A STUDY OF THE RELATIONSHIPS BETWEEN CREDIT IN CERTAIN HIGH SCHOOL MATHEMATICS AND SCIENCE COURSES AND VARIOUS ASPECTS OF SUCCESS AT THE MICHIGAN COLLEGE OF MINING AND TECHNOLOGY

Thesis for the Degree of Ed. D.

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This is to certify that the

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By

Donald Hart Baker

A THESIS

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AND VARIOUS ASPECTS OF SUCCESS

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AN ABSTRACT OF THE THESIS

This study was designed to discover and to make explicit the relationships which may exist between the amount of credit a student possessed in certain high school mathematics and science courses and various aspects of success at the Michigan College of Mining and Technology.

The high school courses involved in the study were algebra, solid geometry, trigonometry, biology, chemistry, and physics. The number of semesters of credit earned in each of the above courses by a student was taken from his high school transcript.

The various aspects of college success investigated in the study were graduation from this college and receiving a good grade (A, B, or C) in the following courses: first and second term algebra, trigonometry, analytic geometry, first year chemistry, and each of the three terms of first year physics. College records were obtained from the registrar's office.

The study population was limited to students who entered the college after 1949 as freshmen without prior college

experiences and who were either graduated or dismissed for academic reasons. A total of 447 students were involved. (277 graduated and 170 dismissed) The majority of the students were male and majoring in a science or branch of engineering.

The main part of the study involved establishing dichotomies with regard to the amount of high school credit in a course or combination of courses and with regard to success or non-success in one of the college experiences. The numbers of students in the resulting four categories were entered in a 2 x 2 contingency table, and a Chi-squared value was computed to determine the probability of a non-chance relationship between the high school and college achievements. If the value of Chi-squared was above that of the 0.01 level of significance, the tetrachoric correlation coefficient was computed. All significant comparisons were reported.

Three principal reasons were postulated to account for the appearance of particular high school courses in the significant comparisons: the advantage of having studied the same subject in high school, the opportunity to improve the grasp of skills and concepts, and the demonstration of high level ability and interest.

Of the approximately 800 statistical comparisons made, almost 390 yielded Chi-squared values above that of the 0.01 significance level. The following table indicates the high school credit found most useful for predictive purposes:

College Success	H.S. Courses	Chi-squared	r_t
Graduation	G*	54.72	0.75
First Term Algebra	A,G,P	41.48	0.48
Second Term Algebra	A,G,T,P	22.27	0.38
Trigonometry	A,G,P	22.12	0.38
Analytic Geometry	A,G,T,P	7.04	0.25
First Year Chemistry	A,C,P	42.54	0.54
First Term Physics	P	19.87	0.55
Second Term Physics	P	12.65	0.45
Third Term Physics	A,P	7.69	0.31

* A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
C - Two or more semesters of chemistry
P - Two or more semesters of physics

A non-credit college course in solid geometry was shown to be equivalent to high school solid geometry. A non-credit college course in elementary algebra was shown to be inferior to three or more semesters of high school algebra.

It must be remembered that the demonstration of a statistical relationship is not, by itself, a proof of a cause-and-effect relationship. Even in the case of two variables, one of which is an event that takes place before the second, it is necessary to investigate the effects of all other variables in the situation before cause-and-effect is proved.

The author wishes to express his gratitude to the following people, who rendered exceptional assistance in this study: Dr. Milosh Muntyan, guidance committee chairman, who had the unenviable task of converting a terse physicist into a fluent educator; Dr. Willard Warrington, who was often consulted on statistical questions; Dr. Walker Hill, who gave valued advice on the conduct of the study; Prof. Thomas Sermon, Registrar of the Michigan College of Mining and Technology, and his staff, who made the necessary records available for the study; and Rebecca L. Baker, who helped substitute for the equipment of the IBM Corporation.

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CHAPTER I

INTRODUCTION

This study was designed to discover and to make explicit the relationships which may exist between certain aspects of students' high school preparation and their success at the Michigan College of Mining and Technology.

The approach to the study was statistical in nature. A Chi-squared value was computed to test for the significance of an apparent association between the high school and college performances being investigated. If the Chi-squared value equaled or exceeded that at the 0.01 level of significance, a tetrachoric correlation coefficient was computed to determine the degree of association. A more detailed discussion of the statistical techniques used in this study is given in a later chapter.

The high school courses considered in this study were limited to mathematics and science courses. More specifically, cognizance was taken of the number of semesters of algebra, solid geometry, trigonometry, biology, chemistry, and physics taken by each student in the study population. Only those courses for which a student received a passing grade in high school were counted. The second chapter treats the subject of high school preparation more completely.

There are many possible criteria of college success.

The most immediate and readily discernible of these is graduation or academic dismissal from college. The study is also concerned with whether or not a good grade, i.e., an A, B, or C, was received in various introductory mathematics, chemistry, and physics courses. The meaning of success in college is considered in more detail in the third chapter.

The study population was limited to those students who entered the Michigan College of Mining and Technology as freshman without prior college experiences and who were either graduated or dismissed for academic reasons from that college. Since college curricula do change, this study was made reasonably current by considering only those students who entered during the academic year 1950-51 or later. This made it possible to include three graduating classes in the study, a number considered necessary to furnish enough cases for statistical reliability.

A total of 447 students were involved in the study. Of these, 277 were graduated, and the remaining 170 were dismissed for academic reasons. At this institution, graduation follows the completion of a particular curriculum with at least an average grade of C. Academic dismissal occurs automatically when a student fails four or more courses within three consecutive quarters.

A larger number of graduated students might have been considered except that students who entered this college after attending any other college were excluded from the study. Apparently about fifty percent of the recent graduating classes consists of such transfer students. These students were not included in the study because of the difficulty involved in comparing their introductory college courses with those being investigated.

The number of students dismissed during the period of the study may also be misleading. As is the case in most colleges and universities, a large percentage of the entering freshmen voluntarily leave this college for various reasons. Undoubtedly a major reason is the imminence of dismissal and the desire to leave with a relatively unblemished record. No estimation could be made of the number of students in this category. Consequently, no student who did not graduate was included in the study unless his record clearly indicated dismissal for academic reasons.

It would undoubtedly be desirable to have a larger study population. This, however, would require including students who entered college before 1950. It is felt that the advantage gained by this step might well be more than canceled by the probability that conclusions derived from a longer study period might be less pertinent to the present situation.

The period of time of the study was chosen so as to minimize the number of students who entered the college more than the usual three months after graduating from high school. Almost all of the world war II veterans had left the college, and few veterans of the Korean conflict had arrived. This decreased the possibility that the students had experiences of a vocational or military nature between high school and college that would obscure the relationships sought in the study. An analysis of high school graduation dates and college entrance dates indicates that only a very small percentage of the students did not graduate from high school and enter college the same year.

A tabulation of the high schools from which these students graduated indicates a rather surprising geographical spread, considering the location and relative smallness of the college. Moreover, the students dismissed from college were by no means all from the generally smaller high schools of Michigan's upper peninsula, as is seen from the following percentages.

Of those in the study who graduated, forty-nine percent went to Michigan upper peninsula high schools, thirty-five percent went to Michigan lower peninsula high schools, and the remaining sixteen percent came from out of state. Of those in the study population who were dismissed, forty-four percent went to upper peninsula high schools, thirty-six percent went to lower peninsula high schools, and the other twenty percent were from out of state.

Moreover, the high schools ranged in size from those in the metropolitan area of Detroit to the country schools of rural Michigan. As nearly as could be determined by a brief survey of the high school data, there were students in appreciable numbers from high schools in all categories of size.

It should also be of interest to note something of the college these students attended. The Michigan College of Mining and Technology is a state-supported institution established in 1885. The main campus is located in Houghton, in the upper peninsula of Michigan. A branch of the college, established in 1946, is located at Sault Ste. Marie. Only freshman and sophomore courses are offered at the branch of the college. Since courses cannot be identical, with the branch 265 miles from the main campus, no student who attended the Sault Ste. Marie branch of the college was included in the study.

The original function of the college was to furnish men trained in mining and metallurgy, especially for the mineral industries of Michigan's upper peninsula. In 1891 this college graduated more mining engineers than did any other college in the country. In 1927 the college increased the scope of its curricula to include most of the major fields of engineering and science. Later, curricula in forestry and engineering administration were added.

At present, the college offers courses leading to the Bachelor of Science degree in nine branches of engineering and six branches of science, as well as in forestry and engineering administration. Courses are also offered leading to the Master of Science degree in most of these fields. The majority of students on the main campus are enrolled in some branch of engineering.

It is of some interest to note that, although the college is coeducational, the overwhelming majority of the students in the study are male. This is accounted for by the fact that most of the curricula offered are in the fields of engineering and science, with no liberal arts type of program available. Most of the girls in the study had majored in chemistry with emphasis on medical technology.

The enrollment on the Houghton campus during the academic year 1955-56 was about two thousand, predominantly undergraduates. In recent years the enrollment has been increasing at the rate of about nineteen percent each year.

There are two major questions which, it is hoped, this study may assist in answering. First, does the possession of high school credit in any course or combination of courses among those under consideration correlate highly with college graduation? That is, could the possession of credit in certain high school courses be used in predicting graduation from college? Second, does the possession of high school credit in any course or combination of courses among those under consideration correlate highly with the achievement of a good grade in certain introductory college courses? That is, are there apparently certain high school courses that are taken by those students who receive good grades in their introductory college courses?

Questions of this general nature have, of course, been asked many times by many people. The Encyclopedia of Educational Research[1] reports numerous investigations, especially to find a suitable predictor of college graduation. Many possibilities have been considered, including intelligence tests, aptitude tests, high school grades, ranking in high school graduating class, and college grades in previous semesters. It seems to be agreed that the degree of intelligence needed for success in college cannot be stated categorically.[2] Many investigators report that high school marks generally provide a more accurate basis for the prediction of college scholarship than do intelligence tests.[3] For example, Segel claims that a comparison of average high school marks and college scholarship yields a median correlation coefficient

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1 Encyclopedia of Educational Research, (New York: The Macmillan Company, revised edition, 1950).

2 Ibid., p. 883.

3 Ibid., p. 883.

of 0.55, which is 0.11 higher than the median coefficient between intelligence tests and college scholarship.[4] Smith,[5] using previous records to estimate college success, found correlations between predicted grade-points and grade-points actually earned for the third, fourth, and fifth semesters to be 0.63, 0.71, and 0.70 respectively. Smith noted that there was a tendency for any record to lose prognostic value after a year or two and that the best single predictor of scholastic success in any given semester is the previous semester's work. Smith made use of all of a student's high school grades in order to have "group objectivity".

Numerous studies have demonstrated that a combination of several factors may be considerably more valuable in predicting general scholarship than any single factor. Edds and McCall,[6] employing a combination of average high school marks, Otis Group Intelligence Test, and Cross English Test scores, obtained a multiple correlation of 0.81 with general scholarship.

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4 Encyclopedia of Educational Research, op. cit., p. 883, citing David Segel, Prediction of Success in College (U. S. Office of Education, Bulletin No. 15, 1934).

5 F. F. Smith, "The Use of Previous Records in Estimating College Success", J. Ed. Psychol., 36: 167-76, 1945.

6 Encyclopedia of Educational Research, op. cit., p. 885, citing J. H. Edds and W. M. McCall, "Predicting the Scholastic Success of College Freshmen", J. Ed. Psychol., 30: 251-63, 1939.

Perhaps the most extensive bibliography of studies in this area appears in an article by Cosand.[7] It also includes tables of correlation coefficients, obtained by a number of investigators, relating various aspects of college success to high school data and/or psychological test scores. The period between 1928 and 1950 is covered, with the work done between 1940 and 1950 receiving major emphasis. Cosand points out that the current trend in college admissions work is toward multiple predictors including some high school data and various psychological tests. The literature previously cited in this chapter appears in Cosand's article and contains correlations representative of those cited by him.

The only investigation known to consider the same sort of high school data, i.e., semesters of credit in high school courses, as this study is reported in a doctoral thesis by Leasman.[8] He studied the records of 1024 graduates of the Illinois public high schools who entered four Illinois universities in the fall of 1950. The college grade point average (C.G.P.A.) was taken as the criterion of college success, and the following categories of high school subjects

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7 J. P. Cosand, "Admissions Criteria", College and University, 28, April, 1953.

8 R. E. Leasman, "The Relation of the Pattern of High School Courses to College Success", Ed. D. thesis, The University of Illinois, 1954.

were considered: English, foreign languages, mathematics, social sciences, natural sciences, and vocational subjects. No distinction was made among the various high school courses in any category; for example, all mathematics courses were treated simply as mathematics, without distinguishing among algebra, geometry, or trigonometry.

Leasman used several statistical treatments in seeking relationships between his criterion of college success and each of the categories of high school credit. For the most part, he used analysis of variance methods, which enabled him to hold constant the factors of ability and aptitude. In addition, contingency tables were employed in those cases where ability and aptitude were not controlled.

The measure of ability was the percentile rank in the high school class. The measure of aptitude was the percentile score on the A.C.E. Psychological Examination.

Most of Leasman's investigation dealt with the 665 students in his study population who had completed at least two years of college. Separate studies were made with that part of the study population attending each of the four Illinois universities involved in the investigation.

Leasman established dichotomies in terms of the amount of high school credit in each category of courses, as was done in this study. For example, in the part of his study involving high school mathematics, he divided the appropriate part of his study population into two groups: those who had three or more units (years) of mathematics and those who had less than this amount of credit. The means of the college grade point averages of the students in the two groups were compared statistically to determine if a significant difference existed between them.

If the factors of ability and aptitude were held constant, Leasman found no significant difference, at the 5% level, between the mean C.G.P.A.'s of the two groups in any of the six categories of high school courses.

If the factors of ability and aptitude were not held constant, Leasman found that students with three or more units of credit in high school foreign languages or in mathematics achieved significantly higher grade point averages than did students with less than this amount of credit. No such results were obtained with the other four categories of high school subjects.

Leasman concluded that the relation between college grade point average and ability and aptitude is higher than between college grade point average and high school course pattern.

