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A Study of Selected Variables for Prediction of Success and Placement in General Chemistry at Western Michigan University

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A STUDY OF SELECTED VARIABLES FOR PREDICTION OF SUCCESS AND PLACEMENT IN GENERAL CHEMISTRY AT WESTERN MICHIGAN UNIVERSITY

by

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CHAPTER I

THE PROBLEM

Introduction

The traditional philosophy that a college or a university is an exclusive institution in which only highly selected individuals receive a concentrated training in the traditional liberal arts no longer exists. In America, for instance, as early as 1870, Harvard, the colonial college with a narrow curriculum, was transformed rather rapidly into a modern university with many new subjects and the elective system (Garrett, 1949). Also, since 1642, when the first entrance requirements were instituted for American higher education, a continuing debate has developed over what constitutes a sound curriculum for education. There are those who advocate the position that anyone who can profit from the college or university education is welcome. However, they express concern that an institution is obligated to guide the student in the selection of courses (Coley, 1973). This often requires that methods of measuring an individual's potential for college work be made available to the student before he or she is placed in a course or a field of study.

The measurement of a student's potential for college work can be made most easily by using the student's past academic records. In the past, such records have included the student's high school grades and/or scores on standardized aptitude and achievement tests.

However, this strategy has not totally solved the problem of prediction, for Keefer (1969) stated, "the accurate prediction of academic

success remains an unsolved problem in education." He further pointed out that prediction was particularly needed for decision making regarding college entrance and retention. Keefer's statements are of added significance if a statement by O'Donnell (1969) is considered. O'Donnell estimated that as few as 40 percent of those students in the United States entering college graduate within four years and only 60 percent eventually complete degree requirements. Among the many reasons cited for this estimation was poor scholarship, i.e., lack of proper academic preparation.

Specifically, Baldridge (1970) learned that New York University, which was relaxed in its admission policy for years, could only graduate 25-30 percent of its entering class within four years. Many members of the New York University community were unhappy with a philosophy that accepted large numbers of relatively poorly prepared students and then failed many of them. As one professor said:

> Sure, we were the great teacher of the masses in New York City. In a sense this was a good thing, and we undoubtedly helped thousands of students who otherwise would never have had a chance. But we were also very cruel. We had almost no admissions standards, and a live body with cash in hand was almost assured of admission. But we did have academic standards, and we were brutal about failing people. There were many years in which no more than 25-30% of an entering class would graduate. Sure, we were the great "School of Opportunity" for New York, but the truth of the matter is that we were also the "Great Slop Bucket" that took everybody and later massacred them.

The problem of poor scholarship has been attacked in many ways. One attempt to solve this problem has consisted of providing adequate guidance to students so that they are placed in the right field of study or in the right sections of particular courses where they could function effectively.

However, the problem is far from being solved. College admission officers or academic advisers are still confronted with the problem of placing freshmen and predicting their performance in a specified field of study or a section of a particular course. In addition, students are curious to know their chances of success in various fields of study, which courses or sections of a course they should choose, and what chances they have in succeeding in the area, course or section in which they have been placed.

In chemistry, particularly, the problem facing the admission officers is due to the fact that students have been exposed to different types of high school chemistry courses. In the past decade, several new chemistry programs have emerged. These have included: (1) Chemical Bond Approach (CBA), (2) Chemical Education Material Study (CHEM Study), and (3) Interdisciplinary Approach to Chemistry (IAC). The one major purpose of the new chemistry programs is to have the students learn most of the principles in chemistry through guided laboratory experiences. In addition, new texts which incorporate this above idea have been published. In contrast, the traditional type of chemistry, using lecture, class recitation-discussion, and supplemental use of the laboratory, has continued to be taught in many high schools (Bennett and Pyke, 1966). The literature reveals that frequently high school graduates who have no chemistry background desire to enroll in a freshmen chemistry course because their field of interest in college requires a semester or an academic year of college chemistry. With such variations in the academic backgrounds of the students from the various high school programs, there is certainly bound to be a wide range of aptitudes and abilities

in any introductory course in chemistry. Therefore, as long as aptitudes and achievement test scores and other student characteristics are still considered pertinent to both placement and success in college courses, continued investigation of the use of these test scores and characteristics is necessary.

Statement of the Problem

The purpose of this study is to determine which variable or combination of variables could be used by academic advisers for prediction of success and placement in the general college chemistry courses at Western Michigan University. The variables considered included the following:

1. Scores on the American College Testing Program which will hereafter be designated the ACT.
2. High school grades.
3. Scores on the American Chemical Society NSTA Cooperative Examination for High School Chemistry which will hereafter be designated the ACS.
4. Scores on the Western Michigan University Chemistry Placement Examination which will hereafter be designated the WMUCPE.

In addition, this study is concerned with various additional variables related to student characteristics such as sex, classification, i.e., freshman, sophomore, etc., as well as variables pertinent to the students' high school academic background which may be useful in predicting success in general college chemistry.

From the data collected, an effort will be made to elicit answers to these questions:

1. What is the relationship of the ACT scores to grades in general college chemistry?

2. What is the relationship of the grades earned in various high school subjects to grades in general college chemistry?

3. What is the relationship of the placement test scores, such as ACS test scores and WMUCPE scores, to grades in general college chemistry?

In addition, the various ACT subtests scores--ACT English, ACT Mathematics, ACT Social Studies, and ACT Natural Science--and high school grades in English, mathematics, social studies, and natural science will also be examined in the light of their effectiveness as predictors of the semester grade in chemistry.

Chemistry 101 and Chemistry 102 are two of the six courses in General Chemistry at Western Michigan University. These two courses are primarily designed for chemistry majors and minors and for those students whose curricula require more than two semesters of chemistry, such as students in: (1) Medical Technology, (2) Paper Science, (3) Biology, etc. Chemistry 101 emphasizes the fundamental principles, theories and problems of chemistry. This course is designed for students who have a poor background in chemistry. Like Chemistry 101, Chemistry 102 emphasizes the theories and fundamental principles of chemistry, but this course is intended for the more able students in chemistry. The objective of the Chemistry Department is to have both Chemistry 101 and Chemistry 102 students cover the same materials, but Chemistry 102 students to cover the material in more depth. Chemistry 101 has four lectures per week and Chemistry 102 three lectures. Both courses have one laboratory period per week. Students in Chemistry 101 meet one additional hour per week for discussion and quiz. Each course

is a four credit hour course. Students completing either Chemistry 101 or Chemistry 102, and who earn a grade of A, B, or C, take the same second course (Chemistry 120) if they wish to continue in the study of chemistry. In other words, both Chemistry 101 and Chemistry 102 serve as prerequisites to Chemistry 120.

Scope of the Study

This study is limited to students who took Chemistry 101 and Chemistry 102 at Western Michigan University (WMU) during the Fall Semesters of 1973 and 1974.

Western Michigan University is located in the city of Kalamazoo, Michigan. Created by the Legislature of Michigan in 1903, the university has continued to serve the educational needs of students from Michigan, students from other states, as well as foreign students. Today, Western Michigan University is a multipurpose university serving a variety of educational and professional needs through its colleges of Applied Sciences, Arts and Sciences, Business, Education, Fine Arts, General Studies, and Graduate Studies. These colleges offer Bachelor of Arts and Bachelor of Science Degrees, Master of Arts and Master of Science Degrees as well as Doctor of Philosophy Degrees in Chemistry, Mathematics, Psychology, Science Education and Sociology. The Doctor of Education Degree is offered by the College of Education in Counseling and Personnel, Educational Leadership, and Special Education. The university has an enrollment of approximately 21,000 students.

Need for the Study

Students with various background experiences and a wide range in abilities and aptitudes continue to enter colleges and universities. Therefore, it is important that these students be placed in the proper courses in which they can perform effectively. In addition it is vital for the students that accurate prediction of their success in a course be determined in order to avoid haphazard guessing regarding their performances in the future.

The obvious loss of human resources, which results from college students' inability to meet minimum academic standards, affects all of society. Therefore, in the interest of the students and society, it is essential that research be aimed at identifying, at an early stage, students who cannot succeed in a particular course.

Thus, specifically, this investigation is undertaken in order to achieve the following objectives:

1. To enable the Chemistry Department of Western Michigan University to effectively place students in the proper general chemistry course.

2. To aid the academic advisers in guiding the students toward a choice of appropriate academic goals.

3. To enhance the purpose of instruction by reducing the element of chance of possible failure through appropriate placement.

4. To eliminate frustration among the less able students who may be unable to comprehend and perform at the same level as the more able students.

Several prior investigations have been conducted regarding the problem posed by this study. However, no one common prediction equation has been found for course placement or prediction of success in

general college chemistry. One reason for this could be that the various colleges and universities differ in the level of difficulty and the course content of their chemistry courses. Consequently, it may be necessary for each individual university or college to conduct its own research in order to arrive at its own particular prediction equation. Since no extensive study of this problem has been undertaken at Western Michigan University, this study attempts to determine those factors which could be used by the Chemistry Department at Western Michigan University to effectively place students in the appropriate general college chemistry course.

CHAPTER II

REVIEW OF THE LITERATURE

The literature reveals that the earliest studies of prediction in education were focused on the overall success of the students in college. The prediction of success in specific courses was only undertaken recently. There are a number of studies reported concerning the prediction of college grade point averages or grades in a specific course. This chapter will attempt to review those studies pertinent to the overall success of students in college as well as studies pertinent to the prediction of success in a specific course. This is done in an attempt to show how the prediction studies in education have evolved from overall success in college to success in specific courses. Therefore, the studies reviewed here have been categorized under two main headings:

1. Studies of Prediction of Success in College
2. Studies of Prediction of Success or Placement in General College Chemistry

Studies of Prediction of Success in College

Many colleges, universities, and researchers have used high school grade point average (HSGPA), high school grades in specific courses, and specific scores on standardized aptitude and achievement tests as predictors of student success in college. These measures, singly or in various combination, have been used by different institutions for a variety of purposes, including guidance, college admissions, placement in college courses, and academic and vocational counseling.

Early studies (Garrett, 1949; Read, 1938; and Douglas, 1931) indicated that high school grade point average is the best predictor for academic success in college. In a study using 200 graduates of the Warren G. Harding High School of Warren, Ohio, Garrett (1949) discovered that there was a correlation coefficient of .67 between the students' high school grade point average and their first semester grade point average obtained in the 52 different colleges attended by the students. Also, Garrett (1949) reviewed 32 prior studies, each of which gave a correlation coefficient between the students' high school grade point average and college grades. These correlation coefficients ranged from .29 to .83.

As a result of his study, Read (1938) emphasized the importance of high school grade point average as the best single predictor for college success when he wrote:

> When we attempt to predict averages for the entire freshmen year, the high school average is the best single criterion available at the first of the year.

Regarding the placement of students according to ability levels based on high school grade point average, Read (1938) said:

> It seems important to note ...that in any situations such as a municipal university with many students from the same school system, prediction of the first semester average, certainly to the extent of placing upper, middle or lower third of the freshmen class, can be made on the basis of high school average alone.

Douglas (1931) summarized 67 studies made before 1931. He found an average correlation coefficient of .54 between the high school grade point averages and grades obtained in college.

Also, next in rank to the high school grade point average as a single basis for predicting college success are the scores on stand-

ardized achievement tests as indicated in several studies (Eurich and Cain, 1941; Butsch, 1939; Weeks, 1957; Munday, 1967; Wills, 1964; and Jones, 1928).

Investigating the relationship between achievement test scores and academic success in college, Eurich and Cain (1949) reported:

> General achievement test scores provide a close second to high school average as a single basis for predicting college scholarship. Various investigations have found the relationship between the College Entrance Board Tests scores and general scholarship to range from .39 to .64.

Butsch (1939) investigated the relationship between the Iowa High School Content Examination scores and the first semester college grades. His sample consisted of 750 freshmen entering Marquette University. The result of his investigation showed a correlation of .47 between the Iowa High School Content Examination scores and the first semester college grades received by the students.

Not only have single variables been found to be effective predictors of college success, but also, combinations of several variables have been found to be effective predictors of academic success in college. Weeks (1957) investigated the degree to which high school grades and the scores on The Differential Aptitude Test could be used as predictors of possible success in the two year terminal technical program at Western Michigan University. He found that the high school grade point average did not show a significant relationship to grades made by the students in the program. However, he found certain combinations of the verbal, numerical, abstract, and spacial reasoning subtest scores on The Differential Aptitude Test as predictors of success in college.

Munday (1967) reviewed the studies of the Standard (Plan A) Research Service in which 398 colleges and universities that were in the ACT Research Service in 1963, 1964, or 1965 had participated. The purpose of his study was to review the experience of ACT Research Services regarding the predictors of college grades. The ACT subscores in English, Mathematics, Social Studies, and Natural Science, and high school reported grades in the same subject matter areas were used to predict college grades in English, mathematics, social studies, and natural science, as well as overall grade point averages. ACT scores taken together in a regression form correlated with the grades in the college courses with coefficients of correlation ranging from .42 for mathematics to .51 for English. The four high school grades taken together in a regression form correlated with the grades in the college courses with coefficients of correlation ranging from .44 for mathematics to .51 for English. When the four ACT scores and the four high school grades were taken together in a regression form, and correlated with the grades in college courses, the coefficients of correlation ranged from .52 for mathematics to .59 for English. The review also showed that the overall college grade point average of the four college courses correlated .52 with the four ACT scores taken together, .55 with the four high school grades taken together, and .63 with the eight variables taken together in a regression form. Munday concluded that both ACT scores and self-reported high school grades were predictive of college grades, and that the effectiveness of the predicton could be increased if the ACT scores and the high school grades were considered together in a regression form.

Wills (1964) investigated the prediction of academic success at Western Michigan University using the scores of the Sequential Test of Educational Progress (STEP). The STEP battery includes Reading, Mathematics, Social Studies, Science, Writing, and Listening Tests. All but the last subtest were administered to a random selection of 390 students. The criterion measures with which the tests scores were correlated included the freshman, sophomore, and cumulative junior grade point averages, and grade point averages in eight individual college subjects. His study revealed that the STEP battery was an average predictor for freshmen grades but below average for the sophomore and junior grades. Also, he found the Reading Test score as the best single predictor in the individual subject areas, with the exception of the business course area, where the Mathematics Test score proved to be the best single predictor.

In certain situations, coefficients of correlation between achievement tests scores and later success in college have been high. A 1928 study by Jones reported a coefficient of correlation of .63 for Fall term and .86 for first year, between scores on the Indiana Composite Achievement Test and college grade point averages. It was, however, believed that the subjects, who were all in the elementary teacher-training group in Indiana State Teachers College, may have inflated the correlation due to the selectivity and common interest of the group.

Additional studies, relating to the pattern of high school subjects taken with later success in college, have also been investigated by Gebhardt, 1923; Bolenbaugh, 1927; and Ross, 1931.

The old belief, so firmly held in the early period of American higher education, was that the pattern or number of units in particular high school subjects, especially foreign language, had much to do with the students later success in college. Gebhardt (1923) repudiated this belief. He studied the relation between the number of units of high school subjects completed and academic success in college. As a result of his investigation, he made the following conclusion:

> There is no significant evidence in this investigation to show that one subject or group of subjects is of greater value in itself than any other, as an aid to successful work... The evidence tends to show that two people of equal ability, studying different subjects in high school may do college work of equal grade.

Bolenbaugh (1927) investigated whether students who entered Stanford University with an academic pattern (college preparatory) of high school work achieved better in college subjects than those who entered with a vocational pattern. His study revealed no significant differences between the achievement of the academic pattern group and those of the vocational group.

Ross (1931) revealed findings opposite to those of Gebhardt (1923). Ross investigated the relationship between the foreign language preparation of freshmen and their college record. He divided all freshmen into groups according to the number of semesters (two to seven) of foreign languages they had completed in high school. Neither the grade received nor the particular language studied was considered. The number of students ranged from 21 who had completed seven semesters of language to 249 who had completed four semesters of language. There were a total of 590 freshmen students in the study. Ross concluded that:

> The inevitable generalization is that college grades are likely to be very closely correlated to the amount of entrance language. The correlation is too close to be accidental.

Regarding class rank as a predictor of college scholarship, Clark (1931) compared high school grade point averages with high school class rank as a means of predicting college grades. His study showed that high school rank was not superior to high school grade point average or vice versa. Therefore, he suggested the use of a combination of these measures as predictors of college success.

In summary, the literature reviewed indicates the high school grade point average as the best single predictor of success in college. The standardized achievement test scores were found to be the next most effective predictors of success in college. The coefficients of correlation found between each of these predictors or combination of predictors and college grade point average ranged from .40 to .50 with considerable lower or higher coefficients also reported. The review also revealed that other variables such as the number of semesters of foreign language studied, the pattern of high school subjects, and class rank were found to be less effective predictors of college grade point averages.

