\ X_2 + .44\ X_3 + .66$, in which X_1 represents grade predicted for calculus, X_2 represents Q-score, and X_3 represents grade in college algebra.

To use this table for predicting the most probable grade in calculus, locate the grade point directly below the student's grade point in college algebra and directly to the right of his Q-score, and round the obtained grade point to the nearest whole number. Transmute the obtained letter grade to the corresponding letter grade. For example, if a student's Q-score was 53 and his college algebra grade point was 2, locate 1.87 in the 50-59 row directly under the heading 2. Round 1.87 to 2, and transmute to the letter grade "C". In approximately two-thirds of the cases a student's actual grade received will probably fall within one grade point of the predicted grade (standard error of estimate was 1.08).

TABLE IX

PREDICTED GRADE POINT IN CALCULUS BASED ON Q-SCORE AND GRADE IN COLLEGE ALGEBRA

Q-Score	Grade Point in College Algebra 0	1	2	3	4
80-89	1.17	1.61	2.05	2.49	2.93
70-79	1.11	1.55	1.99	2.43	2.87
60-69	1.05	1.49	1.93	2.37	2.81
50-59	.99	1.43	1.87	2.31	2.75
40-49	.93	1.37	1.81	2.25	2.69
30-39	.87	1.31	1.75	2.19	2.63
20-29	.81	1.25	1.69	2.13	2.57
10-19	.75	1.19	1.63	2.07	2.51
0-9	.69	1.13	1.57	2.01	2.45

In many instances the counselor or teacher may wish to know only whether a student is most likely to do average, high quality, or unsatisfactory work in calculus.

For a very quick and convenient prediction of the grade category in which a student's work will most likely fall, reference may be made to the prediction chart in Figure 1. The "C" category represents average performance, the "DF" category represents unsatisfactory performance, and the "AB" category represents high quality performance.

To use this chart for predicting the most probable grade category in calculus, locate the point directly above the student's grade point in college algebra and directly to the right of his Q-score. For example, if a student's Q-score was 30 and his grade point in college algebra was 3, the point directly above 3 and directly opposite 30 falls in the "C"

category.

Calculations for the construction of this chart were based on the regression equation, $\bar{X}_1 = .006\ X_2 + .44\ X_3 + .66$, in which X_1 refers to grade in calculus, X_2 represents C-score, and X_3 represents grade in college algebra.

