The number of years of high school science as a predictor of first year college success compared with other predictors

by Keith LaVern Himmel

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of DOCTOR OF EDUCATION
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Abstract:
The number of years of high school science taken by a student in high school were selected as criteria upon which to base a prediction of first year college success as measured by the cumulative college grade point. Science courses taken in high school were reported as being the only difference which distinguished over- and under-achievers in college. Other variables studied which could be used to predict college success were: sex, high school science grade point, high school grade point, ACT composite score and the science courses taken by an individual.

The purpose of the study of years of science taken in high school as a predictor of first year success in college was to determine if the years of science were as good as or better than other predictors of college success being used at the present time. This need for effective prediction of success in college becomes more important as the number of students seeking admission to college increases.

A sample of 498 students, who were enrolling in college for the first time, were selected from the student body at Upper Iowa University, Fayette, Iowa. The sample was found to be similar to students enrolling at other American colleges based upon the ACT composite scores. The data on the sample were collected from the permanent records of the student. The data were analyzed statistically using multi-linear regression analysis, factor analysis, and Pearson's Product-Moment correlation The number of years of science taken by a student in high school was found to have a statistically significant correlation of .24 in predicting college grade point. In predicting a college grade point, the high school grade point had a correlation of .60, the high school science grade point a .56, and the ACT composite score a .44. The ACT score and the high school grade point combined had a correlation of .64 in predicting first year college grade point. All the study variables combined had a correlation of .66 in predicting college grade point.

Factor analysis resulted in the identification of five factors which were statistically significant. Factor I was related to measures of academic excellence, Factor II was correlated with interest in science, chemistry, and physics, Factors III, IV, and V were correlated with specific subject matter courses: general science, biology, and the other sciences.

The conclusions developed from this study were that the amount of science taken in high school does not appear to contribute significantly to the student's success in college. The best predictors of college success are those which measure the student's past academic performance. The best predictor now being used for admission to college is the high school record. Combined with the high school grade point, the ACT composite score contributes little to improving the prediction of first year college grade point.

THE NUMBER OF YEARS OF HIGH SCHOOL SCIENCE AS A PREDICTOR OF FIRST YEAR COLLEGE SUCCESS COMPARED WITH OTHER PREDICTORS

by

KEITH LAVERN HIMMEL

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

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Approved:

Earl N. Ringo
Head, Major Department

Robert J. Thibeault
Chairman, Examining Committee

Louis D. Smith
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

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CHAPTER I

INTRODUCTION

Admission to college is becoming increasingly difficult.[1] As the number of students attending college increases, the admissions officers are faced with the problem of selecting those students who can best succeed in college.[2] Standardized tests and the high school record (generally high school grade point) are being used as the primary sources upon which to base the decision of admission or rejection of a student.[3]

Students who are seeking admission to college have been encouraged by parents and counselors to take more science. The reason often given for taking more courses in science has been that the student in science is taught to think and reason for himself. New "National" programs have been developed which are changing the curriculum in science.[4] These new programs have changed the emphasis from factual information to an understanding of science and the scientific method and to an emphasis on logical thinking.[5]

The changing attitudes toward the curriculum, particularly in

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[1]Lovejoy, Clarence E., Lovejoy's College Guide, New York: Simon and Schuster, 1961-1962, p. 32.

[2]Hanford, G. H., "1963-1965: Peak Years for Admissions Officers," College Board Review, No. 48, 1962, pp. 16-17.

[3]Lovejoy, op. cit., pp. 16-17.

[4]Goodlad, John I., School Curriculum Reform in the United States, The Fund for the Advancement of Education, March 1964, pp. 9-12.

[5]Science Course Improvement Projects, The National Science Foundation, July 1964, pp. 19,22, 29, 30, 32-33.

mathematics and the sciences, have resulted in new mathematics and new science courses.[6] The new programs in science are generally known by the initials of the committee or project group which planned the programs: PSSC (Physical Science Study Committee), CBA (Chemical Bond Approach Project), BSCS (Biological Sciences Study Committee), CHEM Study (Chemical Education Materials Study), and ESCP (Earth Sciences Curriculum Project).[7]

A study by McQuary[8] reported that over-achieving students (students who score one or more grade levels above expected grade level) could only be distinguished from under-achieving students on the basis of high school science grades. The over-achievers scored higher in science and were interested in science courses. The under-achievers were reported as having lower grades in science and greater interest in applied sciences (industrial arts, agriculture, home economics, and other related courses) and the social sciences.

If the sciences aid the student in thinking clearly and logically, then the more extensive the background in the sciences, the greater should be the student's success in college. If this is true, then it should be possible to predict the success of a student in college based upon the amount of science training he has had in high school.

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[6]Goodlad, op. cit., pp. 9-12.

[7]Science Course Improvement Projects, op. cit., pp. 19, 22, 29, 30, 32-33.

[8]McQuary, John P., "Some Differences Between Under- and Over-Achievers in College," College and University 40:117-120, 1954.

The Problem

The problem was to determine if the number of years of science taken by a student in high school could be used to predict college success (as measured by the cumulative college grade point) during the first year of college. The number of years of science, as a predictor, was compared with other variables used for prediction of college success. These other variables, which can be obtained from the high school record of the student included: sex, the high school science grade point, the high school grade point average, individual and combinations of high school science courses, and the standardized test score.

The Procedures

The number of years of science taken in high school as a predictor of first year college success was studied in the following manner.

A review of literature relating to the prediction of success in college was made to determine methods commonly used. Two methods were reported as being commonly used to predict college success. These were standardized tests, such as the American College Test, and the cumulative high school record. Changes in the high school science curriculum were also reviewed in order to obtain an understanding of how science courses were being changed.

The variables used in predicting college success found in the review of literature were assembled and the statistical devices to analyze these variables as predictors were selected. The statistical

devices included factor analysis and multi-linear regression.

A sample of American college students, who were enrolling for the first time in college, were selected from freshman classes at Upper Iowa University. The sample, consisting of 498 students, was selected and analyzed to determine if it was representative of students enrolling in other colleges and universities during the years of 1962-63, 1963-64, and 1964-65.

The data related to the variables under study were collected from the permanent files of the students in the sample and the data placed on cards so that statistical analysis could be performed by electronic computer.

The statistical devices were applied to the data and an analysis of the data was completed.

The Limitations

The study was limited to academic information which was found in the permanent records of the individuals selected for the sample. The variables under study were measured quantitatively.

The success of a student in college was measured by the college grade point which is a quantitative evaluation of the student's academic work. Several studies[9, 10] used the college grade point as a measure of

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[9]Hills, John R., Bush, Marilyn L., Klock, Joseph A., "Predicting Grades Beyond the Freshman Year," College Board Review, No. 54, pp. 23-25, Fall 1964.

[10]Funches, Delars, "A Correlation Between the ACT Scores and the Grade Point Averages of Freshmen at Jackson State College," College and University, pp. 324-326, Spring 1965.

student success.

The science background of a student was measured by the number of years of science taken by the student. This quantitative measure does not measure the quality of science training given in any high school.

The limitations imposed in the selection of the sample were that the student must have registered in college for the first time and have completed two semesters of course work and have credit for not less than 22 nor more than 34 semester hours. Two semesters of college work were chosen in order that the student would have sufficient time to demonstrate his college potential.

It was considered an important first step to show what the literature had revealed regarding college admission and the changing curriculum in science. The results of this literature survey are presented in Chapter II and Chapter III.

CHAPTER II

COLLEGE ADMISSION

The review of the literature relating to college admission was undertaken in order to provide an understanding of the criteria used by colleges to predict the success of a student. The standardized test and the high school record were two methods reported in the literature as being used in the selection of students for college admission. These were studied to provide a better understanding of standardized tests and the high school record and to relate these to the basic problem of grade prediction.

The number of students seeking admission to college is on the increase; Hanford indicated that the number of students entering college between the years of 1962 and 1964 increased by over one-half million students.[1] This increasing number was due to an increase in the number of individuals who graduated from high school.[2] The percentage of high school graduates who were going to college remained about the same over the years based on the number of high school graduates, roughly 5 of 10 white male high school graduates entered college,[3] and 4 of 10 white female high school graduates entered college.[4]

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[1]Hanford, op. cit., pp. 16-17.

[2]Jaffe, A. J. and Walter Adams, "Trends in College Enrollment," College Board Review, No. 55, Winter 1964-65, p. 28.

[3]ibid., p. 28.

[4]ibid., p. 28.

Prediction of achievement of a student is a problem which has faced and is facing college admissions directors. Hanford pointed to this problem when he stated, "A projected increase of 50.5 per cent in the number of college applications during the next two years will pose problems for college admissions staffs."[5] This problem of increasing applications, due perhaps to the obvious economic dimensions of a college education,[6] makes it important that some criteria or norms be established for incoming students which will enable the admissions offices to form some policy of acceptance or non-acceptance of the student into the freshman class.[7]

College admissions counselors are using various methods in selecting students. Lovejoy reported that the following criteria were the most commonly used: (1) secondary school record, (2) rank in class, (3) recommendation by the principal or headmaster, counselor or some other individual acquainted with both the academic and social record of the student, and (4) tests by the College Entrance Examination Board (CEEB) or the American College Testing Program (ACT).[8] These criteria can be summarized as relating to two general areas--standardized tests and secondary school performance.

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[5]Hanford, op. cit., pp. 16-17.

[6]Kauffman, J. F., "Student Personnel Services: Entry into Higher Education," Educational Record, Fall 1964, p. 355.

[7]Hanford, op. cit., pp. 16-17.

[8]Lovejoy, op. cit., pp. 16-17.

Standardized Tests

Lovejoy's College Guide pointed to the test batteries that are commonly used as a part of college admission programs. These test batteries are the tests by the College Entrance Examination Board (CEEB) and the American College Test (ACT). The tests by the CEEB include: the Scholastic Aptitude Test (SAT), the Scholastic Achievement Test, and the Preliminary Scholastic Aptitude Test (PSAT). The ACT is a single test battery.[9] In the 1963-64 school year, 1,170,000 high school seniors took the SAT; 455,000 students took the Scholastic Achievement Test; and over one million took the PSAT.[10] In the school year 1964-65 the American College Testing Program reported 612,000 high school students took the ACT.[11] Other tests were reported as being used in admissions counseling, and these included the Education Testing Services, School and College Ability Test (SCAT) and the National Merit Scholarship Qualifying Test.[12]

Purposes of standardized tests. The purposes of standardized tests have been stated in several ways. In 1935 a purpose of the standardized test was to check on the academic excellence of whole institutions, both secondary and higher.[13]

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[9] ibid., pp. 16-17.

[10] The College Board Today, CEEB, pp. 13-15.

[11] Holland, John L. and Richards, Jr. James M., "Academic and Non-Academic Accomplishment in a Representative Sample Taken From a Population of 612,000," ACT Research Reports, No. 12, May 1966, p. 2.

[12] Caballero, Braulic, Director of Admissions, Upper Iowa University, Fayette, Iowa, 1966.

[13] Hawkes, Herbert E., Lindquist, E. F., and Mann, C. R., The Construction and Use of Achievement Examination, Boston, Houghton Mifflin Company, 1936, p. 376.

The following is a summation by the present writer of ideas expressed by Dr. Paul L. Trump, president of the American College Testing Program, and Dr. Richard Pearson, president of the College Entrance Examination Board, in a panel discussion reported in College and University.[14]

The standardized test provides a prediction of probable academic success. This prediction becomes more accurate as additional factors are included, such as high school performance and rank in the high school class.

The standardized test provides a method of communication between the high school and the college. It describes certain information about the high school student and his academic abilities. It provides a description of the college, in terms of the academic ability of the students admitted and provides a means of predicting the probable success that a student might have at that college. This articulation or communication is important as the numbers of students seeking college admission increase. Harvard College is reported to use the standardized test scores as a means by which relative aptitude of candidates applying for admission can be compared.[15]

The standardized test gives information to the student which

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[14]"National Admissions Testing Programs--Their Value to Colleges--Their Impact on Secondary Schools," College and University, Summer 1964, pp. 488-514.

[15]Whitla, Dean K., "Admission to College: Policy and Practice," Phi Delta Kappa 46:303, March 1965.

shows how he stands in relation to other twelfth grade students and college-bound seniors. This information could be useful to the student in selecting his institution and also shows some of his areas of academic weakness and strength. Tests directly benefit the student by giving him a better understanding of his abilities. They make possible better counseling by the school counselors in the areas of pre-college and academic counseling.