Studies of Prediction of Success or Placement in General College Chemistry

Recently studies dealing with prediction of success of students in college have taken on a new direction. Instead of predicting the overall success of students in college, studies are now focusing on the prediction of success of students in specific courses. Part of

the reason is probably due to the large variety of courses now offered to freshmen by various departments within colleges to meet the varying needs and abilities of freshmen students. Thus during the past few years, the literature dealing with the success of students in a particular college course has increased. These studies that are relevant to the prediction of success and placement of students in general college chemistry are reviewed in this section.

As a criterion measure, Zimmerman and Michael (1967) used the grade point average earned by the students in courses taken in each of the 12 different departments of the California State College, Los Angeles, to compare the predictive validity of three selection devices: (1) scores on the ACT, consisting of the four subtests, English, Mathematics, Social Studies, and Natural Science; (2) scores on the Scholastic Aptitude Test (SAT) of the College Entrance Examination Board, containing both the Verbal and Mathematics sections; and (3) scores on a short form of the Verbal Comprehension subtest and the regular form of the General Reasoning subtest of the Guilford-Zimmerman Aptitude Survey (GZAS). The sample included freshmen who entered college in the Fall of 1962 and 1963. The second purpose of the investigation was to determine, for the 1963 sample, the extent to which an optimally weighted combination of either the GPA earned during the last three years of high school (excluding physical education and military science) or the number of recommended units of A or B work during the same last three years of high school, and subtests scores on the ACT, SAT, or GZAS would exceed that of the correlation coefficient of either one of the high school indices of

achievement taken singly. The coefficients of correlation between the predictors and the criterion variables were found to be .53 or less. However, the authors noted that for college mathematics and chemistry courses, the SAT Mathematics and ACT Mathematics scores were the most valid predictors. Also, they discovered that when the ACT scores were combined with the high school GPA, the former added more to the predictive validity than when either the two portions of SAT or GZAS were used in combination with the high school GPA.

Carlin (1957) investigated whether students who had taken courses in chemistry and physics at the high school level were more or less successful, as judged by the grades that they attained in the first semester of college chemistry course, than students who had not taken these courses, as judged by their grades after the first semester of college chemistry. He concluded:

> A course in chemistry at the high school level is an asset to the high school students who intend to continue the study of chemistry in college. Further, both high school chemistry and high school physics contribute more to success in a college chemistry course than a course in either of these high school subjects alone.

In another study, Longmire (1973) investigated the possible relationship between performance in general college chemistry and high school preparation in chemistry. His sample consisted of 120 students, 88 of whom had had high school chemistry. He examined the achievement in general college chemistry as a possible function of the student's grades in high school science courses, number of units of mathematics, socioeconomic status, and scores on the ACT. In contrast to the previous study, Longmire's study revealed that there was no statistically significant relationship found between the chemistry grade and

(a) completion of high school chemistry, (b) high school preparation in the other sciences, (c) student's socioeconomic status or (d) scores on ACT tests. However, the study revealed a significant relationship between preparation in high school mathematics and the chemistry grade. The correlation coefficient between the chemistry grade and the number of units of high school mathematics was .31. Longmire, therefore, concluded that the best single indicator of performance in general college chemistry was the number of units of high school mathematics completed.

The Kinzers (1948) investigated the predictive ability of the arithmetic placement test, along with the Ohio State Psychological Examination, a Reading Test, number of problems attempted on the arithmetic placement test, and college grade point average. The final chemistry grade was considered as the criterion measure. The sample consisted of 120 students identified as deficient in arithmetic based on the scores they obtained on an arithmetic placement test. The remedial group was chosen from persons scoring in the lowest third on this test. These students took a first course in chemistry and a remedial arithmetic course concurrently. After three weeks of remedial arithmetic instruction, the students were re-tested using a similar basic arithmetic skills test. The average on the second test was 66 as compared to a 23 on the first test. The first arithmetic test correlated .16 with the chemistry grade, and the arithmetic re-test correlated .52 with the chemistry grade.

Sieveking and Savitsky (1969) investigated how effectively grades in college chemistry could be predicted from the following variables: (1) scores on the ACS test; (2) scores on SAT Verbal and Mathematics

tests; (3) high school grade point average; (4) sex; and (5) school of registration (Engineering or Arts and Sciences). The subjects included 996 Vanderbilt University freshmen in 1965, 1966, and 1967. The intercorrelations showed the ACS test score as the best predictor of chemistry grade, whereas other correlation coefficients between the chemistry grade and the other variables ranged from -.02 for sex to .41 for high school grade point average. The final Multiple Regression Equation in this study retained the ACS test score, high school grade point average, SAT Mathematics score, and school of registration.

Chase et al. (1963) investigated the usefulness of the ACT and SAT scores in predicting grades in each of 22 different courses in which freshmen commonly enrolled at the University of Indiana. In addition to the other variables, the authors specifically studied: (1) the relationship between scores on the SAT and grades in each of the 22 different courses; (2) the relationship between scores on the ACT and grades in each of the 22 different courses; and (3) the relative effectiveness of the two tests scores as course grade predictors. Chemistry C100 and Chemistry C105 were among the 22 courses that were investigated. The other 20 courses were in the following general areas: biology, psychology, geology, linguistic, social sciences, music, mathematics, and speech. The relationships between the combinations of the SAT scores and other variables and grades in each of the 22 different courses were as follows: (1) the SAT Verbal score combined with high school rank for the best correlation with the grades received in courses relating to social science, psychology, speech, and linguistics; (2) the total SAT scores (Verbal and Mathe-

matics) combined with high school rank for the best correlation with the grades received in courses relating to mathematics and sciences. The multiple correlation coefficients between the combination of SAT scores and high school rank and grades in each of the 22 courses ranged from .40 for Philosophy 100 to .73 for Chemistry 100 and Zoology 103. The relationships among the ACT scores and grades in each of the 22 different courses were as follows: (1) the ACT Social Studies score combined with high school rank for the best correlation with the grades received in courses relating to social sciences, psychology, and speech; and (2) the total ACT scores combined with high school rank for the best correlation with the grades received in Chemistry 100 and Chemistry 105. The multiple correlation coefficients between the combination of ACT scores and high school rank and grades in each of the 22 courses ranged from .42 for Geology 100 to .76 for Zoology 103. Specifically, Chemistry 100 and 105 grades correlated .71 and .67 respectively with the combination of the total ACT scores and high school rank. No single subtest score of either the SAT or the ACT was found to correlate highly with the chemistry grades. The high correlation coefficients reported above were those between the chemistry grades and a combination of the ACT scores or SAT scores and the high school rank.

Coley (1973) attempted to determine the best predictor or combination of predictors that could be used to predict a student's level of success in general chemistry at a community college. The predictors included in the study were: (1) grades received in Chemistry 31 (a prerequisite to the general chemistry course Chemistry 1A); (2) scores on the Toledo Chemistry Placement Examination (TCPE); (3) scores on the

ACT; and (4) high school chemistry and algebra grades. The criterion measure was the Chemistry 1A grade. Students taking Chemistry 31 were those who scored less than 50 on the TCPE. The author reported that for these students the Chemistry 31 grade was the best predictor of success in Chemistry 1A. The correlation coefficient between the Chemistry 31 grade and Chemistry 1A grade was .43. When the TCPE score was combined with the Chemistry 31 grade, the multiple correlation increased to .44 and thus was regarded of no significance in the regression equation. For those students scoring 50 or above on the TCPE, and thus not required to take Chemistry 31, the score on the TCPE correlated .39 with the Chemistry 1A grade. None of the other variables studied were found to aid in the prediction of success in Chemistry 1A.

Schelar et al., (1963) investigated the placement of students in Chemistry 210, a general chemistry course at Northern Illinois University. Mathematics scores, total scores on the SAT, and reading comprehension test scores were examined as predictors. The authors decided to compute biserial r's using the criteria of "success" and "failure" as the arbitrary dichotomy. Success was defined as receiving a grade of A or B; failure as F or D. In a pilot study, the biserial correlation between the Cooperative Mathematics Pretest scores and grades in Chemistry 210 was .93. In order to determine whether a chemistry placement test score would also correlate with the chemistry grade, one of the authors constructed a trial test called the Chemistry Placement Test. This test consisted of three parts: (1) mathematical and chemical problems, (2) questions requiring reasoning ability, and (3) factual questions based on recall of high school chemistry. In the Fall after

the pilot study, all students who were enrolled in Chemistry 210 took the Chemistry Placement Test in addition to the ACT Mathematics test. A high biseral correlation of the Chemistry Placement Test scores ($r_{bis} = .93$) with the final grades in Chemistry 210 was obtained. This correlation was compared with the biseral correlation, $r_{bis} = .76$, which was obtained between the ACT Mathematics score and the chemistry final grade. Therefore, the authors concluded that the Chemistry Placement Test score was the best predictor for placement purpose at Northern Illinois University.

At San Diego State College, Merzbacher (1949) studied the correlation between performance in the Freshmen Testing Program and the first semester grade in chemistry. The American Council on Education Psychological Examination subtests (Quantitative section and Linguistic section) and total scores, and the Iowa High School Content Examination subtests (English, Mathematics, and Science) and their total scores were correlated with the first semester grade in chemistry. The best predictors from the correlation were found to be the Quantitative section of the American Council on Education Psychological Examination and the Science section of the Iowa High School Content Examination. The coefficient of correlation between the Quantitative section of the American Council on Education Psychological Examination and the Chemistry grade was .45 and the coefficient of correlation between the Science section of the Iowa High School Content Examination and Chemistry was .45. When the two predictors were combined, they yielded a multiple correlation of .56.

Morris (1973) prepared an ACT Standard Research Service Report for the students in Chemistry 102 at Western Michigan University. Using the

ACT scores and high school grades as predictors of the Chemistry 102 grade, he reported a correlation of .30 between the ACT English score and the Chemistry 102 grade. A correlation of .38 was reported between the high school mathematics grade and the Chemistry 102 grade. He reported a multiple correlation of .37 between the Chemistry 102 grade and the four subtests scores of English, mathematics, social studies, and natural science and a multiple correlation of .45 between the Chemistry 102 grade and the grades in high school English, mathematics, social studies, and natural science. To obtain the optimum prediction equation for the Chemistry 102 grade, he recommended the use of the combination of the ACT scores and the high school grades in a regression equation.

The studies reviewed above dealt with predictors that could be used to determine a student's success in a college general chemistry course. Most of the studies made use of ACT scores, high school grades, ACS test scores, and scores on individual college placement examinations as predictors of grades in chemistry courses. The results of these studies tend to indicate that universities differ in the number and types of variables used in their prediction equations. Thus there is a necessity for developing unique prediction equations which reflect the special circumstances of each school.

The following conclusions seem to be valid from the studies reviewed:

1. A single predictor is not generally found that is capable of predicting the success of a student in a freshmen chemistry course.

2. The correlation between a single predictor and the criterion measure is often low, and that the correlation is only moderate or high when two or more predictors are combined and correlated with the criterion measure.

3. Grades in high school mathematics and chemistry courses and scores on achievement tests and locally made chemistry placement examinations have been found to correlate best with college chemistry grades, and that they increase the efficiency of the prediction of the criterion measure when they are combined.

4. Prediction equations derived by the different colleges and universities tend to be independent of one another. This may be due partly to the fact that colleges differ in the objectives of their courses.

This research study was initiated with the dual purpose of arriving at a method for predicting success in general college chemistry and a method for effective placement in General Chemistry courses at Western Michigan University.

CHAPTER III

THE RESEARCH DESIGN

The purposes of this chapter are to describe: (1) the pertinent terms and their definitions; (2) the procedures by which the predictors (independent) variables and the measure of criterion (dependent) variables were selected; (3) the population and the sample; (4) the procedures used to collect the data; and (5) the methods used to analyze the data.

Definition of Terms

For the purpose of this study, some of the terms used are defined as follows:

The American College Testing Program (ACT) Scores refer to the scores on the ACT battery of tests which the students usually take during their junior or senior year in high school. The ACT battery consists of four subtests. They are:

1. The English Usage Test (ACT English), a 40 minute 75-item multiple choice test, which measures the student's understanding and use of punctuation, capitalization, usage, phraseology, style, and organization. Each item has four alternative answers. The student must select the best answer among the four choices. (The American College Testing Program, 1973-74)

2. The Mathematics Usage Test (ACT Mathematics), a 50 minute 40-item multiple choice test, which measures the student's comprehension of verbal problems as well as the student's understanding in computing problems in high school mathematics, including arithmetic, algebra, and geometry. The student must select the best answer from five alternative answers. (The American College Testing Program, 1973-74)

3. The Social Studies Reading Test (ACT Social Studies), a 35 minute 52-item test, which measures the student's ability to understand a certain passage and to draw inferences and conclusions, to make deductions from experimental or graphic data, and to recognize a writer's bias, style, and mode of reasoning. The test, also, measures the student's factual recall for high school courses in history, civics, geography, and economics. All items are multiple choice questions with four alternative answers. The student must select the best answer among the four choices. (The American College Testing Program, 1973-74)

4. The Natural Sciences Reading Test (ACT Natural Sciences) a 35 minute 52-item multiple choice test, which measures the student's ability to read and interpret passages which concerns a variety of scientific topics from biology, chemistry, and physics. The test also measures the student's recall of factual information in the natural sciences, and the student's ability to apply what he or she learned in high school science courses to familiar, new, or analogous problems. Arithmetic computation and algebra are not emphasized. All items are multiple choice questions and the student selects the best answer from the four choices. (The American College Testing Program, 1973-74)

The ACT Composite Score is the average of the combined standard scores on the four ACT tests.

The High School Grade refers to the grade a student received in a particular high school course. The grades are student reported and appear on the profile which is part of the American College Testing Program. In this study, the letter grades were assigned the following numerical values:

A = 4

B = 3

C = 2

D = 1

The High School Grade Point Average is the average of the high school grades received in English, mathematics, social studies, and natural sciences.

Size of Graduating Class refers to the number of students in a graduating class of a particular student. The size of the graduating class was coded as follows: (The American College Testing Program, 1974-75)

Less than 25 = 1

25-99 = 2

100-199 = 3

200-399 = 4

400-599 = 5

600-899 = 6

900 or more = 7

Rank in High School Graduating Class refers to the student's academic standing in his or her graduating class. The ranks were coded as follows: (The American College Testing Program, 1974-75)

Top Quarter = 1

Second Quarter = 2

Third Quarter = 3

Fourth Quarter = 4

Number of Semesters Studied in Certain High School Subjects refers to the number of academic semesters a student spent in studying a particular course. The coding was as follows: (The American College Testing Program, 1974-75)

Zero Semesters = 0

One Semester = 1

Two Semesters = 2

Three Semesters = 3

Four Semesters = 4

Five Semesters = 5

Six Semesters = 6

Seven Semesters = 7

Eight Semesters = 8

Sex refers to a male or female student included in the sample. The coding was as follows:

Male = 1

Female = 2

Classification refers to the university status of the student who took Chemistry 101 or 102 during the Fall Semester of 1973 or 1974. The coding was as follows:

Freshmen = 1

Sophomore = 2

Junior = 3

Senior = 4

Others = 5

The American Chemical Society NSTA Cooperative Examination: High School Chemistry (ACS) is a 90 minute 90-item multiple choice test. Hereafter this test is designated as the ACS test. The test consists of parts I and II, each part consisting of 45 multiple choice items and taking 45 minutes. The examination measures the student's ability to recall, comprehend, and apply knowledge learned in high school chemistry. (Buros, 1965)

The Western Michigan University Chemistry Placement Examination (WMUCPE) is a 45 minute 45-item multiple choice test which is depart-

mentally constructed and it is designed to measure the student's knowledge of high school chemistry and high school arithmetic and algebra. One-third of the test involves mathematical calculations.

The Chemistry Final Examination is a 33-item multiple choice test intended to measure the student's general achievement in Chemistry 101 or 102.

The Chemistry Grade refers to the final grade a student received in either Chemistry 101 or 102. The coding of the letter grades were as follows:

A = 4

B = 3

C = 2

D = 1

E = 0

The Predicted Grade refers to the grade a student would have received according to the prediction formula.

Success in Chemistry 101 or 102 means a student could earn a predicted grade of A, B, or C in Chemistry 101 or 102. A student was considered unsuccessful if he or she could earn a predicted grade of D or E.

Selection of the Variables

Two criteria were used to select the variables. They were: (1) the availability of the data, and (2) the demonstrated effectiveness of these variables in previous studies which attempted to predict success in college chemistry.

Since the ACS test score had been used previously as a criterion for student placement in the different general chemistry courses at Western Michigan University, it was selected as one of the independent variables. During the Fall Semester of 1974, the ACS test was replaced by the WMUCPE, and so the WMUCPE score was also included as one of the independent variables.