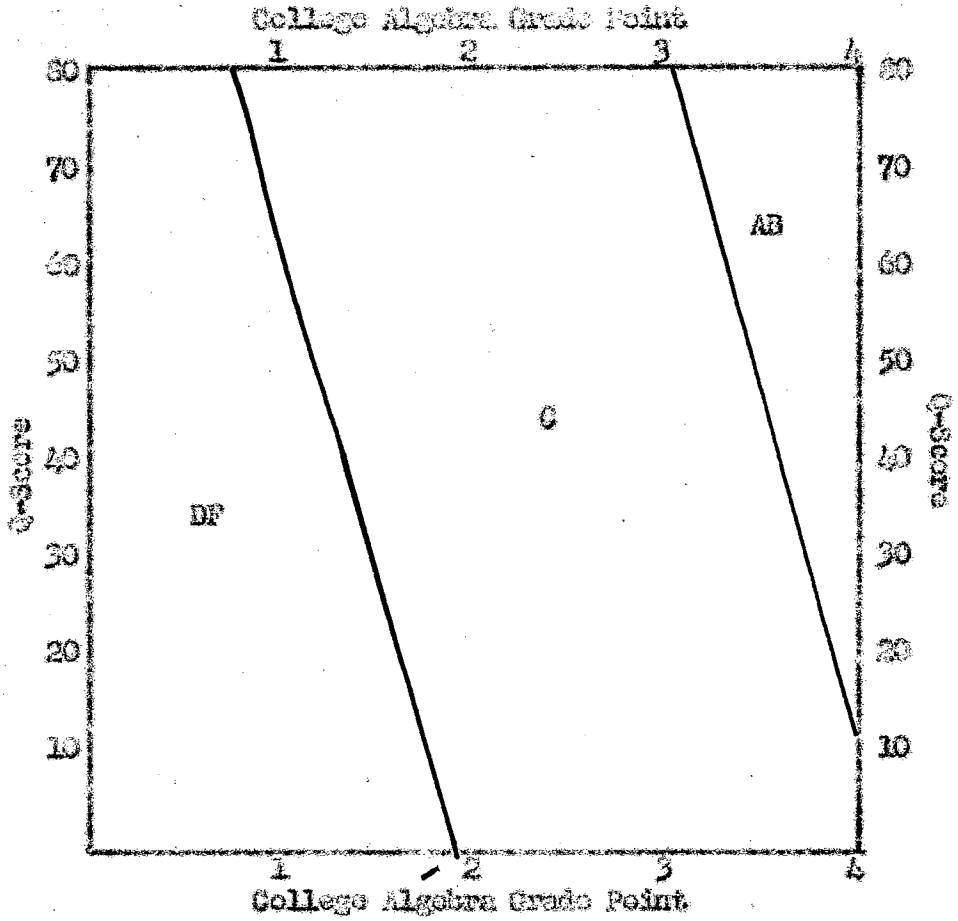

Figure 1. Prediction Chart For Grade in Calculus Based On C-Score and College Algebra Grade

To locate the line in the prediction chart which separates the "DF" category from the "C" category, it was necessary to find two points. This was done by substituting in the regression equation 1.5 for X_1 (a grade point of 1.5 separates the "C's" from the "D's" at this institution) and two C-scores for X_2. C-scores of 80 and 0 were used. On substituting 1.5 for X_1 and 80 for X_2 in the regression equation, X_3

was found to be .81, and substituting 1.5 for X_1 and 0 for X_2 in the equation, X_3 became 1.91. A line was drawn between the point .81 to the right of a Q-score of 80 and the point 1.91 to the right of a Q-score of 0.

The line separating the "AB" category from the "C" category was located in a similar manner. A grade point of 2.5 separates the "B" and "C" grades.

To test the effectiveness and accuracy of this chart the grade category of each student in this study was predicted and compared with the actual grade made in calculus. Table X is a contingency table representing the relationship between predicted and actual grade categories.

TABLE X

COMPARISON OF PREDICTED AND ACTUAL GRADE CATEGORIES IN CALCULUS

Predicted Grade Category	Actual Grade Category DF	C	AB	Total
DF	(3.9) 9	(4.9) 4	(5.2) 1	14
C	(32.9) 32	(40.3) 43	(43.1) 42	117
AB	(8.2) 4	(10.1) 9	(10.7) 16	29
Total	45	56	59	160

Independence values are represented by figures in parentheses; they give the number of people whom we should expect to find in the various categories in the absence of any real relationship. For example, if there were no association between predicted and actual grade categories, we should expect to find, by chance, 3.9 persons in the "DF" predicted,

"DF" actual category. There were 9 persons in the category. Other entries in the table have a similar meaning.

To determine the significance of the relationship between predicted and actual grade categories, the coefficient of contingency was computed and the chi-square test of significance was applied. Appropriate formulas were chosen for these computations.[10]

The contingency coefficient was .31, and the chi-square value was 17. A chi-square value of 13.28 is significant at the .01 level of confidence. It may be concluded that not once in one hundred times would a chi-square value or a contingency coefficient as large as those obtained occur if there were no association between predicted and actual grade categories.

Relationships Revealed by Scattergrams

The final purpose of this chapter was to present scattergrams or two-way distribution tables between grades received in calculus and in algebra, and each of the factors in an effort to make the data more useful and meaningful. Data presented in the scattergrams reveal graphically and numerically at a glance some very pertinent information which probably would be overlooked if correlation data alone were studied. Percentages of students falling in certain categories regarding performance on the independent factors in relation to grade received in calculus and in algebra were figured and should prove helpful in interpreting the data.

Grade in Calculus and Semesters of High School Mathematics. Table XI was prepared to display the relationship between semesters of high

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[10]Garrett, op. cit., pp. 368, 254.

school mathematics completed and grade in calculus.