It should be pointed out that the approach to this study differs in several ways from that of Leasman. Fewer categories of high school subjects are involved, and distinctions are made among the various courses in any category. In addition, this study is concerned with graduation or the type of grade received in a single college course rather than with the college grade point average, as an indication of college success. However, Leasman's study was the only one discovered, among investigations carried out during the last twenty-five years, that considered the college student's high school preparation from the same standpoint as does this study. It is of interest to note that the apparently slight difference in the approaches of these two studies yields somewhat different conclusions, as evidenced by Leasman's conclusions mentioned earlier and those of this study discussed in the final chapter.

There have, of course, been many more investigations of the relationships between college success and high school preparation than the few mentioned in this chapter. With the exception of the study by Leasman, these investigations have been cited to indicate the diversity of approach to this area of study and to indicate the highest of the correlations obtained. It will be noticed that, in general, the correlation coefficients thus far reported are not entirely satisfactory for the prediction of college success.

CHAPTER II

THE HIGH SCHOOL PREPARATION OF THE STUDY POPULATION

As was mentioned in the introductory chapter, the high school preparation data on the 447 students making up the study population consist essentially of the number of semesters of credit each student received in mathematics and science courses.

The actual data are as follows:

1. The student's name
2. The location of the high school from which he graduated
3. The year of graduation
4. The number of semesters of credit in:
   a. algebra
   b. solid geometry
   c. trigonometry
   d. biology
   e. chemistry
   f. physics

This data was obtained directly from official high school transcripts made available by the registrar's office of the Michigan College of Mining and Technology. Although some of the transcripts had been issued before the student's actual graduation from high school, letters from the high school authorities were available to indicate the credits received between the date of issue of the transcript and the date of graduation.

It may be observed that no records were made of the semesters of plane geometry taken by each student. Among the entrance requirements of this college is an inflexible one that each student must have credit in two semesters of high school plane geometry. Since this is apparently the maximum number of semesters of plane geometry offered by all, or practically all, high schools, there are no comparisons that can be made involving this subject, and consequently no record of it was kept.

A very pertinent question may be asked at this point as to why the marks received in these high school courses were not used in this study. It is apparent that most investigations reported in the literature involve comparisons of high school marks with some aspect of college success. However, after considering his own educational experiences and after discussing the question with a number of college faculty members, this investigator concluded that there must be a significant loss of validity whenever course grades from different institutions are combined and treated as essentially equivalent. There is certainly the possibility of some sort of internal consistency in grading procedures in any one high school, although even this would seem to be more a goal than a probability. With each high school supplying only a few students for the study population, it seemed a dubious procedure to assume that the grades received in any particular course at different high schools had a reasonable degree of comparability.

Of course, in ignoring the grades received in these courses, one is rejecting most of the available indications of differences of ability, retaining only the possession or lack of credit. Inasmuch as college success is partly a function of ability, the rejection of these indications might conceivably result in such a homogeneity that there remain no distinctions identifiable with college success. At least, there must be some loss in the sensitivity of the statistical results.

After a consideration of these arguments, it seemed that the procedure of grouping students according to the number of semesters of credit received in a particular high school course is a more defensible one. It is true that the same question of equivalence is present, but to a much lesser extent. There is no doubt that a certain level of performance might earn course credit for a student in one school but not in a different school, or perhaps not even in the same school under a different teacher or at a different time. Here, however, one is concerned only with consistency in the pass-or-fail judgments of the teachers rather than in the which-of-five-grades type of decision. While the question of comparability still exists, the counting of course credit seems to reduce its importance about as much as possible. Consequently, the approach of this study is seen to be a reasonable compromise involving some gain in comparability of student achievement and some loss in sensitivity of the statistical results.

A problem arose during the processing of the data on high school science courses. In general, it was found that students possessed either no credit or credit for two semesters of a particular science course. However, a relatively few students had credit for only one semester or for more than two semesters in some science course. The difficulty arose in determining how the unusual amount of credit should be considered in making comparisons involving high school science and the various aspects of college success.

Since most students with any credit in a particular science had credit for two semesters, it was felt that all students would have to be considered as having either no credit or credit for two semesters of each science. Then it was arbitrarily decided that students having credit in only one semester would be treated as having no credit and that students having credit in more than two semesters would be treated as having only two semesters.

This decision is mainly justified by the small number of students who did not follow the usual pattern with regard to the amount of credit in a high school science. There were not enough to these students to yield statistical reliability if they were grouped in separate categories, and yet it was felt that their science courses should be involved in the comparisons, along with those of the other students. The decision to count one semester of credit as no credit is based largely on the feeling that less than half as much is likely to be learned in one semester of a science compared to that learned in two semesters.

CHAPTER III

THE COLLEGE SUCCESS ASPECTS OF THE STUDY POPULATION

The consideration of college success in this study is limited to two types: graduation from the Michigan College of Mining and Technology and the receiving of a good grade (A, B, or C) in introductory mathematics, chemistry, and physics courses.

The following college information was obtained for each student:

1. The year of matriculation
2. The existence of any entrance conditions and when they were satisfied
3. The grades received in:
   - a. the first and second terms of algebra
   - b. trigonometry
   - c. analytic geometry
   - d. the first year of chemistry (one grade given)
   - e. the first year of physics (three grades given, one for each of three terms)
4. Whether the student was graduated or dismissed for academic reasons.

There are only two non-credit courses, designed to satisfy entrance requirement deficiencies, which are of interest in this study. A course indicated as <u>A00</u> is taken by those students who, on a placement test given during their first term in college, show poor preparation in mathematics. A survey shows that the students most likely to have to take the A00 course are those with credit in less than three semesters of high school algebra. This course is taken before the first term of regular college algebra. In order to observe the effect of A00 on college success, various combinations of high school algebra and/or A00 were used in making statistical comparisons. The results of these are described in later chapters.

The other non-credit course, indicated as A0, is one in solid geometry for those students deficient in it. Students are nominally required to have had a semester of solid geometry in high school or to take the A0 course. In contrast to A00, which records indicate as always taken in the first term of residence, A0 seems to be taken at any time before graduation, often during the last term of residence. Consequently, caution had to be exercised in counting the number of students who had taken A0 before any one of the college courses taken as a criterion of college success. Moreover, a significant number of students somehow escaped taking A0 even though they did not have high school credit in solid geometry.

The majority of the students at this college take four introductory mathematics courses in the freshman year. The first term of algebra is usually taken during the first term of residence. The second term of algebra and a course in trigonometry are taken during the second term. A course in analytic geometry follows in the third term. Successful completion of the mathematics courses taken the previous term is the only prerequisite for entering the later courses of this group. That is, the courses must be taken and passed in the order given above, being contingent upon no other college courses. Several of the college curricula do not require the course in analytic geometry. Consequently, this added to the effect of dismissals in reducing the number of students available for comparisons involving analytic geometry.

The students taking the medical technology, pre-dental, or pre-medical curricula are allowed to take a different series of three introductory mathematics courses, only roughly comparable to the four described earlier. Because of the lack of equivalence between the individual courses of the two series, data concerning the three-course series were not used in this study. Only a very small fraction of the study population took the three-course series.

The introductory course in chemistry, considered in this study, is normally taken by all students in the freshman year. There are no college course prerequisites. The course is described in the college bulletin as "A study of the

principles of chemistry and of the properties, preparation, and uses of the more common elements and their compounds. Principles of, and practice in, the separation and identification of the more common cations are taken up in the latter part of the course." Both lecture and laboratory work are included in the course. During the period of the study all college curricula required the successful completion of this first-year course in chemistry. At that time one grade was given for the entire year's work.

There are two introductory three-term sequences in physics. Since they appear to be equivalent except for a small difference in the mathematical approach to the subject matter, data on these courses were combined, and no distinction was made between them at any point in the study. The first term's work is concerned with mechanics and sound; the second with heat and light; the third with electricity and magnetism. Both lecture and laboratory work are included in these courses. The prerequisites for the engineering physics sequence, taken by almost all of the students in the study population, consist of the four introductory mathematics courses described earlier. A three-term sequence in calculus must be taken at least concurrently with the three terms of this physics course. The prerequisite to the other introductory physics course is either the three-term series of introductory mathematics or the first three terms of the four-term series. A few students in the engineering physics course take what is usually the third term of the course between the first and ordinarily second terms. Since no distinction between these and the normal cases was made in recording the data, it will be impossible to draw any conclusions involving the order in which the second and third terms of the course are taken.

As was described in the first chapter, graduation requires the successful completion of one of the four-year curricula with a C average both for the entire four years and for the last year.

Dismissal occurs automatically if a student fails four or more courses within three consecutive terms. There are no other grounds for academic dismissal. A dismissed student may apply to a committee composed of faculty and administrative representatives for readmission. An appreciable percentage of dismissed students are readmitted. Strenuous efforts were made to insure that no student was included in the study if he was dismissed during the period of the study but later readmitted without finally graduating. That is, it is believed that all of the students in the study population were either graduated or dismissed to return no more.

It was necessary to decide how to treat the quite appreciable number of courses that were failed and repeated by some of the students in the study population. The decision was made to count only the first grade received in any of the courses being considered and to ignore grades received on repetitions of any of them. No allowance for course repetition was made in any of the computations. This procedure will have to be remembered if any conclusions are drawn concerning the effect of one college course on a presumably later one. No comparisons of this nature are considered to be within the scope of this study.

CHAPTER IV

THE STATISTICAL TECHNIQUES USED IN THE STUDY

It is, of course, possible to gain an impression of the association between credit in a given high school course and college success by computing several numerical proportions, using the numbers of those who did and did not achieve college success and of those who did and did not have the high school credit. While this procedure is relatively quick and perhaps satisfactory under some circumstances, it has several shortcomings.

If only the proportions mentioned above are used to judge, perhaps, the relative merits of high school courses as they appear to be related to college success, two particular difficulties arise. This procedure gives no indication of the probability that the distribution of numbers in the categories mentioned is not merely a chance distribution, indicating an association that does not exist. In addition, it is extremely difficult with this procedure to compare the apparent association between credit in one high school course and college success with the apparent association between credit in a different high school course and college success. For these reasons, a more elaborate statistical treatment of the data is indicated.

At this point, it might be well to mention that the

following discussion of the statistical techniques employed in this study presupposes a basic knowledge of statistics. Treatments of the various concepts used in this study may be found in most statistics textbooks.[1,2,3]

It will be observed that both the high school and college data described earlier represent rather natural dichotomies. For example, a student did or did not receive credit in a particular high school course; he did or did not achieve college success. Taking advantage of these two dichotomies, one can divide the study population into four categories, and the number of students (that is, the frequency) in each category can be entered in a two-by-two contingency table. From the data presented in such a table, it is possible to obtain several statistical indications. See Figure 1 on the following page for an example of the 2 x 2 contingency table as it was used in this study.

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1 C. C. Peters and W. R. Van Voorhis, Statistical Procedures and their Mathematical Bases (New York: McGraw Hill Company, 1940).

2 M. J. Hagood and D. O. Price, Statistics for Sociologists (New York: Henry Holt and Company, revised, 1952).

3 Quinn McNemar, Psychological Statistics (New York: John Wiley and Sons, second edition, 1955).

		College		
		Dismissed	Graduated	totals
High School	Have credit in solid geometry	b 108 (125)	a 220 (203)	t_1 328
	Do not have credit in solid geometry	d 62 (45)	c 57 (74)	t_2 119
	totals	t_3 170	t_4 277	N 447

Figure 1

AN EXAMPLE OF THE TWO-BY-TWO CONTINGENCY

TABLE USED IN THIS STUDY

The numbers 108, 220, 62, and 57 are the observed frequencies obtained from the data. The numbers 328 and 119 are the row totals; 170 and 277 are the column totals. The total number of cases involved in the comparison is 447. The numbers 125, 203, 45, and 74 are the expected frequencies, explained in any of the references given on the previous page.

The first computation based on the data in the contingency table is the testing of the null hypothesis: that there is no association between the classification along the vertical marginal and the classification along the horizontal marginal. If this hypothesis can be rejected, there is small probability that the apparent association between classifications is due to chance. Consequently, it will be assumed that the association actually exists.

The null hypothesis was tested in this study by determining a Chi-squared value for the observed distribution in the two-by-two contingency table. The following equation can be used to compute Chi-squared:

$$\chi^2 = \sum \frac{(f_{obs.} - f_{exp.})^2}{f_{exp.}}$$

However, according to many authors, a correction for continuity should be applied to Chi-squared if the expected cell frequency in any cell is less than a certain minimum value. Although there is not general agreement regarding the exact minimum value, those mentioned in the literature would indicate that the Yates correction for continuity is necessary in this study. Consequently, that correction was applied to every value of Chi-squared.

With reference to the equation given above, the correction consists of reducing by one-half unit the magnitude of each difference between the observed and expected frequencies in a cell. For example, referring to Figure 1, in cell a the difference (the deviation) is 17. This was reduced to 16.5 before squaring and dividing by the expected frequency 203. The correction reduces the value of Chi-squared compared to that obtained without using the correction.

It is also suggested by authorities on statistics that the Chi-squared test of significance is not valid if the expected frequency of any cell is less than five. A few of the comparisons in the study were rejected for this reason.

The value of Chi-squared can be used to test the null hypothesis mentioned earlier. First, however, the investigator must decide upon the confidence level above which he wishes to operate. This level and the number of degrees of freedom in the distribution of frequencies determine the critical value of Chi-squared. If a comparison yields a value of Chi-squared less than this critical value, the null hypothesis cannot be rejected.

The choice of confidence level, called by some the level of significance, is to some extent an arbitrary matter. The lower the chosen confidence level, the greater certainty one has that the apparent association is not due to chance. On the other hand, in not rejecting the null hypothesis when the Chi-squared value is below the critical value, the investigator runs the risk of discarding distributions in which a dependency or association actually exists. There is always this risk, and it must be recognized that some comparisons, rejected in this study because of a low Chi-squared value, may involve some degree of association between the high school credit and college success.

The 0.01 confidence level represents a compromise, acceptable to this investigator, between accepting a chance distribution and rejecting a valid association. Consequently the critical value of Chi-squared is 6.635, which represents that confidence level with the one degree of freedom inherent in a two-by-two contingency table. Comparisons were rejected if they yielded Chi-squared values less than this.

After determining that a given distribution is very likely due to a valid relationship, one can compute the degree of association by one of several statistical concepts. Among these are the contingency coefficient and the tetrachoric correlation coefficient, r_t. The tetrachoric correlation coefficient has the advantage of ranging in possible values between positive and negative one; thus comparing in range with the more commonly seen Pearsonian correlation coefficient, which is used with other types of distributions.