The second category of independent variables were: (1) the scores on the ACT which consists of four ability tests in the areas of English, Mathematics, Social Studies, and Natural Science; (2) four self-reported high school grades covering the same areas as the ACT scores; and in addition (3) 12 variables related to high school education. These data were obtained from the ACT profile which the university receives for each entering freshman.

The last category of independent variables includes the sex and the classification (freshmen, sophomore, etc.) of the student as reported at the time of enrollment in the general chemistry courses.

Two dependent variables were selected as the criterion measures. They were: (1) the scores on the chemistry final examination; and (2) semester grade in general chemistry. Since the final chemistry grade was a function of the final examination score, the former was selected as the primary dependent variable.

Table I is a listing of both the independent and the dependent variables.

Table I

Selected Independent and Dependent Variables

Variable Name	Variable Type
Sex	Independent Variable
ACT English Score	" "
ACT Mathematics Score	" "
ACT Social Studies Score	" "
ACT Natural Science Score	" "
ACT Composite Score	" "
High School English Grade	" "
High School Mathematics Grade	" "
High School Social Studies Grade	" "
High School Natural Science Grade	" "
High School Grade Point Average	" "
Classification	" "
ACS Score	" "
WMUCPE Score	" "
Size of High School Graduating Class	" "
Rank in High School Graduating Class	" "
Number of Sem. Studied High School English	" "
Number of Sem. Studied High School Mathematics	" "
Number of Sem. Studied High School Social Studies	" "
Number of Sem. Studied High School Natural Science	" "

Table I (continued)

Variable Name	Variable Type
Number of Sem. Studied Language (Spanish)	Independent Variable
Number of Sem. Studied Language (German)	" "
Number of Sem. Studied Language (French)	" "
Number of Sem. Studied Language (Others)	" "
Number of Sem. Studied Business or Commercial Courses	" "
Number of Sem. Studied Vocational or Occupational Courses	" "
Chemistry Final Examination Score	Dependent Variable
Chemistry Grade	" "

The Population

At Western Michigan University, the enrollment record in general chemistry indicates that generally, more students enroll in general chemistry during the Fall Semester than any other semester or session. Table II shows comparisons of student enrollment in general chemistry during the different semesters and sessions of the 1973-74 and 1974-75 academic years.

Table II

Student Enrollment in General Chemistry

	Enrollment by Academic Year (1973-74)		Enrollment by Academic Year (1974-75)	
	Chem. 101	Chem. 102	Chem. 101	Chem. 102
Fall Semester	468	127	348	165
Winter Semester	196	56	213	55
Spring Session	31	0	29	0
Summer Session	25	0	24	0

The population of the study was restricted to those students in General Chemistry at Western Michigan University in the Fall Semesters of 1973 and 1974 because of four reasons: (1) the larger enrollment would probably assure that the sample included students with a wider range in abilities; (2) during the Fall Semester of 1973, students were assigned to Chemistry 101 or 102 based on ACS test scores; (3) during

the Fall Semester of 1974, the students were assigned to Chemistry 101 or 102 based on WMUCPE scores; and (4) students enrolled in Chemistry 101 or 102 during the Fall Semesters of 1973 or 1974 were administered the same Chemistry Final Examination.

Prior to and including the Fall Semester of 1973, the scores on the 1958 ACS test Form N, Part I, with maximum score of 45, were used as a measure of criterion for student placement into either Chemistry 101 or Chemistry 102. The Chemistry Department had previously decided that students who obtained raw scores of 14 or less were to be placed in Chemistry 101 while those with scores of 16 or above were to be placed in Chemistry 102. Students who obtained a score of 15 were given the option to enroll in either Chemistry 101 or Chemistry 102. Occasionally, students who obtained a score of 40 or above were advised to by-pass the first semester course and enroll in Chemistry 120. For reasons, which are beyond the scope of this investigation, there were students in Chemistry 101 and Chemistry 102 who never took the ACS placement test. This, caused the sample for the study to be smaller than expected, since the ACS test score was an integral part of the data.

During the Fall Semester of 1973, two sections of Chemistry 101 and one section of Chemistry 102 involving 595 students were taught by three professors. Of these, 468 students were enrolled in Chemistry 101 and 127 students were enrolled in Chemistry 102. Table III shows the enrollment distribution, indicating the number and percentage of students either with ACS or with no ACS placement test scores.

Table III

Summary of Student Enrollment Distribution - Fall 1973

Placement Characteristics	Chemistry 101		Chemistry 102	
	No.	%	No.	%
Students with ACS test scores	214	45.7	96	75.6
Students with no ACS test scores	254	54.3	31	24.4
Total	468	100.0	127	100.0

Table III indicates that 54.3 percent of the 468 students in Chemistry 101 did not have ACS test scores. This could mean that they were either assigned or they chose to take Chemistry 101. In other words, they had not been placed based on the results of the ACS test, the criterion for student placement in chemistry at that time. Similarly, 24 percent of the 127 students were either assigned or the students chose to take Chemistry 102.

Table IV shows the grades earned in Chemistry 101 and 102 in the Fall Semester of 1973.

Table IV

Grades Earned in Chemistry 101 and 102 - Fall 1973

Grades	Chemistry 101		Chemistry 102	
	No.	%	No.	%
A, B, C	233	49.8	83	65.4
D, E	128	27.3	30	23.6
X, I, W	107	22.9	14	11.0
Total	468	100.0	127	100.0

X - means a student failed to complete the course or failed to withdraw officially from a course.

I - means the student's work is of passing quality but the student is prevented from completing all of the course requirements because of reasons beyond the control of the student.

W - means a student withdrew officially from the course.

Table IV shows that 50.2 percent of the subpopulation earned grades of D, E, X, I, and W; and only 49.8 percent earned grades of A, B, and C. The unsuccessful performance in Chemistry 101 by students who earned grades of D, E, I, X, or W may have been due to the fact that these students decided to take Chemistry 101 with no ACS scores to support their placement in that course, or it may have been due to assigning students with very low scores on the ACS test to Chemistry 101 instead of assigning them to some remedial chemistry course other than Chemistry 101.

The members of the Chemistry Department suspected that the ACS test was not satisfactorily placing students in the correct courses. Therefore, the department replaced the ACS test with a departmentally constructed test, the WMUCPE, during the Fall Semester of 1974. Students who scored 25 or less on this 45-item multiple choice test were assigned to Chemistry 101 while those with raw scores of 28 and above were placed in Chemistry 102. Students with a raw score of 26 or 27 were given the option to enroll in either Chemistry 101 or Chemistry 102. This part of the study consisted of 513 general chemistry students in the Fall Semester of 1974, of which 348 students were in Chemistry 101 and 165 students in Chemistry 102.

Table V shows the enrollment in Chemistry 101 and Chemistry 102 and indicates the number and percentage of students enrolled who had taken the WMUCPE or who had not taken the WMUCPE.

Table V

Summary of Student Enrollment Distribution - Fall 1974

Placement Characteristics	Chemistry 101		Chemistry 102	
	No.	%	No.	%
Students with WMUCPE scores	272	78.2	131	79.4
Students with no WMUCPE scores	76	21.8	34	20.6
Total	348	100.0	165	100.0

Table V shows that 348 students enrolled in Chemistry 101 and that 21.8 percent did not have WMUCPE scores. Similarly, 20.6 percent of the 165 students in Chemistry 102 did not have WMUCPE scores. The subsequent grades earned by the 1974 subpopulation in both Chemistry 101 and Chemistry 102 are in Table VI.

Table VI

Grades Earned in Chemistry 101 and 102 - Fall 1974

Grades	Chemistry 101		Chemistry 102	
	No.	%	No.	%
A, B, C	220	63.2	105	63.6
D, E	91	26.2	34	20.6
X, I, W	37	10.6	26	15.8
Total	348	100.0	165	100.0

Table VI shows that 36.8 percent of the 348 students enrolled in Chemistry 101 earned grades of D, E, X, I, and W. Similarly, 36.4 percent of the 165 students enrolled in Chemistry 102 earned grades of D, E, X, I, and W.

The sex and classification data of the population are summarized in Table VII.

Table VII

Summary of Students' Sex and Classification Characteristics

Characteristics	Chem. 101 (1973)		Chem. 102 (1973)		Chem. 101 (1974)		Chem. 102 (1974)	
	No.	%	No.	%	No.	%	No.	%
Males	282	60.3	88	69.3	207	59.5	127	77.0
Females	186	39.7	39	30.7	141	40.5	38	23.0
Freshmen	305	65.2	104	81.9	244	70.1	140	84.9
Sophomores	109	23.3	14	11.0	62	17.8	18	10.9
Juniors	31	6.6	5	3.9	30	8.6	2	1.2
Seniors	10	2.1	2	1.6	11	3.2	2	1.2
Others	13	2.9	2	1.6	1	.3	3	1.8
Total	468	100.0	127	100.0	348	100.0	165	100.0

In summary, the total population of the study consisted of 1,108 students. Of this number 704 students were males and 404 were females. Also, 793 students were freshmen, 203 sophomores, 68 juniors, 25 seniors, and 19 others. Also, a total of 816 students took Chemistry 101 and 292 took Chemistry 102.

The Sample

The nature of the study dictated that the sample should include only those students for whom there were complete data available. The sample, therefore, consisted of those students who were enrolled in Chemistry 101 and Chemistry 102 during the Fall Semesters of 1973 and 1974 and

1. who took either the ACS test in the Fall of 1973 or the WMUCPE in the Fall Semester of 1974.
2. who took the chemistry final examination administered at either the end of Fall Semester of 1973 or 1974, and who also completed the requirements of Chemistry 101 or 102 in those semesters.
3. whose classification were known.
4. for whom ACT scores in the four ability test areas of the ACT and the ACT Composite scores were available on the Magnetic Tape Student Record 1972-73 and 1973-74 at Western Michigan University.
5. whose high school grades in English, mathematics, social studies, natural science, and high school grade point average were available.
6. who indicated the following information on the ACT Profile:
    a. size of the high school graduating class.
    b. rank in his or her graduating class.
    c. number of the semesters studied certain subjects.

With the exception of item six, 105 of the 468 students in Chemistry 101 and 67 of the 127 students in Chemistry 102, during the Fall of 1973, all met the criteria for selection as stated above. Similarly, for the Fall 1974 Semester, 104 of the 348 students in Chemistry 101 and 63 students of the 165 students in Chemistry 102, met the selection criteria. Therefore, the total sample for the study consisted of

339 students. This number constitutes about 31 percent of the total population.

Since 172 students of the total sample had taken the ACS test and 167 students had taken the WMUCPE, the sample was divided into two groups: (1) a subsample of Chemistry 101 and 102 students for the Fall of 1973 (ACS test groups), and (2) a subsample of Chemistry 101 and 102 students for the Fall of 1974 (WMUCPE group). This dichotomy was also necessary because the students in the 1973 subsample had not met the sixth criterion listed above. Each of the subsamples was subdivided into two subgroups, one including students who took Chemistry 101 and the other who took Chemistry 102. This was done to investigate which single variable or combinations of variables could serve as the best predictor(s) of student success in a particular course. A discussion of these four subgroups appears in Chapter IV.

Tables VIII and IX summarize variables used in the study.

Table VIII

List of the Variables on Which Complete Data were Gathered for the 1973 Subsample

Variable Number	Variable Name
1	Sex
2	ACT English Score
3	ACT Mathematics Score
4	ACT Social Studies Score
5	ACT Natural Science Score
6	ACT Composite Score
7	High School English Grade
8	High School Mathematics Grade
9	High School Social Studies Grade
10	High School Natural Science Grade
11	High School Grade Point Average
12	Classification
13	ACS Score
14	Chemistry Final Examination Score
15	Chemistry Grade

Table IX

List of Variables for Which Complete
Data were Gathered for the 1974 Subsample

Variable Number	Variable Name
1	Sex
2	ACT English Score
3	ACT Mathematics Score
4	ACT Social Studies Score
5	ACT Natural Science Score
6	ACT Composite Score
7	High School English Grade
8	High School Mathematics Grade
9	High School Social Studies Grade
10	High School Natural Science Grade
11	High School Grade Point Average
12	Size of Graduating Class
13	Rank in High School Graduating Class
14	Number of Semesters Studied English
15	Number of Semesters Studied Mathematics
16	Number of Semesters Studied Social Studies
17	Number of Semesters Studied Natural Science
18	Number of Semester Studied Spanish

Table IX (continued)

Variable Number	Variable Name
19	Number of Semesters Studied German
20	Number of Semesters Studied French
21	Number of Semesters Studied Other Languages
22	Number of Semesters Studied Business Courses
23	Number of Semesters Studied Vocational Courses
24	WMUCPE Score
25	Chemistry Final Examination Score
26	Chemistry Grade

Collection of Data

The data for this study were gathered from three sources. The first was the record books of the five professors who had taught the various sections of the two courses included in this study. The data collected from this source included the following: (1) student's name, (2) student social security number, (3) sex, (4) classification, (5) scores on the chemistry final examination, and (6) chemistry grade. The second source of data was the Chemistry Department file of the ACS test scores and the WMUCPE scores. The third source of the data was the ACT Magnetic Tape Student Record of students who entered Western Michigan University during the academic years of 1973-74 and 1974-75. The ACT Standard Research Service provides this ACT record to Western Michigan University for freshmen students who designated Western as their choice of academic institution at the time they took the ACT test.

In order to obtain the data from the ACT Magnetic Tape Record, it was necessary to prepare a list of the social security numbers of the 1108 students included in Chemistry 101 and 102 in the Fall of 1973 and 1974. This provided the investigator with the ACT scores, high school grades, and other pertinent information on high school education that were on the tape for those particular students.

Of the 1108 computer cards the author received on the total population, only 554 cards contained the ACT scores, high school grades, and pertinent data on the students' high school education. The remaining 564 cards contained no data because they were for transfer

or foreign students who are not required to submit ACT scores for admission to Western Michigan University.

The data concerning the students' classification, Chemistry Final Examination scores, chemistry grades, ACS test scores, sex, and WMUCPE scores were then added on those computer cards.

A complete set of data which consisted of ACT scores, high school grades, ACS test score, sex, classification, information on high school education, chemistry final score and chemistry grade was found for 339 student who took Chemistry 101 and 102 for the Fall Semesters of 1973 or 1974. The rest of the students were discarded from the sample because one or more of the variables were not available. All data were collected and treated in the most confidential manner.

Statistical Techniques of Analysis

In order to analyze the data for this study, the methods of intercorrelation analysis and the stepwise regression analysis were employed as the two major statistical techniques.

The intercorrelation analysis determines the coefficient of correlation between one variable and another variable. One primary purpose for analyzing the data by this method was to identify a single variable which was highly predictive of the chemistry grade. Therefore, particular consideration was given to the coefficients of correlation between each predictor (independent) variable and the criterion (dependent) variable (chemistry grade) in order to substantiate the use of the stepwise regression analysis. Although the intercorrelations among the variables are of interest in this investigation, the co-

efficients of correlation between the predictors and the chemistry grade are more basic to the goals of this study. The intercorrelation matrices can be found in Appendix A.

The stepwise regression analysis was performed in order to identify those variables that were relatively effective in predicting the chemistry grade. This analysis was done because no single variable could be identified by the previous analysis as highly predictive of the chemistry grade. Two phases were involved in analyzing the data by this method. In the first phase, all the independent variables for each subgroup were entered into the stepwise regression method for that subgroup. The result was that six variables, the ACT English score, ACT Mathematics score, high school mathematics grade, high school social studies grade, high school natural science grade, and ACS test score or WMUCPE score were found to be the most effective in predicting the chemistry grade. The second phase of the stepwise regression analysis was performed by entering only the above six independent variables. This second analysis was performed to maximize the predictive effect of the six variables, while, utilizing the minimum number of variables.

As each variable was added in the stepwise regression analysis, an F-value was computed to test whether the variable added was or was not a significant factor in predicting the chemistry grade. The level of significance for the F-values was set at the .05 level.

A *t*-test was employed in one of the preliminary analysis to test whether there was a significant difference between the performance of the students in Chemistry 101 and the students in Chemistry 102 on the chemistry final examination. The level of significance for this statistical test was set at the .05.

The computer program was designed to print out the following statistical data for each variable: (1) the means, (2) the standard deviations, (3) t-values, (4) an intercorrelation matrix of each variable with each of the other variables, (5) the multiple correlation coefficient or predictive weight (multiple R) which each added variable in the stepwise regression had on the chemistry grade, (6) the coefficient of determination (R^2) which when multiplied by 100 gives the percentage of the variance of the chemistry grade accounted for by the independent variable(s), (7) the standard error of estimate, and (8) a constant for each regression equation.

The data were analyzed with appropriate computer programs using the PDP-10 System Computer at Western Michigan University.

CHAPTER IV

ANALYSIS AND RESULTS

This chapter contains the findings of this study. These findings include: (1) a descriptive analysis of the general characteristics of the sample, (2) the results of the analysis of the means, and the standard deviations of the test scores, high school grades, and related variables, (3) coefficients of correlation between the predictors (independent) variables and the criterion (dependent) variable chemistry grade, and (4) the stepwise regression analysis.