TABLE XI

RELATIONSHIP BETWEEN SEMESTERS OF HIGH SCHOOL MATHEMATICS AND GRADE POINT IN CALCULUS

Semesters of H. S. M.	Grade Point in Calculus				
	0	1	2	3	4
8	3	8	15	10	6
7	4	3	3	9	1
6	5	8	20	13	4
5	1	2	4	1	3
4	6	3	8	6	3
3	0	2	2	0	1
2	0	0	4	2	0
1	0	0	0	0	0

An examination of the data presented shows that of the students in this study who had four or more semesters of high school mathematics, 87 per cent passed calculus and 13 per cent failed. On a probability basis, computed on the performance of this sample, these figures indicated that the chances were about 9 in 10 that a student at this institution who had as many as four semesters of mathematics in high school would pass calculus and the chances of failure were about 1 in 10. The chances were 7 in 10 of making a "C" or better in calculus and the chances of making less than a "C" were 3 in 10 if four or more semesters of high school mathematics were completed. The chances of making a "B" or better in calculus were 4 in 10 and the chances of making an "A" were 1 in 10. It was also of interest to note that only one person with less than four

semesters of high school mathematics earned a grade of "A" and only two earned a grade of "B". None with less than four semesters of high school mathematics failed calculus, and two received a grade of "D". Due to the small number of students with less than four semesters of high school mathematics enrolled in calculus, these figures probably were not very significant.

Although a large number of semesters of high school mathematics was in no sense a guarantee of satisfactory performance in calculus, there was some evidence here to support the inference that a student was more likely to make a high grade in calculus, an "A" or "B", if he had completed four or more semesters of high school mathematics.

Grade in Calculus and Grade Point Average in High School Mathematics. Data were presented in Table XII to show the relationship between grade point average in high school mathematics and grade in calculus.

TABLE XII

RELATIONSHIP BETWEEN GRADE POINT AVERAGE IN HIGH SCHOOL MATHEMATICS AND GRADE POINT IN CALCULUS

G. P. A. in H. S. M.	Grade Point in Calculus 0	1	2	3	4
3.5 - 4.0	6	4	12	13	6
3.0 - 3.49	9	8	29	20	9
2.5 - 2.99	2	8	9	4	2
2.0 - 2.49	2	4	2	2	1
1.5 - 1.99	0	1	2	2	0
1.0 - 1.49	0	1	2	0	0

It was observed that of those students in this study who had a grade point average of "C" or better in high school mathematics, 88 per

cent passed calculus and 12 per cent failed, which indicated that if a student entered this institution with an average grade of "C" or better in high school mathematics, his chances were about 9 in 10 of passing calculus and 1 in 10 of failing. The chances that a student would make a "C" or better in calculus were about 7 in 10, and the chances of receiving less than a "C" were about 3 in 10. The chances of making a "B" or better in calculus were about 4 in 10, and the chances of making an "A" were a little better than 1 in 10. It was also interesting to note that of those students having a grade point average of less than "C" in high school mathematics, none earned an "A" in calculus and only two earned "B".

This evidence suggested that there was only a very slight chance that a student at this institution would do work of "A" or "B" quality in calculus without having achieved at least a "C" average in high school mathematics courses.

Grade in Calculus and A. C. E. Q-Score. Table XIII was prepared to show the relationship between A. C. E. Q-score and grade in calculus. Of the students in this study who made the mean score or better on the quantitative portion of the A. C. E. Psychological Examination, it was found that 91 per cent received a passing grade in calculus and 9 per cent received a failing grade. Speaking in terms of probability, this meant that students who earned a mean Q-score or better on the A. C. E. (Q) had more than 9 chances in 10 of passing the course in calculus as compared to less than 1 chance in 10 of failure. The chances were about 8 in 10 of making a "C" grade or better in calculus and 2 in 10 of making less than a "C". The chances were about 9 in 20 of receiving "B" or better and about 3 in 20 of receiving an "A".

TABLE XIII

RELATIONSHIP BETWEEN A. C. E. Q-SCORE AND GRADE POINT IN CALCULUS

Q-Score	Grade Point in Calculus 0	1	2	3	4
75 - 79	0	0	0	1	0
70 - 74	0	0	0	0	0
65 - 69	0	0	1	0	0
60 - 64	0	3	2	7	0
55 - 59	1	2	4	3	3
50 - 54	2	2	10	7	4
45 - 49	11	10	21	13	10
40 - 44	2	2	10	3	0
35 - 39	2	5	5	3	1
30 - 34	1	2	3	3	0
25 - 29	0	0	0	1	0

It was also interesting to observe that only one person having a Q-score less than the mean of the group received an "A" in calculus, and that no person with a Q-score of 60 or above received an "F" in calculus.

There was good evidence that students at this institution who had a low Q-score were not at all likely to exhibit a high level of performance in calculus, whereas students with a relatively high Q-score were not likely to do poorly in calculus. If the cutting score had been set at 45, just slightly below the mean for the group, more than one-fourth of the failures and only one "A" would have been eliminated. The reader should be reminded, however, that merely having a high score on one or a combination of the factors of this study was not necessarily a guarantee

of success in the study of calculus.