Gallagher reported that the identification of gifted or superior students was possible through the use of standardized tests of achievement and group intelligence measures. These standardized measures identified more of the gifted students than any other device.[16]

Pearson and Trump pointed out in their discussion of standardized testing that there were abuses of the scores obtained on the standardized tests. Among these abuses were the use of the test score as an absolute measure of a student's ability. Each man pointed out several times that the test score is relative and can provide useful information when used in conjunction with other factors, particularly past academic performance. Another abuse emphasized was the incorrect use of the test results. Some institutions abused the standardized test results by using the scores to create an impression of academic excellence of the institution based on norms of the enrolling students or by using these results as proof of their highly selective admission standards.[17]

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[16]Gallagher, James, Jr., Teaching the Gifted Child, Boston, Allyn and Bacon, Inc., 1964, p. 9.

[17]"National Admissions Testing Programs," op. cit., pp. 488-514.

College Entrance Examination Board Tests. The CEEB was formed in 1900 through the cooperation of the Association of Colleges and Secondary Schools of the Middle States, the National Education Association, and secondary school and college leaders who saw the need for a group to provide direction and co-ordination and research in facilitating the transition of students from high school to college.[18] Three tests were prepared by the CEEB: (1) Scholastic Aptitude Test (SAT); (2) Scholastic Achievement Tests; and (3) Preliminary Scholastic Aptitude Test (PSAT).

The Scholastic Aptitude Test measures reading ability and word comprehension, and includes a mathematics section. Lovejoy described the Scholastic Aptitude Test as follows:

> The Scholastic Aptitude Test comprises a verbal section to measure reading ability and word comprehension and a single mathematical section to measure aptitude for handling the quantitative concepts in mathematics based on the assumption that the student has had arithmetic, simple elementary algebra and plane geometry. It is an objective test to be taken in stride without attempting cramming or reviewing.[19]

The SAT has value in predicting college grade point. A study conducted in Georgia concluded that SAT scores together with high school grade averages can be used to predict the freshman grade point beyond the first year of college with a correlation averaging in the 0.60's and these "freshman grades correlate in the 0.60's with the cumulative

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[18] The College Board Today, op. cit., p. 4.

[19] Lovejoy, op. cit., p. 30.

sophomore and cumulative senior averages."[20] The ACT Research Reports state that the SAT has a predictive correlation of the freshman grade point similar to that of ACT.[21]

Supplements to the SAT were the Scholastic Achievement Tests. These tests were designed to provide additional information about the candidate in specific subject matter areas.[22] These tests are one-hour objective examinations. The Achievement Tests are offered in 14 subjects and supplemental tests are available in eight other specialized areas.[23] Colleges may use the Scholastic Achievement Test scores in several ways: (1) as evidence of preparation and qualification to do college-level work, (2) for placement, and (3) in guidance and advisory work.[24]

The Preliminary Scholastic Aptitude Test (PSAT) is designed to provide early information concerning a student's aptitude and is generally given the junior year of high school.[25] This (PSAT) test is

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[20]Hills, John R., Bush, Marilyn L., Klock, Joseph A., op. cit., pp. 23-25.

[21]Munday, Leo, "Comparative Predictive Validities of the American College Tests and Two Other Scholastic Aptitude Tests," ACT Research Reports, No. 6, p. 1, August 1965.

[22]"A Description of the College Board Achievement Tests," CEEB, 1965, p. 11.

[23]ibid., p. 11.

[24]ibid., p. 13.

[25]The College Board Today, op. cit., p. 12.

similar to the SAT and will help in the guidance of a student during the junior and senior years.[26]

American College Testing Program Test. The American College Test (ACT) is relatively new in the field of admissions testing. The test appeared in the late 1950's and was an adaptation of the Iowa Test of Educational Development.[27] Lovejoy described the ACT as follows:

> The ACT is an admissions, scholarship, guidance and placement test battery designed to provide information and service to colleges, high schools, and students. The basic test battery consists of four tests, averaging 45 minutes in length, covering the fields of English, Mathematics, the Social Studies, and the Natural Sciences. The tests in English and Mathematics are designed particularly for use in placing students in freshman English and Mathematics classes.[28]

The correlation between ACT scores and the year-end grade point is reported to be 0.59 at Jackson State College, Jackson, Mississippi.[29] Funches' study concluded that the ACT composite score would be a reliable factor if used to predict first-year college success.[30] In comparison with other standardized tests, SAT and SCAT, Munday reported that the predictive validity of the ACT is about the same as the SAT, and both

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[26] ibid., p. 12.

[27] National Admissions Testing Program, op. cit., p. 498.

[28] Lovejoy, op. cit., p. 30.

[29] Funches, op. cit., pp. 324-326.

[30] ibid., p. 326.

SAT and ACT were better predictors than the SCAT.[31]

Use of the admissions tests by the colleges. The use of the SAT and ACT scores by college admissions offices varies from college to college. Studies using the SAT or the ACT scores as predictors of college success indicated that these test scores when combined with the high school record in one manner or another had good predictive value.[32,33,34] In each of the reports, however, the authors indicated there were other variables which needed to be considered in predicting the success of a student. The ACT in response to this need for further information about the student added a section to their test which was designed to provide further information concerning student competencies and achievements during the high school years,[35] such as participation in student government, athletic awards, and special honors. The analysis of this information suggested strongly that academic and non-academic accomplishments were relatively independent dimensions of talent.[36] Other variables were weighed, however, by the college admission personnel in the selection of students.

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[31] Munday, op. cit., p. 1.

[32] Lewis, J. W., "Pre-College Variables as Predictors of Freshman, Sophomore, and Junior Achievements," Education and Psychological Measurements 24:352-353, Summer 1964.

[33] Kunhart, W. E., Olson, E. V., "American Council on Education Psychological Examination Score as Predictors of Success in Academic College Courses," Journal of Educational Research 57:514-517, July 1964.

[34] Hills, Bush, Clock, op. cit., pp. 23-25.

[35] Holland and Richards, Jr., op. cit., pp. 3-4.

[36] ibid., p. 1.

One of these was the high school record or the past academic record of the student.

Secondary School Record

The high school record, particularly the high school grade point average, was reported as being one of the best indicators of college success. After reviewing the high school record as a predictor of college success, Giusti concluded that the high school grade average is the best predictor in current use. He stated:

> The most significant conclusion resulting from the exploration of the field of prediction studies is the unquestionable superiority and stability of the high school grade average as a single source of data for predicting college success.[37]

Elton, in a study of the high school record as a predictor of college success, found the following: (1) The best predictor of college success is the cumulative high school grade point; (2) The second best predictor is the grade point average for the ninth, tenth, and eleventh grades.[38] Elton also reported that the high school average is more critical in predicting success of male students than female students.[39]

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[37]Giusti, J. P., "High School Average as a Predictor of College Success: A Survey of the Literature," College and University 39:200-209, 1964.

[38]Elton, Charles F., "Three Year High School Average as a Predictor of College Success," College and University, p. 167, Winter 1965.

[39]ibid., p. 167.

Elton concluded:

> Admissions officers who select students on the basis of the high school record may be confident that, for all practical purposes, the grade average through the eleventh year is as good in prediction as the four-year average.[40]

The CEEB pointed to the importance of a good school record in gaining admission to college: "this (high school grade point) is the most important part of a student's application to college."[41] The value of the high school record may be due in part to the fact that the typical high school curriculum covers a variety of academic areas. Miller suggested that general ability measures were usually superior to interest scores for prediction of course grades.[42]

The reason students succeed or fail in college has been studied. Essentially the success or failure of a student in college must depend upon the student, his abilities and weaknesses. McQuary pointed up the problem of why students do or do not succeed in college when he stated:

> . . . staff have often asked "why" students fail. Frequent answers are motivation, persistence, drive, hard work, etc., or the lack of these. Although one has some conception of what these terms mean, they are of little practical value to the person who does the individual counseling, since as yet we do not have nor have we been able to adequately measure or identify them.[43]

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[40] ibid., p. 167.

[41] The College Board Today, op. cit., pp. 16-17.

[42] Miller, Adam, "General Ability and Interest Measures as Differential Predictors of Academic Achievement," Education and Psychological Measurements 24:357-362, Summer 1964.

[43] McQuary, John P., op. cit., 117-120.

In a study of over-achievers (students who scored one or more grade levels above expected grade level), the over-achievers were reported to have had a less fortunate family situation or a poorer socio-economic status than under-achieving students.[44] The over-achieving student was apt to have better marks in science than the under-achieving student.[45] No other subject matter field could be used to distinguish between the two groups.[46]

Lovejoy indicated that the high school record was the single most important measure of student achievement. To gain admission to college, the student high school record is coupled with other criteria, usually one of the standardized tests, to predict the probability of success of any one individual student. For any student, however, college success is based on the individual effort of the student and the student's abilities both academically and socially. These cannot at the present time be measured with any degree of success and so cannot be figured into the total prediction of college success.

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[44] McQuary, op. cit., p. 117.

[45] ibid., pp. 118-119.

[46] ibid., pp. 118-119.

CHAPTER III

CHANGING HIGH SCHOOL SCIENCE CURRICULUM

The American public in the late 1950's was impressed by "Sputnik" and the technological advances in science, and as a result more and more students were encouraged and sometimes pushed into science courses. The students were encouraged to take more science, not only in high school but college, as this was the "best" way to attain economic success.

Would this training in science better enable the student to succeed in college, and thus afford a method of predicting his college success was the question posed in this study. In order to better understand these changes in the science curriculum that were and are affecting the student in high school, and to understand the role of science in the training of high school students; this literature review was included in this study. Science grades in high school were the only factor which could be found that would distinguish between the under- and over-achievers in college.[1]

Changes in the high school science curricula began in the 1950's and since have moved at a rapid pace. Pearson pointed to these changes when he said:

> In a single decade, we saw major curriculum innovation in mathematics, sciences and foreign languages.... The tempo of change since 1960 has if anything, been greater than in the 1950's. The reforms that were stated in the preceding decade remained, in may instances, unfinished.[2]

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[1] McQuary, op. cit., pp. 117-120.

[2] National Admissions Testing Programs, op. cit., pp. 489-499.

These changes in the science curriculum are sometimes viewed erroneously as "national" reforms.[3] Goodlad has identified three factors as responsible for the "national" aspects of the reform movement.[4] The first of these factors is the extensive support given by the National Science Foundation. Second, project groups such as, the Biological Science Curriculum Study, which are not approved by local or state agencies that have jurisdiction over school curriculum. Third, many of the projects have been advised or sanctioned by national bodies concerned with specific phases of pre-collegiate curriculum.

There is a shift in the new science programs from the more practical applications of science to an understanding of the basic principles which operate in nature. An example of this is the shift in physics. While the tradititonal physics course might stress the working of a refrigerator, for example, the new programs would emphasize the exchange of energy as matter changes state, the expansion and contraction of gases, and the effects of pressure.

The emphasis is away from detailed factual information. In the BSCS program, for example, the traditional philogenetic approach to the study of the living world loses emphasis and the similarity and differences of living things are stressed. No longer are the students required to memorize long lists of characteristics of each biological

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[3]Goodlad, John I., School Curriculum Reform in the United States, The Fund for the Advancement of Education, March 1964, p. 6.

[4]ibid., p. 6.

grouping, but instead are led to understand how and why living things are grouped together. Each group of living things is viewed as a part of a continuum and not as separate and distinct individual groups.

Perhaps the most dramatic difference between the new and traditional science courses is the shift in the role of the laboratory. In most of the traditional laboratories the student followed a laboratory manual to perform an experiment, and then found and reported the results. If the student was at all capable, most of these results could have been predicted in advance and the entire experiment reproduced without ever having been in the laboratory. In the new programs the laboratory is a key part of the instruction. The students are taught to develop a hypothesis as to what is happening and develop experiments of their own to test their hypothesis. The laboratory is an integral part of the science course.

The five national projects affecting the high school science curriculum are: (1) Physical Science Study Committee, PSSC; (2) Chemical Bond Approach Project, CBA; (3) Chemical Education Materials Study, CHEM Study; (4) Biological Science Curriculum Study, BSCS; and (5) Earth Science Curriculum Project, ESCP.