The data analyzed in this chapter were collected from 339 students, composed of four subgroups. Subgroup I consisted of 105 students who took Chemistry 101 during the Fall of 1973 at Western Michigan University, Subgroup II of 67 students who took Chemistry 102 during the Fall of 1973, Subgroup III of 104 students who took Chemistry 101 during the Fall of 1974, and Subgroup IV consisted of 63 students who took Chemistry 102 during the Fall of 1974. Subgroups I and II were placed in Chemistry 101 and 102 on the basis of their scores on the ACS placement test. Likewise, Subgroups III and IV were placed in Chemistry 101 and 102 on the basis of their scores on the WMUCPE, a faculty constructed placement test that has replaced the ACS test.

The total sample used in this study is only 31 percent of the original population. The size of the sample was controlled by the lack of complete data for many students.

General Characteristics of the Sample

Table X shows that, generally, more male than female students enroll in courses in General Chemistry. Further, the data indicate that the students in Chemistry 101 received more D's and E's than students in Chemistry 102. The data, also, show that students who enroll in General Chemistry are predominantly freshmen.

Table X

General Characteristics of the Sample

Characteristics	Chem. 101 (1973)		Chem. 102 (1973)		Chem. 101 (1974)		Chem. 102 (1974)	
	No.	%	No.	%	No.	%	No.	%
Males	59	56.2	48	71.6	54	51.9	46	73.0
Females	46	43.8	19	28.4	50	48.1	17	27.0
A, B, C, Grades	73	69.5	51	76.1	68	65.4	49	77.8
D, E, Grades	32	30.5	16	23.9	36	34.6	14	23.2
Freshmen	105	100.0	66	98.5	104	100.0	63	100.0
Sophomores	0	0.0	1	1.5	0	0.0	0	0.0
Juniors	0	0.0	0	0.0	0	0.0	0	0.0
Seniors	0	0.0	0	0.0	0	0.0	0	0.0
Others	0	0.0	0	0.0	0	0.0	0	0.0

Analyses of the Means and Standard Deviations of the Data

Table XI presents the means and standard deviations of the variables for Subgroup I, who completed Chemistry 101 during the Fall of 1973. Since the mean of 1.42 regarding sex is based on a code of 1 for male and 2 for female the data indicate that more male students enrolled in Chemistry 101 than female students. The means of the ACT scores ranged from 18.58, for the ACT English score, to 23.15 for the ACT Natural Science score. The ACT composite mean was found to be 20.95 which is about one point higher than 20.00 the mean composite score for the college bound high school students as reported by the American College Testing Program in 1974-75. The means of the high school grades ranged from 2.80, for the high school mathematics grade, to 3.35 for the high school social studies grade. Student classification was not considered a factor in the analysis of the variables for this subgroup since all the students were freshmen. The mean of the grade in General Chemistry 101 was 1.98, a "C" on the four point scale at Western Michigan University.

In Table XII, the mean of 1.30 regarding sex based on a code of 1 for male and 2 for female indicates that more male than female students enrolled in Chemistry 102, Subgroup II. Also the data indicate that the means of the ACT scores ranged from 20.37 for the ACT English section, to 27.37 for the ACT Natural Science section. The ACT mean composite score of 24.88 for this subgroup, was about five points higher than the National mean composite score for the college bound students. This indicates that high ability students are entering Chemistry 102 classes.

Table XI

Means and Standard Deviations of Scores, Grades, and Other Related Variables for Subgroup I

Variable Name	Mean	Standard Deviation
1. Sex	1.42[a]	0.50
2. ACT English Score	18.58	3.81
3. ACT Mathematics Score	22.02	5.08
4. ACT Social Studies Score	19.55	6.00
5. ACT Natural Science Score	23.15	5.40
6. ACT Composite Score	20.95	3.95
7. High School English Grade	3.23[b]	0.65
8. High School Mathematics Grade	2.80[b]	0.96
9. High School Social Studies Grade	3.35[b]	0.69
10. High School Natural Science Grade	3.02[b]	0.98
11. High School Grade Point Average	3.05[b]	0.53
12. ACS Score	7.68	4.13
13. Chemistry Final Examination Score	20.68	5.56
14. Chemistry Grade	1.98[b]	1.09

[a]Coding male = 1, female = 2

[b]Coding A = 4, B = 3, C = 2, D = 1, E = 0

Table XII

Means and Standard Deviations of Scores, Grades, and Other Related Variables for Subgroup II

Variable Name	Mean	Standard Deviation
1. Sex	1.30	0.46
2. ACT English Score	20.37	4.28
3. ACT Mathematics Score	27.69	3.91
4. ACT Social Studies Score	23.73	5.35
5. ACT Natural Science Score	27.31	4.63
6. ACT Composite Score	24.88	3.53
7. High School English Grade	3.25	0.68
8. High School Mathematics Grade	3.21	0.83
9. High School Social Studies Grade	3.34	0.71
10. High School Natural Science Grade	3.37	0.67
11. High School Grade Point Average	3.28	0.50
12. Classification	1.01[a]	0.12
13. ACS Score	20.01	7.42
14. Chemistry Final Examination Score	23.49	4.65
15. Chemistry Grade	2.25	1.15

[a]Coding: Freshman = 1, Sophomore = 2, Junior = 3, Senior = 4, Others = 5

The high school grades for this group ranged from 3.21 for high school mathematics to 3.37 for high school natural science. A classification mean of 1.01[a] showed that freshmen were the largest component of this

group. The mean of the grades in General Chemistry 102 was found to be 2.25 on the four point scale.

Table XIII presents the means and the standard deviations of the scores and grades, and other data for Subgroup III, the Fall 1974 Chemistry 101 students. The mean of 1.45 regarding sex is based on a code of 1 for male and 2 for female and the data indicate that more male students enrolled in this course than female students. The interpretations of the means of the ACT scores, and high school grades are quite similar to those given for Subgroup I, the Fall of 1973 Chemistry 101 students. This indicates homogeneity between the two groups taking the same course in different semesters. The size of graduating class mean of 4.27[a] indicates that the average student in Subgroup III graduated in a class of 200-399 students. The mean rank in high school graduating class was found to be 1.63[b]. This indicates that on the average, most students in Subgroup III graduated in the second quarter of their class. The means of the number of semesters certain subjects were studied ranged from 0.29[c] for German to 7.29 for English. The mean of the grades in General Chemistry 101 for this group was 1.97 which is very close to 1.98 the mean reported for Subgroup I.

[a]Coding: 25 = 1, 25-99 = 2, 100-199 = 3, 200-399 = 4, 400-599 = 5, 600-899 = 6, 900 or more = 7

[b]Coding: Top quarter = 1, second quarter = 2, third quarter = 3, fourth quarter = 4

[c]Coding: Zero Semesters = 0, One Semester = 1, Two Semesters = 2 Three Semesters = 3, Four Semesters = 4, Five Semesters = 5, Six Semesters = 6, Seven Semesters = 7, Eight Semesters = 8

Table XIII

Means and Standard Deviations of Scores, Grades, and Other Related Variables for Subgroup III

Variable Name	Mean	Standard Deviation
1. Sex	1.45	0.50
2. ACT English Score	17.88	4.32
3. ACT Mathematics Score	21.73	5.19
4. ACT Social Studies Score	19.48	6.13
5. ACT Natural Science Score	22.75	4.72
6. ACT Composite Score	20.57	3.95
7. High School English Grade	3.19	0.76
8. High School Mathematics Grade	2.86	1.09
9. High School Social Studies Grade	3.48	1.14
10. High School Natural Science Grade	3.06	0.87
11. High School Grade Point Average	2.98	0.65
12. Size of Graduating Class	4.27	1.35
13. Rank in High School Graduating Class	1.63[a]	0.66
14. Number of Semesters Studied English	7.29	1.16
15. Number of Semesters Studied Mathematics	6.43	1.55
16. Number of Semesters Studies Soc. Studies	5.91	1.80
17. Number of Semesters Studied Nat. Science	5.94	1.97
18. Number of Semesters Studied Spanish	1.20	1.93
19. Number of Semesters Studied German	0.29	1.05
20. Number of Semesters Studied French	1.10	2.14

Table XIII (continued)

Variable Name	Mean	Standard Deviation
21. Number of Semesters Studied Lang(Others)	0.46	1.25
22. Number of Semesters Studied Business	1.63	1.74
23. Number of Semesters Studied Voc. Courses	1.32	2.29
24. WMUCPE Score	20.64	4.99
25. Chemistry Final Examination Score	20.10	5.21
26. Chemistry Grade	1.97	1.08

[a]Coding: Top quarter = 1, Second quarter = 2, Third quarter = 3, Fourth quarter = 4

Table XIV shows the means and the standard deviations of the various scores and grades and other data for Subgroup IV, the Fall 1974 Chemistry 102 students. The interpretations of the means of sex, ACT scores, and high school grades are similar to those interpretations given in Table XII for students who took the same course during the Fall of 1973 semester. The mean rank in high school graduating class was 1.25. This indicates that the majority of the students in Subgroup IV graduated in the top quarter of their high school class. The means for the number of semesters a subject was studied ranged from 0.48 for other foreign languages to 7.49 for English. The mean of the grades in General Chemistry 102 was found to be 2.10 which is close to the 2.25 chemistry grade mean reported for a similar subgroup in Table XII.

Table XIV

Means and Standard Deviations of Scores, Grades, and Other Related Variables for Subgroup IV

Variable Name	Mean	Standard Deviation
1. Sex	1.29	0.46
2. ACT English Score	19.75	4.69
3. ACT Mathematics Score	26.92	4.12
4. ACT Social Studies Score	23.54	5.22
5. ACT Natural Science Score	27.49	4.32
6. ACT Composite Score	24.56	3.71
7. High School English Grade	3.37	0.63
8. High School Mathematics Grade	3.17	0.87
9. High School Social Studies Grade	3.67	0.76
10. High School Natural Science Grade	3.38	0.79
11. High School Grade Point Average	3.36	0.48
12. Size of Graduating Class	3.95	1.18
13. Rank in High School Graduating Class	1.25	0.59
14. Number of Semesters Studied English	7.49	0.89
15. Number of Semesters Studied Mathematics	7.37	1.15
16. Number of Semesters Studied Soc. Studies	5.74	1.98
17. Number of Semesters Studied Nat. Science	7.13	1.45
18. Number of Semesters Studied Spanish	1.55	2.55
19. Number of Semesters Studied German	0.57	1.69
20. Number of Semesters Studied French	0.97	1.88

Table XIV (continued)

Variable Name	Mean	Standard Deviation
21. Number of Semesters Studied Lang (Others)	0.48	1.19
22. Number of Semesters Studied Business	1.21	1.59
23. Number of Semesters Studied Voc. Courses	1.47	2.14
24. WMUCPE Score	30.02	3.95
25. Chemistry Final Examination Score	22.87	4.93
26. Chemistry Grade	2.10	1.07

To compare the achievement of the students in Chemistry 101 with those in Chemistry 102, the mean score on the chemistry final examination of students in Chemistry 101 was compared with the mean score on the same final examination taken by students in Chemistry 102. The *t*-test analysis, presented in Tables XV and XVI for students who took Chemistry 101 and 102 during the Fall of 1973 and 1974 indicates that the students in Chemistry 102 achieved higher than the students in Chemistry 101 at the .05 level of significance.

Table XV

t-Test Data for the Relationship Between Chemistry 101 and 102 Achievement on the Chemistry Final - 1973

Course	Means	Degrees of Freedom	t-Value*
Chemistry 101 (1973)	20.68	170	3.45
Chemistry 102 (1973)			

*t-value at .05 level of significance for 170 degrees of freedom is 1.65.

Table XVI

t-Test Data for the Relationship Between Chemistry 101 and 102 Achievement on the Chemistry Final - 1974

Course	Means	Degrees of Freedom	t-Value*
Chemistry 101 (1974)	20.10	165	3.41
Chemistry 102 (1974)	22.87		

*t-value at .05 level of significance for 165 degrees of freedom is 1.65.

In Chapter I, three broad questions were stated for which the study was designed to investigate. These questions were:

1. What is the relationship of the ACT scores to grades in general college chemistry?

2. What is the relationship of the grades earned in various high school subjects to grades in general college chemistry?

3. What is the relationship of the placement test scores, such as ACS test scores and WMUCPE scores, to grades in general college chemistry?

To provide answers to these broad questions, two major statistical methods of analysis were employed. These were: (1) a correlation matrix and (2) stepwise regression analyses.

In most studies involving a correlational design, the question is often asked about how high the coefficient of correlation between a predictor and a criterion measure must be in order for the relation to be considered consequential. In this study, the author has adopted both the interpretations of Merzbacher (1949) for the coefficient of correlation (r) and those of the American College Testing Program (1975) for the multiple coefficient of correlation (R).

Merzbacher (1949) interpreted the coefficients of correlation as follows:

> A coefficient of correlation from 0.00 to 0.19 denotes indifferent or negligible correlations.
>
> A coefficient of correlation from 0.20 to 0.39 denotes low correlation, present but slight.
>
> A coefficient of correlation from 0.40 to 0.49 denotes a reasonable, and probably significant relationship.
>
> A coefficient of correlation from 0.50 to 0.69 denotes substantial or remarkable relationship.

> A coefficient of correlation from 0.70 to 1.00 denotes high relationship seldom found because of complicating factors and uncertain measures.

Similarly, the American College Testing Program (1975) interprets the coefficients of the multiple correlation (R) as follows:

> R values less than .30 - a very low correlation. There is small relationship between predictors and criterion. Grade predictions based on these predictors will be only slightly better than chance. The regression equation will be of little value unless the college is highly selective. Unusual campus conditions probably exist and should be investigated. Correlations this low seldom occur in the prediction of academic grades using the standard ACT data.
>
> R values .30 to .40 - a low correlation. A definite but small relationship exists. Grade predictions based on these predictors may be quite useful in selecting extreme groups (such as, scholarship winners) from much larger groups (applicants) and will have moderate value in guidance applications.
>
> R values .40 to .70 - a typical correlation in testing applications. A marked relationship exists. Grade predictions based on these predictors will be useful in most educational programs, such as guidance, admissions, class sectioning, or advising. Normally, multiple correlations between ACT data and college grades are in this range.
>
> R values .70 to .80 - a high correlation. A substantial relationship exists. Grade predictions based on these predictions will be useful for most educational purposes.
>
> R values .80 or above - a high correlation. Unusual campus conditions probably exist and should be examined. Correlations this high are rare and suspect.

Coefficients of Correlation Between the Independent Variables and the Chemistry Grade

This investigation, therefore, examined the coefficients of correlation between each predictor (independent) variable and the criterion (dependent) variable--chemistry grade. Even though the Chemistry Final Examination score was considered initially as one of the criterion

measures, hereafter, it was regarded secondary to the principal criterion measure--the final chemistry grade. This was done for two reasons: (1) the final chemistry grade was a function of the chemistry final examination score, and (2) the correlation coefficients between the chemistry final score and the final chemistry grade were high, i.e., ranging from .75 to .88 (see Appendix A). These coefficients of correlation indicate a very high relationship between these two variables.

The coefficients of correlation between the independent variables and the final chemistry grade are reported in Tables XVII through XX that follow. The results of the intercorrelation matrices which are cumbersome to interpret are reported in Appendix A.

Table XVII shows the correlations between each predictor variable and the final chemistry grade for Subgroup I. A coefficient of correlation of .53 was obtained between the ACT Mathematics score and the final grade received in General Chemistry 101. Using Merzbacher's interpretations, this "r" denotes a substantial or remarkable relationship. Next in rank order are the ACT Composite score, the high school mathematics grade, and the high school grade point average with coefficients of .40, .39, and .39 respectively. These "r's" denote a reasonable relationship.

Table XVII

Coefficients of Correlation Between Predictor (Independent) Variables and the Criterion (Dependent) Variable (Chemistry Grade) for Subgroup I

	Variable	Correlation Coefficient
1.	Sex	0.03
2.	ACT English Score	0.22
3.	ACT Mathematics Score	0.53
4.	ACT Social Studies Score	0.22
5.	ACT Natural Science Score	0.27
6.	ACT Composite Score	0.40
7.	High School English Grade	0.13
8.	High School Mathematics Grade	0.39
9.	High School Social Studies Grade	0.17
10.	High School Natural Science Grade	0.16
11.	High School Grade Point Average	0.39
12.	ACS Score	0.31
13.	Chemistry Grade	1.00

Note: Classification was not a factor in the analysis of this data as all students in this subgroup were freshmen.