Grade in Calculus and A. C. E. L-Score. In Table XIV the distribution of the L-scores in relation to grades made in calculus was displayed. Of the students who scored at or above the mean score on the linguistic portion of the A. C. E., 92 per cent received a passing grade in calculus and 8 per cent failed.

TABLE XIV

RELATIONSHIP BETWEEN A. C. E. L-SCORE AND GRADE POINT IN CALCULUS

L-Score	Grade Point in Calculus 0	1	2	3	4
95 - 99	0	1	1	2	1
90 - 94	0	1	1	1	0
85 - 89	0	0	3	1	1
80 - 84	0	0	1	0	1
75 - 79	0	1	1	4	1
70 - 74	0	1	10	3	0
65 - 69	3	7	8	3	3
60 - 64	9	6	14	13	6
55 - 59	2	1	8	4	2
50 - 54	1	4	4	3	1
45 - 49	2	3	3	4	0
40 - 44	1	1	2	1	2
35 - 39	0	0	0	0	0
30 - 34	1	0	0	0	0

Expressed in probability terms, about 9 out of 10 students at this institution whose L-score was at the mean or above had a chance to pass

calculus, and there was about 1 chance in 10 of failure. The chances were 3 in 4 of receiving a "C" or better in calculus and 1 in 4 of receiving less than "C". The chances were 4 in 10 of receiving "B" or better and more than 1 in 10 of receiving an "A" in calculus.

These percentages were not particularly striking when compared to those below the mean, for 11 per cent of the students having an L-score below the mean received an "A" and 38 per cent received a "B" or better in calculus, which yielded the same probabilities as for those who scored at or above the mean. If the comparison had stopped here, it would probably have been concluded that the L-score was of very little value in determining what the chances were for successful performance in calculus, but a valuable inference was drawn from examining "F" grades in calculus and corresponding L-scores. No student who received an L-score of 70 or above received an "F" in calculus. If the cutting score had been placed at 60, which was about four score points below mean performance, nearly one-half of the failures in calculus would have been eliminated for this group. Only about 30 per cent of the students making "A" and "B" in calculus made L-scores of less than 60.

Grade in Calculus and the Cooperative Algebra Test Score. Data were presented in Table XV to show the distribution of scores made on the Cooperative Algebra Test by students of this study in relation to the grades made in calculus. It was found that 87 per cent of the subjects who scored at or above the mean received a passing grade in calculus and 13 per cent failed. Seventy-two per cent made a "C" or better and 28 per cent received less than "C" in calculus. Forty per cent received "B" or better and 11 per cent made "A" in calculus. However, 13 per cent of those who scored below the mean on the Cooperative Algebra Test received

an "A" in calculus and 28 per cent received a grade of "B" or better.

TABLE XV

RELATIONSHIP BETWEEN COOPERATIVE ALGEBRA TEST SCORE AND GRADE POINT IN CALCULUS

Cooperative Algebra Test	Grade Point in Calculus				
	0	1	2	3	4
55 - 59	1	0	0	2	0
50 - 54	0	1	5	3	1
45 - 49	2	1	5	1	3
40 - 44	1	2	3	4	1
35 - 39	11	13	23	24	7
30 - 34	1	4	6	2	3
25 - 29	1	2	3	1	2
20 - 24	1	2	5	0	0
15 - 19	1	1	4	0	0
10 - 14	0	0	1	2	1
5 - 9	0	0	1	2	0

A comparison of these percentages gave very little evidence to support a belief that a score above the mean on the Cooperative Algebra Test was indicative of high level performance in calculus. It was also observed that there was no place near the mean where scores could be cut in order to eliminate a large portion of the failures.

Grade in Calculus and the Nelson-Denny Reading Test Score. Data were presented in Table XVI to show the distribution of scores on the reading test in relation to the grades made in calculus. Of the students scoring at or above the mean, 91 per cent received a passing grade and 9 per cent failed. Seventy-five per cent received grades of "C" or

better in calculus and 25 per cent made less than a "C". Forty-one per cent made "B" or better and 14 per cent received "A" in calculus.