Physical Science Study Committee

The PSSC has acted as a pioneer in many areas of curriculum reform. The PSSC course in physics emphasizes the basic structure of physics, the acquisition of new physical knowledge, and the necessity for understanding rather than memorizing basic physics concepts. The

laboratory is the focal point where the students gain first-hand experience in discovering and verifying physical phenomena.[5,6]

The course consists of four parts, each building on the preceding part. Part I deals with the fundamental concepts of time, space, and matter; Part II is concerned with a detailed examination of light; Part III deals with motion; and Part IV covers electricity and the physics of the atom.[7]

An examination prepared and administered by the College Entrance Examination Board has been used to compare students in PSSC programs with those in conventional high school physics classes. There is no evidence to suggest that these high school graduates (PSSC) are in any way at a disadvantage in college physics, although they sometimes have indicated their dissatisfaction with college fare.[8,9]

Chemical Bond Approach Project and Chemical Education Materials Study

The CBA and CHEM Study are beginning to influence American education in the area of high school chemistry.[10] CBA and CHEM Study

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[5] ibid., pp. 22-23.

[6] Science Course Improvement Projects, op. cit., pp. 29-30.

[7] Goodlad, op. cit., pp. 22-23.

[8] Science Course Improvement Projects, op. cit., p. 22.

[9] ibid., p. 22.

[10] Goodlad, op. cit., pp. 28-33.

stress basic concepts and principles and offer treatment in depth of a few selected areas instead of the shallow overview of many areas. Both programs advocate a research chemist's approach to meaningful experimentation, but they are somewhat different in content, approach, and pedagogy.[11,12]

The central theme of the CBA course is chemical bonds. The course attempts to confront the student with the implications of logical argument based on theory. Special attention is given to three major ideas: structure, kinetic theory, and energy.[13,14]

The course emphasizes laboratory work with the thought that a student will develop an appreciation of chemistry if he performs the functions characteristic of a chemist: the ability to identify a problem, design an experiment which will shed light on this problem, carry out the technical operations of this experiment, and arrive at a conclusion based on analysis of his own data.[15,16]

The CHEM Study program in high school chemistry was designed to reduce the gap between scientist and teachers in the understanding of science; to stimulate able high school students to continue the study of

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[11] ibid., pp. 28-33.

[12] Science Course Improvement Projects, op. cit., p. 22.

[13] ibid., p. 22.

[14] Goodlad, op. cit., pp. 28-33.

[15] ibid., p. 22.

[16] Science Course Improvement Projects, op. cit., p. 23.

science in college; to encourage teachers to keep up with their fields through courses in the advancing frontiers of science; and to develop an understanding of the importance of science for students who do not continue chemistry after high school.[17,18]

The CHEM Study course begins with an overview of chemistry. Behavior of substances are explained according to the theory of atoms and energy. The periodic table, its development and uses are introduced early in the course. Topics of energy, equilibrium, acids, and bases follow. Structural relationships of matter and their influence on chemical reactivity are also included in the course. The concepts are introduced in the laboratory and then are further developed and tied together through kinetic theory and atomic-molecular concepts of behavior of matter.[19,20] CHEM Study builds the laboratory into the sequence of the text; principles are developed through students' laboratory exercises.[21]

Both CBA and CHEM Study are designed to make the student think for himself; he is encouraged in the laboratory to explore. In both programs the laboratory is the key to much of the learning in the programs. CBA encourages the student to theorize and speculate, then

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[17] ibid., p. 23.

[18] Goodlad, op. cit., pp. 32-33.

[19] ibid., pp. 32-33.

[20] Science Course Improvement Projects, op. cit., p. 23.

[21] Goodlad, op. cit., pp. 32-33.

test; while CHEM Study encourages the student to observe in the laboratory then move to the area of theory for explanation of what was observed.[22]

Biological Sciences Curriculum Study

Three versions of primary teaching materials have been developed by BSCS. Each set of materials differs in approach but each is organized around the same unifying concepts. Nine unifying concepts are found in each of the three versions: changes of living things through time, diversity of type and unity of pattern of living things, genetic continuity of life, biological roots of behavior, complementarity of organisms and environment, complementarity of structure and function, regulation and homeostasis, science as inquiry, and intellectual history of biological concepts.[23,24]

The Green version of BSCS emphasizes the biological community, beginning with the complexity and diversity of life and coming to cellular structure relatively late in the course. The Yellow version emphasizes cellular biology at the outset, divides the subject matter into seven sections: cells, micro-organisms, plants, animals, genetics, evolution, and ecology. The Blue Version stresses physiology and bio-chemical evolutionary processes with emphasis on contributions that

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[22] ibid., pp. 32-33.

[23] ibid., pp. 25-28.

[24] Science Course Improvement Projects, op. cit., p. 19.

molecular biology has made to the general understanding of the universe. All three versions of BSCS stress investigation and principles; the universal rather than the applied aspects of biology.[25,26]

Earth Science Curriculum Project

The ESCP is an interdisciplinary program in which astronomers, geologists, geophysicists, meteorologists, oceanographers and physical geographers, together with educators and teachers are attempting to improve earth science courses in the schools as well as to improve the training of teachers. The Committee has and is conducting surveys of sequence of earth science subjects from grades K-12.[27]

The study has developed the unifying themes for the materials being prepared. These themes are: the flow of energy, adaptation to environmental change, conservation of mass and energy, significance of components and their relationship to time and space, uniformitarianism, comprehension of scale, and prediction. The ESCP will make no attempt in their new textbook to cover the entire field of knowledge in earth science, but will try to develop a system of basic concepts and principles.[28]

In almost every instance of curriculum revisions studied, the

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[25] Goodlad, op. cit., pp. 32-33.

[26] Science Course Improvement Projects, op. cit., p. 19.

[27] ibid., p. 25.

[28] ibid., p. 25.

traditional course was viewed as not reflecting the current thinking of science and scientists, and the materials being presented were "behind the times." The revisions stress student effort and the ability of students to think. The laboratory experience is improved and becomes an integral part of the course revision. In every instance basic concepts and principles are stressed and much of the material of the traditional course has been removed. These changes are slowly being incorporated into the high school curriculum as teachers are trained and as the general citizenry are convinced of the value of the curriculum revisions. No data is available relative to the number of schools which have adopted all of the revisions or even partially adopted one or more of the new programs.

The new curricula in science have in the past few years become a part of the high school program. However, the students in the study sample had completed their school science training between 1958 and 1963, prior to the wider acceptance of the science curricula revisions. The students currently entering college, and perhaps even more so in the future as these new curricula are developed, will have had more extensive training in the use and application of individualized thinking, individual planning, and personal investigation. This training may alter the results of this study, if this problem were to be investigated in the future.

After completing the review of the literature relating to prediction of college success and the changes that are affecting the science curriculum, the statistical methods for the analysis of data and a study sample had to be selected. Chapter IV is a discussion of the study sample and Chapter V discusses the statistical methods used.

CHAPTER IV

THE STUDY SAMPLE

If the number of years of high school science taken by a student was to be used as a predictor of first-year college success, a study sample had to be selected. The sample selected was chosen from the freshman students who enrolled at Upper Iowa University, Fayette, Iowa, during the school years of 1962-63, 1963-64, and 1964-65. The sample consisted of all students who enrolled in college for the first time and were full-time students who had met the restrictions placed on this sample. The high school and college transcripts were examined and the data taken from these records. Permission to use the college records was obtained from the Vice-President and Dean of Upper Iowa University, Dr. Herschel Hendrix.[1]

Selection of the Sample. The selection of the years from which to choose the sample was based on the requirement by Upper Iowa University that beginning with the 1962-63 school year all students must have taken and have in their records the results of at least one national standardized achievement test. This provided the basis for national comparison. The individuals who were to be a part of the sample were selected from the list of freshmen and new students provided by the Office of the Registrar. All students on these lists, who were not excluded from the sample by the limitations, were used.

Limitations Imposed on the Sample. Several limitations were

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[1] See Appendix A., p. 73.

imposed on the sample. The student must have been registered for the first time in college as a full-time student for two semesters and have completed a minimum of 22 and not more than 34 semester hours of course work at Upper Iowa University. Table 1 contains a list of courses available to the enrolling students and is provided to indicate the type of courses a typical freshman at Upper Iowa University might take.

TABLE I. COURSES OPEN TO FRESHMEN STUDENTS AT UPPER IOWA UNIVERSITY AND THE SEMESTER CREDIT HOURS FOR EACH COURSE

COURSE	Credit Hours
Communication Skills	6
Music Understanding	2
Art Appreciation	2
Understanding of Drama	2
Foreign Language	10
General Botany I	4
General Botany II	4
General Zoology	4
Invertebrate Zoology	4
Microbiology	4
Introduction to Modern Mathematics	5
Algebra and Introductory Calculus	10
Introductory Physics	10
General Chemistry	10
World Civilization	8
Introduction to Business	3
American Government	3
Introduction to Sociology	6
General Psychology	3
Fundamentals of Speech	2
Introduction to the Bible	3
Introduction to Philosophy	3
Personal Health	2
Basic Sports	2

The number of credit hours taken by any freshman is limited by action of Upper Iowa University to a maximum of 17 semester hours per semester for regular students. Students who are admitted by the University on a trial basis take up to a maximum of 13 semester hours the first semester; and if the grade point exceeds 2.00, the student is allowed to take credit up to 17 semester hours the second semester; or the student goes on probation for the second semester if he fails to achieve the required 2.00 average. Students admitted on probation take up to 12 semester hours of credit the first semester; and if the grade point exceeds 2.00, the student may register the second semester as a regular student; or if the grade point falls below 2.00, the probation may be contined for the second semester with a maximum credit load of 12 semester hours; or the University may suspend the student.

The success of a student in this sample in college was measured by the cumulative college grade point after completing two semesters of college work with a minimum of 22 semester hours of work. The cumulative college grade point is a measure of college academic success and is found by dividing the total number of grade points by the total college hours. The grade points are found by multiplying the credit hours for each course by the grade listed as a number; A = 4, B = 3, C = 2, D = 1, and F = 0. The same 4-point scale was applied to the high school grades reported on the high school transcript.

The number of years of science was used in order to quantify the amount of science taken in high school and is not an attempt to evaluate the quality of the science courses. Science for the purpose of this

study is defined as general science, biology, chemistry, physics, and other courses related to these areas such as earth science, physical science and physiology.

Data Collected from Permanent Records. The data for each student were collected from the permanent records of Upper Iowa University by the present writer. Each record folder was examined to determine if the student's records met the requirements defined in this study. If the record met the requirements, the following items were recorded: (1) sex of the student; (2) science courses taken in high school--general science, biology, chemistry, physics, and others; (3) the number of years of science taken--i.e., 2.0 years, or 2.5 years if the student had taken 5 semesters of science; (4) the high school science grade point; (5) the high school grade point; (6) ACT composite score; (7) college hours taken; and (8) college cumulative grade point.

In predicting college grade point, sex of the student was reported by Elton as being important. The high school grade point was six times more effective in predicting college success for males than for females.[2]

The total number of years of science was noted in order to test this criteria as a predictor of college success. The specific science courses were noted in order to determine if any one course or combination of science courses could be used as predictors of college success.

The science grade point was used so that science grades as

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[2]Elton, op. cit., p. 167.

predictors of college success could be statistically tested. McQuary had reported that science grades were the only statistically significant factor found which could be used to differentiate between under- and over-achievers in college.[3]

The high school grade point was selected as a criteria as it has been reported as one of the most significant predictors of success by Giusti.[4] Other studies, cited earlier, reported the use of the high school grade point as a part of prediction for college success of any student.

The ACT composite score was chosen to provide a check of the sample against national norms. This check would make it possible to say that the sample was representative of a national college population based on students who had taken the ACT. The ACT was selected as the national norm since most students who enrolled at Upper Iowa University since 1962-1963 had taken this test, and the results were a part of the students' permanent records.

The college credit hours were noted in order to compute the college grade point for each student in the sample.

The cumulative college grade point was used as a measure of academic success in college. This technique of measuring college success had been reported in several studies.[5,6,7]

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[3]McQuary, op. cit., pp. 118-119.

[4]Giusti, op. cit., pp. 200-209.

[5]Hills, Bush, and Klock, op. cit., pp. 23-25

[6]Munday, op. cit., pp. 1-10.

[7]Funches, op. cit., pp. 324-326.

The data collected for each student were recorded on IBM punch cards so the data could be programed for an electronic computer and analyzed.

The Selected Sample. The students whose records were used for this study were selected from lists of freshmen and new students for the years 1962-1963, 1963-1964, and 1964-1965. These lists contained 709 names of freshmen, transfer students, and special students. Application of the limitations of this study reduced the sample number to 498 students. Table 2 is a listing of the various categories of the total number of students and demonstrates how the sample of 498 students was derived.