Table XVIII indicates the correlations between each predictor variable and the final chemistry grade for Subgroup II. A coefficient of correlation of .47 was obtained between the high school grade point average and the chemistry grade. Next in rank order are the high school

Table XVIII

Coefficients of Correlation Between Predictor (Independent) Variables and the Criterion (Dependent) Variable (Chemistry Grade) for Subgroup II

	Variable	Correlation Coefficient
1.	Sex	-0.12
2.	ACT English Score	0.24
3.	ACT Mathematics Score	0.34
4.	ACT Social Studies Score	0.27
5.	ACT Natural Science Score	0.21
6.	ACT Composite Score	0.33
7.	High School English Grade	0.46
8.	High School Mathematics Grade	0.15
9.	High School Social Studies Grade	0.34
10.	High School Natural Science Grade	0.43
11.	High School Grade Point Average	0.47
12.	Classification	-0.03
13.	ACS Score	0.18
14.	Chemistry Grade	1.00

English grade, the high school natural science grade, the ACT Mathematics score, and the high school social studies grade with coefficients of .46, .43, .34, and .34 respectively. According to Merzbacher's interpretation, the "r's" of .43, .46, and .47 indicate a probable re-

lationship while that of .34 (ACT Mathematics score) indicates a low correlation but possibly a slight relationship between the predictor and the dependent variable.

Table XIX indicates the correlation between each predictor variable and the final chemistry grade for Subgroup III. A coefficient of .47 was obtained between the WMUCPE score and the final chemistry grade. The ACT Mathematics score and the ACT Natural Science score are next in line to the WMUCPE score, with coefficients of correlation of .42 and .40 respectively. According to Merzbacher's interpretation, these "r's" denote a reasonable and probable significant relationship.

Table XIX

Coefficients of Correlation Between Predictor (Independent) Variables and the Criterion (Dependent) Variable (Chemistry Grade) for Subgroup III

Variable	Correlation Coefficient
1. Sex	-0.07
2. ACT English Score	0.22
3. ACT Mathematics Score	0.42
4. ACT Social Studies Score	0.19
5. ACT Natural Science Score	0.40
6. ACT Composite Score	0.38
7. High School English Grade	0.14
8. High School Mathematics Grade	0.29

Table XIX (continued)

Variable	Correlation Coefficient
9. High School Social Studies Grade	0.23
10. High School Natural Science Grade	0.34
11. High School Grade Point Average	0.34
12. Size of Graduating Class	-0.16
13. Rank in High School Graduating Class	-0.33
14. Number of Semesters Studied English	0.15
15. Number of Semesters Studied Mathematics	0.23
16. Number of Semesters Studied Social Studies	0.02
17. Number of Semesters Studied Natural Science	0.16
18. Number of Semesters Studied Spanish	0.13
19. Number of Semesters Studied German	0.07
20. Number of Semesters Studied French	0.06
21. Number of Semesters Studied Others (Lang)	-0.06
22. Number of Semesters Studied Business	-0.10
23. Number of Semesters Studied Voc. Courses	-0.07
24. WMUCPE Score	0.47
25. Chemistry Grade	1.00

Table XX shows the correlations between each predictor variable and the final chemistry grade for Subgroup IV. A coefficient of .40 was obtained between each of the three variables, the ACT English score, ACT Mathematics score or the ACT Composite score and the final chemistry grade. Next in line are the high school grade point average and the

Table XX

Coefficients of Correlation Between Predictor (Independent) Variables and the Criterion (Dependent) Variable (Chemistry Grade) for Subgroup IV

	Variable	Correlation Coefficient
1.	Sex	0.08
2.	ACT English Score	0.40
3.	ACT Mathematics Score	0.40
4.	ACT Social Studies Score	0.29
5.	ACT Natural Science Score	0.19
6.	ACT Composite Score	0.40
7.	High School English Grade	0.11
8.	High School Mathematics Grade	0.26
9.	High School Social Studies Grade	0.24
10.	High School Natural Science Grade	0.28
11.	High School Grade Point Average	0.36
12.	Size of Graduating Class	0.05
13.	Rank in High School Graduating Class	-0.27
14.	Number of Semesters Studied English	0.07
15.	Number of Semesters Studied Mathematics	-0.08
16.	Number of Semesters Studied Social Studies	0.10
17.	Number of Semesters Studied Natural Science	0.00
18.	Number of Semesters Studied Spanish	0.17
19.	Number of Semesters Studied German	0.09
20.	Number of Semesters Studied French	-0.09

Table XX (continued)

Variable	Correlation Coefficient
21. Number of Semesters Studied Others (Lang)	0.00
22. Number of Semesters Studied Business	0.18
23. Number of Semesters Studied Voc. Courses	0.02
24. WMUCPE Score	0.34
25. Chemistry Grade	1.00

WMUCPE score which correlated .36 and .34 respectively. According to Merzbacher's interpretations, the degree of the relationship between the predictors and the criterion ranged from a slight relationship for the high school grade point average and WMUCPE score to a significant relationship for ACT English and ACT Mathematics scores.

According to Merzbacher's interpretations, the correlation analysis shows that only the ACT Mathematics score for Subgroup I denotes a substantial relationship with the final chemistry grade. This variable correlated .53 with the criterion measure--the chemistry grade. The other variables, high school grade point average, ACT Natural Science score, high school English grade, high school natural science grade, and the ACT Composite score had coefficients of correlation ranging from .40 to .47 for the four subgroups. According to Merzbacher these correlations denote a probably significant relationship. The coefficients of correlation between the rest of the variables and the chemistry grade ranged from zero to 39. According to Merzbacher, these correlation

could be interpreted as ranging from low to very low correlation. In summary, according to Merzbacher's interpretation, the analysis failed to indicate a single predictor denoting a high relationship with the chemistry grade i.e., a coefficient of correlation ranging from .70 to 1.00

Regression Analysis

Since no single variable could be identified as a predictor of success in general college chemistry, a second technique, the stepwise regression analysis, was employed to help identify the most successful predictors. Two phases were involved in analyzing the data by the stepwise regression technique. The first phase consisted of entering all of the independent variables one at a time in a stepwise regression fashion for each subgroup. This was done in order to identify those variables which accounted for the most variance in general college chemistry grades.

To establish some agreement of predictors which could be used in the regression equations for all the various groups, the second phase of the regression analysis was concerned with maximizing the predictive effect of the six most important predictors that were identified in phase one.

Careful scrutiny of the six important predictors by further stepwise regression analysis revealed two or three variables which were found to be the most important in predicting chemistry grades for the various subgroups.

In this process, each variable was added in a stepwise regression analysis for each subgroup and an F-value was calculated to show if the

addition of that variable significantly increased the prediction of the equation. The F-value, therefore, indicated whether the variable added was or was not a significant factor in predicting the chemistry grade. Since the .05 level of confidence was used as a cut-off point, any single variable whose F-value fell below this value could be eliminated from the prediction equation.

Phase I

Tables XXI, XXII, XXIII, and XXIV present the summaries of the first phase of the process as the independent variables were entered into the stepwise regression analysis. Each time a variable was entered into the stepwise regression analysis the multiple coefficient of correlation (R), the coefficient of determination (R^2) and the standard error of estimate were reported. It should be emphasized that the R squared when multiplied by 100 gives the percentage of the variance in the dependent variable accounted for by the variance in the independent variable(s).

Table XXI shows the results of the entry of the 12 independent variables into the stepwise regression analysis for Subgroup I. Four variables, the ACT Mathematics score, the high school mathematics grade, the ACS test score, and the high school social studies grade appear to have predictive effect on the chemistry grade. Together, these four variables had a multiple coefficient of correlation of .59 compared to a multiple coefficient of correlation of .61 obtained when each of the 12 variables were entered into the stepwise regression analysis. Further examination of the table reveals that the ACT Mathematics score

is the most effective predictor of success in college chemistry. The ACT Mathematics score alone correlated .53 with the criterion of ac- acounted for 28 percent of the total variance in chemistry grades as compared to 35 percent of the total variance in the grades for the four variables. Even though one would naturally expect ACT Natural Science score and the high school natural science grade to predict chemistry grade, it is interesting to note for Subgroup I that the ACT Natural Science score and the high school natural science grade appeared in the list as the sixth and the eighth most effective variables, respectively. This seems to indicate that these two variables have relatively weak predictive ability.

A similar summary is shown in Table XXII for Subgroup II. It indicates that the high school grade point average is the most effective predictor of success for college Chemistry 102 (Fall 1973). This variable correlates .47 with the criterion, and a multiple coefficient of correlation of .66 was obtained when four additional variables, high school mathematics grade, sex, high school social studies grade, and the ACS test score were entered in the stepwise regression analysis. The multiple coefficient of correlation of .66 was only three points less than the multiple coefficient of correlation of .69 obtained when all 13 variables were used in the stepwise regression analysis. The five main variables accounted for 44 percent of the total variance in chemistry grades as compared to 47 percent accounted for by all 13 variables. It is interesting to note that even though the ACS test score was used to place students in this subgroup, it appeared as the fifth most important variable in the list. The ACT Natural Science

score, the ACT Mathematics score, and the high school natural science grade appeared in the list as the seventh, eighth, and the thirteenth variables respectively. This seems to indicate their relative weak predictive influence on the chemistry grade for this particular subgroup.

Table XXI

Summary of Stepwise Regression Analysis of Multiple Correlations, Coefficients of Determination, and Standard Errors of Estimate for Subgroup I

Step No.	Variable No. Entering	Variable Name	Multiple Correlation (R)	Coefficient of Determination (R^2)	STD Error of EST.
1	3	ACT Math Score	.53	.28	.93
2	8	H.S. Math Grade	.57	.32	.91
3	12	ACS Score	.58	.34	.90
4	9	H.S. Soc. Stud. Gr.	.59	.35	.90
5	1	Sex	.60	.36	.90
6	5	ACT Nat. Sci. Score	.60	.36	.90
7	6	ACT Composite Score	.60	.36	.90
8	10	H.S. Nat. Sci. Gr.	.60	.36	.91
9	7	H.S. Eng. Grade	.60	.36	.91
10	11	H.S. GPA	.60	.36	.92
11	2	ACT Eng. Score	.60	.36	.92
12	4	ACT Soc. Stud. Score	.61	.37	.92

Table XXII

Summary of Stepwise Regression Analysis of Multiple Correlations, Coefficients of Determination, and Standard Errors of Estimate for Subgroup II

Step No.	Variable No. Entering	Variable Name	Multiple Correlation (R)	Coefficient of Determination (R^2)	STD Error of EST.
1	11	H.S. GPA	.47	.22	1.01
2	8	H.S. Math Grade	.57	.32	.96
3	1	Sex	.61	.37	.93
4	9	H.S. Soc. Stud. Gr.	.64	.41	.91
5	13	ACS Score	.66	.44	.90
6	2	ACT Eng. Score	.67	.45	.90
7	5	ACT Nat Sci. Score	.68	.46	.89
8	3	ACT Mathematics Score	.68	.46	.89
9	7	H.S. Eng. Grade	.69	.47	.90
10	6	ACT Composite Score	.69	.47	.91
11	4	ACT Soc. Stud. Score	.69	.47	.91
12	12	Classification	.69	.47	.92
13	10	H.S. Nat. Sci. Gr.	.69	.47	.94

Twenty-four independent variables were entered in the stepwise regression analysis of data for Subgroups III and IV as shown in Tables XXIII and XXIV. In Table XXIII, only the first four variables, the

WMUCPE score, the high school natural science grade, the ACT Mathematics score and the high school mathematics grade were found to be meaningful predictors of the chemistry grade. The WMUCPE score alone correlated .47 with the criterion, and when combined with the three other effective variables, the multiple coefficient of correlation was .59, compared to a multiple coefficient of correlation of .72 for all the 24 variables.

Table XXIII

Summary of Stepwise Regression Analysis of Multiple Correlations, Coefficients of Determination, and Standard Errors of Estimate for Subgroup III

Step No.	Variable No. Entering	Variable Name	Multiple Correlation (R)	Coefficient of Determination (R^2)	STD Error of EST.
1	24	WMUCPE Score	.47	.22	.96
2	10	H.S. Nat. Sci. Gr.	.54	.29	.92
3	3	ACT Mathematics Score	.57	.33	.90
4	8	H.S. Math Grade	.59	.35	.89
5	17	No. of Sem. Studied Nat. Sci.	.61	.37	.88
6	23	No. of Sem. Studied Voc.	.62	.39	.87
7	19	No. of Sem. Studied German	.64	.41	.87
8	7	H.S. Eng. Grade	.65	.42	.86
9	9	H.S. Soc. Stud. Gr.	.67	.45	.84
10	14	No. of Sem. Studied Eng.	.68	.46	.84

Table XXIII (continued)

Step No.	Variable No. Entering	Variable Name	Multiple Correlation (R)	Coefficient of Determination (R^2)	STD Error of EST.
11	11	H.S. GPA	.69	.47	.83
12	12	Size of Grad. Class	.69	.47	.83
13	5	ACT Nat. Sci. Score	.69	.47	.83
14	4	ACT Soc. Stud. Score	.70	.49	.83
15	2	ACT Eng. Score	.71	.50	.83
16	1	Sex	.71	.50	.83
17	22	No. of Sem. Studied Bus.	.72	.52	.83
18	6	ACT Composite Score	.72	.52	.83
19	16	No. of Sem. Studied Soc. Sci.	.72	.52	.84
20	15	No. of Sem. Studied Math	.72	.52	.84
21	20	No. of Sem. Studied French	.72	.52	.84
22	18	No. of Sem. Studied Spanish	.72	.52	.85
23	21	No. of Sem. Studied Lang. (Others)	.72	.52	.85
24	13	Rank in Grad. Class	.72	.52	.86

The ACT English score is found to be the most influential predictor of success in chemistry for Subgroup IV. Following the ACT English score in order of importance, were the WMUCPE score, the high school natural science grade, the ACT Natural Science score, and the ACT Mathematics score. Together, these five variables had a multiple coefficient of correlation of .60 as compared to the multiple coefficient of correlation of .69 for all 24 variables.

Table XXIV

Summary of Stepwise Regression Analysis of Multiple Correlations, Coefficients of Determination, and Standard Errors of Estimate for Subgroup IV

Step No.	Variable No. Entering	Variable Name	Multiple Correlation (R)	Coefficient of Determination (R^2)	STD Error of EST.
1	2	ACT Eng. Score	.40	.16	.99
2	24	WMUCPE	.48	.23	.96
3	10	H.S. Nat. Sci. Gr.	.53	.28	.93
4	5	ACT Nat. Sci. Score	.57	.32	.91
5	3	ACT Math Score	.60	.36	.90
6	15	No. of Sem. Studied Math	.62	.38	.89
7	9	H.S. Soc. Stud. Gr.	.64	.41	.88
8	19	No. of Sem. Studied German	.65	.43	.87
9	1	Sex	.67	.45	.87

Table XXIV (continued)

Step No.	Variable No. Entering	Variable Name	Multiple Correlation (R)	Coefficient of Determination (R^2)	STD Error of EST.
10	12	Size of Grad. Class	.67	.45	.87
11	18	No. of Sem. Studied Spanish	.67	.45	.87
12	21	No. of Sem. Studied Lang. (Others)	.68	.46	.88
13	7	H.S. Eng. Grade	.68	.46	.88
14	16	No. of Sem. Studied Soc. Sci.	.68	.46	.89
15	13	Rank in Grad. Class	.68	.46	.90
16	6	ACT Composite Score	.68	.46	.91
17	22	No. of Sem. Studied Bus.	.69	.48	.92
18	23	No. of Sem. Studied Voc.	.69	.48	.93
19	11	H.S. GPA	.69	.48	.94
20	17	No. of Sem. Studied Nat. Sci.	.69	.48	.95
21	4	ACT Soc. Stud. Score	.69	.48	.96
22	8	H.S. Math Grade	.69	.48	.97
23	14	No. of Sem. Studied Eng.	.69	.48	.98
24	20	No. of Sem. Studied French	.69	.48	.99

In summary, various combinations of ten variables: (1) ACT Mathematics score, (2) high school mathematics grade, (3) ACS test score, (4) high school social studies grade, (5) high school grade point average, (6) sex, (7) high school natural science grade, (8) ACT English score, (9) ACT Natural Science score, and (10) WMUCPE score were found to be among the top variables in predicting success in general college chemistry for the subgroups (see Table XXV). The rest of the variables, in particular, the ACT Social Studies score, the ACT Composite score, the high school English grade, size of graduating class, rank in high school graduating class, and the number of semesters studied certain subjects were found to be of minimal value in predicting success in general college chemistry. It should be noted that the ACT Mathematics score appeared most frequently in the top four or five variables for the various subgroups.

Table XXVI presents the frequency of the ten most important variables identified in this study (Table XXV). With the exception of the ACT English score, each variable listed only once as a meaningful contributor to general chemistry success was excluded from further analysis. The ACT English score was included with the most frequent variables for further analysis because it was assumed that a proficiency in English was essential for successful work, particularly in Chemistry 102. This assumption was partly supported by the fact that the ACT English score correlated the highest with the criterion in Chemistry 102 during the Fall of 1974.