TABLE XVI

RELATIONSHIP BETWEEN READING TEST SCORE AND GRADE POINT IN CALCULUS

Reading Test Score	Grade Point in Calculus				
	0	1	2	3	4
140 - 149	0	0	1	0	0
130 - 139	0	0	4	2	2
120 - 129	0	0	3	0	2
110 - 119	1	3	2	2	1
100 - 109	3	3	5	7	1
90 - 99	1	2	4	0	2
80 - 89	4	7	11	13	4
70 - 79	2	0	12	3	1
60 - 69	4	7	8	5	2
50 - 59	2	2	4	5	0
40 - 49	2	0	0	4	2
30 - 39	0	2	2	0	1

These percentages were very close to those obtained on comparing the L-score and the calculus grades. This was to be expected since the correlation between the L-score and the reading score was .74. Of the students who had scores below the mean on the reading test, 8 per cent received grades of "A" and 33 per cent received "B" or better in calculus.

It was of some significance to note that none of the students scoring 120 or above on the reading test received either a "D" or an "F" in calculus. If the cutting score had been set at 80 on the reading test,

about one-half of the "D's" and "F's" would have been avoided for this group, but almost one-half of the "A's" and "B's" would also have been eliminated. It was also of some interest to observe that one student in the lowest class interval, 30-39, on the reading test, received an "A" in calculus and that two in this interval received "C".

Grade in Calculus and the Guilford-Zimmerman Reasoning Test Score. Data were presented in Table XVII to show the relationship between scores on the reasoning test and calculus grades.

TABLE XVII

RELATIONSHIP BETWEEN REASONING TEST SCORE AND GRADE POINT IN CALCULUS

Score on Reasoning Test	Grade Point in Calculus				
	0	1	2	3	4
24 - 28	2	1	0	2	0
21 - 23	0	2	2	4	2
18 - 20	1	2	11	6	3
15 - 17	4	8	16	9	3
12 - 14	7	7	12	9	5
9 - 11	3	3	10	7	3
6 - 8	1	2	5	3	2
3 - 5	1	1	0	1	0

An examination of the data disclosed that of the students who scored at or above the mean on the reasoning test, 91 per cent passed calculus and 9 per cent failed. Seventy-four per cent made a "C" or better, and 26 per cent made less than "C" in calculus. Thirty-seven per cent received "B" or better, and 10 per cent received "A" in calculus. An examination of the number of students who received a score less than the

mean on the reasoning test revealed that 37 per cent earned "B" or better, and 12 per cent made an "A" in calculus. About the same percentage of low performers on the reasoning test made outstanding grades in calculus ad did the high performers on the reasoning test.

The reasoning test seemed to hold very few possibilities for helping to determine the level of performance that students in calculus might be expected to reach.

Grade in Calculus and Grade in College Algebra. Data in Table XVIII were presented to show the relationship of grades made in college algebra to grades made in calculus.

TABLE XVIII

RELATIONSHIP BETWEEN GRADE POINT IN COLLEGE ALGEBRA AND GRADE POINT IN CALCULUS

Grade Point in 173 Algebra	Grade Point in Calculus				
	0	1	2	3	4
4	0	4	8	9	7
3	6	6	21	15	9
2	10	11	23	16	2
1	3	5	3	1	0
0	0	0	1	0	0

Eighty-nine per cent of the students studied who made a "C" or better in college algebra passed calculus, and 11 per cent failed. Seventy-five per cent of those who received "C" or better in college algebra also received "C" or better in calculus. A grade of "B" or better was made by 39 per cent of the students receiving "C" or better in college algebra, and 12 per cent received "A".

The most helpful information from Table XVIII was that no student

with less than a "C" in college algebra received an "A" in calculus and only 1 student with less than "C" in college algebra made "B" in calculus. No student who received an "A" in college algebra failed calculus.

According to the records obtained there was one student who had an "F" in college algebra who went on to complete calculus. This student received a grade of "C" in calculus.

Grade in College Algebra and Semesters of High School Mathematics. The relationship between the number of semesters of high school mathematics completed and the grade made in college algebra was shown in Table XIX.

TABLE XIX

RELATIONSHIP BETWEEN SEMESTERS IN HIGH SCHOOL MATHEMATICS AND GRADE POINT IN COLLEGE ALGEBRA

Semesters in H. S. M.	Grade Point in College Algebra				
	0	1	2	3	4
8	0	7	10	14	11
7	0	2	7	8	3
6	1	0	28	16	5
5	0	2	3	5	1
4	0	1	11	9	5
3	0	0	2	2	1
2	0	0	1	2	3
1	0	0	0	0	0

An examination of Table XIX showed that 92 per cent of the students who completed four or more semesters of high school algebra received "C" or better in college algebra, 52 per cent made a grade of "B" or better in college algebra, and 18 per cent earned an "A".