TABLE 2. SELECTION OF SAMPLE FROM 709 FRESHMEN AND NEW STUDENTS AT UPPER IOWA UNIVERSITY FROM 1962-63, 1963-64, 1964-65

Sample Divisions	Number
Freshmen and new students listed by the Registrar	709
Transfer students	114
Special students	9
Students with less than two semesters of work	59
Records not found	10
Duplicated names	19
Total records eliminated	211
Total records in sample	498

The largest number of student records eliminated from the sample were the records of transfer students (114 out of 709). These student names were included in the freshman-new student lists. The

second largest group eliminated were the students who had not completed two full semesters of work at Upper Iowa University (59 out of 709).

Information concerning the selected sample. The data concerning the study sample was compiled and tabulated in Table 3, page 34. The sample was based on 498 individuals, 156 females and 342 males.

A major portion of the students in the sample had taken two science courses, biology and general science (88 per cent and 73 per cent, respectively). Forty-nine per cent of the students had taken chemistry and 31 per cent had taken physics. Only 13 per cent had taken a science course or courses other than those listed. Ninty-one per cent of the females had taken biology, 87 per cent of the males. Thirty-nine per cent of the males had taken physics, 13 per cent of the females.

The students represented in the sample had taken an average of two and one-half years (2.52) of science in high school. The males had taken about one-half year more science than the females.

The mean high school science grade point was 2.13, based on a 4 point scale. This was about 0.19 points below the mean high school grade point of 2.32. The females had a higher mean grade point in science and a higher mean high school grade point than males.

The mean ACT composite score for males was higher than the score for females (19.61 to 19.50, respectively). The 136 students, who had not taken the ACT, had scores for other national tests.

TABLE 3. CHARACTERISTICS OF THE STUDENTS REPRESENTED IN THE SAMPLE IN TERMS OF MALE, FEMALE, AND TOTAL SAMPLE

Characteristics	Male	Female	Total
Observations	342	156	498
Science Courses, By Percentage			
General Science	.77	.66	.73
Biology	.87	.91	.88
Chemistry	.51	.46	.49
Physics	.39	.13	.31
Other	.14	.10	.13
Years of Science			
Mean	2.64	2.25	2.52
Standard Deviation	.92	.92	.94
High School Science Grade Point			
Mean	2.02	2.36	2.13
Standard Deviation	.68	.84	.75
High School Grade Point			
Mean	2.19	2.62	2.32
Standard Deviation	.52	.61	.58
Number Who Took ACT Test	243	119	362
ACT Test Composite Score			
Mean	19.61	19.50	19.57
Standard Deviation	3.80	3.96	3.86
College Hours Taken			
Mean	28.70	30.12	29.15
Standard Deviation	3.03	2.88	3.05
College Grade Point			
Mean	2.25	2.55	2.34
Standard Deviation	.61	.64	.63

The students in the sample had completed an average of 29.15 semester hours of work during the first year of college. The females had about one and one-half more semester hours of work than the males. The mean college grade point for the 498 individuals in the sample was 2.34. Females had a higher mean grade point than males (2.55 to 2.25).

Selected sample compared to national norms. The national means selected to compare with the sample were supplied to Upper Iowa University by the American College Testing Research Service. The research service supplies data to schools at four levels of institutions: Level I includes schools that offer less than four years but more than two years of work beyond the twelfth grade; level II includes those institutions that offer only the bachelor's or the first professional degree and would include Upper Iowa University; level III includes those institutions which offer a Master's and/or the second professional degree; and level IV includes those institutions that offer the Doctor of Philosophy and/or equivalent degrees. The sample was selected from a level II college. Table 4, page 36, is a compilation of the mean ACT composite scores for all institutions and level II schools.

The mean composite ACT score for the sample is slightly higher than the mean score for level II institutions and slightly below the mean composite ACT score for all institutions that use the ACT Research Service. These differences using the $\bar{z}$ test for significance were found to be not significantly different from zero.

TABLE 4. ACT COMPOSITE SCORE MEANS FOR ALL INSTITUTIONS, LEVEL II SCHOOL AND THE SAMPLE, SUMMER 1964

Statistical Categories	Level of Institution		Sample
	All Levels	Level II	
Number of observations	103,256	20,605	362
Number of colleges	205	21	1
Mean ACT Score	19.82	19.41	19.57
Standard deviation	4.77	4.71	3.86

College Grade Point compared to other institutions. To determine if the median grade point of the sample was significantly different from the median grade point earned at other institutions, seven institutions were checked. The six institutions included three state colleges, one state university, and two private liberal arts colleges. Table 5, page 37, is a compilation of the data concerning the median grade point at six Montana institutions. This information was supplied by the registrars at each of the institutions.

The median grade earned by the sample is higher than that earned at any of the state colleges. These differences using the $\tilde{z}$ test for significance were found to be not significantly different from zero. Two of the state colleges, however, reported the median earned grade point for male students. If the female grade points had been added the median would have been higher; this was according to the registrars.

TABLE 5. THE MEDIAN GRADE POINT EARNED BY FRESHMAN AT SIX MONTANA COLLEGES AND THE SAMPLE, SPRING 1966

Institution	Median G. P.	Number of Freshmen
Northern Montana State College	2.00	765*
Western Montana State College	2.24	160*
Eastern Montana State College	1.80	532
Montana State University	2.10	2557
Rocky Mountain College	2.20	183
College of Great Falls	2.28	76*
Upper Iowa University	2.30	498

*Male Students only

One liberal arts college, Carroll College, Helena, Montana, reported a mean freshman grade point of 2.37; this compared to the 2.34 mean for the sample. The grades earned by the freshman students in the sample at Upper Iowa University were similar to the grades earned by freshman students at Montana schools of higher education.

CHAPTER V

THE STATISTICAL METHODS USED IN THE ANALYSIS OF THE SAMPLE DATA

In order to evaluate the relationships of the variables in the prediction of success in college, multiple regression analysis and factor analysis were selected as the statistical techniques. These techniques are readily adaptable to electronic computers.

By the use of statistical tests the experimenter seeks to find out what could be determined by manipulation of variables and experimental controls. In using the statistical approach to experimentation the researcher allows many things to vary at the same time and then by the use of statistical tools, it is possible to identify particular relationships for study.[1]

Multi-linear regression analysis. Regression analysis may be defined as the estimation or prediction of the value of one variable from the values of other given variables.[2] In consideration of the relation that exists between two physical quantities, one variable is thought of as being the independent variable, and the other variable being dependent on it. The dependent variable is the variable whose values are distributed at random about the regression function, so that its expected value is some function of the observed value of the

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[1] Cattell, Raymond B., Factor Analysis, Harper & Brothers, New York, 1952, pp. 3-7.

[2] The discussion of multi-linear regression is based on Williams, E. J., Regression Analysis, John Wiley & Sons, Inc., New York, 1959.

independent variable.

Regression analysis enables the effects of variables to be evaluated from the experimental data. Regression analysis can also be used when the variables affecting the results cannot be obtained by controlled experimentation. This statistical technique makes it possible to consider the effect of one variable on others; thus it is possible to assess the effect of other variables through a regression analysis.

Regression analysis is a method of comparing the linear relation between two or more variables; one variable is dependent on the other(s). Changes in the dependent variable are determined by the changes in the independent variable(s). Multi-linear regression is effective if few variables are included in the regression equation. Three or four variables will provide a satisfactory relationship.

The correlation coefficient obtained from regression analysis gives an indication of the magnitude of the relationship among the variables. The sign associated with a correlation coefficient does not alter the degree of relationship, just the direction. The positive coefficient indicates that as the X values change, the Y values change in the same direction and in the same proportion. A negative correlation indicates direction, so that as the X values change, the Y values react in the inverse manner.

The test of significance is used to determine if the hypothesis being tested is tenable or untenable. A significance test at the 2.5 per cent level means that the results obtained in repeated testings would be expected to fall within the range indicated 97.5 per cent of

the time. Another way of stating the significance is to state that the difference between two correlations is not significantly different from zero.

In order to test if the difference between two correlation coefficients is significant, the Fisher Z' test was used. A level of significance of 0.1 per cent was used. The formula for the Fisher Z' test used was:

$$Z^1 = \frac{Z'_1 - Z'_2}{\sigma_{Z_1 - Z_2}}$$

where $r = Z^1$ and $\sigma_{Z_1 - Z_2} = \sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}}$

r = correlation coefficient

Z' = Fisher Z score

n = number of observations

$Z_1 - Z_2$ = Standard error of estimate

t = Table value of t with n-2 degrees of freedom

Test for significance:

$Z^1 < t$ not significantly different than zero

$Z^1 > t$ significantly different than zero

The standard error of estimate is a measure of the error in all of the predictions of the expected Y scores with the actual Y scores. The higher the correlation coefficients the smaller is the standard error of the estimate; the lower the correlation coefficient the

greater is the difference between expected Y scores and the actual Y scores.

Confidence intervals and confidence limits were set on all correlation coefficients. The confidence interval means that at a particular degree of confidence that the population coefficients are expected to fall within this range of value. The confidence limits are the high and low values of the confidence interval. Thus, at a 2.5 per cent level of confidence, with repeated sampling of the population, the correlations will fall within the confidence interval 97.5 times in 100.

The confidence interval and the confidence limits were determined using the Fisher Z' method. Five per cent confidence intervals were established for all regression coefficients. The formula used to determine the confidence limits was:

$$\text{Confidence limits} = Z' \pm t \quad (\sqrt{Z})$$

where $r = Z'$ and $\sqrt{Z} = \dfrac{M}{N - M - 2}$

r = correlation coefficient

Z' = Fisher Z' score

M = Number of independent variables

N = Number of observations

Z = Standard error of estimate

The all pairs correlations are the Pearson Product-Moment correlation coefficients obtained by comparing every variable with each other.[3]

Factor Analysis. In factor analysis the experimenter's arbitrary choice as to what are the important variables does not occur. Factor analysis seeks to determine the degree of association among the variables and to statistically select new factors which appear to be functioning. In analyzing variables it is important to determine the real independent factors at work, and in factor analysis the experimenter is able to identify the important major influences between which regular relations are likely to exist. Through factor analysis of many variables it is possible to determine which factor or factors are at work, the nature of each factor, the correlations among the factors, and the relative magnitude in respect to their contribution to the variance of a particular variable or of most variables.[4]

In the use of factor analysis measures are taken on a number of variables in a certain field. Then all of the possible correlation coefficients among the variables are worked out to see to what extent they covary (Pearson's Product-Moments Correlation Coefficients). Factor analysis techniques are then applied to the correlation coefficients by which method some of the variables are grouped together

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[3]Downie, N. M., Heath, R. W., Basic Statistical Methods, Harper & Brothers, Inc., New York, 1959, p. 83.

[4]The discussion of factor analysis is based on Cattell, Raymond B., Factor Analysis, Harper & Brothers, Inc., New York, 1952.

because they behave in the same way or measure the same things. Factor analysis can be called factor synthesis or at least variable synthesis, since it analyzes out distinct factors at work among the variables and shows groups of variables together in ways which permit the synthesis of new entities.

Factor analysis holds whole factors constant and groups the variables to give estimates of the relation between variables and the new factors. Factor analysis is concerned with how much relationship exists while other methods indicate what, if any, significant relations exist. Factor analysis does give an interpretation of a given body of data and thus affords a fundamental description of the particular set of variables analyzed.

CHAPTER VI

PREDICTION OF COLLEGE SUCCESS

Based upon the survey of the literature, ten variables were selected as possible predictors of first year college success as measured by the cumulative college grade point. The ten variables reported as possibilities for the prediction of success were: (1) sex, (2) years of science, (3) high school grade point, (4) high school science grade point, (5) ACT composite score, (6) biology, (7) chemistry, (8) physics, (9) general science, and (10) other science courses.

These variables were tested using multiple regression analysis, all pairs correlation, and factor analysis to determine the effectiveness of each variable, and the variables used in combination to predict college success.[1]

Statistical tests on the data. Nine different test combinations of variables were evaluated using multi-linear regression analysis. The evaluation in each test combination was based on data for females, males, and all individuals in the sample. The statistical test combinations were: (1) sex and years of science as predictors of college grade point, (2) American College Test composite score as a predictor of college grade point, (3) high school grade point as a predictor of college grade point, (4) high school science grade average and sex as a predictor of

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[1]The computer program for the analysis of the data was developed by and performed by Mr. Ralph Huntsinger, Montana State College, Department of Chemical Engineering.

college grade point, (5) sex, high school grade average and ACT as predictors of college grade point, (7) all variables as predictors of college grade point, (8) all variables without ACT composite score as a predictor of college grade point, (9) sex and courses as predictors of the ACT composite score. The results of these tests have been compiled in Table 6, page 46.