Table XXV

Summary of the Top Predictors for the Four Subgroups

Step No.	Subgroup I Variable Name	Subgroup II Variable Name	Subgroup III Variable Name	Subgroup IV Variable Name
1	ACT Math Score	H.S. GPA	WMUCPE Score	ACT Eng. Score
2	H.S. Math Grade	H.S. Math Grade	H.S. Nat. Sci. Gr.	WMUCPE Score
3	ACS Score	Sex	ACT Math Score	H.S. Nat. Sci. Gr.
4	H.S. Soc. Stud. Gr.	H.S. Soc. Stud. Gr.	H.S. Math Gr.	ACT Nat. Sci. Score
5		ACS Score		ACT Math Score

Table XXVI

Frequency of the Ten Influential Variables

Variable Number	Variable Name	Frequency
3	ACT Math Score	3
4	H.S. Math Grade	3
13	ACS Score	2
24	WMUCPE Score	2
9	H.S. Soc. Studies Grade	2
10	H.S. Nat. Sci. Grade	2
11	H.S. GPA	1
1	Sex	1
2	ACT English Score	1
5	ACT Nat. Sci. Score	1

Phase II

Tables XXVI through XXXIV present summaries of the second phase of the stepwise regression analysis using the six variables screened from Table XXVI. These six variables with their new variable codes include the following:

1. ACT English score
2. ACT Mathematics score
3. High school mathematics grade

4. High school social studies grade

5. High school natural science grade

6. ACS test score or WMUCPE score

Each time a variable was entered into the stepwise regression analysis the multiple coefficient of correlation (R), the coefficient of determination (R^2), F-value, and the standard of error of estimate were reported. An R squared multiplied by 100 gives the percentage of the variance of the dependent variable accounted for by the independent variable(s). A variable whose F-value was less than the F-value at the .05 level of confidence was considered as not significant in predicting the General Chemistry grade.

Table XXVII is a summary of the stepwise regression analysis of the six top variables identified for Subgroup I (Chemistry 101, Fall 1973).

In Table XXVII, the F-values for the ACT English score, high school social studies grade, high school natural science grade, and the ACS test score were all below 3.92, the F-value at the .05 level of significance. Since the F-values for the above variables were below 3.92, the variables were not considered significant, and so they are not included in the prediction equation.

Table XXVII

Summary of Regression Analysis of Data
for Subgroup I Variables

Step No.	Variable No. Entered	Variable Name	R	R^2	F-Value
1	2	ACT Math Score	.53	.28	39.35*
2	3	H.S. Math Grade	.57	.32	6.95*
3	6	ACS Test Score	.58	.34	2.19
4	4	H.S. Soc. Sci. Grade	.59	.35	2.20
5	1	ACT Eng. Score	.59	.35	0.09
6	5	H.S. Nat. Sci. Grade	.59	.35	0.05

*Significant at .05 level.

The data in Table XXVIII show the multiple R, multiple R^2, standard error of estimate, the regression constant, and the regression coefficients of the two significant predictors for Subgroup I (Chemistry 101, Fall 1973).

Using the regression constant and the regression coefficients from Table XXVIII, a prediction equation for the semester grade in General Chemistry 101 for Subgroup I is found to be:

$$\text{General Chemistry Grade} = 0.10(\text{ACT Math score}) + 0.26(\text{H.S. Math grade}) - 0.85.$$

Table XXVIII

Regression Analysis for the Two Significant Predictors of Success in Chemistry for Subgroup I

Dependent Variable is Chemistry 101 Grade

Multiple R = 0.57

Multiple R^2 = 0.32

Standard Error of Estimate = 0.91

Constant = -0.85

Variable in Equation	Coefficient
ACT Math Score	.10
High School Math Grade	.26

A summary of the stepwise regression analysis for the six top variables identified in the first phase for Subgroup II (Chemistry 102, Fall 1973) is presented in Table XXIX. For this subgroup, the high school natural science grade was the most effective predictor contributing .43 of the total correlation coefficient. The ACT Mathematics score also contributed significantly to the multiple correlation coefficient, bringing the correlation coefficient to .51.

Table XXIX

Summary of Regression Analysis of Data
for Subgroup II Variables

Step No.	Variable No. Entered	Variable Name	R	R^2	F-Value
1	5	H.S. Nat. Sci. Grade	.43	.18	14.50*
2	2	ACT Math Score	.51	.26	6.72*
3	1	ACT Eng. Score	.53	.28	1.84
4	6	ACS Test Score	.55	.30	1.76
5	3	H.S. Math Grade	.56	.31	1.47
6	4	H.S. Soc. Sci. Grade	.57	.33	0.93

*Significant at .05 level.

The data indicate that the ACT English score, ACS test score, high school mathematics grade, and the high school social studies grade are not included in the prediction equation because their F-values fell below 3.92, the F-value at the .05 level of significance.

The data in Table XXX show the multiple R, multiple R^2, standard error of estimate, the regression constant, and the regression coefficients of the two significant predictors for Subgroup II (Chemistry 102, Fall 1973).

Table XXX

Regression Analysis for the Two Significant Predictors of Success in Chemistry for Subgroup II

Dependent Variable is Chemistry 102 Grade

Multiple R = 0.51

Multiple R^2 = 0.26

Standard Error of Estimate = 1.00

Constant = -2.25

Variable in Equation	Coefficient
ACT Math Score	.08
High School Natural Science Grade	.66

Using the regression constant and the regression coefficients from Table XXX, a prediction equation for the semester grade in General Chemistry 102 for Subgroup II is found to be:

General Chemistry Grade = 0.08(ACT Math score) + 0.66 (H.S. Nat. Science grade) -2.25.

Table XXXI is a summary of the regression analysis of the data for Subgroup III (Chemistry 101, Fall 1974). The data indicate that the WMUCPE score was the most effective predictor contributing .47 of the total correlation coefficient. The high school natural science grade and the ACT Mathematics score also contributed significantly to the multiple correlation coefficient, bringing the correlation coefficient to .57.

Table XXXI

Summary of Regression Analysis of Data for Subgroup III Variables

Step No.	Variable No. Entered	Variable Name	R	R^2	F-Value
1	6	WMUCPE Score	.47	.22	28.62*
2	5	H.S. Nat. Sci. Grade	.54	.29	10.50*
3	2	ACT Math Score	.57	.33	5.56*
4	3	H.S. Math Grade	.59	.35	3.56
5	4	H.S. Soc. Sci. Grade	.60	.36	1.96
6	1	ACT Eng. Score	.61	.37	0.09

*Significant at .05 level.

In Table XXXI, the F-values for the high school mathematics grade, high school social studies grade, and the ACT English score were all below 3.92, the F-value at the .05 level of significance, so they are not included in the prediction equation.

The data in Table XXXII give the multiple R, multiple R^2, standard error of estimate, the regression constant, and the regression coefficients of the three significant predictors for Subgroup III (Chemistry 101, Fall 1974).

Table XXXII

Regression Analysis for the Three Significant Predictors of Success in Chemistry for Subgroup III

Dependent Variable is Chemistry 101 Grade

Multiple R = 0.57

Multiple R^2 = 0.33

Standard Error of Estimate = 0.90

Constant = -1.42

Variable in Equation	Coefficient
ACT Math Score	.05
High School Natural Science Grade	.28
WMUCPE Score	.07

Using the regression constant and the regression coefficients from Table XXXII, a prediction equation for the semester grade in General Chemistry 101 for Subgroup III is found to be:

General Chemistry Grade = 0.05(ACT Math score) + 0.28 (H.S. Nat. Sci. grade) + 0.07 (WMUCPE score) -1.42.

Table XXXIII shows a summary of the stepwise regression analysis of the data for Subgroup IV (Chemistry 102, Fall 1974). The ACT English score was the most effective predictor contributing .40 of the total correlation coefficient. The WMUCPE score and the high school natural science grade also contributed significantly to the multiple correlation coefficient, bringing the correlation coefficient to .53.

Table XXXIII

Summary of Regression Analysis of Data for Subgroup IV Variables

Step No.	Variable No. Entered	Variable Name	R	R^2	F-Value
1	1	ACT English Score	.40	.16	11.77*
2	6	WMUCPE Score	.48	.23	5.55*
3	5	H.S. Nat. Sci. Grade	.53	.28	4.02*
4	2	ACT Math Score	.55	.31	2.42
5	4	H.S. Soc. Sci. Grade	.57	.33	1.42
6	3	H.S. Math Grade	.57	.33	0.00

*Significant at .05 level.

The data in Table XXXIII show that the ACT Mathematics score, the high school social studies grade, and the high school mathematics grade are not included in the prediction equation for this subgroup, because their F-values fell below 3.92, the F-value at .05 level of significance.

The data in Table XXXIV show the multiple R, multiple R^2, standard error of estimate, the regression constant, and the regression coefficients of the three significant predictors for Subgroup IV (Chemistry 102, 1974).

Table XXXIV

Regression Analysis for the Three Significant Predictors of Success in Chemistry for Subgroup IV

Dependent Variable is Chemistry 102 Grade

Multiple R = 0.53

Multiple R^2 = 0.28

Standard Error of Estimate = 0.93

Constant = -2.68

Variable in Equation	Coefficient
ACT English Score	.06
High School Natural Science Grade	.31
WMUCPE Score	.08

Using the regression constant and the regression coefficients from Table XXXIV, a prediction equation for the semester grade in General Chemistry 102 for Subgroup IV is found to be:

General Chemistry Grade = 0.06(ACT Eng. score) + 0.31(H.S. Nat. Sci. grade) + 0.08(WMUCPE score) -2.68.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The purpose of this study was to determine which variable or combination of variables could be used by academic advisers for prediction of success and placement in general college chemistry courses at Western Michigan University. Generally, the predictor variables selected were the following:

1. Scores on the American College Testing Program (ACT).
2. High school grades and other background data pertinent to success in chemistry.
3. Placement tests scores on the 1958 American Chemical Society (ACS) National Science Teachers Association (NSTA) Cooperative Examination for High School Chemistry (ACS) and the Western Michigan University Chemistry Placement Examination (WMUCPE).

This study was guided by the following broad questions:

1. What is the relationship of the ACT scores to grades in general college chemistry?
2. What is the relationship of the grades earned in various high school subjects to grades in general college chemistry?
3. What is the relationship of the placement tests scores, such as ACS test scores and WMUCPE scores to grades in general college chemistry?

Summary

The sample consisted of 339 students for whom complete data were available. Four subgroups were identified within the sample. They

were: (1) Subgroup I--105 students from the Fall 1973 Chemistry 101 class, (2) Subgroup II--67 students from the Fall 1973 Chemistry 102 class, (3) Subgroup III--104 students from the Fall 1974 Chemistry 101 class, and (4) Subgroup IV--63 students from the Fall 1974 Chemistry 102 class. Chemistry 101 is an introductory college course for students with inadequate backgrounds in high school chemistry, whereas Chemistry 102 is designed for students with strong backgrounds in high school chemistry.

Two criteria were used to select the variables. They were: (1) the availability of the data, and (2) the demonstrated effectiveness of these variables in previous studies which attempted to predict success in college chemistry.

The available data for Subgroups I and II consisted of 12 and 13 independent variables respectively, and one dependent variable--the final chemistry grade while 24 independent variables and the same dependent variable were used for Subgroups III and IV. Specifically, the predictor (independent) variables consisted of the following: (1) ACT Composite and subtest scores in English, mathematics, social studies, and natural science, (2) self-reported high school grades in English, mathematics, social studies, and natural science and other variables describing students and their high school educational experience, and (3) scores on the ACS test and WMUCPE.

The data were collected from the following sources: (1) the record books of the five chemistry professors who taught General Chemistry 101 and/or 102 during the Fall Semesters of 1973 and 1974, (2) Chemistry Department files containing the ACS and WMUCPE tests scores, (3) and

the ACT Magnetic Tape of Student Records for freshmen entering Western Michigan University in 1972-73 and 1973-74. All data from these sources were transferred to IBM cards for further analysis.

In order to analyze the data, two major statistical methods were employed. They were an intercorrelation analysis and the stepwise regression analysis. First an intercorrelation analysis was used in order to determine the relationship of one variable to others, particularly, between each predictor (independent) variable and the main dependent variable--semester grade in General Chemistry. This was done in an attempt to identify a single variable that might be highly predictive of the chemistry grade.

The second statistical analysis employed was the stepwise regression analysis. This consisted of two phases. The first phase considered all the independent variables entered into a stepwise regression analysis for each subgroup. This involved calculating the multiple correlation coefficient (R), the coefficient of determination (R^2), and the standard error of estimate. A multiple coefficient of correlation (R) is an index which denotes strength of relationship between one variable and two or more other variables taken together. A coefficient of determination (R^2) is an index which when multiplied by 100 gives the percentage of the variance in the dependent variable that is associated with the variance in the independent variables. The standard error of estimate denotes the expected dispersion of actual grades about the predicted grades.

The second phase of the analysis consisted of identifying the six independent variables from Phase I which were found to be the most

effective predictors. These six variables were: (1) the ACT English score, (2) the ACT Mathematics score, (3) the high school mathematics grade, (4) the high school social studies grade, (5) the high school natural science grade, and (6) the ACS test score or the WMUCPE score. These six variables were then entered into the stepwise regression analysis for each subgroup. This analysis involved calculating the multiple R, the multiple R^2, the standard error of estimate and the F-values. Any variable whose F-value fell below 3.92, the F-value at the .05 level of confidence, was not considered significant in predicting the semester grade in chemistry and was, therefore, not included in the prediction equation for the particular subgroup.

Conclusions

The results of the analysis of the stepwise regression in Phase II showed four prediction equations for Subgroups I, II, III, and IV. The statistical analysis regarding these equations are found in Chapter IV. Each variable in the prediction equation was found to be significant at the .05 level, (i.e., its value was found to be greater than 3.92, the F-value at the .05 level of confidence). These four prediction equations are:

1. The prediction equation for Subgroup I (Chemistry 101, Fall 1973) was found to be:

$$\text{General Chemistry grade} = 0.10(\text{ACT Math score}) + 0.26(\text{H.S. Math grade}) - 0.85.$$

2. The prediction equation for Subgroup II (Chemistry 102, Fall 1973) was found to be:

General Chemistry grade = 0.08(ACT Math score) + 0.66(H.S. Nat. Sci. grade) -2.25.

3. The prediction equation for Subgroup III (Chemistry 101, Fall 1974) was found to be:

General Chemistry grade = 0.05(ACT Math score) + 0.28(H.S. Nat. Sci. grade) + 0.07(WMUCPE score) -1.42.

4. The prediction equation for Subgroup IV (Chemistry 102, Fall 1974) was found to be:

General Chemistry grade = 0.06(ACT Eng. score) + 0.31(H.S. Nat. Sci. grade) + 0.08(WMUCPE score) -2.68.

The stepwise regression analysis reported in Chapter IV indicates that the relationship between the ACS test scores and the chemistry grade was not significant. The similar stepwise regression analysis for Subgroups III and IV indicates that the relationship between the WMUCPE score and the chemistry grade is significant. The ACS placement test used in 1973 was replaced by the WMUCPE in 1974. Since the WMUCPE score was a significant predictor of the chemistry grade, while the ACS test score was not, the author recommends that the Chemistry Department at Western Michigan University continue to use the WMUCPE test for placement purposes. However, the three variables in equations No. 3 and No. 4 are more accurate predictors than the single score from the WMUCPE alone.

Recommendation and Instruction for the Use of One Prediction Equation

Since prediction equations No. 3 and No. 4 listed above contain different variables for the Chemistry 101 and 102 classes, they would be cumbersome for an administrator or adviser to use in the advising process. A single equation containing a minimum number of common variables would be more convenient and therefore usable. This phase of the stepwise regression analysis involved identifying a single prediction equation for both chemistry classes. The equation should combine the features of maximum predictive value with the minimum number of variables. Analysis of the data and the prediction equations that evolved from the stepwise regression analysis indicates that two variables, the ACT Mathematics score and the WMUCPE score fit the criterion of maximum predictability. These variables were chosen while others were rejected for the following reasons:

First the ACT Mathematics score was selected as one of the variables because:

a) In the initial correlation analysis the ACT Mathematics score correlated higher (.53) with the chemistry grade than any other independent variable.

b) The ACT Mathematics score occurred three or four times in the list of variables identified in Phase I as contributing the most to the multiple coefficient of correlation (R).

c) In the analysis of the six most effective predictors identified in Phase I, the ACT Mathematics score was found to add to the percentage of variance for each subgroup.

d) The F-values for the ACT Mathematics scores were found to be consistently significant at the .05 level in regression equations for Subgroups I, II, and III.