The validity of the tetrachoric correlation coefficient depends upon several conditions. It must be demonstrated, or at least assumed, that the dichotomized characteristics are actually continuously distributed, not discretely distributed, and that they are also normally distributed. Furthermore, the statistical regression must be linear.

It may be observed that these conditions are often very difficult to demonstrate and can only be assumed to exist, on the basis of a carefully reasoned judgment. There seems to be sufficient cause in this study to assume that these conditions have been reasonably well met; or at least there is no evidence that they have not.

The exact equation for computing the tetrachoric correlation coefficient is somewhat difficult to use, and other methods are commonly employed. Perhaps the most convenient one, and the one finally used in this study, involves reference to a set of curves[4] from which the correlation coefficient can be read directly, with the aid of certain proportions from the distribution.

Since, in a study of this nature, the task of sorting data becomes of overwhelming magnitude when all data must be scanned for each comparison, it is essential that some mechanical process be employed. No mechanical sorter of the IBM type was available; however it did prove effective to transcribe the data to special cards, one for each student, by notching or leaving unnotched a series of holes around the edge of each card. A semi-mechanical sorting was possible by lining up a group of cards and inserting a long slender rod through any particular hole. Lifting the rod removed the unnotched cards. The card holes were coded to represent the various high school and college data. The cards thus sorted were counted visually to obtain the frequencies for the contingency tables.

Visual counting is, of course, more susceptible to

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4 L. Chesire, M. Saffir, and L. L. Thurstone, Computing Diagrams for the Tetrachoric Correlation Coefficient (Chicago: University of Chicago Bookstore, 1933).

error than is mechanical counting. All reasonable precautions were observed in order to obtain accurate frequency values. Continual cross-checking and rechecking of the computations were carried out to reduce the possibility of errors.

At first glance, it might appear that the six high school courses considered in this study would permit only six comparisons with any one aspect of college success. However, the possibility of using credit in two or more high school courses in one comparison makes many more comparisons available. The procedure adopted in this study and described in the next chapter allows for at least sixty-three comparisons, enumerated below.

There are six comparisons taking one high school course at a time, fifteen taking two courses at a time, twenty taking three courses at a time, fifteen taking four courses at a time, six taking five courses at a time, and finally one taking all six courses at once. These numbers can be easily verified on the basis of combination and permutation theory.

It must be remembered that the demonstration of a statistical relationship is not, by itself, a proof of a cause-and-effect relationship. Even in the case of two variables, one of which is an event that takes place before the second, it is necessary to investigate the effects of all other variables in the situation before cause-and-effect is demonstrated. Of course, cause-and-effect is a possible reason for a statistical relationship and as such will be considered in those cases where a statistical relationship is obtained.

CHAPTER V

COLLEGE GRADUATION AS RELATED TO HIGH SCHOOL PREPARATION

Perhaps the most interesting question with which this study is concerned is whether or not the knowledge of the courses a student took in high school can be used in the prediction of graduation from college.

Even after deciding to restrict the consideration of the study to the number of semesters of credit in certain high school courses, disregarding grades and other courses, the investigator still had several alternatives in treating the high school data.

The first alternative might be called the positive type of comparison. In this treatment the study population would be divided into two categories: the first would include all students who did possess credit in a particular high school course or combination of courses; the second would include the remaining students, who did not possess credit in all of the courses being considered at that time. For example, in comparing graduation from college with credit in high school solid geometry and chemistry, the first category would include students who did have credit in solid geometry and chemistry; the second would include those who did not have credit in one or both of these two subjects.

In the chapter on statistical procedures it was shown

that there are sixty-three different combinations of the six high school courses considered in the study, taking them first one at a time, then two at a time, and so forth.

The second alternative might be called the positive and negative type of comparison. In this treatment the study population would again be divided into two categories. This time the first category would include students who did have credit in some of the high school courses and who did not have credit in others. The second category would include the remainder of the study population. For example, the first category might include those students who had credit in solid geometry and chemistry but who did not have credit in trigonometry. The second category would include the students who did not fit into this pattern.

It can be imagined that there are a great many more possible ways of combinaing the high school data using this type of comparison than exist using the first alternative.

There is no doubt that the second alternative would provide a more exhaustive analysis of the relationships between credit in the high school courses and graduation from college. Nevertheless, it is believed that the end results of the two approaches would be somewhat similar; inasmuch as both alternatives involve roughly the same range of course combinations. If this premise is granted, a practical aspect of the study sways the argument in favor of the first alternative. The unfortunate, but common, limitation of the time available for the study made the first alternative the desirable one. The lack of completely mechanized card sorting and counting equipment contributed to the very appreciable difference in the time required to carry out the complete set of comparisons by the two procedures. Consequently, in view of the approximate equivalence of the two methods, the first alternative was taken.

In searching for the best basis for predicting graduation from college, three main series of comparisons were made. In the first series no attention was paid to the non-credit college courses, A0 and A00, described in an earlier chapter. The second and third series, which take these two courses into account in different ways, demonstrate the necessity of considering this type of course, designed to remedy entrance deficiencies, in a study of this sort.

Of the sixty-three comparisons in the first series, only twenty-seven yielded Chi-squared values greater than 6.635, which represents the 0.01 significance level. The high school course combinations with their Chi-squared and tetrachoric correlation coefficient values for these twenty-seven comparisons are shown in Table I on page thirty-six. The comparisons were first separated into groups with respect to the number of high school courses involved; then the comparisons in each group were ranked according to the

TABLE I

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GRADUATION FROM COLLEGE

Courses	Chi-squared	r_t
P	16.20	0.39
G	12.74	0.30
A	10.53	0.32
G,P	26.03	0.40
A,P	22.94	0.40
C,P	15.72	0.33
A,G	15.28	0.33
A,C	10.42	0.27
G,C	10.36	0.25
A,G,P	29.67	0.42
G,C,P	20.02	0.35
A,C,P	19.62	0.35
A,G,C	11.57	0.27
G,B,P	10.40	0.25
G,T,P	9.72	0.24
A,G,T	8.54	0.23
A,G,B	7.77	0.22
A,T,P	7.70	0.22
A,G,C,P	21.93	0.37
A,G,T,P	12.77	0.28
A,G,B,P	12.59	0.27
G,B,C,P	9.37	0.24
A,B,C,P	7.55	0.22
A,G,B,C	7.37	0.21
G,T,C,P	7.02	0.21
A,G,B,C,P	10.97	0.26
A,G,T,C,P	8.85	0.23

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

values of Chi-squared. Table Ia in the appendix shows the cell frequencies observed in these twenty-seven comparisons.

In analyzing the data presented in Table I, attention was first drawn to the highest values of Chi-squared and r_t in each group of course combinations. Considering only these top-ranking values in each group, one may notice that both Chi-squared and the correlation coefficient increase to a maximum in the case of the three-course combination, then decrease. The following extract from Table I points out this trend:

Courses	Chi-squared	r_t
P	16.20	0.39
G,P	26.03	0.40
A,G,P	29.67	0.42
A,G,C,P	21.93	0.37
A,G,B,C,P	10.97	0.26

where the symbols representing the courses are the same as those used in Table I.

Thus it appears that the pattern of credit in three or more semesters of algebra, one or more semesters of solid geometry, and two or more semesters of physics shows the highest degree of relationship to graduation from this college. On the basis of the first series of comparisons, this combination of high school credit is apparently the best predictor of graduation from college.

Another sort of observation of Table I involves the frequency with which each high school course appears, out of

the thirty-two combinations in which it might appear. Solid geometry has the highest frequency, nineteen, followed closely by physics with eighteen and algebra with seventeen. Chemistry appears thirteen times; biology seven; and trigonometry six.

This observation of frequencies is rather thought provoking, in view of the courses students commonly take early in their work at this college. Courses in chemistry, algebra, and trigonometry are taken in the freshman year; physics is taken in the sophomore year. Solid geometry is taken only as a non-credit course to overcome an entrance deficiency. Relatively few students take college courses directly related to biology.

Discussions with faculty members of the appropriate departments have yielded the information that the introductory mathematics and science courses are taught at this college essentially as if the student had little or no high school background in those subjects.

One might expect that the high school courses that are essentially duplicated in the early college years would not yield the higher correlations when compared to graduation from college. Those high school courses not duplicated in college would be expected to correlate highly with graduation if they provided a valuable preparation for college.

It is readily apparent that this does not occur in these comparisons involving graduation from this college. Physics, chemistry, and algebra are among the high school courses that are duplicated; yet they appear to be important. The picture is further confused when the remaining high school courses are considered. Trigonometry is duplicated; it does not seem to be important. Solid geometry is not duplicated; it seems to be quite important. Biology is not duplicated; yet it does not seem to be very important.

The unexpected pattern of this information must be due to a combination of several factors. It is certainly reasonable to expect that certain high school courses do provide subject matter background useful in college. It is also quite probable that the possession of credit in a course does not necessarily imply a retained knowledge of the course subject matter. Differences in motivation undoubtedly exist. Finally, there is very likely a sort of hierarchy of courses, common to most high schools, which is taken by those students who are seriously concerned with preparing themselves for college. The following paragraphs treat these factors as they may affect the statistical results of this study.

First, it must be re-emphasized that a statistical comparison cannot be used, alone, to demonstrate a cause-and-effect relationship. Consequently, the discussion which follows is based on conjecture reinforced by a limited knowledge of students and of high school and college curricula. Any conclusions must be considered as tentative and subject to modification in the light of further investigation.

If one assumes that high school courses provide a desirable subject matter preparation for college, these statistics are difficult to believe. There is every reason to expect that the student with the most complete high school background would be the one most likely to be successful in college. Yet this appears to be refuted by the fact that the highest Chi-squared and r_t values were found to be associated with a combination of three high school courses rather than with a combination of all six of the courses involved in the study. With the possible exception of biology, all of the courses in mathematics and science in high school should provide a useful background for students enrolled in science or engineering curricula in college. Yet one might interpret these statistics to indicate that a student with credit in only algebra, solid geometry, and physics is more likely to graduate from college than one with additional credit in mathematics and science.

This skepticism is well founded. Remember that the entire study population is forced into two categories with respect to the students' high school records. This dichotomy is a natural one when credit or no credit in only one course is involved, but it leaves something to be desired when credit in more than one course is considered. For example, consider the comparison involving a combination of three high school courses A, B, and C. The first category in the dichotomy would include only those with credit in all three courses. The second category, however, would include those with credit in A but not B or C, credit in B but not A or C, credit in C but not in A or B, credit in A and B but not C, and so forth. In this example, the second category would actually consist of seven groups, only one of which includes those with no credit in A, B, or C. It requires only intuition to imagine that the contrast between the two categories becomes progressively weakened as more high school courses are added. Consequently, one might expect that the statistical symptoms of the contrast would also suffer.

Unfortunately, this is difficult to demonstrate. This investigator was unable to find any other statistical treatment that would satisfactorily indicate the benefit or detriment of a more extensive high school background. Some analyses were carried out with the aid of contingency coefficients for tables containing as many cells as there were different groups. Thus the example cited in the previous paragraph would call for a two-by-eight contingency table to treat graduation or dismissal from college and the eight different categories of high school credit. The drawback to this approach is that it is impossible to compare the contingency coefficients obtained from contingency tables of different sizes, which cannot be avoided in this situation.

Hence, one is forced to conclude that the statistical data obtained in this study cannot be used to justify the exclusion of any high school course for those students intending to go to college.

The second factor mentioned at the beginning of this discussion is the doubtfulness of assuming that credit in a given high school course implies a retained knowledge of the course content. Any teacher will verify the impression that some students, in spite of a record of previous courses, react to a course with the innocence of the academic new-born. Again, this study was handicapped by an inability to evaluate this factor. It is certain only that it must be influential to some extent.

The third factor mentioned earlier is motivation. There is no reason to believe that any student has the same degree of motivation during two consecutive days, to say nothing of a period of years. There are numerous cases of students with mediocre high school records who somewhere find the incentive to excel in their college endeavors. Undoubtedly a vocational decision can mark the turning point. This frequently comes in the early college years. It is the question of motivation that undermines any prediction of college success based on the high school record.

The last factor, concerning a proposed hierarchy of courses, allows for interesting speculation. Specifically, it is suggested that a pyramid-like arrangement of high school courses may be constructed on the basis of the sequence of courses taken by the student who plans to go to college. Algebra and biology, of the courses considered in this study, probably constitute the bottom, or earliest, layer of the pyramid. Trigonometry and chemistry likely have an intermediate position. Among those with whom this idea has been discussed, there are conflicting opinions as to the relative levels of physics and solid geometry. In any event, one or the other probably represents the highest level of achievement in most high schools.

If this idea has any basis in fact, it is possible to explain the statistical results of this chapter by stating that the students most likely to graduate from this college are those who have reached the highest level of the hierarchy of high school courses.

The above discussion has been carried out with the express purpose of demonstrating the difficulty involved in establishing reasons for the differences in Chi-squared and the tetrachoric correlation coefficient observed in different combinations of high school courses when compared to graduation from college. This study can claim only to point out the existence of the relationships, not the reasons for them.

When the two non-credit courses A0 and A00 are considered, it is possible to obtain much higher correlations between high school credit and graduation from college than were obtained in the first series of comparisons. The statistical results of the comparisons in the second series are shown in Table II on page forty-five. The statistical results of the comparisons in the third series are shown in Table III on page forty-six.

As usual, no comparisons yielding Chi-squared values less than 6.635 were entered. Furthermore, these two series consist solely of comparisons which include algebra or solid geometry or both. The other comparisons, those not including algebra or solid geometry, would be duplicates of the corresponding ones in the first series.

The procedure in the second series involves eliminating certain students from the study population in some comparisons if they took A0 or A00. Specifically, no student who took A0 was included in any comparison which included high school solid geometry, and no student who took A00 was included in any comparison which included high school algebra. Thus the number of students involved in the comparisons in this series varied depending upon the high school subjects included in each comparison. Table IIa in the appendix lists the cell frequencies and the total number of students in each. Of the sixty-three comparisons possible using all six high

TABLE II

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GRADUATION FROM COLLEGE*

Courses	Chi-squared	r_t
G	51.55	0.78
G,P	62.12	0.70
A,G	39.22	0.73
G,C	25.95	0.44
G,T	13.81	0.32
G,B	12.52	0.31
A,P	11.53	0.33
A,G,P	46.97	0.66
G,C,P	39.44	0.53
G,T,P	18.45	0.37
G,B,P	17.87	0.35
A,G,C	14.59	0.37
G,B,C	11.42	0.28
A,G,B	10.57	0.29
A,G,T	10.00	0.28
A,C,P	9.39	0.26
G,T,C	8.07	0.24
A,G,C,P	25.40	0.45
G,B,C,P	15.56	0.34
A,G,T,P	14.17	0.33
G,T,C,P	12.91	0.31
A,G,B,P	11.76	0.31
A,G,B,C	7.52	0.25
A,G,T,C,P	9.16	0.27
A,G,B,C,P	9.03	0.27

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

* Wherever algebra, A, appears in a course combination, no student who took AOO was counted. Wherever solid geometry, G, appears, no student who took AO was counted.