This evidence was not particularly striking when the performance of students who completed less than four semesters of high school mathematics was observed. Of this group, 100 per cent received "C" or better in college algebra, 73 per cent received "B" or better, and 36 per cent received "A".

On the basis of these figures it appeared that for the students studied here, the less mathematics completed in high school the better the chance of making a high grade in college algebra.

The reader will recall that the coefficient of correlation between grades in college algebra and semesters of high school mathematics completed was -.06.

Grade in College Algebra and Grade Point Average in High School Mathematics. In Table XX data were presented concerning the relationship between grades received in high school mathematics and grades made in college algebra.

TABLE XX

RELATIONSHIP BETWEEN GRADE POINT AVERAGE IN HIGH SCHOOL MATHEMATICS AND GRADE POINT IN COLLEGE ALGEBRA

G. P. A. in H. S. M.	Grade Point in College Algebra				
	0	1	2	3	4
3.5 - 4.0	0	0	16	15	10
3.0 - 3.49	1	2	27	29	16
2.5 - 2.99	0	3	13	8	1
2.0 - 2.49	0	5	3	2	1
1.5 - 1.99	0	1	2	2	0
1.0 - 1.49	0	1	1	0	1
.5 - .99	0	0	0	0	0
0 - .49	0	0	0	0	0

In examining Table XX it was found that 93 per cent of the students having a "C" average in high school mathematics received a "C" or better in college algebra and 7 per cent received less than "C". Fifty-four per cent received "B" or better in college algebra, and 18 per cent received "A".

Of these students who had less than a "C" average in high school mathematics, 12 per cent earned "A", 37 per cent received "B" or better, and 75 per cent received "C" or better in college algebra.

A comparison of these percentages indicated that, for the students of this study, a high level of performance in college algebra was much more likely to follow high level performance in high school mathematics than low level performance. This was expected. However, there was some doubt, in view of the low relationship between quantity of high school mathematics and college algebra grade, as to whether this relationship was due to background in high school mathematics or to other factors such as innate ability or industriousness.

Grade in College Algebra and A. C. E. Q-Score. In Table XXI the relationship between the A. C. E. Q-score and the grade made in college algebra was displayed. Of the students who scored at or above the mean on the quantitative portion of the A. C. E. Psychological Examination, 95 per cent received a grade of "C" or better in college algebra, and only 5 per cent received less than "C". Sixty-six per cent made "B" or better and 25 per cent made "A" in college algebra.

Of those students scoring below the mean Q-score, only 11 per cent received an "A" and only 39 per cent received "B" or better in college algebra. It was interesting to note that only one person with a Q-score above 50 made less than a "C" in college algebra.

TABLE XXI

RELATIONSHIP BETWEEN THE A. C. E. Q-SCORE AND GRADE POINT IN COLLEGE ALGEBRA

A. C. E. Q-Score	Grade Point in College Algebra				
	0	1	2	3	4
75 - 79	0	0	0	1	0
70 - 74	0	0	0	0	0
65 - 69	0	0	0	0	1
60 - 64	0	0	1	5	6
55 - 59	0	0	5	6	2
50 - 54	0	1	6	12	6
45 - 49	0	6	27	21	11
40 - 44	0	0	10	6	1
35 - 39	0	2	9	3	2
30 - 34	1	3	4	1	0
25 - 29	0	0	0	1	0

Grade in College Algebra and A. C. E. L-Score. Table XXII was prepared to show the relationship between the A. C. E. L-score and grade point in college algebra.

An examination of the data revealed that 95 per cent of the students of this study who scored at the mean or above on the linguistic portion of the A. C. E. Psychological Examination received a grade of "C" or better in college algebra and 5 per cent received less than "C". Sixty-four per cent made "B" or better and 25 per cent made "A" in college algebra.

If a student scored below the mean L-score, his chances of passing the course in college algebra remained about 9 in 10, but his chances of

making an "A" dropped to about 1 in 10, and the chances of making "B" or better were only 4 in 10.