The WMUCPE score was selected as the second variable because:

a) In the two instances (Subgroups III and IV) in which the WMUCPE score was available as a predictor, it correlated highest with the chemistry grade for Subgroup III, and third highest for Subgroup IV.

b) The F-values for the WMUCPE score were found to be significant at the .05 level in those situations where it was a factor.

Other variables such as the ACT English score, the high school mathematics grade, and the high school natural science grade were components of the original prediction equations for the various subgroups. They were eliminated from the final equation because of the desire for a minimum number of variables and the following specific considerations:

a) The ACT English score appeared only once as a significant predictor. That was for Subgroup IV and in no other case was it found to be a significant factor in prediction.

b) The high school mathematics grade appeared only once (Subgroup I) as a significant predictor. In other cases it was not found to be an important component of the prediction process.

c) Although the high school natural science grade appeared as a significant factor for Subgroups II, III, and IV, it was judged to be less important than the ACT Mathematics and WMUCPE scores. Also, the initial analysis of the correlation between high school natural science grade and chemistry grade ranged from .16 to .43 for the various subgroups. (See Tables XVII to XX). Since Merzbacher's interpretation correlation coefficients place this range of correlation in the negligible to probable relationship category, it was decided to eliminate this variable from contention.

When the ACT Mathematics score and the WMUCPE score are selected as the variables for the prediction equation for Chemistry 101 and 102, new equations using these two variables, but having different regression constants and coefficients can be identified. These two equations were constructed in the same manner as the four prediction equations

for Subgroups I to IV reported on pages 93 and 94. The same technique of stepwise regression analysis was used and the process generated new equations with corresponding regression constants and coefficients. The tables summarizing the results of this process are reported in Appendix B. These prediction equations are:

The prediction equation for Chemistry 101 is:

$$\text{General Chemistry grade} = 0.06(\text{ACT Math score}) + 0.08(\text{WMUCPE score}) - 0.87.$$

The prediction equation for Chemistry 102 is:

$$\text{General Chemistry grade} = 0.08(\text{ACT Math score}) + 0.06(\text{WMUCPE score}) - 1.79.$$

Examination of the two equations above indicates that the WMUCPE score plays a larger role in the prediction of Chemistry 101 grade than the Chemistry 102 grade. This is particularly interesting since the purpose of the WMUCPE placement test is to identify those who require the extra attention and help of the Chemistry 101 course. Evidently, it is performing that function.

An example of the calculation of the predicted grade

The following are examples of the calculation of the predicted grade in Chemistry 101 or 102 for a student with an ACT Mathematics score of 20 and a WMUCPE score of 25.

$$\begin{aligned}\text{Chemistry 101 grade} &= 0.06(\text{ACT Math score}) + 0.08(\text{WMUCPE score}) - 0.87 \\ &= 0.06(20) + 0.08(25) - .87 \\ &= 2.33\end{aligned}$$

The equation indicates that a student with an ACT Mathematics score of 20 and WMUCPE score of 25 could most likely obtain a grade of 2.33 in Chemistry 101. However, not all students with these scores will get a "C" grade in this course, since the standard error of estimate for this equation is .93 (see Appendix B, Table XLII for the standard error of estimate). This means that some students in chemistry with an expected grade of 2.33 could receive grades ranging from 1.40, a "D", to 3.26, a "B" (i.e., 2.33 $\pm$ .93). In other words, the standard error of estimate measures the expected dispersion of actual grades about the predicted grade.

If the same scores were used in the prediction equation for the Chemistry 102 students, the calculation would be as follows:

$$\begin{aligned} \text{Chemistry 102 grade} &= 0.08(\text{ACT Math score}) + 0.06(\text{WMUCPE score}) - 1.79 \\ &= 0.08(20) + 0.06(25) - 1.79 \\ &= 1.31 \end{aligned}$$

Again, this does not mean that all students with these scores will receive a grade of 1.31 or "D". Since the standard error of estimate is now .98 (see Appendix B, Table XLIII for the standard error of estimate), the grades could range from .33, a "D", to 2.29, a "C". Thus a student with scores as indicated above would probably be well advised to enroll in Chemistry 101 instead of Chemistry 102, because he has a better chance of succeeding.

Table XXXV shows a summary of the predicted grades when selected scores on the ACT Mathematics and WMUCPE were entered into the prediction equations for Chemistry 101 and 102. Note that this table

Table XXXV

List of Predicted Grades in Chemistry
Using ACT Mathematics and WMUCPE Scores

ACT Math Score	WMUCPE Score	Predicted Grade Chem. 101 (1974)	Predicted Grade Chem. 102 (1974)
10	10	0.53	-0.39
	15	0.93	-0.09
	20	1.33	0.21
	25	1.73	0.51
	30	2.13	0.81
	35	2.53	1.11
	40	2.93	1.41
	45	3.33	1.71
15	10	0.83	0.01
	15	1.23	0.31
	20	1.63	0.61
	25	2.03	0.91
	30	2.43	1.21
	35	2.83	1.51
	40	3.23	1.81
	45	3.63	2.11
20	10	1.13	0.51
	15	1.53	0.71
	20	1.93	1.01
	25	2.33	1.31
	30	2.73	1.61
	35	3.13	1.91
	40	3.53	2.21
	45	3.93	2.51
25	10	1.43	0.81
	15	1.83	1.11
	20	2.23	1.41
	25	2.63	1.71
	30	3.03	2.01
	35	3.43	2.31
	40	3.83	2.61
	45	4.23	2.91
30	10	1.73	1.21
	15	2.13	1.51
	20	2.53	1.81
	25	2.93	2.11
	30	3.33	2.41
	35	3.73	2.71
	40	4.13	3.01
	45	4.53	3.31
35	10	2.03	1.61
	15	2.43	1.91
	20	2.83	2.21
	25	3.23	2.51
	30	3.63	2.81
	35	4.03	3.11
	40	4.43	3.41
	45	4.83	3.71
36	10	2.09	1.69
	15	2.49	1.99
	20	2.89	2.29
	25	3.29	2.59
	30	3.69	2.89
	35	4.09	3.19
	40	4.49	3.49
	45	4.89	3.79

could be used by an adviser to easily and quickly estimate the grade of a student on the basis of ACT Mathematics and WMUCPE scores without having to calculate it from the appropriate equation.

The numerical grades in Figures I and II are the same as those from Table XXXV, the only difference is that the grades have been changed to two significant figures, and displayed in another format which might be even more convenient to use. For example, to determine a student's predicted grade, you locate his WMUCPE score along the horizontal axis and locate his ACT Mathematics score along the vertical axis. The point determined by the intersection of the vertical line through his WMUCPE score and the horizontal line through his ACT Mathematics score will be located in one of the diagonal areas running from upper left to lower right. The diagonal area in which the point falls corresponds to the student's predicted grade. For example, an adviser would use Figure I to predict what grade a student in Chemistry 101 with an ACT Mathematics score of 22 and WMUCPE score of 24 would likely receive. Using Figure I, the adviser would notice that his predicted grade is a "C". If the same student were to be placed in Chemistry 102, the adviser would use Figure II and would predict a grade of "D". Thus, the figures are tools an adviser can use for placing the students in the proper chemistry courses.

Since the predicted grades illustrated previously are averages over an entire class of people, and since an individual student might be expected to earn a grade higher or lower than the average, it might be helpful if an adviser could have some convenient method of knowing the probability of a grade different than the average predicted grade.

Figure I

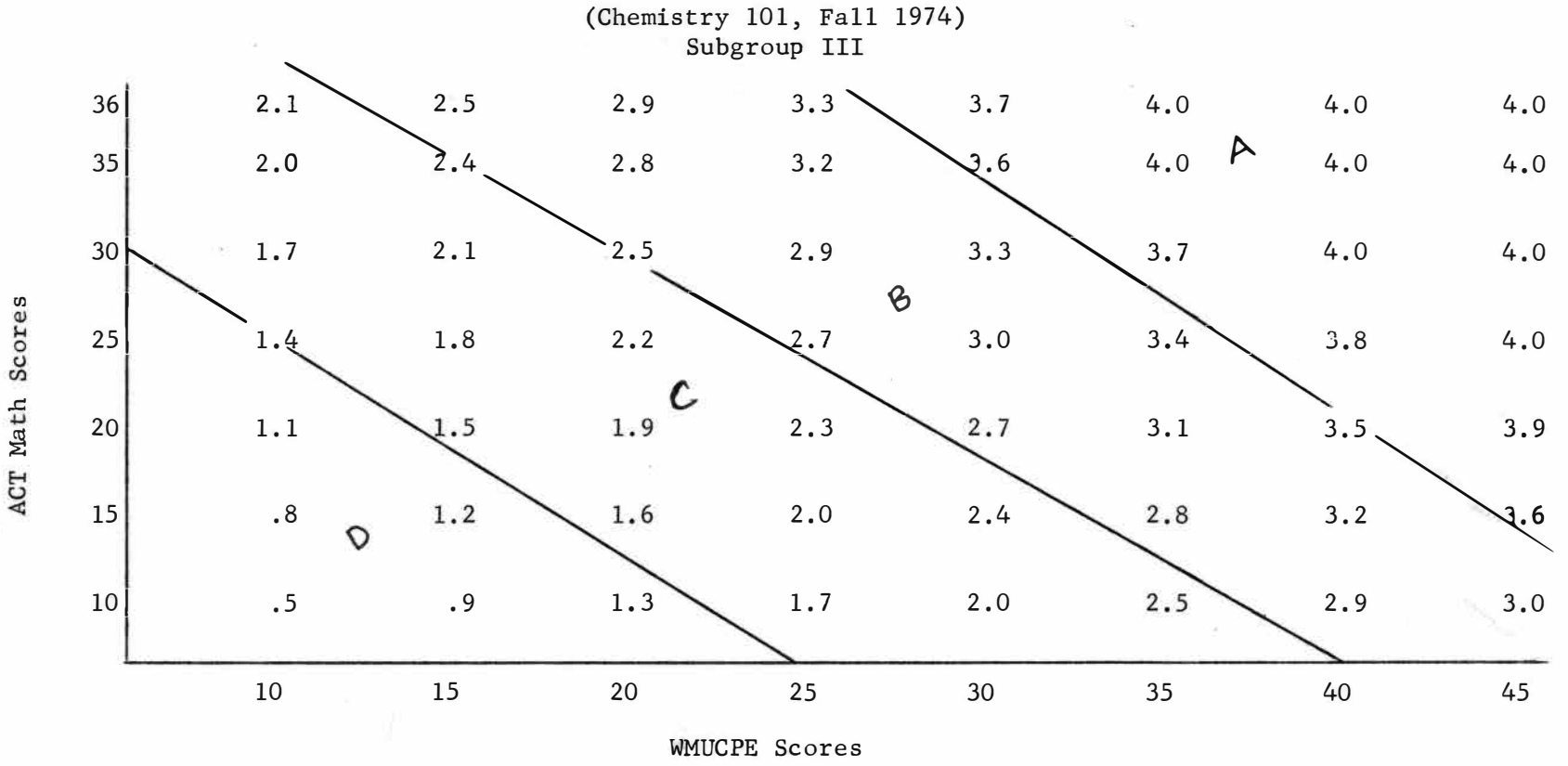

Figure I - Illustration of Predicted Grades in Chemistry 101 from ACT Mathematics scores and the WMUCPE scores.

Figure II

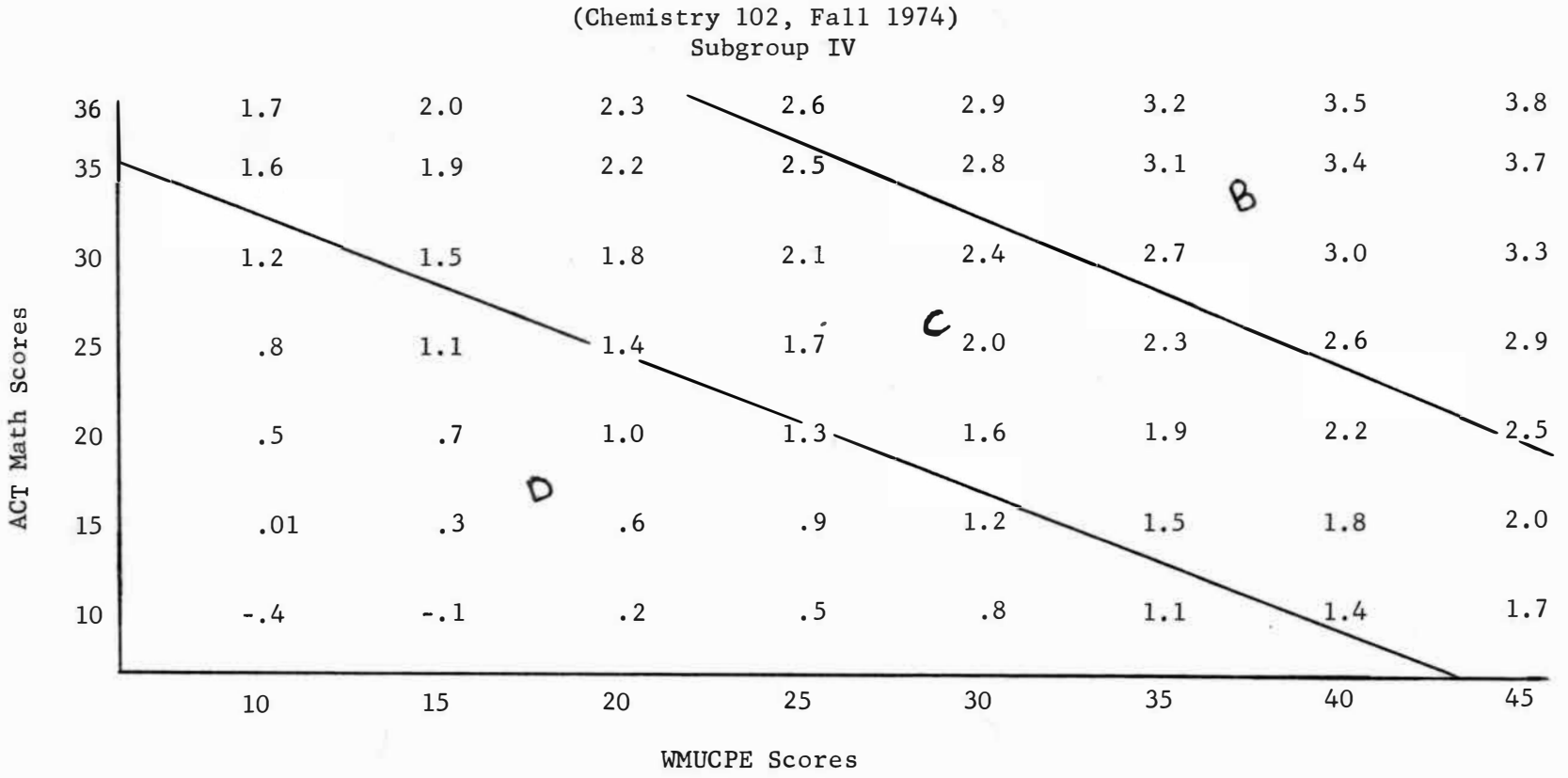

Figure II - Illustration of Predicted Grades in Chemistry 102 from ACT Mathematics scores and the WMUCPE scores.

Table XXXVI is a table which can be used for this purpose. For example for a predicted grade of 2.3, the table shows that 8 percent of the students with this grade are expected to earn less than D, 37 percent are expected to earn less than C, 63 percent are expected to earn C or higher, and 23 percent are expected to earn a grade of B or higher. The expectancy values of Table XXXVI were obtained by using the methods outlined in Your College Freshmen.[1]

Recommendations for Future Research

Since this study is involved with a limited sample in a particular department at one university, additional data and analysis which will be available in future semesters would be useful to validate and extend the findings of this study. Also, similar research at other institutions in chemistry courses would be helpful to extend the generality of these conclusions. Four particular areas of research which are suggested by this study and where additional research would be helpful are:

1. A replication of this study which would include a larger sample of the students, particularly students in Chemistry 102. A larger sample than the one used in this study would perhaps include more students with a wider range in abilities, and thus insure the identification of a more common and stable predictor for performance in General Chemistry.

2. A new placement test to be designed which would include more mathematics in order to investigate if a mathematics score could serve as a single predictor of chemistry grade.

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[1]See American College Testing Program, Your College Freshmen, (Iowa City: American College Testing Program, 1975), 125-126.