TABLE III

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GRADUATION FROM COLLEGE*

Courses	Chi-squared	r_t
G	54.72	0.75
G,P	61.72	0.63
A,G	37.99	0.58
G,C	26.65	0.43
A,P	16.50	0.37
G,B	9.99	0.26
G,T	8.49	0.23
A,G,P	52.17	0.57
G,C,P	38.80	0.48
A,G,C	22.05	0.38
G,B,P	17.50	0.33
A,C,P	15.40	0.32
G,T,P	12.93	0.28
G,B,C	9.68	0.24
A,G,B	9.34	0.24
A,G,T	8.46	0.23
A,G,C,P	33.55	0.43
A,G,B,P	15.99	0.31
G,B,C,P	14.88	0.30
A,G,T,P	12.60	0.28
A,G,B,C	8.58	0.24
G,T,C,P	8.54	0.23
A,G,B,C,P	13.71	0.28
A,G,T,C,P	8.55	0.23

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

* Credit in AOO is considered equivalent to credit in three or more semesters of algebra. Credit in AO is considered equivalent to credit in solid geometry.

school courses, it can be shown that only forty-eight contain algebra and/or solid geometry. In twenty-five of these, Chi-squared values above the 0.01 significance level were obtained.

The third series involves a somewhat different way of treating AO and AOO. In this series a student who took AOO was considered the same as a student who had credit in three or more semesters of high school algebra, and a student who took AO was considered the same as a student who had credit in high school solid geometry. Thus all students in the study population were included in each comparison. Table IIIa in the appendix contains the cell frequencies observed in these comparisons. There were twenty-four, out of the possible forty-eight, with Chi-squared values above the 0.01 significance level in this series.

The second and third series have several characteristics that are similar. They both yielded values of Chi-squared and r_t that are considerably higher than those values for the corresponding comparisons in the first series. This would indicate that AO and AOO exert an appreciable influence on the students who take these non-credit courses. This observation is somewhat confirmed by the results of a fourth, brief, series to be described later in this chapter. If there were no appreciable effect of taking AO or AOO, one would expect that the results of the second and third series would be practically identical with those of the first series.

In both the second and third series the highest value of Chi-squared occurs for the comparison between solid geometry and physics and graduation from college, while the highest value of r_t occurs for the comparison involving solid geometry alone. Given values of Chi-squared so much greater than that at the 0.01 significance level, it would seem that the comparison with the highest value of r_t would have the most predictive value. That is, with such high probabilities of an association in both of the top comparisons in each series, the comparison with the higher degree of association should be the more useful.

Therefore, it appears that the best predictor of graduation from this college is credit in high school solid geometry or in <u>AO</u>.

It seems likely that the discussion earlier in this chapter concerning the reasons for differences in the statistical values in the first series also applies to the results of the second and third series. Certainly it is ridiculous to suggest that the student most likely to graduate from college is the one who takes only solid geometry in high school. More likely, credit in solid geometry represents about the highest level of achievement in high school.

Several more comparisons involving <u>AO</u> or <u>AOO</u> were made in an effort to establish the apparent value of these courses.

The first compares high school credit for three or more semesters of algebra, but no A00, with credit in A00 - in place of the usual dichotomy of high school credit or no credit. College graduation or dismissal, as usual, provided the other dichotomy for the comparisons in this series. This comparison yielded a Chi-squared value of 20.08 and an r_t of 0.42, indicating that three or more semesters of high school algebra are preferable to taking A00. The second comparison in this group involved credit in A00 compared to less than three semesters of high school algebra and no A00. A Chi-squared value of 0.01 was obtained in this case, and r_t was not determined. In view of the low Chi-squared value, it is not likely that a relationship exists.

The third comparison involved credit in A0 against no credit in high school or college solid geometry. This yielded a Chi-squared value of 40.19 and an r_t value of 0.85, indicating that students who took A0 were more likely to graduate from this college than those who did not take a course in solid geometry. The fourth comparison was between high school credit in solid geometry and credit in A0. The Chi-squared value for this was 0.16, too low for further consideration. Again, in view of the low Chi-squared value, it may be assumed that no relationship exists.

In summary, the investigation of graduation from college as related to credit in certain high school courses has shown that the student most likely to graduate from the Michigan College of Mining and Technology is one who has either taken solid geometry in high school or taken the college non-credit course in solid geometry, AO. A Chi-squared value of 54.72 and a tetrachoric correlation coefficient of 0.75 were obtained in comparing credit or no credit in solid geometry with graduation or dismissal from this college.

It has been pointed out that these statistics, because of the several factors that influence them, cannot be used alone to justify any particular high school curriculum for those students who plan to go to college.

A statistical study of the two non-credit courses, AO and AOO, indicated that a student who has credit for three or more semesters of high school algebra is somewhat more likely to graduate from this college than is one who must take AOO to remedy a deficiency in algebra and that a student who takes AO to remedy a deficiency in solid geometry is much more likely to graduate than one who has never taken a course in solid geometry.

CHAPTER VI

PERFORMANCE IN FIRST YEAR MATHEMATICS AS RELATED TO HIGH SCHOOL PREPARATION

As was described in the introductory chapter, most students at the Michigan College of Mining and Technology take four elementary mathematics courses during their freshman year. These are first term algebra, normally taken during the first term; second term algebra and trigonometry, two separate courses normally taken during the second term; and analytic geometry, normally taken during the third term. The only college prerequisite for any one of these courses is credit in those courses which precede it in the sequence described above.

The criterion of college success throughout this part of the study was a good grade, i.e., an A, B, or C, in the particular mathematics course being considered. The study population was divided into two groups: those who received a good grade the first time they took the course and those who received a poor grade, i.e., a D or F, the first time they took the course.

The high school data was treated the same as described in the preceding chapter.

The 2 x 2 contingency table was, as before, used to obtain a Chi-squared value and if that was significant at the

0.01 level, a tetrachoric correlation coefficient was calculated.

The remainder of this chapter is divided into five sections, one for each of the four college mathematics courses under consideration, and a summary.

FIRST TERM ALGEBRA

Again, as in the case of college graduation, three main series of comparisons were made. In the first series no attention was paid to the non-credit college courses, A0 and A00, described in an earlier chapter. The second and third series, which take these two courses into account in different ways, yielded results quite different from those obtained in the comparable series in the study of college graduation. The fourth series was also included in this part of the study.

Of the sixty-three comparisons in the first series, fifty-eight yielded Chi-squared values greater than 6.635, which represents the 0.01 significance level. In addition, an extra comparison involving only high school algebra was made, in which the study population was divided into two groups: those who had four or more (instead of the usual three or more) semesters of high school algebra and those who had less than four semesters. This comparison was included with those of the first series.

The high school course combinations with their values of Chi-squared and tetrachoric correlation coefficients for these fifty-nine comparisons are shown in Table IV on pages fifty-four and fifty-five. Table IVa in the appendix shows the cell frequencies observed in these comparisons.

In attempting to analyze the data presented in Table IV by considering the highest values of Chi-squared in each group of course combinations, as was done in the previous chapter, one finds a rather surprising pattern. This is shown in the following extract from Table IV:

Courses	Chi-squared	r_t
T	31.82	0.43
G,P	38.27	0.46
A,G,P	41.48	0.48
A,G,T,P	38.48	0.47
A,G,T,C,P	29.93	0.43
A,G,T,B,C,P	13.02	0.31

where the symbols representing the courses are the same as those used in Table IV.

The first unexpected observation is that trigonometry, not algebra, yields the highest Chi-squared value among the comparisons involving single high school courses. The second is that trigonometry does not appear again until the four-course combination, in contrast to the orderly growth of the pattern in the study of graduation from college (see page 37). These observations will be discussed later in this section.

It is much easier to appreciate the pattern built up by considering the highest tetrachoric correlation in each

TABLE IV

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN FIRST TERM ALGEBRA

Courses	Chi-squared	r_t
T	31.82	0.43
G	27.60	0.42
A (4/)	25.09	0.39
A	23.07	0.46
P	12.46	0.34
G,P	38.27	0.46
A,T	34.90	0.44
G,T	34.44	0.44
A,G	31.45	0.43
A,P	31.44	0.46
T,P	30.48	0.41
G,C	23.87	0.37
T,C	21.39	0.36
A,C	19.27	0.36
T,B	18.44	0.33
G,B	10.73	0.26
C,P	8.81	0.24
A,B	7.21	0.21
A,G,P	41.48	0.48
A,G,T	39.17	0.48
A,T,P	33.76	0.44
G,T,P	32.06	0.43
A,G,C	28.21	0.40
G,C,P	27.48	0.39
A,T,C	26.08	0.39
A,C,P	23.96	0.38
G,T,C	23.76	0.38
T,C,P	21.79	0.35
A,T,B	17.96	0.33
G,B,P	17.50	0.33
G,T,B	16.14	0.33
T,B,P	14.62	0.30
A,B,P	12.22	0.27
A,G,B	12.08	0.28
G,B,C	11.68	0.28
T,B,C	11.51	0.28
A,B,C	9.14	0.24

table continued on next page

TABLE IV (continued)

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN FIRST TERM ALGEBRA

Courses	Chi-squared	r_t
A,G,T,P	38.48	0.47
A,G,C,P	32.65	0.44
A,G,T,C	30.07	0.43
A,T,C,P	25.67	0.39
G,T,C,P	23.97	0.38
A,G,B,P	19.13	0.35
A,G,T,B	18.48	0.36
A,T,B,P	16.11	0.33
G,B,C,P	15.37	0.31
G,T,B,P	13.86	0.31
A,G,B,C	13.46	0.30
A,T,B,C	13.42	0.30
A,B,C,P	11.53	0.27
G,T,B,C	11.38	0.28
T,B,C,P	10.05	0.27
A,G,T,C,P	29.93	0.43
A,G,B,C,P	18.48	0.33
A,G,T,B,P	16.08	0.34
A,G,T,B,C	14.01	0.32
A,T,B,C,P	11.86	0.29
G,T,B,C,P	10.47	0.28
A,G,T,B,C,P	13.02	0.31

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

group of course combinations. This is shown in the following extract from Table IV.

Courses	Chi-squared	r_t
A	23.07	0.46
A,P	31.44	0.46
or G,P	38.27	0.46
A,G,P	41.48	0.48
or A,G,T	39.17	0.48
A,G,T,P	38.48	0.47
A,G,T,C,P	29.93	0.43
A,G,T,B,C,P	13.02	0.31

where the symbols are again the same as those used in Table IV.

This pattern, built up without undue rearranging of the data in Table IV, gives one a more reasonable picture of the apparent relative importance of the high school subjects under consideration. As courses appear in the growing pattern, it is easy to visualize the opportunities that these courses present for increasing skill in the various algebraic manipulations. Nor is it surprising that biology is the last to appear.

In both of these extractions from Table IV it is the combination of algebra, solid geometry, and physics that yielded both the highest Chi-squared value and highest tetrachoric correlation coefficient of all the comparisons in this series. The high school credit represented by this combination would therefore provide the best predictor of a good grade in first term algebra at this college, although the combination of algebra, solid geometry, and trigonometry is practically as good.

Again, as in the case of graduation from college, it is quite unreasonable to assume that the student suffers by taking more than the three courses noted in the previous paragraph. The reader is referred back to pages forty and forty-one for a discussion of the possible reason for the decreasing in Chi-squared and r_t observed with combinations of more than three high school courses. It must be restated that this statistical handicap impairs the value of the data when it is used to justify a particular combination of high school courses as a college entrance requirement.

Perhaps the best generalization concerning this series of comparisons arises from simply counting the number of the comparisons that exhibit significant Chi-squared values. It seems apparent that the capable student can hardly avoid becoming proficient in the various aspects of elementary algebra. This would help explain the existence of the several patterns, shown earlier in this section, derived from the data obtained in the first series.

It was expected that somewhat higher correlation coefficients would again be obtained with the second and third series of comparisons, in which the two non-credit courses A0 and A00 were considered. This was observed in the part of the study dealing with graduation from college, discussed in Chapter Five. However, the correlations obtained in these two series were slightly lower than the corresponding ones of the first series, and after making sample computations to determine that this was very likely to occur in all comparisons where the criterion of college success was a good grade in a particular course, the second and third series were discontinued.

There were forty-eight comparisons in the second series, of which forty-three yielded Chi-squared values higher than 6.635, the critical value for the 0.01 significance level. These are shown in Table V on pages fifty-nine and sixty, with the observed cell frequencies shown in Table Va in the appendix. In this series no student who took <u>AO</u> was included in any comparison which included solid geometry, and no student who took <u>AOO</u> was included in any comparison that included algebra. Thus the number of students involved in the comparisons in this series varied depending upon the high school subjects included in each comparison. This series contains only comparisons which include algebra or solid geometry or both.