All statistical tests were evaluated at the 0.1 per cent level of significance. The difference between the regression coefficients for all in the sample, males, and females were checked using the Fisher Z' test to determine if the differences were significantly different from zero. In each group of correlations for all, male, and female the differences were not significantly different from zero, thus it could be assumed that they were due to chance.

A correlation coefficient exceeding .321 is statistically significant at the 0.1 per cent level of confidence for 102 observations. As the number of observations increase the critical value of the correlation coefficient decreases. A confidence interval was established for each correlation using the Fisher Z' method, and the confidence limits are reported for each tests. The confidence interval allows an interpretation of the results, such that with a confidence of 95 per cent the interval contains the population correlation. The high and low values of the confidence interval are called the confidence limits. A confidence of five per cent means that with repeated sampling the correlations obtained should fall within the interval 95 times in 100.

Correlations exceeding .321 may be considered as statistically

TABLE 6. STATISTICAL TESTS, CORRELATION COEFFICIENT AND STANDARD ERROR FOR MALES, FEMALES, AND THE ENTIRE SAMPLE

Statistical Tests			Correlations			Standard Error for all
No.	Variable	Predicting	Male	Female	All	
1	3,4	2	.21	.14	.24	.014
2	7	2	.42	.52	.44	.052
3	6	2	.56	.62	.60	.045
4	5,3	2	.50	.57	.57	.063
5	3,6,7	2	.60	.64	.64	.091
6	6,7	2	.60	.64	.64	.074
7	3-13	2	.62	.69	.66	.157
8	3-13 less 7	2	.58	.65	.62	.168
9	3,8,9,10,11,12	7	.38	.48	.40	.110

Variables:

2. College grade point
3. Sex
4. Number of years of science
5. Science high school grade point
6. High school grade point
7. ACT composite score
8. Physics
9. Biology
10. Chemistry
11. General Science
12. Other Science Courses
13. College hours

significant at the 0.1 per cent level. Five test combinations resulted in correlation coefficients of .60 or greater: test 3, high school grade point as a predictor of college success; test 5, sex, high school grade average, and ACT composite score as a predictor of college grade point; test 6, high school grade point and ACT composite score as a predictor of college grade point; test 8, all variables as predictors of college success; test 9, all variables less ACT composite score as a predictor of college success. Test 4, high school science grade point as a predictor of college grade point, had a correlation in the .50's. One test had a correlation coefficient in the .40's; test 2, ACT composite score as a predictor of college grade point. Test 1, sex and years of science predicting college grade point had a correlation coefficient in the .20's.

Sex and years of science as predictors of college grade point. Sex was included as a variable in the prediction of college grade point as it had been reported that the high school grade point was more effective in predicting college success for males than females. In addition, the high school teaching experiences of colleagues of the present writer indicated that females tend to take less science in high school than males. In the study sample males had taken about one-half year more science than females (2.6 to 2.2 years). The number of years of science taken by the student in high school was hypothesized by the present writer as a variable which could be used to predict college success. Table 7, page 48, is a compilation of the correlations for sex and years of science as predictors of college grade point.

Confidence intervals and limits are also noted. The correlation coefficients for males and females fall below the 0.1 per cent level of confidence for 102 observations. By the use of the "t" test for the point-biserial r, it is possible to determine the level of confidence for the correlations. Using 498 observations, the correlation of .24 is statistically significant at the 0.1 per cent of confidence. For 342 observations for males, .21 is significant at the 0.1 per cent level. The correlation coefficient of .14 for females is significant at the .10 per cent level.

TABLE 7. SEX AND YEARS OF SCIENCE AS PREDICTORS OF COLLEGE SUCCESS

Statistical Categories	Male	Female	All
Number of Observations	342	156	498
Standard Error of Estimate	.091	.101	.074
Standard Error of the Mean (Sigma)	.62	.164	.61
Correlation Coefficient	.21	.14	.24
Confidence Limits			
high	.37	.32	.37
low	.03	-.04	.10

Using the formula for confidence limits, $Y \pm t \cdot (\text{sigma})$ it is possible to predict the range of the predicted college grade point. Y = the predicted college grade point, t is the t statistic for n-2 degrees of freedom, and sigma equals the standard error of the mean.

The confidence interval or range based on a predicted college grade point of 2.34 is 4.61 to 1.17; a range from A to D.

If a student had completed three years of science in high school (general science, biology, and chemistry) it is possible to predict his expected college grade point.[2] The predicted college grade point for the first year would be 2.29, with a confidence interval of 3.31 to 1.17, B to D. In predicting the college grade point, assuming one year of science, the expected grade point would be 2.09 with a confidence interval of 3.28 to 0.90, B to D.

American College Test composite score as a predictor of the college grade point. The American College Test composite score has been reported in the literature as having a correlation of .44 when used in prediction of college grade point. This value was reported by Munday. Table 8, page 50, is a compilation of information on the sample under study relating to the ACT composite score as a predictor of college grade point. The correlation of the Act composite score in predicting

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[2]The regression equation

$Y = B_1 + B_3X_3 + B_4X_4 \cdots B_nX_n$

Y = Predicted grade point

B_1 = Regression constant

B_3 to B_n = regression coefficient for variables 3 - n

X_3 to X_n = the value of the variable 3 - n

The regression coefficients and the regression constant may be obtained from the Statistical Tests. See Appendix B, page 76.

college grade point was .44, which is the same correlation reported by Munday.

When predicting college grade point on the basis of sex and the ACT composite score, a higher predictive value is obtained for females than males (.53 to .42). The difference is not statistically significant from zero, as determined using the Fisher Z' test, page 40. The range or confidence interval based on a predicted grade point of 2.34 is 3.46 to 1.22 for all students. At the 2.5 per cent level of confidence it is possible to state that the grade range would be B to D.

TABLE 8. AMERICAN COLLEGE TEST COMPOSITE SCORE AS A PREDICTOR OF COLLEGE GRADE POINT

Statistical Categories	Male	Female	All
Number of Observations	243	119	362
Standard Error of Estimates	.064	.093	.052
Standard Error of the Mean	.48	.53	.57
Correlation Coefficient	.42	.53	.44
Confidence limits			
high	.52	.77	.57
low	.31	.40	.35
Predicted college grade point	2.25	2.55	3.46
Range of predicted grade point			
high	3.19	3.58	3.46
low	1.19	1.52	1.22

A student with an ACT composite score of 20 (approximately equal to the mean ACT score of the sample) the predicted college grade point, based on the regression equation developed from the data on the sample, would be 2.41, with a confidence interval of 3.51 to 1.30, a range of from B to D.

High School cumulative grade point predicting college grade point. The high school grade point has been identified in the literature as the one most consistent predictor of the college grade point. Table 9 is a compilation of the data concerning the prediction of the college grade point using the high school cumulative grade point.

TABLE 9. HIGH SCHOOL CUMULATIVE GRADE POINT AS A PREDICTOR OF COLLEGE GRADE POINT

Statistical Categories	Male	Female	All
Number of Observations	342	156	498
Standard error of estimate	.054	.081	.045
Standard error of the mean	.50	.50	.50
Correlation coefficient	.56	.62	.60
Confidence limits			
high	.66	.70	.69
low	.46	.56	.51
Predicted college grade point	2.25	2.55	2.34
Range of predicted college grade point			
high	3.63	3.63	3.32
low	1.27	1.57	1.36

The high school grade point had a coefficient of .60 in predicting college grade point. There was a difference in the predictive value for males and females (.56 to .62). Funches reported that the high school grade point was more effective in predicting college grade point for males than for females. Giusti reported that of all the variables studied, the high school grade point was the best single predictor of the college grade point.

If a student had a high school grade point of 2.00, his predicted college grade point would be 2.12 with a predicted range of 3.11 to 1.14, B to D. Assuming a high school grade point of 3.00, the predicted college grade point would be 2.78, with a range of 3.76 to 1.90, B to D.

Sex and high school science grade point as predictors of college grade point. The high school science grade point has been reported in the literature as being the only academic factor which was significant in differentiating between the background of under- and over-achievers in college. Sex was also considered with the science average, as the male student in the sample had taken approximately one-half year more science than the females (2.2 to 2.6 years). From the sample a difference in grade point was found; the females had a higher grade point in science than the males (2.36 to 2.02). Table 10, page 53, is a compilation of the data relating to sex and high school science averages as predictors of college grade point.

The high school science grade point combined with sex as a predictor of college grade point had a correlation of .55 which is lower than the correlation of the high school grade point. The high school

science grade point is higher for the prediction for females than males (.57 to .50); this difference is not statistically different from zero.

TABLE 10. SEX AND HIGH SCHOOL SCIENCE GRADE POINT AS A PREDICTOR OF COLLEGE GRADE POINT

Statistical Categories	Male	Female	All
Number of Observations	342	156	498
Standard error of estimate	.076	.114	.063
Standard error of the mean	.53	.53	.53
Correlation coefficient	.50	.57	.55
Confidence limits			
high	.60	.70	.63
low	.30	.40	.31
Predicted college grade point	2.25	2.55	2.34
Range of predicted grade point			
high	3.26	3.56	3.12
low	1.25	1.54	1.33

The range of the predicted college grade point for all students was 3.25 to 1.33, B to D. A student with a high school science grade point of 2.00 would have a predicted college grade point of 2.23; if his science grade point was 3.00, the predicted college grade point would be 2.67. The confidence interval at the 2.5 per cent level would range from B to D in each example.

ACT composite score and the high school grade point as predictors of college grade point. The combination of the standardized test score

and the high school grade point as predictors of the college grade point was reported in the literature. The correlations of the ACT and the high school grade point in predicting college grade point were reported as being in the range of the .60's (correlations). An analysis of the sample resulted in the correlation of .64. The correlation was higher for females than for males (.64 to .60). This difference was not statistically different from zero. The range of the grade point based on a predicted college grade point of 2.34 was from 3.26 to 1.42 for the sample. Table 11, page 55, is a compilation of the data relating to ACT composite score and the high school grade point as predictors of college grade point.

A student with a 2.00 high school grade point and an ACT composite score of 20 would have a predicted college grade point of 2.10 with a range of 3.12 to 1.18, B to D.

All study variables predicting college grade point. The test of all of the variables under study as predictors of college grade point was performed in order to determine if the variables selected for this study could provide a prediction of success which would be significantly better than the high school grade point, ACT composite score, years of science, or any other combination of variables. Table 12, page 56, is a compilation of the data concerning the prediction of college grade point based on the use of all of the variables. The correlation among all variables predicting the college grade point was .66, slightly higher for females than for males (.69 to .62). With the ACT score excluded, the correlation for prediction of college grade point was .62.

The difference between these correlations was not significantly different from zero. Without the ACT score the correlation was slightly higher for females than for males (.65 to .58). The range, or confidence interval, based on a predicted college grade point of 2.34 was from 3.28 to 1.40, B to D.

TABLE 11. AMERICAN COLLEGE TEST COMPOSITE SCORE AND THE HIGH SCHOOL GRADE POINT AS PREDICTORS OF COLLEGE GRADE POINT

Statistical Categories	Male	Female	All
Number of Observations	243	119	362
Standard error of estimate	.091	.101	.076
Standard error of the mean	.49	.52	.47
Correlation coefficient	.60	.64	.64
Confidence limits			
high	.70	.98	.72
low	.47	.51	.54
Predicted college grade point	2.25	2.55	2.34
Range of predicted grade point			
high	3.20	3.56	3.26
low	1.30	1.54	1.42

Predicting a college grade point for a student using all of the variables resulted in a predicted grade point of 2.09; if the ACT composite score were excluded, the predicted grade point would be 2.14, and have a confidence interval from B to D. These predictions were made assuming three years of science (general science, chemistry, and

biology), a 2.00 high school grade point, a 2.00 science grade point, and an ACT composite score of 20.