TABLE XXII

RELATIONSHIP BETWEEN THE A. C. E. L-SCORE AND GRADE POINT IN COLLEGE ALGEBRA

A. C. E. L-Score	Grade Point in College Algebra				
	0	1	2	3	4
95 - 99	0	0	0	3	2
90 - 94	0	0	0	3	0
85 - 89	0	0	0	2	3
80 - 84	0	0	0	1	1
75 - 79	0	0	3	0	4
70 - 74	1	0	5	5	3
65 - 69	0	3	8	10	3
60 - 64	0	4	19	16	9
55 - 59	0	1	9	7	0
50 - 54	0	1	7	3	2
45 - 49	0	2	6	2	2
40 - 44	0	1	4	2	0
35 - 39	0	0	0	0	0
30 - 34	0	0	1	2	0

Grade in College Algebra and Cooperative Algebra Test Score. In Table XXIII data were prepared to show the relationship between Cooperative Algebra Test scores and grades in college algebra. From the data presented, it was observed that of the students in this study who scored at or above the mean on the Cooperative Algebra Test, 94 per cent received a grade of "C" or better in college algebra, 59 per cent

received "B" or better, and 20 per cent received an "A".

Of those scoring below the mean on the Cooperative Algebra Test, 87 per cent received a grade of "C" or better, 41 per cent received "B" or better, and 13 per cent made an "A" on college algebra.

TABLE XXIII

RELATIONSHIP BETWEEN COOPERATIVE ALGEBRA TEST SCORE AND GRADE POINT IN COLLEGE ALGEBRA

Cooperative Algebra Test	Grade Point in College Algebra				
	0	1	2	3	4
55 - 59	0	0	1	1	1
50 - 54	0	1	2	5	2
45 - 59	0	0	2	7	3
40 - 44	0	0	6	3	2
35 - 39	1	5	29	28	15
30 - 34	0	3	5	6	2
25 - 29	0	1	5	1	2
20 - 24	0	2	3	2	1
15 - 19	0	0	4	2	0
10 - 14	0	0	2	1	1
5 - 9	0	0	3	0	0

A comparison of these percentages revealed that students scoring below the mean were only a little less likely to fall in the high grade categories in college algebra than were the students scoring at or above the mean on the Cooperative Algebra Test.

Grade in College Algebra and Nelson-Denny Reading Test Score. The distribution of the reading test scores in relation to grades made in

college algebra was displayed in Table XXIV.

TABLE XXIV

RELATIONSHIP BETWEEN READING TEST SCORE AND GRADE POINT IN COLLEGE ALGEBRA

Reading Test Score	Grade Point in College Algebra 0	1	2	3	4
140 - 149	0	0	0	1	0
130 - 139	0	0	0	4	4
120 - 129	0	0	1	2	2
110 - 119	0	1	3	3	2
100 - 109	0	3	7	4	5
90 - 99	0	0	4	3	2
80 - 89	1	1	19	10	8
70 - 79	0	1	11	4	2
60 - 69	0	2	7	14	3
50 - 59	0	3	3	6	1
40 - 49	0	0	4	4	0
30 - 39	0	1	3	1	0

Ninety-four per cent of the students scoring at or above the mean on the reading test received a grade of "C" or better in college algebra. Sixty per cent of these students earned "B" or better, and 30 per cent received "A" in college algebra. It was of some value to observe that only four persons who had a reading score equal to or greater than the mean received less than a "C" grade in college algebra, whereas there were nine persons with reading scores below the mean who received less than a "C" grade in college algebra.

Only 10 per cent of the students with less than a mean reading score

received an "A" in college algebra and 46 per cent received "B" or better. The chances of a student making an "A" in college algebra if his reading score was less than the mean were only 1 in 10 compared to three chances in 10 if he scored at or above the mean.

Grade in College Algebra and the Guilford-Zimmerman Reasoning Test Score. Data were presented in Table XXV concerning the relationship between the score on the reasoning test and the grade made in college algebra by the subjects of this sample.

TABLE XXV

RELATIONSHIP BETWEEN REASONING TEST SCORE AND GRADE POINT IN COLLEGE ALGEBRA

Reasoning Test Score	Grade Point in College Algebra				
	0	1	2	3	4
24 - 26	0	1	1	2	1
21 - 23	0	0	4	3	3
18 - 20	0	2	5	9	7
15 - 17	0	0	17	13	10
12 - 14	1	3	14	17	5
9 - 11	0	3	15	7	1
6 - 8	0	2	5	4	2
3 - 5	0	1	1	1	0

All except three, or 96 per cent, of the students scoring at or above the mean on the reasoning test received a "C" or better in college algebra. Sixty-two per cent received a "B" or better, and 27 per cent received an "A".