The third series consists of the same forty-eight comparisons as the second series, with an additional six for a more detailed examination of the effects of <u>AO</u> and <u>AOO</u>. In the first forty-eight comparisons, students who took <u>AO</u> were treated as if they had credit for high school solid geometry,

TABLE V

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN FIRST TERM ALGEBRA *

Courses	Chi-squared	r_t
G	22.46	0.40
A	8.66	0.37
G,P	32.19	0.44
G,T	29.76	0.43
A,T	22.26	0.39
G,C	19.30	0.35
A,G	18.95	0.40
A,P	14.86	0.37
G,B	8.29	0.24
G,T,P	28.87	0.42
A,G,T	27.93	0.43
A,G,P	26.64	0.44
G,C,P	23.43	0.38
A,T,P	22.66	0.40
G,T,C	20.40	0.35
A,T,C	16.02	0.34
A,G,C	15.28	0.35
G,B,P	14.64	0.31
G,T,B	13.86	0.31
A,T,B	10.48	0.29
A,C,P	9.61	0.29
G,B,C	9.37	0.25
A,G,B	6.95	0.23
A,G,T,P	28.64	0.44
G,T,C,P	20.71	0.37
A,G,T,C	20.07	0.38
A,G,C,P	19.16	0.37
A,G,B,C	17.50	0.23
A,T,C,P	16.66	0.35
G,B,C,P	12.77	0.29
G,T,B,P	11.98	0.29
A,G,T,B	11.79	0.32
A,G,B,P	10.68	0.28
A,T,B,P	9.77	0.28
G,T,B,C	9.51	0.26
A,T,B,C	7.33	0.24

table continued on next page

TABLE V (continued)

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN FIRST TERM ALGEBRA *

Courses	Chi-squared	r_t
A,G,T,C,P	21.65	0.39
A,G,T,B,P	10.82	0.29
A,G,B,C,P	9.12	0.26
G,T,B,C,P	8.77	0.25
A,G,T,B,C	8.37	0.26
A,T,B,C,P	6.83	0.23
A,G,T,B,C,P	8.07	0.26

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

* Whenever A appears in a course combination, students with credit in <u>AOO</u> were not counted. Whenever G appears in a course combination, students with credit in <u>AO</u> were not counted.

and students who took A00 were treated as if they had credit for three or more semesters of high school algebra. In the additional six comparisons either A0 or A00 was ignored in several comparisons involving both algebra and solid geometry. These six are clearly indicated in the table. Of the first forty-eight, there were again forty-three comparisons that yielded Chi-squared values higher than 6.635, although not all the same as in the second series. The forty-nine comparisons in the third series are shown in Table VI on pages sixty-two and sixty-three, with the observed cell frequencies given in Table VIa in the appendix. Every comparison in the third series involved the 439 students who took the first term algebra course.

The results of the second and third series are very similar, and the values are somewhat lower than those obtained in the first series. As might be expected, the six additional comparisons of the third series yielded values intermediate between those of the first series and the others of the third series.

It is rather surprising that controlling A0 and A00 does not lead to higher values of Chi-squared and the correlation coefficient. No very profound reason, statistical or educational, can be given to explain this. Apparently these two courses are not very effective as preparation for the first term of algebra at this college.

TABLE VI

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN FIRST TERM ALGEBRA *

Courses	Chi-squared	r_t
G	19.31	0.36
G,T	33.07	0.43
G,P	30.96	0.43
A,T	30.20	0.42
A',G	28.05	0.41
A,G'	28.01	0.41
A,G	18.91	0.35
G,C	16.44	0.32
A,P	16.17	0.35
G,B	7.97	0.23
A,C	6.82	0.23
A',G,T	39.21	0.47
A,G',T	34.38	0.44
A,G,T	33.72	0.44
G,T,P	30.90	0.43
A,G,P	30.60	0.43
A,T,P	29.22	0.41
G,T,C	23.14	0.38
G,C,P	21.48	0.36
A,T,C	21.29	0.35
G,T,B	16.58	0.34
A,T,B	16.20	0.33
A,G,C	16.10	0.32
G,B,P	13.95	0.29
A,C,P	11.35	0.28
A,G,B	8.28	0.23
G,B,C	8.10	0.23
A',G,T,P	36.78	0.47
A,G',T,P	33.21	0.44
A,G,T,P	32.06	0.43
A,G,T,C	23.53	0.38
G,T,C,P	22.57	0.37
A,G,C,P	20.85	0.35
A,T,C,P	20.49	0.35

table continued on next page

TABLE VI (continued)

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN FIRST TERM ALGEBRA *

Courses	Chi-squared	r_t
A,G,T,B	17.02	0.34
A,G,B,P	14.58	0.30
A,T,B,P	14.56	0.31
G,T,B,P	13.86	0.31
G,B,C,P	12.58	0.28
G,T,B,C	11.91	0.29
A,T,B,C	11.43	0.28
A,G,B,C	8.45	0.24
A,G,T,C,P	23.22	0.38
A,G,T,B,P	14.44	0.32
A,G,T,B,C	12.30	0.30
A,G,B,C,P	12.02	0.28
G,T,B,C,P	10.47	0.28
A,T,B,C,P	10.00	0.27
A,G,T,B,C,P	10.96	0.28

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

* A includes those students with credit in <u>AOO</u>; G includes those students with credit in <u>AO</u>.

' A' does not include those students with credit in <u>AOO</u>; G' does not include those students with credit in <u>AO</u>.

Again, as in the study of graduation from college, a fourth, short series of comparisons was made to determine the apparent value of AO and AOO. (See page forty-nine for the description of these comparisons.) In this case, of course, the criterion of college success was the achievement of a good grade in the first term algebra course. Only one of the comparisons yielded a Chi-squared value higher than that of the 0.01 significance level. That compared high school credit for three or more semesters of algebra, but no AOO, with credit in AOO - in place of the usual dichotomy of high school credit. A Chi-squared value of 22.94 and a tetrachoric correlation coefficient of 0.45 were obtained, indicating again that three or more semesters of high school algebra are preferable to AOO.

In summary, it seems that there are more than a few patterns of high school course combinations that correlate fairly well with receiving a good grade in the first term algebra course at the Michigan College of Mining and Technology. The most important consideration seems to be that the student take, in addition to three or more semesters of high school algebra, several more high school courses in which algebra is used.

The best predictor of a good grade in first term algebra, with r_t equal to 0.48, is credit in a combination of high school algebra, solid geometry, and either physics or trigonometry. There were, however, a number of other combinations which yielded correlations only slightly less.

SECOND TERM ALGEBRA

Only one main series of comparisons was made in the study of second term college algebra. In this series there was no attempt to control the effect of A0 and A00 inasmuch as lower values of Chi-squared and the correlation coefficient were obtained when this was done.

Thirty-six of the regular sixty-three comparisons yielded Chi-squared values above that of the 0.01 level of significance. In addition, the four-or-more semesters of algebra dichotomy of the previous section was investigated in this part of the study (see page fifty-two). These thirty-seven comparisons are shown in Table VII on pages sixty-six and sixty-seven. The observed cell frequencies for these comparisons are shown in Table VIIa in the appendix.

A cursory inspection of Table VII leads to two observations. There are not nearly as many significant comparisons, and the Chi-squared and correlation values are quite a bit smaller, compared to those involving first term algebra shown in Table IV.

These observations are not entirely unexpected. It is reasonable that the effect of the high school background on a specific college course should diminish as related college

TABLE VII

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN SECOND TERM ALGEBRA

Courses	Chi-squared	r_t
T	12.58	0.29
A	11.49	0.34
G	8.84	0.27
A (4/)	6.66	0.20
A,T	18.28	0.34
G,T	15.87	0.33
G,P	15.48	0.33
T,P	14.37	0.31
A,P	14.35	0.34
A,G	10.95	0.29
T,C	8.06	0.23
G,C	7.67	0.23
A,T,P	20.41	0.36
A,G,T	19.90	0.36
A,G,P	18.54	0.35
G,T,P	18.10	0.34
G,C,P	12.72	0.29
A,T,C	11.80	0.28
G,T,C	10.41	0.26
T,C,P	9.77	0.25
A,G,C	9.08	0.25
A,C,P	8.49	0.25
A,T,B	7.86	0.23
G,T,B	7.19	0.22
G,B,P	6.77	0.21

table continued on next page

TABLE VII (continued)

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN SECOND TERM ALGEBRA

Courses	Chi-squared	r_t
A,G,T,P	22.27	0.38
A,G,C,P	14.50	0.31
A,T,C,P	13.75	0.30
G,T,C,P	13.13	0.29
A,G,T,C	12.91	0.29
A,G,T,B	9.89	0.26
A,G,B,P	8.83	0.24
A,T,B,P	7.54	0.24
G,T,B,P	6.68	0.22
A,G,T,C,P	15.81	0.33
A,G,T,B,P	9.34	0.25
A,G,B,C,P	7.36	0.22

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

courses form a part of the more immediate background. In this case, one would expect that the first term algebra would become a dominant factor in determining a student's success in second term algebra. Furthermore, the results of the study by Smith, cited on page eight of the introductory chapter, indicated that records lose their prognostic value as time elapses.

An analysis of the data shown in Table VII, in terms of the highest values in each group of high school course combinations, indicates the same sort of confusion as observed in the study of first term algebra, with only one difference beyond those already mentioned. High school trigonometry has replaced solid geometry in the apparent order of importance of these subjects.

Following are extracts from Table VII, indicating the highest values in each group of course combinations:

Courses	Chi-squared	r_t
T	12.58	0.29
A,T	18.28	0.34
A,T,P	20.41	0.36
A,G,T,P	22.27	0.38
A,G,T,C,P	15.81	0.33
- - - -	- - - -	- - - -
A	11.49	0.34
A,T	18.28	0.34
or A,P	14.35	0.34
A,T,P	20.41	0.36
or A,G,T	19.90	0.36
A,G,T,P	22.27	0.38
A,G,T,C,P	15.81	0.33

The first part above ranks the course combinations by the highest Chi-squared values; the second by the highest correlation coefficients.

It will be observed that the best predictor of a good grade in second term college algebra, with r_t equal to 0.38, is the high school credit represented by the combination of algebra, solid geometry, trigonometry, and physics.

The short series of comparisons investigating the particular effect of AO and AOO again yielded only one with a value of Chi-squared above that of the 0.01 significance level. That was again the comparison of high school credit for three or more semesters of algebra, but no AOO, with credit in AOO - in place of the usual dichotomy of high school credit. A Chi-squared value of 25.65 and a tetrachoric correlation of 0.53 were obtained, indicating that apparently AOO is an even poorer substitute for high school algebra in the case of second term algebra than in the case of first term algebra.

TRIGONOMETRY

Again only the first of the main series of comparisons was made in studying the relationship of high school credit and, this time, a good grade in college trigonometry.

There were twenty-seven, out of the sixty-three, comparisons that yielded Chi-squared values above that of the 0.01 significance level. The comparison involving four or more semesters of high school algebra did not yield a value high enough for inclusion in the table. These twenty-seven comparisons are shown in Table VIII on page seventy-one, with the observed cell frequencies shown in Table VIIIa in the appendix.

Following is the usual extract from the table, showing the course combinations with the highest Chi-squared values in each group of combinations:

Courses	Chi-squared	r_t
G	17.53	0.35
G,P	20.17	0.36
A,G,P	22.12	0.38
A,G,T,P	18.18	0.35
A,G,T,C,P	11.76	0.28

Inasmuch as trigonometry and second term algebra are both normally taken during the second term of the freshman year, it is not surprising that their Chi-squared and correlation values are quite comparable in magnitude.

The surprising observation is that high school trigonometry is apparently not important enough to appear in the top-ranking comparisons until the four-course combination. This is quite strange in view of the place occupied by trigonometry in the study of the two college algebra courses. Perhaps the most tenable explanation is that proficiency in trigonometry depends largely upon the level of high school achievement as evidenced by credit in solid geometry and physics. This idea was discussed in some detail on page

TABLE VIII

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN TRIGONOMETRY AND ANALYTIC GEOMETRY

	Courses	Chi-squared	r_t
Trigonometry	G	17.53	0.35
	T	11.91	0.28
	A	8.70	0.31
	G,P	20.17	0.36
	A,G	19.12	0.37
	G,T	16.93	0.34
	A,T	14.75	0.32
	T,P	10.92	0.27
	G,C	10.67	0.27
	A,P	9.77	0.28
	T,C	8.74	0.25
	A,G,P	22.12	0.38
	A,G,T	19.68	0.35
	G,T,P	15.47	0.32
	A,T,P	13.52	0.31
	G,C,P	13.33	0.30
	A,G,C	11.28	0.27
	G,T,C	10.96	0.27
	A,T,C	10.33	0.27
	T,C,P	7.72	0.24
	A,G,T,P	18.18	0.35
	A,G,C,P	14.07	0.31
	A,G,T,C	12.26	0.29
	G,T,C,P	10.34	0.27
	A,T,C,P	9.25	0.26
	A,G,T,B	7.66	0.25
	A,G,T,C,P	11.76	0.28
Analytic Geometry	A,G,T,P	7.04	0.25

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

forty-three, in connection with graduation from college.

The best predictor of a good grade in college trigonometry is high school credit in the combination of algebra, solid geometry, and physics - with r_t equal to 0.38.

The fourth, short series involving AO and AOO again yielded a significant value of Chi-squared only in the case of the comparison concerning AOO. This time the dichotomy gave a Chi-squared value of 17.87 and a tetrachoric correlation coefficient of 0.44, indicating that AOO is also not a very good substitute for high school algebra as preparation for college trigonometry.

ANALYTIC GEOMETRY

The size of the study population was considerably reduced in that part of the study dealing with success in the college analytic geometry course. Apparently, students begin to drop out of this college in sharply increasing numbers at the end of the second term of the freshman year; also students majoring in forestry are not required to take the course in analytic geometry. This resulted in a decrease in the study population from over four hundred for the second term courses to three hundred thirty-two for this course.

The usual sixty-four comparisons of the regular series, including the two involving only high school algebra, yielded only one with a Chi-squared value above that of the 0.01 level of significance. This is shown at the bottom of Table VIII on page seventy-one, with the observed cell frequencies shown similarly in Table VIIIa in the appendix.

Analytic geometry differs markedly in one respect from the other mathematics courses discussed in this chapter in that no comparable course is commonly offered in high school, in contrast to high school courses in advanced algebra and trigonometry. Thus, in this case, the high school courses could only serve as lower level preparation for this course.

This, and the greater time lapse between high school and taking analytic geometry, probably account for the lack of comparisons yielding Chi-squared values above the chosen level of significance.

In view of the low correlation coefficient obtained in the one comparison, 0.25, it is doubtful that it is useful for predictive purposes.

Again the short series yielded a significant value of Chi-squared only in the case of the comparison concerning A00. This time the Chi-squared value was 7.28 and the tetrachoric correlation coefficient was 0.26, indicating a very weak preference for high school algebra over A00.

SUMMARY

The part of the investigation concerned with the four elementary college mathematics courses yielded a number of unanticipated, as well as anticipated, results.

In view of Smith's study of previous records, cited on page eight, it is reasonable to find the number of comparisons yielding Chi-squared values above that of the 0.01 significance level decreasing with the later college courses.