Table XXXVI

Grade Expectancies in Chemistry 101 and 102

Based on ACT Math and WMUCPE Scores, Percent Expected to Earn: (S.E. EST. .93)						Based on ACT Math and WMUCPE Scores, Percent Expected to Earn: (S.E. EST. .98)				
Predicted Chem. 101 Gr.	Less Than 1.0 (D)	Less Than 2.0 (C)	2.0 (C) Or Higher	3.0 (B) Or Higher		Less Than 1.0 (D)	Less Than 2.0 (C)	2.0 (C) Or Higher	3.0 (B) Or Higher	Predicted Chem. 102 Gr.
4.0	0	2	98	86	*	0	2	98	85	4.0
3.9	0	2	98	84	*	0	3	97	82	3.9
3.8	0	3	97	80	*	0	3	97	79	3.8
3.7	0	3	97	77	*	0	4	96	76	3.7
3.6	0	4	96	75	*	0	5	95	73	3.6
3.5	0	5	95	71	*	1	6	94	69	3.5
3.4	1	7	93	67	*	1	8	92	66	3.4
3.3	1	8	92	63	*	1	9	91	62	3.3
3.2	1	10	90	59	*	1	11	89	58	3.2
3.1	1	12	88	54	*	2	13	87	54	3.1
3.0	2	14	86	50	*	2	15	85	50	3.0
2.9	2	17	83	46	*	3	18	82	47	2.9
2.8	3	19	81	41	*	3	21	79	42	2.8
2.7	3	23	77	37	*	4	24	76	38	2.7
2.6	4	26	74	33	*	5	27	73	34	2.6
2.5	5	29	71	30	*	6	30	70	30	2.5
2.4	7	33	67	26	*	8	34	66	27	2.4
2.3	8	37	63	23	*	9	38	62	25	2.3
2.2	10	41	59	20	*	11	42	58	21	2.2
2.1	12	46	54	17	*	13	46	54	18	2.1
2.0	14	50	50	14	*	15	50	50	15	2.0
1.9	17	54	46	12	*	18	54	46	13	1.9
1.8	19	59	41	10	*	21	58	42	11	1.8
1.7	23	63	37	8	*	24	62	38	9	1.7
1.6	26	67	33	7	*	27	66	34	8	1.6
1.5	29	71	29	5	*	31	70	30	6	1.5
1.4	33	74	26	4	*	34	73	27	5	1.4
1.3	37	77	23	3	*	38	76	24	4	1.3
1.2	41	81	19	3	*	42	79	21	3	1.2
1.1	46	83	17	2	*	46	82	18	3	1.1
1.0	50	86	14	2	*	50	85	15	2	1.0
.9	54	88	12	1	*	54	87	13	2	.9
.8	59	90	10	1	*	58	89	11	1	.8

3. A continued investigation is needed of the ACT English score or some other score on a verbal ability test in order to validate the effectiveness of this variable as a predictor. This is particularly necessary because ACT English score appeared as the most effective predictor for Subgroup IV (Chemistry 102, 1974).

4. A further investigation of the high school natural science grade in combination with the ACT Mathematics score or the WMUCPE score in order to investigate the predictive value of such combinations as possible functions of the chemistry grade. This investigation would be necessary because the high school natural science grade contributed significantly to three of the four prediction equations developed for the various subgroups.

APPENDIX A

Tables of Intercorrelation Matrix of
Scores, Grades, and Other Related Variables

Table XXXVII

Intercorrelation Matrix of Scores, Grades, and Other Related Variables for Subgroup I

(Chemistry 101, Fall 1973)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Sex	1.00													
2.	ACT Eng.	.33	1.00												
3.	ACT Math	-.06	.31	1.00											
4.	ACT Soc. Stud.	-.03	.49	.42	1.00										
5.	ACT Nat. Sci.	-.20	.40	.43	.62	1.00									
6.	ACT Composite	-.02	.66	.71	.85	.82	1.00								
7.	H.S. Eng.	.21	.37	.15	.31	.22	.31	1.00							
8.	H.S. Math	.12	.19	.36	.09	.12	.24	.18	1.00						
9.	H.S. Soc. Stud.	.04	.13	.08	.03	.03	.08	.24	.15	1.00					
10.	H.S. Nat. Sci.	.26	.19	.21	-.14	-.03	.06	.13	.31	.26	1.00				
11.	HSGPA	.23	.40	.42	.18	.23	.38	.57	.62	.57	.60	1.00			
12.	ACS	-.27	.15	.38	.31	.36	.40	.09	.09	-.08	-.03	.10	1.00		
13.	Chemistry Final	.03	.24	.51	.37	.43	.51	.11	.27	.05	.08	.26	.35	1.00	
14.	Chemistry Grade	.03	.22	.53	.22	.27	.40	.13	.39	.17	.16	.39	.31	.77	1.00

Table XXXVIII

Intercorrelation Matrix of Scores, Grades, and Other Related Variables for Subgroup II

(Chemistry 102, Fall 1973)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Sex	1.00														
2.	ACT Eng.	.26	1.00													
3.	ACT Math	-.39	.26	1.00												
4.	ACT Soc. Stud.	-.13	.42	.56	1.00											
5.	ACT Nat. Sci.	-.22	.29	.59	.65	1.00										
6.	ACT Composite	-.15	.62	.76	.88	.82	1.00									
7.	H.S. Eng.	.38	.51	.22	.28	.16	.37	1.00								
8.	H.S. Math	.03	.22	.33	.14	.12	.25	.31	1.00							
9.	H.S. Soc. Stud.	.05	.22	.54	.61	.41	.58	.35	.29	1.00						
10.	H.S. Nat. Sci.	.03	.08	.15	.08	.18	.15	.32	.40	.30	1.00					
11.	HSGPA	.16	.35	.47	.42	.33	.50	.68	.75	.68	.68	1.00				
12.	Classification	-.08	-.04	.00	.10	.15	.07	-.23	-.33	-.06	.12	-.19	1.00			
13.	ACS	-.24	-.10	.13	.06	.18	.09	-.15	.02	-.05	.07	-.03	-.13	1.00		
14.	Chemistry Final	-.18	.19	.34	.27	.22	.32	.39	.13	.27	.45	.42	.01	.31	1.00	
15.	Chemistry Grade	-.12	.24	.34	.27	.21	.33	.46	.15	.34	.43	.47	-.03	.18	.88	1.00

Table XXXIX

Intercorrelation Matrix of Scores, Grades, and Other Related Variables for Subgroup III

(Chemistry 101, 1974)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1. Sex	1.00																									
2. ACT Eng.	.40	1.00																								
3. ACT Math	-.05	.41	1.00																							
4. ACT Soc. Stud.	.17	.61	.31	1.00																						
5. ACT Nat. Sci.	.03	.44	.92	.68	1.00																					
6. ACT Composite	.16	.76	.68	.85	.81	1.00																				
7. H.S. Eng.	.33	.33	.26	.26	.16	.33	1.00																			
8. H.S. Math	.24	.32	.17	.06	.19	.23	.23	1.00																		
9. H.S. Soc. Sci.	.13	.09	.18	.14	.15	.18	.26	.15	1.00																	
10. H.S. Nat. Sci.	.16	.11	.28	.12	.16	.22	.44	.29	.16	1.00																
11. HSGPA	.20	.28	.40	.24	.20	.36	.53	.38	.28	.48	1.00															
12. Size Class	.01	.01	.01	.05	.01	.02	.28	.09	.18	.22	.22	1.00														
13. Rank Class	.22	-.46	-.38	-.40	-.43	-.53	-.55	-.35	-.42	-.29	-.48	.13	1.00													
14. No.Sem. Eng.	.02	.10	.01	.13	.17	.13	.01	.03	.02	-.00	-.06	.14	-.05	1.00												
15. No.Sem. Math	-.23	.01	.44	.05	.22	.24	-.05	.04	.24	.17	.27	.12	-.13	.21	1.00											
16. No.Sem. Soc. Sci.	-.09	.13	-.01	.06	.07	.08	-.03	-.09	-.26	.00	-.04	-.04	.03	.30	.02	1.00										
17. No.Sem. Nat. Sci.	-.14	-.23	-.10	-.03	.16	-.07	-.06	-.09	.14	-.08	-.02	-.18	-.05	.20	.17	.11	1.00									
18. No.Sem. Spanish	-.06	.05	.21	.02	.16	.14	-.06	.03	-.07	-.11	.06	.16	-.08	.01	.13	-.02	.00	1.00								
19. No.Sem. German	.17	.03	.02	-.06	-.04	-.02	.13	.12	-.22	.24	.13	-.11	-.01	.11	-.04	.14	-.16	.18	1.00							
20. No.Sem. French	-.10	-.05	.01	-.13	-.05	-.08	.04	.10	-.23	.13	.06	-.03	.03	.03	-.01	.16	.01	-.01	.38	1.00						
21. No.Sem. Others(Lang)	.17	-.14	.02	-.22	-.18	-.17	.01	.14	-.22	.09	-.01	.03	.06	.00	.02	.04	-.15	.10	.45	.28	1.00					
22. No.Sem. Bus.	-.10	-.13	-.00	-.21	-.13	-.16	-.09	-.06	.02	-.06	-.00	.18	.08	.02	.20	.02	.23	.02	.10	.15	.24	1.00				
23. No.Sem. Voc.	-.04	-.01	.07	.00	-.03	.01	.04	-.03	-.06	.14	.22	.11	-.04	.22	.17	.14	-.03	.13	.37	.27	.24	.22	1.00			
24. WMUCPE	-.19	.13	.41	.30	.43	.41	.22	.13	.10	.16	.26	.01	-.35	.09	.16	.05	.26	.19	-.22	.00	-.08	-.02	.06	1.00		
25. Chemistry Final	-.02	.18	.32	.15	.31	.30	.07	.15	.19	.22	.33	.13	-.28	.12	.11	.01	.12	.08	.01	.03	-.03	-.05	-.00	.40	1.00	
26. Chemistry Grade	-.07	.22	.42	.19	.40	.38	.14	.29	.23	.34	.34	.16	-.33	.15	.23	.02	.16	.13	.07	.06	-.06	-.10	-.07	.47	.75	1.00

Table XL

Intercorrelation Matrix of Scores, Grades, and Other Related Variables for Subgroup IV

(Chemistry 102, 1974)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1. Sex	1.00																									
2. ACT Eng.	.40	1.00																								
3. ACT Math	-.12	.39	1.00																							
4. ACT Soc. Stud.	.23	.63	.35	1.00																						
5. ACT Nat. Sci.	-.02	.57	.42	.72	1.00																					
6. ACT Composite	.17	.82	.65	.86	.85	1.00																				
7. H.S. Eng.	.25	.39	.23	.36	.18	.37	1.00																			
8. H.S. Math	.20	.31	.43	.34	.15	.39	.21	1.00																		
9. H.S. Soc. Sci.	.00	.09	.00	.33	.11	.17	.19	.16	1.00																	
10. H.S. Nat. Sci.	.19	.23	.07	.41	.22	.30	.17	.21	.37	1.00																
11. HSGPA	.25	.43	.35	.59	.31	.53	.55	.67	.57	.68	1.00															
12. Size Class	.15	.02	-.03	-.11	-.20	-.11	.02	-.09	-.02	-.20	-.14	1.00														
13. Rank Class	-.15	-.27	-.27	-.33	-.16	-.34	-.29	-.34	-.17	-.17	-.44	.04	1.00													
14. No.Sem. Eng.	.12	.02	.12	-.02	-.12	-.01	.11	.05	-.02	-.02	.05	.13	.12	1.00												
15. No.Sem. Math	-.23	.06	.19	.01	-.06	.04	.06	.06	.06	.02	.09	-.06	-.20	.20	1.00											
16. No.Sem. Soc. Sci.	.14	.05	-.00	.13	.07	.09	.08	.11	-.09	.12	.16	-.05	-.11	.14	.06	1.00										
17. No.Sem. Nat. Sci.	.04	.05	-.10	.07	.08	.04	.02	.00	.10	.26	.15	-.12	.20	.03	.28	.28	1.00									
18. No.Sem. Spanish	.13	.24	-.06	.16	.01	.12	.13	.04	.13	.05	.10	-.26	-.07	.09	-.11	.02	.14	1.00								
19. No.Sem. German	.09	.08	-.01	.05	-.02	.03	.11	-.05	-.26	-.02	-.04	-.02	-.08	.15	.10	.15	.01	.30	1.00							
20. No.Sem. French	-.28	-.26	-.14	-.14	.05	-.16	-.41	-.18	.05	-.08	-.23	-.03	.24	-.03	.21	.12	.28	-.18	.04	1.00						
21. No.Sem. Others(Lang)	.08	-.09	-.01	-.13	-.14	-.10	-.15	-.15	-.00	-.15	-.21	-.08	.18	.36	-.05	.09	.04	-.09	.13	.09	1.00					
22. No.Sem. Bus.	-.09	-.03	.30	-.03	-.08	.04	.19	.21	.08	.00	.15	.22	-.01	.17	-.01	.02	-.03	-.04	.19	-.06	.11	1.00				
23. No.Sem. Voc.	.07	-.15	-.14	-.08	-.25	-.19	-.02	.12	.09	-.08	.06	.36	.06	.29	.05	.09	.03	-.09	.10	.17	.10	.29	1.00			
24. WMUCPE	-.12	.19	.42	.25	.42	.39	-.17	.22	.04	-.05	.10	-.09	-.23	-.01	-.04	.25	.02	-.04	-.03	.26	-.04	.07	-.02	1.00		
25. Chemistry Final	.05	.42	.49	.43	.36	.53	.20	.38	.23	.34	.48	-.06	-.40	.00	-.00	.17	-.09	.08	.03	-.03	-.07	.17	.03	.38	1.00	
26. Chemistry Grade	**.08**	**.40**	**.40**	**.29**	**.19**	**.40**	**.11**	**.26**	**.24**	**.28**	**.36**	**.05**	**-.27**	**.07**	**-.08**	**.10**	**.00**	**.17**	**.09**	**-.09**	**.00**	**.18**	**.02**	**.34**	**.82**	**1.00**

APPENDIX B

Stepwise Regression Analysis of the Two Recommended Variables - ACT Mathematics score and the WMUCPE score

Stepwise Regression Analysis of the Recommended Variables for Chemistry 101

Table XLI shows a summary of the stepwise regression analysis of the ACT Mathematics score and the WMUCPE score for Subgroup III (Chemistry 101, Fall 1974).

Table XLI

Summary of Regression Analysis of Data for Subgroup III Using Two Predictors

Step No.	Variable No. Entered	Variable Name	R	R^2	F-Value
1	2	WMUCPE score	.47	.22	28.62*
2	1	ACT Math score	.53	.28	8.90*

*Significant at .05 level.

The F-value (Table XLI) computed for each predictor was found to be above the F-value of 3.92, the F-value at the .05 level of confidence. Therefore, each predictor was found to be significant in predicting the grade in General Chemistry 101.

The data in Table XLII show the multiple R, multiple R^2, standard error of estimate, the regression constant, and the regression coefficients of the ACT Mathematics score and WMUCPE score for Subgroup III (Chemistry 101, Fall 1974).

Table XLII

Regression Analysis for the Two Recommended Predictors of Success in Chemistry for Subgroup III

Dependent Variable is Chemistry 101 Grade

Multiple R = 0.53

Multiple R^2 = 0.28

Standard Error of Estimate = 0.93

Constant = -0.87

Variable in Equation	Coefficient
ACT Math Score	0.06
WMUCPE score	0.08

Using the regression constant and the regression coefficients from Table XLII, a prediction equation for the semester grade in General Chemistry 101 for Subgroup III is found to be:

General Chemistry Grade = 0.06(ACT Math score) + 0.08 (WMUCPE score) -0.87.

Stepwise Regression Analysis of the Recommended Variables for Chemistry 102

Table XLIII indicates a summary of the stepwise regression analysis of the ACT Mathematics score and the WMUCPE score for Subgroup IV (Chemistry 102, Fall 1974).

Table XLIII

Summary of Regression Analysis of Data for Subgroup IV Using Two Predictors

Step No.	Variable No. Entered	Variable Name	R	R^2	F-Value
1	1	ACT Math score	.40	.16	11.54*
2	2	WMUCPE score	.44	.19	2.66

*Significant at .05 level.

The F-value (Table XLIII) computed for the WMUCPE score is below the F-value of 3.92, the F-value at the .05 level of confidence. Thus, by using only ACT Math score and the WMUCPE score, the latter was not found to contribute significantly to the prediction of the chemistry grade.

The data in Table XLIV indicate the multiple R, multiple R^2, standard error of estimate, the regression constant, and the regression coefficients of the ACT Mathematics score and the WMUCPE score for Subgroup IV (Chemistry 102, Fall 1974).

Table XLIV

Regression Analysis for the Two Recommended Predictors of Success in Chemistry for Subgroup IV

Dependent Variable in Chemistry 102 Grade

Multiple R = 0.44

Multiple R^2 = 0.19

Standard Error of Estimate = 0.98

Constant = -1.79

Variable in Equation	Coefficient
ACT Math score	0.08
WMUCPE score	0.06

Using the regression constant and the regression coefficients from Table XLIV, a prediction equation for the semester grade in General Chemistry 102 for Subgroup IV is found to be:

General Chemistry Grade = 0.08(ACT Math score) + 0.06 (WMUCPE score) -1.79.

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