Of those students scoring below the mean on the reasoning test only

10 per cent received an "A" in college algebra, and 45 per cent received "B" or better.

On the basis of this evidence it appeared that good reasoning ability was rather closely related to high quality performance in college algebra.

Summary

Evidence was presented to show that the present sample was representative of students who enroll in a program of mathematics and persist through calculus.

Data on correlations between all of the factors involved in this study were presented and analyzed.

Multiple regression equations were computed and a table and chart for rapid and convenient prediction of grades in calculus were prepared.

Scatter diagrams were presented to display the relationship between each factor and grades in calculus and in algebra.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this chapter was to review the objectives of the study, briefly state the major findings, and make recommendations for future practice and further study.

Review of Objectives

The major objective of this study was to determine the relationship between certain factors and academic success in college algebra and in calculus. The independent factors were the number of semesters of high school mathematics completed, grade-point average in high school mathematics, A. C. E. Q-score, A. C. E. L-score, reading comprehension, reasoning ability, and achievement in algebra at the time of entrance into college.

The answer to three questions was sought: (1) What was the relationship between each of the factors and success in college algebra? (2) What was the relationship between each of the factors and success in calculus? (3) What was the comparison of these relationships?

A fourth major task involved the combination of the most promising factors into a prediction team for the most probable grade in calculus.

Conclusions

In answer to the first question, it was found that all of the factors, except the number of semesters of high school mathematics completed, were significantly related to grades made in college algebra.

Factors significant at the .01 level of confidence and their coefficients of correlation were A. C. E. Q-scores, .38; A. C. E. L-score, .29; grade point average in high school mathematics, .28; scores on the reasoning test, .23; scores on the reading test, .23. The coefficient of correlation between the Cooperative Algebra Test scores and grades in college algebra was .16, which was significant at the .05 level of confidence. The coefficient of correlation between the number of semesters of high school mathematics completed and grades in college algebra was -.06.

In regard to the second question, it was found that the coefficient of correlation between A. C. E. Q-scores and grades in calculus was .16. This correlation was significant at the .05 level of confidence. Grades in college algebra and grades in calculus were related by a correlation coefficient of .34, which was significant at the .01 level of confidence. None of the other coefficients of correlation were large enough to be considered significant at the .05 level of confidence.

In answer to the third question, it may be said that all factors, except one, semesters of high school mathematics completed, were more closely related to grades in college algebra than to grades in calculus. In the case of high school mathematics completed, the coefficients of correlation so nearly approached zero that a comparison was not feasible.

Variables most closely related to academic success in college algebra were A. C. E. Q- and L-scores and grade-point averages in high school mathematics; those least related were Cooperative Algebra Test scores and semesters of high school mathematics completed.

Variables most closely related to academic success in calculus were grade in college algebra and A. C. E. Q-score; those least related

were reasoning test scores, Cooperative Algebra Test scores, and semesters of high school mathematics completed.

The regression equation involving grade made in college algebra and Q-score seemed to show considerable promise for predicting grades in calculus.

The prediction chart designed for predicting "AB", "C", and "DF" grade categories yielded predictions significant at the .01 level of confidence for the students involved in this study.

Although some correlations were low, data presented in scattergram tables gave evidence of the feasibility of setting cutting scores on some tests for the purpose of counseling students about the risk involved in attempting to continue in a program of mathematics through calculus. Tests offering the most promise in this direction were the Q-scores and L-scores on the A. C. E. Psychological Examination and the grade in college algebra.

Recommendations

The results of this study indicate that valuable relationships between certain factors and academic success in a specific mathematics course coming late in the program, such as calculus, can be discovered relatively early. It is recommended that further research be conducted involving such variables as grades made in the sequence of courses preceding calculus, study habits, motivation, and industriousness, in addition to the variables revealed as most promising by this study.

The development and use of a regression equation for predicting grades in calculus, before students have progressed far in a mathematics program, seems feasible. It is recommended that the regression equation developed in this study be used to predict grades in calculus for other

groups of students at this institution in order to test its efficiency.

In view of the very slight relationship between the quantity of high school mathematics completed and academic success in college algebra and in calculus, as revealed by the present study, it would appear unwarranted to place much emphasis on the completion of any given number of units of high school mathematics as a prerequisite to college mathematics.

The reliability of relationships such as those determined by the present study is seriously limited by present grading practices in high schools and colleges. It is recommended that research continue on methods of improving the marking system.

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