After observing the similar effect in the part of the study concerned with graduation from college, it was not surprising to find the maximum values of Chi-squared and of the correlation coefficient occurring with the three- or four-course combinations of high school credit. As was suggested in the preceding chapter, statistical reasons make it unlikely for the maximum values to occur with combinations of more high school courses. Consequently, it is unwise to use the statistical results of this study to justify the exclusion, particularly, of any course from among the entrance requirements of the college.

Following is a table of the best course combinations to use for predictive purposes for the four college courses in this part of the study:

College Course	H.S. Courses	Chi-squared	r_t
First Term Algebra	A,G,P	41.48	0.48
	or A,G,T	39.17	0.48
Second Term Algebra	A,G,T,P	22.27	0.38
Trigonometry	A,G,P	22.12	0.38
Analytic Geometry	A,G,T,P*	7.04	0.25

* The only significant comparison obtained

The first unexpected observation in this part of the study was that controlling the two non-credit college courses, A0 and A00, did not lead to higher values of Chi-squared and of the correlation coefficient than when the two courses were ignored. Apparently, the value of these two courses can be discounted as far as preparation for the four college courses is concerned.

Another surprising observation was the somewhat confused pattern formed by the top-ranking comparisons in each group of high school course combinations. One might expect that credit in high school algebra would be the best single predictor of success in college algebra; instead, high school trigonometry yielded a higher Chi-squared value for both terms of college algebra. For college trigonometry, credit in high school solid geometry turned out to be the best single-course predictor. This phenomenon might be at least partially explained in terms of the proposed hierarchy of high school courses discussed in Chapter Five.

In an attempt to determine the relative merits of A0 and high school solid geometry and of A00 and three or more semesters of high school algebra, the only comparison yielding statistically significant results was in each case that one involving A00. It was concluded that A00, the non-credit college course in algebra, was not a particularly effective substitute for three or more semesters of high school algebra in any of the four college mathematics courses.

CHAPTER VII

PERFORMANCE IN FIRST YEAR CHEMISTRY AS RELATED TO HIGH SCHOOL PREPARATION

During the interval of time covered by this study all students at the Michigan College of Mining and Technology were required to take the same three-term course in elementary chemistry, described on pages twenty and twenty-one. At that time a student did not receive a grade for the course until he had completed the three terms of work; at which time he received one grade. Inasmuch as there are no college prerequisites, this course in chemistry is normally taken in the freshman year.

The criterion of college success was again the achievement of a good grade (A, B, or C) in the college course. As before, that part of the study population that completed the course was divided into two groups: those who received a good grade the first time they took the course and those who received a poor grade (D or F) the first time they took the course.

There were 379 students involved in this part of the investigation. The difference between this number and the 447 involved in the study of graduation from college is entirely due to dismissals before completion of the course in chemistry.

The high school data was treated in the same way as described in the preceding chapters.

The 2 x 2 contingency table was, as before, used to obtain a Chi-squared value and, if that was significant at the 0.01 level, the correlation coefficient was calculated.

Only one main series of comparisons was made, that series in which <u>AO</u> and <u>AOO</u> are ignored. There were forty-five comparisons, out of the total of sixty-three, that gave significant Chi-squared values. These are shown in Table IX on pages seventy-eight and seventy-nine, with the observed cell frequencies given in Table IXa in the appendix.

The usual analysis of the statistical results, in terms of the top-ranking values is each group of high school course combinations yields again some surprising observations, as well as some to be expected. Following is the extract from Table IX indicating these comparisons:

Courses	Chi-squared	r_t
P	28.10	0.57
A,P	35.79	0.53
A,C,P	42.54	0.54
A,G,C,P	38.29	0.52
A,G,T,C,P	27.38	0.47
A,G,T,B,C,P	11.39	0.33

Once again the pattern shows an increase to a maximum then a decrease in the values of Chi-squared, for probably the same statistical reason that was discussed in Chapter Five. It is therefore unwise to use these statistics alone

TABLE IX

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN CHEMISTRY

Courses	Chi-squared	r_t
P	28.10	0.57
C	10.91	0.36
A	9.75	0.36
G	7.90	0.28
A,P	35.79	0.53
C,P	33.10	0.52
G,P	27.33	0.45
A,C	20.74	0.43
G,C	15.62	0.36
A,G	12.91	0.34
T,C	12.90	0.33
T,P	10.54	0.30
G,T	9.07	0.28
A,T	8.57	0.27
A,C,P	42.54	0.54
A,G,P	35.16	0.50
G,C,P	31.87	0.48
A,G,C	20.34	0.40
T,C,P	19.38	0.40
A,T,C	17.34	0.37
A,T,P	15.83	0.36
G,T,P	15.50	0.36
A,G,T	14.45	0.34
G,T,C	13.84	0.34
B,C,P	9.43	0.28
A,B,C	8.63	0.28
T,B,C	7.33	0.26

table continued on next page

TABLE IX (continued)

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN CHEMISTRY

Courses	Chi-squared	r_t
A,G,C,P	38.29	0.52
A,T,C,P	24.76	0.44
A,G,T,P	22.38	0.43
G,T,C,P	21.12	0.42
A,G,T,C	18.91	0.40
A,B,C,P	13.68	0.34
G,B,C,P	12.04	0.32
A,T,B,C	8.98	0.29
T,B,C,P	8.56	0.28
A,G,B,P	7.99	0.26
G,T,B,C	7.74	0.27
A,G,B,C	7.47	0.25
A,G,T,C,P	27.38	0.47
A,G,B,C,P	13.64	0.34
A,T,B,C,P	10.38	0.31
A,G,T,B,C	9.69	0.29
G,T,B,C,P	9.69	0.29
A,G,T,B,C,P	11.39	0.33

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

to justify the exclusion of any high school courses from among the college entrance requirements.

The pattern shown on page seventy-seven is built up in an orderly fashion, in contrast to those obtained in the investigation of college mathematics. Physics, the top-ranking single course, appears in all of the other top-ranking combinations; algebra, which first appears in the two-course combination, appears in all of the remaining ones. It seems reasonable then to use this pattern in estimating the relative importance of the high school courses as far as the first year course in college chemistry is concerned.

With this premise, it is surprising to note the position of high school chemistry in the pattern on page seventy-seven and in Table IX. Noting that the combination of algebra and physics has a Chi-squared and r_t only slightly greater in magnitude than has the combination of chemistry and physics, one would then conclude that three or more semesters of high school algebra are about equivalent to a year of high school chemistry as preparation for college chemistry. This would seem to indicate an appreciable difference in the levels of the usual high school chemistry course and the chemistry course at this college. Numerous comments by students at this college tend to reinforce that conclusion.

It also appears that a year of high school biology is relatively unimportant to success in college chemistry.

The high correlation found between credit for a year of high school physics and success in college chemistry is possibly due to two reasons. Physics, a science usually taught with a rigorous approach, might be good preparation for dealing with the complex aspects of college chemistry. Also, credit for physics, representing perhaps the peak of achievement in high school, might indicate the ability and seriousness of the student.

For predictive purposes high school credit in the combination of algebra, chemistry, and physics is probably the best - with r_t equal to 0.54; inasmuch as that combination yielded a Chi-squared value appreciably higher than that of any other combination. Although physics alone yielded a slightly higher correlation coefficient, the difference between the Chi-squared values of physics and the algebra-chemistry-physics combination makes the latter somewhat preferable.

The short series of comparisons involving <u>AO</u> and <u>AOO</u> again yielded a significant Chi-squared value only in the comparison with algebra and <u>AOO</u>. A Chi-squared value of 18.16 and a correlation coefficient of 0.48 reaffirm the conclusion that three or more semesters of high school algebra are preferable to <u>AOO</u>.

CHAPTER VIII

PERFORMANCE IN FIRST YEAR PHYSICS AS RELATED TO HIGH SCHOOL PREPARATION

During the interval of time covered by this study all students at the Michigan College of Mining and Technology were required to take one of the two three-term courses in elementary physics, described on pages twenty-one and twenty-two. Students received grades at the end of each of the three terms. College mathematics prerequisites resulted in physics being taken normally during the sophomore year.

The criterion of college success was again the achievement of a good grade (A, B, or C) in the college course. As before, that part of the study population that completed a portion of the course for which a grade was given was divided into two groups: those who received a good grade the first time they took that part of the course and those who received a poor grade (D or F) the first time they took that part of the course.

The high school data was treated in the same way as described in the preceding chapters.

The 2 x 2 contingency table was, as before, used to obtain a Chi-squared value and, if that was significant, a tetrachoric correlation coefficient was calculated.

Inasmuch as controlling AO and AOO in the comparisons of high school credit and college success did not lead to higher values of Chi-squared and r_t, only the first of the three main series of comparisons was made for each of the three terms of physics. In this series AO and AOO were ignored. Also, for each term, the effect of these two non-credit college courses was investigated in the usual short series. However, no comparison of the short series yielded a significant Chi-squared value for any of the three terms of physics.

The remainder of this chapter is divided into four sections, one for each of the three terms of the elementary physics sequence, and a summary.

FIRST TERM PHYSICS

There were 347 students in the study population who received a grade for the first term of physics, which is concerned with a study of mechanics and sound. The other 100 students of the original study population were all dismissed before receiving a grade in this course.

There were only eleven, of the sixty-three, comparisons that yielded Chi-squared values above that of the 0.01 significance level. These are shown in the first part of Table X on page eighty-four, with the observed cell frequencies given in Table Xa in the appendix.

Following is the usual extract from the table giving

TABLE X

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN PHYSICS

	Courses	Chi-squared	r_t
First Term Physics	P	19.87	0.55
	A,P	18.56	0.45
	C,P	13.84	0.38
	G,P	12.51	0.33
	A,G	6.79	0.26
	A,G,P	16.33	0.37
	A,C,P	16.15	0.37
	G,C,P	9.43	0.28
	A,G,C	7.01	0.26
	A,G,C,P	12.58	0.33
	A,G,T,P	7.00	0.25
Second Term Physics	P	12.63	0.45
	C	7.47	0.32
	G,P	13.08	0.36
	C,P	12.78	0.37
	G,C	12.60	0.36
	A,C	6.74	0.29
	G,C,P	14.80	0.38
	A,G,P	10.87	0.33
	A,G,C	10.61	0.33
	A,C,P	9.08	0.32
	G,T,P	9.05	0.30
	G,T,C	8.39	0.29
	A,G,C,P	12.69	0.35
	G,T,C,P	11.35	0.34
	A,G,B,C	8.57	0.29
	A,G,T,P	7.96	0.28
	G,T,B,P	7.91	0.31
	G,T,B,C	7.77	0.32
	A,G,T,C	7.36	0.27
	A,G,B,P	7.36	0.27

table continued on next page

TABLE X (continued)

CHI-SQUARED VALUES AND TETRACHORIC CORRELATION COEFFICIENTS FOR VARIOUS COMBINATIONS OF HIGH SCHOOL COURSES COMPARED WITH GOOD GRADES IN PHYSICS

	Courses	Chi-squared	r_t
	A,G,T,C,P	10.17	0.33
	G,T,B,C,P	9.15	0.32
	A,G,B,C,P	8.57	0.30
	A,G,T,B,P	7.22	0.30
	A,G,T,B,C	7.08	0.30
	A,G,T,B,C,P	7.65	0.31
Third Term Physics	A,P	7.69	0.31
	A,T,P	7.49	0.28
	A,G,T,P	8.06	0.29
	A,T,C,P	7.05	0.27
	A,G,T,C,P	8.18	0.30

A - Three or more semesters of algebra
G - One or more semesters of solid geometry
T - One or more semesters of trigonometry
B - Two or more semesters of biology
C - Two or more semesters of chemistry
P - Two or more semesters of physics

the top-ranking course combinations in each group:

Courses	Chi-squared	r_t
P	19.87	0.55
A,P	18.56	0.45
A,G,P	16.33	0.37
A,G,C,P	12.58	0.33

The small number of significant comparisons is not at all surprising, in view of the trend observed in that part of the study dealing with college mathematics and also in view of Smith's study cited on page eight. The relatively low values of Chi-squared are also likely due, especially, to the background in college mathematics and science gained during the freshman year.

Unusual is the observation that, in this series, the highest Chi-squared value and correlation coefficient are associated with credit in a single high school course, rather than with a combination of three or more courses. Perhaps this also is the result of college mathematics courses intervening between high school mathematics and college physics, in addition to the statistical "dilution" effect discussed on pages forty and forty-one.

It is not surprising to see the preponderance of mathematical courses appearing in the significant comparisons, since mathematical logic is commonly used throughout the first term of college physics.

It is apparent that the best predictor of a good grade in first term college physics is credit for one year of high school physics, with r_t equal to 0.55.

SECOND TERM PHYSICS

There were 316 students in the study population who received a grade in the second term of physics, which is concerned with a study of heat and light. The decrease of 31 students, compared to the number receiving a grade in the first term of physics, is representative of the difficulty of the first two years of engineering curricula.

It must be remembered that the phrase "second term" applied to this part of the year of college physics does not necessarily signify that the students took this part of the course consecutively with the first term. As stated on page twenty-two, a small fraction of the study population reversed the usual order of the second and third terms.

There were twenty-six, of the sixty-three, comparisons that yielded Chi-squared values above that of the 0.01 level of significance. These are also shown in Table X on pages eighty-four and eighty-five, with the observed cell frequencies given in Table Xa in the appendix.

Following is the extract from the table giving the top-ranking course combinations in each group:

Courses	Chi-squared	r_t
P	12.63	0.45
G,P	13.08	0.36
G,C,P	14.80	0.38
A,G,C,P	12.69	0.35
A,G,T,C,P	10.17	0.33
A,G,T,B,C,P	7.65	0.31

There is a marked difference between the patterns of top-ranking course combinations in the cases of first and second terms of physics. In that of the first term, algebra appears to be more important than solid geometry and chemistry. The reverse is apparent in the pattern of the second term.

It is believed that this is symptomatic of the appreciable difference between the approaches to the subject matter of these two terms. In the first term a relatively high level of mathematical competence is perhaps a major requirement for the successful completion of the work, with comprehension of the subject matter unfortunately of secondary importance. In the second term mathematical manipulations are of secondary importance to the ability to visualize processes and to understand abstract concepts.