TABLE 12. ALL STUDY VARIABLES AND ALL STUDY VARIABLES LESS ACT COMPOSITE SCORE AS PREDICTORS OF COLLEGE GRADE POINT

	All Variables			All Variables Less ACT		
	Male	Female	All	Male	Female	All
Observations	342	156	498	243	119	362
Standard error of estimate	.185	.277	.157	.207	.305	.163
Standard error of the mean	.47	.51	.48	.50	.50	.50
Correlation coefficient	.62	.69	.66	.58	.65	.62
Coefficient limits						
high	.79	.88	.80	.79	.88	.78
low	.35	.29	.45	.25	.17	.35
Predicted college grade point	2.25	2.55	2.34	2.24	2.55	2.34
Range of college grade point						
high	3.17	3.54	3.28	3.23	3.52	3.32
low	1.33	1.56	1.40	1.27	1.57	1.36

All courses and sex as predictors of the ACT composite score. In order to determine if any course would provide a satisfactory predictor of the ACT composite score, a test for the correlation between sex and the composite score was performed. All courses and sex provided a correlation of .40 in predicting the ACT composite score. The female prediction was higher than the male (.48 to .38); however, this

difference was not significantly different from zero. Table 13 is a compilation of the data relating to all courses and sex as predictors of the ACT composite score.

TABLE 13. ALL COURSES AND SEX AS PREDICTORS OF THE AMERICAN COLLEGE TEST COMPOSITE SCORE

Statistical Categories	Male	Female	All
Number of Observations	243	119	362
Standard error of estimate	.133	.201	.110
Standard error of the mean	.35	.37	.35
Correlation coefficient	.38	.48	.40
Confidence limits			
high	.59	.72	.56
low	.14	.13	.20
Predicted ACT composite score	19.61	19.50	19.57
Range of Predicted ACT score			
high	20.29	20.22	20.29
low	18.89	18.78	18.93

Table 14, page 58, is a compilation of the all pairs correlations between the ACT composite score and the individual courses. Correlations between the physical sciences, chemistry and physics, and the ACT score were in the 30's, and were significant at the 0.1 per cent level. The other science courses did not show significant correlations.

TABLE 14. CORRELATIONS BETWEEN ACT COMPOSITE SCORE AND VARIOUS SCIENCE COURSES

Statistical Categories	Male	Female	All
Number of Observations	243	119	362
Courses:			
Physics	.36	.30	.32
Biology	-.10	.03	-.06
Chemistry	.24	.41	.30
General Science	.03	-.02	.01
Other science courses	-.08	-.22	-.13

The confidence limits were determined for the predicted ACT composite score of 19.57. The limits were from 20.29 to 18.93. A student with three years of science--general science, chemistry, and biology--would have a predicted ACT composite score of 19.15.

Test of predicted correlations. In order to determine the effectiveness of the predictive correlations, five student records were selected from the sample and the college grade point was predicted for each: the five individual records selected were numbers 2018, 2137, 3068, 4142, and 4187: three males and two females. The selection was based on the earned college grade point; one B average, two C averages, and two students with D averages. Table 15, page 59, is a composite of the high school transcript information for each of the students.

TABLE 15. HIGH SCHOOL RECORD OF FIVE SELECTED INDIVIDUALS IN THE SAMPLE

Transcript information from student record	Student				
	2018	2137	3068	4142	4187
Sex	M	M	F	M	F
Years of Science	3.00	3.00	2.00	4.00	4.00
High School Science Grade Point	3.00	1.50	3.00	1.50	2.85
High School Grade Point	2.90	2.21	2.85	2.25	2.80
ACT Composite score	21.00	16.00	16.00	18.00	20.00
General Science	yes	yes	yes	yes	yes
Biology	yes	yes	yes	yes	yes
Chemistry	yes	yes	no	yes	yes
Physics	no	no	no	yes	yes
Other science courses	no	no	no	no	no

Using the transcript information for each of the five students, the predicted first year college grade point was then determined using the multi-linear regression equations which had been developed. The actual earned first year college grade point was determined for each individual student. Table 16, page 60, is a compilation of the earned college grade point and the predicted college grade point for each individual. The basis for determining the predicted college grade point for each was: sex and years of science, high school grade point, sex and high school science grade point, ACT composite score, ACT composite

score and the high school grade point, all variables, and all variables less the ACT composite score.

TABLE 16. PREDICTED FIRST YEAR COLLEGE GRADE POINT FOR FIVE INDIVIDUALS BASED UPON SELECTED VARIABLES

Selected Variables used for Prediction	Student Record Numbers				
	2018	2137	3068	4142	4187
	Individual Predicted Grade Point				
Sex, Years of Science	2.29	2.29	2.52	2.42	2.78
H. S. Grade Point	2.71	2.26	2.87	2.28	2.64
Sex, H. S. Science Grade Point	2.67	1.46	2.82	2.01	2.65
ACT Composite Score	2.48	2.14	2.06	2.26	2.41
ACT and HSGP	2.90	2.17	2.72	2.24	2.61
All Variables	2.71	2.01	2.60	2.01	2.58
All Variables less ACT Composite score	3.18	1.87	2.74	2.00	2.71
EARNED COLLEGE G. P.	3.10	1.89	0.93	2.14	2.45

The earned college grade point when compared with the predicted grade point for this sample of five individuals showed that the ACT composite score gave the most accurate prediction for 3068, 4142, and 4187. All variables less ACT composite score was most accurate for 2018 and 2137. The second most accurate prediction was the ACT composite score and the high school grade point for 2018, all variables for 2137,

sex and years of science for 3068, all variables and sex and high school science grade point for 4142, and all variables for 4187.

All of the predicted college grade points fell within the expected confidence interval except those for number 3068. Number 3068 was selected for this prediction of grade point because of her very low earned college grade point 0.93; 1.00 is a D average.

Factor Analysis of the data. The analysis of the data by means of factor analysis resulted in the location of five new factors which could be identified by a description in terms of the correlations between the new factors and the variables of this study. The five factors, designated by Roman numerals I, II, III, IV, and V, account for 76.29 per cent of the variation within the all pairs correlations. The percentage of the variation in the data, accounted for by the new factors identified, was:

Factor I	28.64 per cent
Factor II	18.86 per cent
Factor III	10.43 per cent
Factor IV	9.34 per cent
Factor V	8.92 per cent

Table 17, page 62, is a compilation of the correlations between each new factor and the variables in this study.

Factor I is characterized by high correlations with the variables, high school grade point, high school science grade point, college grade point and college hours; all of these correlations exceed .75. Factor I would seem to be related to academic excellence of the student as measured by the variables with high correlations with Factor I.

TABLE 17. FACTORS I, II, III, IV, AND V, CORRELATIONS WITH ALL VARIABLES AND ALL VARIABLES LESS ACT COMPOSITE SCORE

Factor	Variable	Correlation all	Correlation less ACT
I	High school grade point	.88	.88
	High school science grade point	.82	.81
	College grade point	.81	.80
	College hours	.73	.75
	Sex	-.42	-.46
	ACT	.58	---
	Chemistry	.12	.15
	Years of science	.12	.08
	General Science	.09	.12
	Other science	-.08	-.08
	Physics	.00	.04
	Biology	-.06	-.01
II	Years of science	.83	.82
	Physics	.78	.76
	Chemistry	.74	.79
	ACT	.47	---
	Sex	.35	.35
	High school science grade point	.12	.13
	Other sciences	-.10	-.04
	High school grade point	.09	.08
	General Science	.05	.06
	College grade point	-.02	.02
	Biology	.02	.03
	College hours	-.00	.02
III	General Science	.94	-.92
	Years of science	.38	-.35
	Sex	.26	-.35
	Chemistry	-.21	.26
	Physics	.13	-.14
	ACT	-.10	---
	High school science grade point	.09	-.15
	Other sciences	-.09	.04
	College grade point	.05	-.04
	College hours	-.02	.01
	High school grade point	-.01	-.00
	Biology	-.00	.04
IV	Biology	.94	-.00
	Sex	-.30	.08

TABLE 17 Continued

Factor	Variable	Correlation all	Correlation less ACT
	Years of science	.23	.21
	ACT	-.14	---
	Physics	-.12	-.20
	College hours	.08	.03
	High school science grade point	-.04	-.03
	High school grade point	-.03	-.09
	College grade point	-.03	.01
	General science	-.02	-.06
	Other sciences	-.01	.98
	Chemistry	-.00	-.00
V	Other sciences	.97	-.01
	Years of science	.19	.27
	Physics	-.14	-.08
	Sex	.09	-.16
	General science	-.09	-.02
	High school grade point	-.07	-.04
	College hours	.06	.01
	High school science grade point	-.06	.02
	Chemistry	-.05	-.00
	College grade point	-.04	.02
	ACT	-.04	---
	Biology	-.01	.98

Correlations written .00, or -.00, were not significant in the third decimal place, i.e. -.001 or .001.

Factor II is characterized by a high correlation with years of science, physics, and chemistry with correlations exceeding .73. Factor II would seem to be related to the physical science background and interest in science as measured by years of science.

Factor III is characterized by a correlation with general science of .94. Years of science and sex are related to this factor with correlations of .38 and .26 respectively. Factor III would seem to be related to the elementary physical science background of the individual student because of the high correlation with the general science course.

Factor IV is characterized by a high correlation with biology. Sex and years of science are related to this factor with correlations of -.30 and .23 respectively. Factor IV seems to be related to the training of the student in the life sciences.

Factor V is characterized by a high correlation with the other sciences, .97. Years of science and physics have a fairly low correlation of .19 and -.14 respectively to this factor. Factor V would seem to be related to the additional science background, additional in that these courses would be taken by the student in addition to the science courses normally taught.

When ACT as a variable is removed from the set of variables under study, the descriptions of Factor IV and V are approximately reversed.

By means of the computer program, all factors--I, II, III, IV, and V--were identified as significant using the Chi Square test of significance. These five factors accounted for 76.29 per cent of the variation.

Through the use of factor analysis the data collected on the sample shows three general arrangements: the data relating to measures of the academic excellence of the student; the student background in the physical sciences with years of science as a measure of student

interest and thus the student had taken physics and chemistry; and a background in the basic information concerning elementary science principles.

CHAPTER VII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The study of years of high school sciences as a predictor of college success was undertaken to determine if the years of science could be used to predict first year college grade point more effectively than other variables used at the present time.

Several variables had been reported in the literature as being used to predict college success as measured by the college grade point; these included the high school grade point average, standardized test scores, and combinations of these two. Ten variables were selected as possibly affecting the prediction of college success. These variables were: (1) sex, (2) years of science, (3) high school science grade average, (4) high school grade point, (5) ACT composite score, (6) biology, (7) physics, (8) chemistry, (9) general science, and (10) other sciences.

These variables were statistically tested as predictors of college success as individual variables and in various combinations. The methods of statistical analysis used were: Pearson Product-Moment regression correlations, multi-linear regression analysis, and factor analysis.

Summary

A sample of 498 students who enrolled at Upper Iowa University during the school years 1962-63, 1963-64, and 1964-65 was studied. The sample of students was representative of students enrolling at other

institutions of higher education during this period of time, based on data obtained from the ACT composite score norms. The mean composite score of the sample was slightly below all students enrolling at all institutions represented in the ACT research program, but slightly above students enrolling at Level II schools similar to Upper Iowa University. Further evidence was developed in that the predictive value of the ACT composite score for predicting college grade point was the same for the sample as was reported for the ACT composite score in a national study. The median college grade point was similar to the median college grade point of freshmen enrolled at Montana Colleges.

Three variables were found to have correlations above .44 in predicting college grade point: the high school grade point .60, the high school science grade point .57, and the ACT composite score of .44. In combination with the ACT composite score, the high school grade point had a correlation of .64 in predicting college grade point. Each of these variables had a higher predictive correlation for females than for males.

When all of the variables under study were used to predict college grade point, the correlation was .66, and without the ACT composite score the correlation was .62.

A correlation of .40 was found when sex and all courses were used to predict the ACT composite score.

The years of science were found to have a correlation of .24 which is at the lower level of prediction for the college grade point.

When factor analysis was used, Factor I was found to have a high correlation with the variables which measure academic excellence of the student: high school grade point, high school science grade point, college grade point, college hours, and ACT composite score. In using factor analysis, it was then possible to speculate that the variables were closely related and tended to measure the same things.

Factor II had a high correlation with years of science, physics and chemistry. If years of science were a measure of interest, then physics and chemistry would in all probability have been a part of the normal high school program for a student with a high level of interest. Factor II could be interpreted as relating to interest in the physical sciences. Factor III, IV, and V each correlated with a specific course in science and had a low correlation with interest (years of science). The interpretation could then be made that these factors would represent the required courses for all students in high school.

Conclusions

Based upon the analysis of data collected and analyzed from a sample of 498 student records at Upper Iowa University, from 1962 to 1965, the following conclusions were developed.

The amount of science taken in high school does not appear to contribute significantly to the student's success in college. The years of science cannot be used as an effective predictor of first year college success as measured by college grade point.