With this premise it is possible to explain the appearance of the high school courses in the pattern above in terms of the hierarchy of courses proposed in Chapter Five. Aside from the importance of high school physics as a specific part of the background, it is apparently most important that the student have demonstrated the ability and interest to take the higher level high school courses.

Inasmuch as there is little difference between the Chi-squared values for the combination of solid geometry, chemistry, and physics - the highest - and physics alone, the higher correlation coefficient obtained in the case of physics alone - r_t equal to 0.45 - makes credit for one year of high school physics the best predictor of a good grade in the second term of college physics.

THIRD TERM PHYSICS

There were 315 students in the study population who received a grade in the third term of physics, which is concerned mainly with a study of electricity and magnetism. This is almost the same number of students as the number who completed the second term of the course.

There were only five, of the sixty-three, comparisons that yielded Chi-squared values above that of the 0.01 level of significance in the study of third term physics. These are shown in Table X on page eighty-five, with the observed cell frequencies given in Table Xa in the appendix.

The size of this series does not warrant the usual extraction of top-ranking combinations; consequently the reader is referred directly to Table X in the discussion of the relative importance of the various high school courses.

The size of this series is undoubtedly a reflection of the increased effect of the accumulated college background, rather than an indication of the relative simplicity of this part of the three-term sequence. On the contrary, it is generally conceded that this is the most difficult term of the three. A study of electricity and magnetism probably involves abstract concepts of the highest level among those encountered in elementary physics.

In common with the first term, it is often possible to substitute skill in mathematical manipulation for comprehension in the third term's work. This very possibly accounts for the closer resemblance of the significant course combinations in this series to those of the first term rather than to those of the second term.

For predictive purposes, credit in algebra and physics, r_t equal to 0.31, is slightly preferable, although all Chi-squared and correlation values are so uniformly low that none of them is probably worth much for this purpose.

SUMMARY

The patterns of the significant comparisons in the investigation of elementary physics differed to some extent from those of the other college courses involved in the study. They can, however, be explained by the same influences that were postulated for the other courses. The course content

effect of high school physics on performance in college physics is probably more pronounced than, for example, the effect of high school chemistry on performance in college chemistry. In the first and third terms of physics, high school courses that emphasize mathematical skills seem to be important, compared to those high school courses that might be regarded as indicating the highest level of achievement. In the case of second term physics, the level of achievement in high school seems to be the more important.

As far as the use of high school credit in predicting performance in college physics is concerned, credit for one year of high school physics seems to be the best criterion for the first and second terms of college physics. There is no very good criterion, of those studied, for the third term.

CHAPTER IX

SUMMARY AND CONCLUSIONS

This study has established the existence of a large number of statistical relationships between credit in certain high school mathematics and science courses and various aspects of success at the Michigan College of Mining and Technology. These relationships are in the form of Chi-squared values and tetrachoric correlation coefficients, obtained from 2 x 2 contingency tables made up by dichotomizing the high school credit and the college achievement of between 447 and 315 students.

More than 800 statistical comparisons were made, with almost 390 of these yielding a Chi-squared value above that of the 0.01 significance level. If a comparison showed a significant relationship, according to the Chi-squared criterion, a tetrachoric correlation coefficient was computed in order to determine the degree of association. The statistical results are shown in Tables I through X, with the contingency tables' observed cell frequencies for these comparisons given in Tables Ia through Xa in the appendix.

After the existence of these significant relationships had been established, it seemed desirable to suggest reasons to account for the apparent importance of particular high school courses, credit for which correlated with success in

one of the aspects of college work under consideration.

Three principal reasons have been proposed to explain the existence of the significant relationships. The first, and most obvious, is that familiarity with the course content of a particular high school course is required, or at least advantageous, for success in a college course that is concerned with the same area of study. For example, success in college physics might depend in part upon a study of the same subject matter at the high school level.

Another reason is that a particular high school course may give the student an opportunity to improve certain skills that were learned in an earlier course and useful in some college course. An example of this might be the various algebraic procedures learned perhaps in the first high school algebra courses, with skill in using them improved in high school trigonometry and physics and essential to success in college chemistry. In this example, credit in high school trigonometry and physics would correlate with success in college chemistry.

The third reason is that success in a college course may depend, at least in part, upon a level of ability and interest demonstrated by credit in certain high school courses. It is proposed, in this regard, that a hierarchy of courses exists in high school - with algebra and biology at a lower level, trigonometry and chemistry at an intermediate level,

and solid geometry and physics at the highest level. Thus credit in high school solid geometry and physics might correlate highly with success in college analytic geometry, in spite of relatively little similarity in the subject matter of these three courses.

There are numerous reasons why a significant statistical relationship between credit in a high school course or courses and college success is not obtained. Perhaps the most obvious of these is that no aspect of the high school course is a factor in achieving a particular kind of college success. An example might be the comparison of credit in high school Spanish with success in college chemistry. It would be surprising if a significant relationship were obtained, in view of the complete lack of similarity between the two courses. Had a greater variety of high school or college courses been considered in this study, that reason might have been quite important. Within the limitations of the study, only biology seems to be but weakly related to college success.

The fact that the student may not retain the skills or subject matter implied by the possession of credit in a particular high school course can certainly mask a relationship that might otherwise be demonstrated.

Change in the direction or degree of the student's motivation is undoubtedly a major factor.

There is also the question of the caliber of the high school and college courses. If any course were relatively undemanding of the students' intellectual efforts, compared to the generally accepted standard at that educational level, one would expect to find few significant relationships - whether the course was considered as high school preparation or as a criterion of college success. With many high schools contributing students to the study population, such an effect would be relatively unlikely. However, it is a distinct possibility in the case of a college course taken by all of the students. The nature of both high school and college courses would have to be examined more closely before deciding that any course or set of courses is to be condemned.

The four reasons mentioned above must be faced by any investigator who attempts to relate any details of high school achievement to any aspect of college success. There is, in addition, a handicap inherent in the statistical approach of this study that tends to reduce the statistical indications in a large group of the comparisons that were made.

This handicap is the result of dichotomizing the study population with regard to high school credit, no matter how many high school courses may be involved in a particular comparison. If only one high school course is involved, the study population divides naturally into two parts: the first including only those students who possess at least a certain minimum amount of credit in that subject and the second including those students who do not fall into the first group. Thus the 2 x 2 contingency table is an appropriate tool for seeking a relationship between high school credit in one course and some aspect of college success.

If, on the other hand, credit in two or more high school courses is to be investigated, the study population actually consists of more than two parts. There are students who possess at least the minimum amount of credit in all of the high school courses involved in the comparison, students who have at least the minimum credit in all but one of the high school courses, students who have at least the minimum credit in all but two of the high school courses, and so forth.

If the 2 x 2 contingency table is also used with these multi-group study populations, all but the first group of those mentioned in the previous paragraph would be combined into one, the group containing those who did not possess at least the minimum credit in all of the high school courses involved in that particular comparison. As the number of high school courses in the comparison is increased, the number of groups squeezed into one classification increases even more rapidly. If there are two high school courses involved, the "have not credit" group actually contains three groups; if there are three high school courses involved, the "have not credit" group actually contains seven groups.

Not very much background in statistics is required to enable one to see that it becomes progressively more difficult to obtain statistical indications of relationships that may actually exist, as the number of high school courses is increased in the comparisons.

The reader might well ask why, in view of this difficulty, some other statistical approach was not employed. The following line of reasoning was used: there were too few different amounts of credit involved to use the common Pearsonian correlation coefficient, hence the advantage of the contingency table; Chi-squared values and correlation coefficients for different-sized contingency tables are not easy to compare, hence the use of only 2 x 2 contingency tables.

This rather lengthy discussion has as its main purpose calling attention to the fact that relatively low statistical results arising from combinations of several high school courses cannot be interpreted as indicating as weak a relationship as would the same results for a single course. That is, the positive aspect of the evidence should be emphasized rather than the negative aspect.

This is particularly important to remember if the results of this study are used to justify the modification of college entrance requirements.

The following paragraphs give very brief summaries and interpretations of the statistical results.

Graduation from the Michigan College of Mining and Technology is best predicted by the possession of credit in solid geometry, either from high school or from the college course AO. Chi-squared is 54.72, and r_t is 0.75. The order of importance of the high school courses can be explained on the basis of a hierarchy of courses, with credit in physics and solid geometry indicating the highest level of interest and ability.

A good grade (A, B, or C) in first term college algebra is best predicted by high school credit for three or more semesters of algebra, one or more semesters of solid geometry, and a year of physics. Chi-squared is 41.48, and r_t is 0.48. The most important courses seem to be those that give an opportunity for improving mathematical skills.

A good grade in second term college algebra is best predicted by high school credit for three or more semesters of algebra, one or more semesters of solid geometry, one or more semesters of trigonometry, and a year of physics. Chi-squared is 22.27, and r_t is 0.38. Here also the improvement of mathematical skill seems to be the dominant factor.

A good grade in trigonometry is best predicted by high school credit for three or more semesters of algebra, one or more semesters of solid geometry, and a year of physics. Chi-squared is 22.12, and r_t is 0.38. In this case the proposed hierarchy of courses would help explain the apparent order of importance of the high school courses.

A good grade in analytic geometry is predicted by the same high school credit that was described for second term algebra. Chi-squared is 7.04, and r_t is 0.25. This was the only combination of high school courses that led to a Chi-squared value greater than that of the 0.01 significance level. The fact that this course is preceded by three other college mathematics courses would help account for the scarcity of significant comparisons.

A good grade for the first year of chemistry at this college is best predicted by high school credit for three or more semesters of algebra, one year of chemistry, and one year of physics. Chi-squared is 42.54, and r_t is 0.54. Credit for physics alone yielded a slightly higher r_t but a much lower Chi-squared value. The interpretation of the statistics is somewhat more difficult in this case. Perhaps a combination of all three reasons, mentioned earlier, best serves to explain the apparent order of importance of the high school courses.

Good grades for each of the first two terms of college physics are best predicted by high school credit for one year of physics. For the first term, Chi-squared is 19.87, and r_t is 0.55. For the second term, Chi-squared is 12.63, and r_t is 0.45. A good grade for the third term of college physics is best predicted by high school credit for three or more semesters of algebra and one year of physics. Chi-squared is 7.69, and r_t is 0.31. This pair of values is not appreciably better than the others obtained in the study of third term physics. Again, a combination of all three reasons gives perhaps the best explanation for the order of importance of the high school courses.

Throughout the study there has been concern for the effect of taking the two non-credit college courses AO and AOO. AO is a one term course in solid geometry for those students without high school credit in that subject. AOO is a one term course in elementary algebra for those who show a lack of ability in algebra on an entrance examination.

Taking AO correlates significantly with college success only in the case of graduation from college, in which it is apparently equivalent to high school solid geometry and much better than no formal course in the subject.

Three or more semesters of high school algebra were shown to be preferable to AOO in the cases of graduation and all freshman courses. No significant results were obtained concerning the value of AOO in the study of the three terms of college physics.

This study is potentially of value to four groups of people: high school students, high school faculties, college admissions officers, and college faculties concerned with the specific college courses involved in the study.

High school students with college ambitions, especially in the broad area of engineering, can see the advantages of taking as many as possible of the high school courses involved in this study, with the possible exception of biology. It may be surprising to some that a course, for example, in physics is apparently beneficial in a later course not necessarily concerned directly with physics.

High school faculties, particularly advisers and those responsible for curricula, should be interested in making available - and advising students to take - those courses that seem to be related to future success in college.

College admissions officers are apparently still searching for methods of predicting the graduation of prospective students and for bases of realistic entrance requirements. The correlation coefficients obtained in this study are high enough to warrant consideration. The use of credit in solid geometry to predict graduation from this college, with an r_t of 0.75, represents about as good a procedure as any given in the literature. It has been shown that solid geometry is more important than perhaps has been realized. A deficiency in algebra cannot be completely overcome by brief college courses such as A00. Even though trigonometry is taken early in college, it is apparently worthwhile to study the same subject in high school. A year of high school physics is not a luxury. A year of biology does not seem to be nearly as important as a year of physics or chemistry.

Those on college faculties who are concerned with the content and approach of elementary mathematics and science courses should be interested to note that high school courses do contribute to the background of college students, personal opinions to the contrary. Students with little high school credit in mathematics and science can be expected to have difficulty with the elementary college courses in the same fields.

The fact that this study is not concerned with other high school courses should not be interpreted as a judgment of any other course. It is quite possible that these courses might yield as interesting information with the same statistical approach used in this study.

APPENDIX

TABLE Ia

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE I
(ENTIRE STUDY POPULATION USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
P	260	138	17	32
G	220	108	57	62
A	257	140	20	30
G,P	210	88	67	82
A,P	241	115	36	55
C,P	233	115	44	55
A,G	217	103	60	67
A,C	226	115	51	55
G,C	194	93	83	77
A,G,P	207	83	70	87
G,C,P	189	79	88	91
A,C,P	216	98	61	72
A,G,C	191	89	86	81
G,B,P	144	61	133	109
G,T,P	151	66	126	104
A,G,T	155	70	122	100
A,G,B	150	68	127	102
A,T,P	166	78	111	92
A,G,C,P	186	75	91	95
A,G,T,P	149	61	128	109
A,G,B,P	142	57	135	113
G,B,C,P	132	55	145	115
A,B,C,P	151	69	126	101
A,G,B,C	134	59	143	111
G,T,C,P	136	61	141	109
A,G,B,C,P	130	52	147	118
A,G,T,C,P	134	57	143	113

* Cell a contains those who graduated and who possessed credit in all high school courses shown.

Cell b contains those who were dismissed and who possessed credit in all high school courses shown.

Cell c contains those who graduated and who did not possess credit in all high school courses shown.

Cell d contains those who were dismissed and who did not possess credit in all high school courses shown.

TABLE IIa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE II

Courses	Cell a*	Cell b	Cell c	Cell d	Total
G	218	108	3	38	367
G,P	208	88	13	58	367
A,G	209	92	3	27	331
G,C	192	93	29	53	367
G,T	157	75	64	71	367
G,B	151	72	70	74	367
A,P	235	105	24	30	394
A,G,P	200	77	12	42	331
G,C,P	187	79	34	67	367
G,T,P	151	66	70	80	367
G,B,P	143	61	78	85	367
A,G,C	183	81	29	38	331
G,B,C	135	62	86	84	367
A,G,B	145	59	67	60	331
A,G,T	155	66	57	53	331
A,C,P	210	90	49	45	394
G,T,C	139	69	82	77	367
A,G,C,P	179	70	33	49	331
G,B,C,P	131	55	90	91	367
A,G,T,P	149	58	63	61	331
G,T,C,P	136	61	85	85	367
A,G,B,P	137	53	75	66	331
A,G,B,C	129	53	83	66	331
A,G,T,C,P	134	54	78	65	331
A,G,B,C,P	125	49	87	70	331

* Cell a contains those who graduated and who possessed credit in all high school courses shown.