The over-all high school grade point is the single most effective

predictor of college success. The high school science grade point is almost as effective in predicting the first year college grade point as the high school grade point.

The ACT composite score is of little additional value in predicting college grade point even when combined with the high school grade point.

The best predictors as reported in the literature and as determined in this study can only predict a college grade point within a range of from B to D.

Those variables which measure past student academic performance are the most effective in predicting college success.

The best predictor now being used for admission to college is the high school record.

Recommendations

The following observations and recommendations became evident during the course of this investigation and are presented here to indicate areas of possible future research. These recommendations can be divided into four general areas: the new science curricula, the effectiveness of high school science programs, standardized test information, and college admission policies.

The new science curricula need investigation in terms of the student. Some areas that need investigation are the effect of these science programs on student behavior--academically, psychologically, and socially; the effectiveness of these programs in training of students in

the methods of science, the carry-over of this science training into other areas of the students' academic work; and the effectiveness of the new curricula in science in achieving their aims in reality, not only in theory.

A re-examination of the science programs in secondary schools needs to be made with particular attention to the cost of the programs and their effectiveness in student outcomes compared with the other areas of the curriculum.

Studies could be carried out in the uses made of standardized test information with the aim of improving the use of the test results to benefit both the student and the school. The standardized testing programs should be evaluated in terms of the cost to the student and the time involved in these programs, as well as to the effectiveness of the tests in accomplishing the aims set forth by the test makers.

Admission policies of colleges need to be evaluated in terms of obtaining the most qualified students in the student bodies of their secondary schools. New criteria might be developed which could make better use of the space available in the institutions of higher education.

Research is needed in the area of psychological factors which would improve the methods presently being used in college admissions, to select those students who can best make use of a college education and those who will put forth the greater effort.

APPENDIX

APPENDIX A

Letter Authorizing the use of Upper Iowa University Permanent Student Records for this Study.

July 19, 1966

Mr. Keith Himmel
General Delivery
Bozeman, Montana

Dear Mr. Himmel:

In order to confirm our oral conversation, the following is provided:

You are granted permission to use the official records of the school to obtain information in pursuance of your work relative to your doctoral study.

This permission is granted with the understanding that the information available to you in personnel files be handled in a mature and professional manner.

All data must be handled statistically and reference to an individual student is to be avoided.

Yours truly,

Herschel Hendrix
Vice President and Dean
of the University

HH:lms

APPENDIX B

Computer Data for Statistical Tests Performed on the Total Sample

Key to Appendix B

Variable

2. Number of Observations
3. College Grade Point
4. Total Years of Science
5. High School Science Grade Point
6. High School Grade Point
7. ACT Composite Score
8. Physics
9. Biology
10. Chemistry
11. General Science
12. Other Science
13. College Hours

R Regression coefficient

Sigma Standard Error of the Mean

Multi-linear regression computer program is reported in: Huntsinger, Ralph C., Flow Correlations for Brine Flashing Through Round and Square Submerged Orifices, Doctoral Disseration. Montana State University, Bozeman, Montana, August 1966, pp. 80-83.

MULTIPLE LINEAR REGRESSION - R.C.HUNTSINGER , P.E.

NUMBER OF OBSERVATIONS = 362

MEAN	STD DEVIATION	VARIANCE	
2.3919060E+00	6.3956637E-01	4.0904515E-01	2
6.7127071E-01	4.7040154E-01	2.2127761E-01	3
2.6046961E+00	8.9387279E-01	7.9900858E-01	4
2.2032044E+00	7.2556807E-01	5.2644903E-01	5
2.3881215E+00	5.9631972E-01	3.5559722E-01	6
1.9577348E+01	3.8691691E+00	1.4970470E+01	7
3.3425414E-01	4.7238197E-01	2.2314473E-01	8
8.9502762E-01	3.0694206E-01	9.4213434E-02	9
5.2209944E-01	5.0020274E-01	2.5020279E-01	10
7.5966850E-01	4.2787618E-01	1.8307803E-01	11
1.2983425E-01	3.3658619E-01	1.1329027E-01	12
2.9426795E+01	2.9897470E+00	8.9385872E+00	13

2	3	-.22284915
2	4	.04540040
2	5	.56678304
2	6	.62793461
2	7	.44523672
2	8	.03456067
2	9	-.03792368
2	10	.04485080
2	11	.08225398
2	12	-.13202033
2	13	.57373007

3	4	.19736648
3	5	-.22034062
3	6	-.34388872
3	7	.01324788
3	8	.29639712
3	9	-.06698941
3	10	.02507401
3	11	.10185213
3	12	.02537338
3	13	-.22791135
4	5	.17177722
4	6	.13340351
4	7	.31045892
4	8	.63458960
4	9	.17141895
4	10	.59235961
4	11	.41724016
4	12	.05597229
4	13	.06713985
5	6	.75783486
5	7	.49222922
5	8	.11769290
5	9	-.05532809
5	10	.16619352
5	11	.14480468
5	12	-.14167784
5	13	.47072288
6	7	.53418355
6	8	.10204801
6	9	-.07856702
6	10	.16804553
6	11	.07291947
6	12	-.14742066
6	13	.53706791
7	8	.32909674
7	9	-.06545133
7	10	.30040199
7	11	.01544276
7	12	-.13003835
7	13	.31041824
8	9	-.08211908
8	10	.30276802
8	11	.09703344

```
       8        12          -.20401308
       8        13           .00854724
       9        10          -.11114415
       9        11          -.08716483
       9        12          -.02859030
       9        13           .01424235
      10        11          -.02041531
      10        12          -.14048852
      10        13           .12472620
      11        12          -.18665859
      11        13           .02193826
      12        13          -.05797067

403040102

    1      3.6200000E+02 = Number of Observations
    2      1.4766530E+02 = Total Sum of Squares
    3      2.4300000E+02 = Error Sum of Squares
    4      9.3602980E+02 = Error Sum of Squares
    1      3.5241990E+01 = Error Sum of Squares
    2      1.3910439E+02 = Total Error Sum of Squares for Regression
R**2=   .5797509E-01 R=   .2407801E+00

       3  -3.2794734E-01= Regression Coefficient

       4   6.6546370E-02= Regression Coefficient

       1    2.4387144E+00= Regression Coefficient

       2    1.1794252E+01= Square Root of Total Error Sum of Squares

 1.5588456E+01 4.2525058E+01 1.5588458E+01
 3.5733494E+01
 2.7279835E+00 3.0594602E+01 9.1519415E+00
 2.4354930E+01
 1.8396260E-01 2.9913577E-01 5.9364962E+00
 1.4477420E+01
-3.2794734E-01 6.6546370E-02 2.4387144E+00
 1.1794252E+01

SIGMA =  6.2334565E-01
```

```
3070102

   1      3.6200000E+02
   2      1.4766530E+02
   7      1.4414900E+05
   1      1.3571860E+01
   2      1.1839272E+02
R**2=    .1982360E+00 R=    .4452370E+00

       7    7.3596760E-02

       1    9.5107671E-01

       2    1.0880841E+01

 3.7966944E+02 1.8666237E+01 4.5695487E+01
 4.9164406E-02 3.6840002E+00 3.5037674E+00
 7.3596760E-02 9.5107671E-01 1.0880841E+01

SIGMA =   5.7426901E-01
```

```
3060102

   1      3.6200000E+02
   2      1.4766530E+02
   6      2.1929016E+03
   1      2.1191170E+01
   2      8.9440560E+01
R**2=    .3943021E+00 R=    .6279347E+00

       6    6.7347399E-01
```

```
      1    7.8356834E-01

      2    9.4573015E+00

 4.6828425E+01 1.8461009E+01 4.6003191E+01
 3.9422653E-01 4.6033863E+00 3.6070707E+00
 6.7347399E-01 7.8356834E-01 9.4573015E+00

SIGMA =   4.9913735E-01
```

```
403050102

   1      3.6200000E+02
   2      1.4766530E+02
   3      2.4300000E+02
   5      8.8428230E+02
   1      2.4333570E+01
   2      9.8739390E+01
R**2=   .3313297E+00 R=   .5756125E+00

      3   -1.3998993E-01

      5    4.7960401E-01

      1    1.4292115E+00

      2    9.9367688E+00

 1.5588456E+01 3.2602972E+01 1.5588458E+01
 3.5733494E+01
 2.0914814E+00 2.9736882E+01 9.7296690E+00
 2.8167687E+01
 3.1568430E-01 3.2719189E-01 4.9329066E+00
 7.0501638E+00
-1.3998993E-01 4.7960401E-01 1.4292115E+00
 9.9367688E+00
```

```
SIGMA =  5.2517466E-01
```

```
50306070102

   1      3.6200000E+02
   2      1.4766530E+02
   3      2.4300000E+02
   6      9.6837760E+02
   7      4.7204530E+03
   1      1.0679944E+01
   2      8.6702661E+01
R**2=   .4128433E+00 R=   .6425288E+00

       3  -6.1074328E-02

       6   5.6178566E-01

       7   2.7443979E-02

       1   5.5401077E-01

       2   9.3114255E+00

 1.5588456E+01 3.4993202E+01 3.0573906E+02
 1.5588458E+01 3.5733494E+01
 2.2448148E+00 3.1118764E+01 2.1436465E+02
 1.0251371E+01 2.9044466E+01
 4.1495440E+00 6.8885969E+00 6.8705551E+01
 1.7970731E+00 2.8811645E+00
 1.5196087E-01 1.4924837E-01 2.6156112E-02
 3.2680180E+00 1.8105120E+00
-6.1074328E-02 5.6178566E-01 2.7443979E-02
 5.5401077E-01 9.3114255E+00

SIGMA =  4.9281304E-01
```

```
407060102

   1      3.6200000E+02
   2      1.4766530E+02
   7      1.4414900E+05
   6      9.9919700E+01
   1      1.2460809E+01
   2      8.6949234E+01
R**2=   .4111735E+00 R=   .6412281E+00

      7    2.5397777E-02

      6    5.8544549E-01

      1    4.9657016E-01

      2    9.3246571E+00

 3.7966944E+02 4.5749139E+01 1.8666237E+01
 4.5695487E+01
 1.2049719E-01 9.9959838E+00 1.0540653E+00
 6.3755205E+00
 3.6458138E-02 1.0544867E-01 3.5299870E+00
 1.7528900E+00
 2.5397777E-02 5.8544549E-01 4.9657016E-01
 9.3246571E+00

SIGMA =  4.9282351E-01
```

```
803080910111201O2

   1      3.6200000E+02
```

```
   2      1.4766530E+02
   3      2.4300000E+02
   8      7.5629640E+01
   9      1.3378105E+02
  10      9.1206830E+01
  11      8.1750681E+01
  12      3.9451809E+01
   1      1.9202793E+01
   2      1.3577922E+02
R**2=   .8049338E-01 R=   .2837135E+00

      3  -3.4558097E-01

      8   1.0249928E-01

      9  -9.0011100E-02

     10   1.5088410E-02

     11   1.1893277E-01

     12  -1.8023209E-01

      1   2.5953593E+00

      2   1.1652432E+01

 1.5588456E+01 6.7357536E+00 1.3728107E+01
 8.2753545E+00 1.2316806E+01 2.1169511E+00
 1.5588458E+01 3.5733494E+01
 4.3209876E-01 8.6965300E+00 1.3259161E+00
 3.8244288E+00 1.8440733E+00-1.1796956E+00
 1.8398154E+00 6.0366640E+00
 8.1477852E-01 1.5246495E-01 1.1566375E+01
 3.8321599E+00 6.0925314E+00 1.1673881E+00
 9.2994192E+00 2.3666251E+01
 7.0890760E-02 3.8925037E-01 3.3131896E-01
 9.5502257E+00 1.0129606E+00-1.5501972E-01
 1.8142934E+00 5.0012535E+00
 2.6179854E-01 9.0450360E-02 4.9160314E-01
 1.0606666E-01 9.0416076E+00-5.3684559E-01
 2.3350333E+00 7.2323496E+00
 1.2887702E-01-1.3935066E-01 1.3549638E-01
```

```
-9.9343410E-03-5.9375005E-02 6.2810671E+00
 1.0904510E+00 1.6980603E+00
 1.5004865E-01 1.5860763E-02 5.9058070E-01
 1.6430633E-01 2.6856212E-01 1.7360909E-01
 4.3820988E+00 1.1373124E+01
-3.4558097E-01 1.0249928E-01-9.0011100E-02
 1.5088410E-02 1.1893277E-01-1.8023209E-01
 2.5953593E+00 1.1652432E+01

SIGMA =  6.1931983E-01
```

```
  1203040506070809101112O102

   1      3.6200000E+02
   2      1.4766530E+02
   3      2.4300000E+02
   4      9.3602980E+02
   5      3.1312549E+02
   6      7.7506810E+01
   7      4.1186366E+03
   8      5.2884301E+01
   9      3.6290217E+01
  10      5.1170975E+01
  11      3.4194647E+01
  12      1.7294652E+01
   1      6.6226597E+00
   2      8.2360923E+01
R**2=   .4422459E+00 R=   .6650157E+00

      3  -4.1606273E-02

      4  -1.5879793E-02

      5   1.6211329E-01

      6   4.1962959E-01

      7   3.1389592E-02
```

```
 8  -6.9937452E-02
 9   1.1581920E-02
10  -1.0600444E-01
11   4.9873140E-02
12  -7.1011017E-02
 1   5.2706532E-01
 2   9.0752914E+00
 1.5588456E+01 4.2525058E+01 3.2602972E+01
 3.4993202E+01 3.0573906E+02 6.7357536E+00
 1.3728107E+01 8.2753545E+00 1.2316806E+01
 2.1169511E+00 1.5588458E+01 3.5733494E+01
 2.7279835E+00 3.0594602E+01 2.3898889E+01
 2.5800051E+01 1.9106412E+02 4.1007802E+00
 9.0575304E+00 7.7134564E+00 8.1755327E+00
 1.2576254E+00 9.1519415E+00 2.4354930E+01
-3.9475000E-02 7.8114713E-01 1.7695351E+01
 1.5007610E+01 8.9217800E+01-2.0604066E+00
 2.5627132E+00-9.0216407E-01 1.4218118E+00
-4.5292868E-01 3.9902469E+00 1.4442409E+01
-2.2180562E-02 1.8078896E-01 8.4810990E-01
 8.8037951E+00 4.5702358E+01-1.2771887E+00
 1.8202092E+00-6.3601218E-01 2.0268872E-02
 2.0805771E-01 2.6131288E+00 6.6702597E+00
 2.8910108E+00 1.3680664E+00 6.3916400E-01
 5.1912057E+00 6.4176602E+01-2.2904177E-01
 1.1746626E+00 2.4452999E-01-9.7475142E-01
 3.7069024E-02 1.5109199E+00 2.7632986E+00
 6.8954256E-02 2.5610103E-01 8.8806158E-03
-1.2654528E-01-3.5689210E-03 7.2721588E+00
-2.4391715E+00-1.3572965E-01-2.0292294E+00
-2.2105543E+00-1.3235461E+00-1.1642840E+00
 5.3554268E-02 2.0640128E-01-3.9245412E-02
 6.9290400E-02 1.7106519E-02-3.3541218E-01
 6.0241361E+00-2.9246399E+00-1.4312019E+00
-6.8161663E-01 1.1820068E+00 9.7981227E-01
```

```
-1.4425354E-01 4.0477662E-01-1.1035955E-02
-6.0744935E-02 1.2048627E-02-1.8150257E-01
-4.8548709E-01 7.1533887E+00-3.6227235E+00
-1.9288798E+00-3.3877769E-01-9.8055370E-01
 6.7190590E-02 5.5031134E-01 7.5670032E-02
 3.1536634E-02-6.0184930E-03-4.5064661E-01
-4.8344542E-01-5.0643453E-01 5.8476185E+00
-3.7842728E+00 2.9124122E-01 7.1386994E-01
 5.3114369E-02 6.2251839E-01-1.7554170E-03
-5.9630390E-03 7.8231440E-04-6.8250209E-01
-5.5691748E-01-5.9738334E-01-6.4714746E-01
 4.1586836E+00 4.8728826E-01-3.8477680E-02
 1.1702443E-01-3.7947780E-02-3.6054568E-02
 1.3422521E-01 2.0315777E-02-2.2371530E-02
 2.6255224E-01 4.7860140E-02 1.2563217E-01
 1.1717226E-01 2.5734527E+00 1.3563712E+00
-4.1606273E-02-1.5879793E-02 1.6211329E-01
 4.1962959E-01 3.1389592E-02-6.9937452E-02
 1.1581920E-02-1.0600444E-01 4.9873140E-02
-7.1011017E-02 5.2706532E-01 9.0752914E+00

SIGMA =  4.8509485E-01
```

```
 1103040506080910111201 02

  1      3.6200000E+02
  2      1.4766530E+02
  3      2.4300000E+02
  4      9.3602980E+02
  5      3.1312549E+02
  6      7.7506810E+01
  8      5.2936761E+01
  9      3.7494272E+01
 10      5.1749100E+01
 11      3.4337286E+01
 12      1.7297051E+01
  1      8.2409914E+00
  2      8.5465681E+01
```

```
R**2=   .4212202E+00 R=   .6490148E+00

      3  -5.4304800E-03

      4   1.7942707E-02

      5   1.9187374E-01

      6   5.0148606E-01

      8  -5.4750636E-02

      9  -1.6074530E-02

     10  -1.0338039E-01

     11  -2.7590240E-03

     12  -1.0208882E-01

      1   8.3048256E-01

      2   9.2447645E+00

 1.5588456E+01 4.2525058E+01 3.2602972E+01
 3.4993202E+01 6.7357536E+00 1.3728107E+01
 8.2753545E+00 1.2316806E+01 2.1169511E+00
 1.5588458E+01 3.5733494E+01
 2.7279835E+00 3.0594602E+01 2.3898889E+01
 2.5800051E+01 4.1007802E+00 9.0575304E+00
 7.7134564E+00 8.1755327E+00 1.2576254E+00
 9.1519415E+00 2.4354930E+01
-3.9475000E-02 7.8114713E-01 1.7695351E+01
 1.5007610E+01-2.0604066E+00 2.5627132E+00
-9.0216407E-01 1.4218118E+00-4.5292868E-01
 3.9902469E+00 1.4442409E+01
-2.2180562E-02 1.8078896E-01 8.4810990E-01
 8.8037951E+00-1.2771887E+00 1.8202092E+00
-6.3601218E-01 2.0268872E-02 2.0805771E-01
 2.6131288E+00 6.6702597E+00
 5.8636467E-02 2.5121851E-01 6.5994900E-03
-1.4507228E-01 7.2757652E+00-2.4749409E+00
-1.4336017E-01-1.9975384E+00-2.2106254E+00
```

```
-1.3704539E+00-1.2506956E+00
 1.0328792E-01 2.3099742E-01-2.8280194E-02
 1.5740475E-01-3.4016219E-01 6.1232561E+00
-2.8342649E+00-1.5940717E+00-6.7641376E-01
 1.4260309E+00 1.4523241E+00
-1.1156084E-01 4.1687567E-01-2.6731830E-03
-2.2435960E-03-1.7715430E-01-4.6286894E-01
 7.1936845E+00-3.6832746E+00-1.9085481E+00
-2.0656514E-01-7.1023064E-01
 5.0237490E-02 5.4659403E-01 7.1477766E-02
 2.3017002E-03-4.5380727E-01-4.9732664E-01
-5.1201503E-01 5.8598024E+00-3.7953216E+00
 2.0930849E-01 5.4511983E-01
 5.5345157E-02 6.2329678E-01-1.1718890E-03
-2.1616954E-03-6.8233635E-01-5.5538174E-01
-5.9693451E-01-6.4768747E-01 4.1589722E+00
 5.0230823E-01-7.4267147E-03
 1.7475569E-01-1.9981204E-02-2.0896823E-02
 2.3294950E-01-1.5607327E-02 3.0443657E-01
 6.1668696E-02 1.1394368E-01 1.2077569E-01
 2.8707126E+00 2.3840755E+00
-5.4304800E-03 1.7942707E-02 1.9187374E-01
 5.0148606E-01-5.4750636E-02-1.6074530E-02
-1.0338039E-01-2.7590240E-03-1.0208882E-01
 8.3048256E-01 9.2447645E+00

SIGMA =  4.9344907E-01
```

```
80308091011120107

   1      3.6200000E+02
   7      5.4043400E+03
   3      2.4300000E+02
   8      7.5629640E+01
   9      1.3378105E+02
  10      9.1206830E+01
  11      8.1750681E+01
```

```
  12      3.9451809E+01
   1      1.9202793E+01
   7      4.5371670E+03
R**2=   .1604586E+00 R=   .4005728E+00

       3  -6.0697150E-01

       8   2.2722353E+00

       9  -3.3531900E-01

      10   1.6149366E+00

      11  -9.4083100E-02

      12  -5.1661580E-01

       1   1.8820796E+01

       7   6.7358492E+01

 1.5588456E+01 6.7357536E+00 1.3728107E+01
 8.2753545E+00 1.2316806E+01 2.1169511E+00
 1.5588458E+01 3.0573906E+02
 4.3209876E-01 8.6965300E+00 1.3259161E+00
 3.8244288E+00 1.8440733E+00-1.1796956E+00
 1.8398154E+00 6.0554887E+01
 8.1477852E-01 1.5246495E-01 1.1566375E+01
 3.8321599E+00 6.0925314E+00 1.1673881E+00
 9.2994192E+00 1.7615643E+02
 7.0890760E-02 3.8925037E-01 3.3131896E-01
 9.5502257E+00 1.0129606E+00-1.5501972E-01
 1.8142934E+00 4.9554221E+01
 2.6179854E-01 9.0450360E-02 4.9160314E-01
 1.0606666E-01 9.0416076E+00-5.3684559E-01
 2.3350333E+00 4.3373838E+01
 1.2887702E-01-1.3935066E-01 1.3549638E-01
-9.9343410E-03-5.9375005E-02 6.2810671E+00
 1.0904510E+00 1.7278244E+01
 1.5004865E-01 1.5860763E-02 5.9058070E-01
 1.6430633E-01 2.6856212E-01 1.7360909E-01
 4.3820988E+00 8.2474610E+01
-6.0697150E-01 2.2722353E+00-3.3531900E-01
```

```
 1.6149366E+00-9.4083100E-02-5.1661580E-01
 1.8820796E+01 6.7358492E+01

SIGMA =   3.5800603E+00
```

```
708091011120107

    1      3.6200000E+02
    7      5.4043400E+03
    8      1.2100000E+02
    9      2.3461158E+02
   10      9.1642080E+01
   11      8.7658468E+01
   12      4.0786988E+01
    1      2.0953429E+01
    7      4.5634140E+03
R**2=   .1556019E+00 R=   .3944641E+00

       8    2.0765650E+00

       9   -3.0077000E-01

      10    1.6501351E+00

      11   -1.5022120E-01

      12   -5.9923630E-01

       1    1.8482831E+01

       7    6.7553042E+01

 1.0999999E+01 9.4545463E+00 8.0909098E+00
 9.0000008E+00 3.6363639E-01 1.1000001E+01
 2.3509093E+02
 8.5950413E-01 1.5317034E+01 5.6475777E+00
 1.0244091E+01 2.4523014E+00 1.4363094E+01
```

```
 2.6717459E+02
 4.1862759E-01 3.6871214E-01 9.5729862E+00
 1.1832807E+00-8.2702197E-02 1.9725652E+00
 5.2127099E+01
 1.9159729E-01 6.2322863E-01 1.2360619E-01
 9.3626100E+00-2.4528013E-01 2.8335146E+00
 5.1111872E+01
-9.5915210E-02 1.7961542E-01-5.4009078E-03
-2.6197823E-02 6.3864687E+00 1.3521576E+00
 2.1164696E+01
 7.0087411E-02 6.3510170E-01 1.6979037E-01
 3.0818808E-01 2.1172222E-01 4.5774912E+00
 8.4605034E+01
 2.0765650E+00-3.0077000E-01 1.6501351E+00
-1.5022120E-01-5.9923630E-01 1.8482831E+01
 6.7553042E+01

SIGMA =  3.5853428E+00
```

MULTIPLE LINEAR REGRESSION - R.C.HUNTSINGER , P.E.

NUMBER OF OBSERVATIONS = 498

MEAN	STD DEVIATION	VARIANCE	
2.3467269E+00	6.3848191E-01	4.0765915E-01	2
6.8674698E-01	4.6428270E-01	2.1555843E-01	3
2.5228915E+00	9.4026752E-01	8.8410301E-01	4
2.1334939E+00	7.5053341E-01	5.6330040E-01	5
2.3296787E+00	5.8840831E-01	3.4622434E-01	6
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