Cell b contains those who were dismissed and who possessed credit in all high school courses shown.

Cell c contains those who graduated and who did not possess credit in all high school courses shown.

Cell d contains those who were dismissed and who did not possess credit in all high school courses shown.

TABLE IIIa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE III
(ENTIRE STUDY POPULATION USED IN EACH COMPARISON)

Courses	Cell *a**	Cell *b*	Cell *c*	Cell *d*
G	274	132	3	38
G,P	257	106	20	64
A,G	266	130	11	40
G,C	241	112	36	58
A,P	252	130	25	40
G,B	190	89	87	81
G,T	174	82	103	88
A,G,P	250	104	27	66
G,C,P	231	95	46	75
A,G,C	234	110	43	60
G,B,P	178	74	99	96
A,C,P	225	109	52	61
G,T,P	167	72	110	98
G,B,C	167	76	110	94
A,G,B	185	88	92	82
A,G,T	172	81	105	89
A,G,C,P	224	93	53	77
A,G,B,P	174	73	103	97
G,B,C,P	161	66	116	104
A,G,T,P	165	71	112	99
A,G,B,C	163	75	114	95
G,T,C,P	150	67	127	103
A,G,B,C,P	157	65	120	105
A,G,T,C,P	148	66	129	104

* Cell *a* contains those who graduated and who possessed credit in all high school courses shown.

Cell *b* contains those who were dismissed and who possessed credit in all high school courses shown.

Cell *c* contains those who graduated and who did not possess credit in all high school courses shown.

Cell *d* contains those who were dismissed and who did not possess credit in all high school courses shown.

TABLE IVa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE IV
(439 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
T	199	69	81	90
G	231	94	49	65
A (4/)	159	50	121	109
A	265	126	15	33
P	261	130	19	29
G,P	218	78	62	81
A,T	195	64	85	95
G,T	177	54	103	105
A,G	228	89	52	70
A,P	247	104	33	55
T,P	188	63	92	96
G,C	205	79	75	80
T,C	174	61	106	98
A,C	233	102	47	57
T,B	136	45	144	114
G,B	158	63	122	96
C,P	231	111	49	48
A,B	184	83	96	76
A,G,P	215	73	65	86
A,G,T	175	49	105	110
A,T,P	184	58	96	101
G,T,P	167	49	113	110
A,G,C	203	74	77	85
G,C,P	196	70	84	89
A,T,C	171	56	109	103
A,C,P	220	89	60	70
G,T,C	157	50	123	109
T,C,P	166	57	114	102
A,T,B	133	42	147	117
G,B,P	151	52	129	107
G,T,B	118	36	162	123
T,B,P	129	43	151	116
A,B,P	173	70	107	89
A,G,B	155	60	125	99
G,B,C	142	53	138	106
T,B,C	121	42	159	117
A,B,C	163	68	117	91

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TABLE IVa (continued)

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE IV
(439 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
A,G,T,P	165	44	115	115
A,G,C,P	194	65	86	94
A,G,T,C	156	45	124	114
A,T,C,P	163	52	117	107
G,T,C,P	150	46	130	113
A,G,B,P	148	49	132	110
A,G,T,B	116	33	164	126
A,T,B,P	126	40	154	119
G,B,C,P	138	47	142	112
G,T,B,P	112	35	168	124
A,G,B,C	140	50	140	109
A,T,B,C	119	39	161	120
A,B,C,P	156	61	124	98
G,T,B,C	107	35	173	124
T,B,C,P	116	41	164	118
A,G,T,C,P	149	41	131	118
A,G,B,C,P	136	44	144	115
A,G,T,B,P	110	32	170	127
A,G,T,B,C	106	32	174	127
A,T,B,C,P	114	38	166	121
G,T,B,C,P	103	34	177	125
A,G,T,B,C,P	102	31	178	128

* Cell a contains those who received a good grade in first term algebra and who possessed credit in all high school courses shown.

Cell b contains those who did not receive a good grade in first term algebra and who possessed credit in all high school courses shown.

Cell c contains those who received a good grade in first term algebra and who did not possess credit in all high school courses shown.

Cell d contains those who did not receive a good grade in first term algebra and who did not possess credit in all high school courses shown.

TABLE Va

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE V

Courses	Cell a*	Cell b	Cell c	Cell d	Total
G	231	94	44	55	424
A	256	113	6	12	387
G,P	218	78	57	71	424
G,T	177	54	98	95	424
A,T	193	61	69	64	387
G,C	205	79	70	70	424
A,G	221	79	39	43	382
A,P	240	96	22	29	387
G,B	158	63	117	86	424
G,T,P	167	49	108	100	424
A,G,T	174	46	86	76	382
A,G,P	210	67	50	55	382
G,C,P	196	70	79	79	424
A,T,P	183	55	79	70	387
G,T,C	157	50	118	99	424
A,T,C	169	53	93	72	387
A,G,C	196	67	64	55	382
G,B,P	151	52	124	97	424
G,T,B	118	36	157	113	424
A,T,B	131	40	131	85	387
A,C,P	213	83	49	42	387
G,B,C	142	53	133	96	424
A,G,B	150	52	110	70	382
A,G,T,P	165	41	95	81	382
G,T,C,P	150	46	125	103	424
A,G,T,C	155	42	105	80	382
A,G,C,P	189	60	71	62	382
A,G,B,C	135	45	125	77	382
A,T,C,P	162	49	100	76	387
G,B,C,P	138	47	137	102	424
G,T,B,P	112	35	163	114	424
A,G,T,B	115	31	145	91	382
A,G,B,P	144	45	116	77	382
A,T,B,P	125	38	137	87	387
G,T,B,C	107	35	168	114	424
A,T,B,C	117	37	145	88	387

table continued on next page

TABLE Va (continued)

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE V

Courses	Cell a*	Cell b	Cell c	Cell d	Total
A,G,T,C,P	149	38	111	84	382
A,G,T,B,P	110	30	150	92	382
A,G,B,C,P	132	41	128	81	382
G,T,B,C,P	103	34	172	115	424
A,G,T,B,C	105	30	155	92	382
A,T,B,C,P	113	36	149	89	387
A,G,T,B,C,P	102	29	158	93	382

* Cell a contains those who received a good grade in first term algebra and who possessed credit in all high school courses shown.

Cell b contains those who did not receive a good grade in first term algebra and who possessed credit in all high school courses shown.

Cell c contains those who received a good grade in first term algebra and who did not possess credit in all high school courses shown.

Cell d contains those who did not receive a good grade in first term algebra and who did not possess credit in all high school courses shown.

TABLE VIa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE VI
(439 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
G	236	104	44	55
G,T	178	55	102	104
G,P	222	85	58	74
A,T	196	68	84	91
A',G	229	92	51	67
A,G'	230	93	50	66
A,G	234	103	46	56
G,C	209	88	71	71
A,P	255	122	25	37
G,B	162	69	118	90
A,C	239	119	41	40
A',G,T	176	50	104	109
A,G',T	176	53	104	106
A,G,T	177	54	103	105
G,T,P	167	50	113	109
A,G,P	220	84	60	75
A,T,P	185	62	95	97
G,T,C	158	51	122	108
G,C,P	199	77	81	82
A,T,C	171	60	109	99
G,T,B	119	36	161	123
A,T,B	134	44	146	115
A,G,C	207	87	73	72
G,B,P	154	57	126	102
A,C,P	225	104	55	55
A,G,B	161	68	119	91
G,B,C	145	59	135	100
A',G,T,P	165	45	115	114
A,G',T,P	166	48	114	111
A,G,T,P	166	49	114	110
A,G,T,C	157	50	123	109
G,T,C,P	150	47	130	112
A,G,C,P	197	76	83	83
A,T,C,P	163	56	117	103

table continued on next page

TABLE VIa (continued)

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE VI
(439 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
A,G,T,B	118	35	162	124
A,G,B,P	153	56	127	103
A,T,B,P	127	42	153	117
G,T,B,P	112	35	168	124
G,B,C,P	140	52	140	107
G,T,B,C	108	35	172	124
A,T,B,C	119	41	161	118
A,G,B,C	144	58	136	101
A,G,T,C,P	149	46	131	113
A,G,T,B,P	111	34	169	125
A,G,T,B,C	107	34	173	125
A,G,B,C,P	139	51	141	108
G,T,B C,P	103	34	177	125
A,T,B,C,P	114	40	166	119
A,G,T,B,C,P	102	33	178	126

* Cell a contains those who received a good grade in first term algebra and who possessed credit in all high school courses shown.

Cell b contains those who did not receive a good grade in first term algebra and who possessed credit in all high school courses shown.

Cell c contains those who received a good grade in first term algebra and who did not possess credit in all high school courses shown.

Cell d contains those who did not receive a good grade in first term algebra and who did not possess credit in all high school courses shown.

TABLE VIIa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE VII
(419 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
T	182	82	79	76
A	246	132	15	26
G	210	106	51	52
A (4/)	141	64	120	94
A,T	180	75	81	83
G,T	161	65	100	93
G,P	198	90	63	68
T,P	173	74	88	84
A,P	227	113	34	45
A,G	207	101	54	57
T,C	159	73	102	85
G,C	186	91	75	67
A,T,P	171	67	90	91
A,G,T	159	60	102	98
A,G,P	195	85	66	73
G,T,P	153	58	108	100
G,C,P	179	80	82	78
A,T,C	157	67	104	91
G,T,C	143	60	118	98
T,C,P	153	67	108	91
A,G,C	183	87	78	71
A,C,P	201	100	60	58
A,T,B	122	51	139	107
G,T,B	108	44	153	114
G,B,P	138	62	123	96

table continued on next page

TABLE VIIa (continued)

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE VII
(419 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
A,G,T,P	151	53	110	105
A,G,C,P	176	76	85	82
A,T,C,P	151	61	110	97
G,T,C,P	138	54	123	104
A,G,T,C	141	56	120	102
A,G,T,B	107	40	154	118
A,G,B,P	136	58	125	100
A,T,B,P	116	48	145	110
G,T,B,P	103	42	158	116
A,G,T,C,P	136	50	125	108
A,G,T,B,P	102	38	159	120
A,G,B,C,P	124	53	137	105

* Cell a contains those who received a good grade in second term algebra and who possessed credit in all high school courses shown.

Cell b contains those who did not receive a good grade in second term algebra and who possessed credit in all high school courses shown.

Cell c contains those who received a good grade in second term algebra and who did not possess credit in all high school courses shown.

Cell d contains those who did not receive a good grade in second term algebra and who did not possess credit in all high school courses shown.

TABLE VIIIa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE VIII
(415 STUDENTS USED IN EACH COMPARISON INVOLVING TRIGONOMETRY)
(332 STUDENTS USED IN THE COMPARISON WITH ANALYTIC GEOMETRY)

Courses	Cell a*	Cell b	Cell c	Cell d
G	225	90	48	52
T	189	73	84	69
A	255	119	18	23
G,P	210	78	63	64
A,G	221	86	52	56
G,T	169	57	104	85
A,T	185	68	88	74
T,P	178	68	95	74
G,C	197	79	76	63
A,P	234	103	39	39
T,C	166	64	107	78
A,G,P	206	74	67	68
A,G,T	166	53	107	89
G,T,P	159	53	114	89
A,T,P	174	63	99	79
G,C,P	188	71	85	71
A,G,C	193	76	80	66
G,T,C	150	53	123	89
A,T,C	162	60	111	82
T,C,P	158	61	115	81
A,G,T,P	156	49	117	93
A,G,C,P	184	68	89	74
A,G,T,C	147	50	126	92
G,T,C,P	143	50	130	92
A,T,C,P	154	57	119	85
A,G,T,B	110	37	163	105

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TABLE VIIIa (continued)

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE VIII
(415 STUDENTS USED IN EACH COMPARISON INVOLVING TRIGONOMETRY)
(332 STUDENTS USED IN THE COMPARISON WITH ANALYTIC GEOMETRY)

Courses	Cell a*	Cell b	Cell c	Cell d
A,G,T,C,P	140	47	133	95
A,G,T,P	132	50	87	63

* Cell a contains those who received a good grade in the college course and who possessed credit in all high school courses shown.

Cell b contains those who did not receive a good grade in the college course and who possessed credit in all high school courses shown.

Cell c contains those who received a good grade in the college course and who did not possess credit in all high school courses shown.

Cell d contains those who did not receive a good grade in the college course and who did not possess credit in all high school courses shown.

TABLE IXa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE IX
(379 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
P	275	68	14	22
C	271	74	18	16
A	262	69	27	21
G	233	59	56	31
A,P	258	55	31	35
C,P	252	53	37	37
G,P	226	44	63	46
A,C	246	56	43	34
G,C	214	46	75	44
A,G	230	54	59	36
T,C	177	35	112	55
T,P	186	40	103	50
G,T	173	37	116	53
A,T	190	43	99	47
A,C,P	237	42	52	48
A,G,P	223	39	66	51
G,C,P	209	35	80	55
A,G,C	211	42	78	48
T,C,P	172	29	117	61
A,T,C	174	31	115	59
A,T,P	183	35	106	55
G,T,P	167	30	122	60
A,G,T	171	32	118	58
G,T,C	160	29	129	61
B,C,P	177	38	112	52
A,B,C	172	37	117	53
T,B,C	122	23	167	67

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TABLE IXa (continued)

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE IX
(379 STUDENTS USED IN EACH COMPARISON)

Courses	Cell a*	Cell b	Cell c	Cell d
A,G,C,P	206	31	83	59
A,T,C,P	169	25	120	65
A,G,T,P	165	25	124	65
G,T,C,P	156	23	133	67
A,G,T,C	158	25	131	65
A,B,C,P	166	31	123	59
G,B,C,P	146	26	143	64
A,T,B,C	120	21	169	69
T,B,C,P	119	21	170	69
A,G,B,P	151	31	138	59
G,T,B,C	109	19	180	71
A,G,B,C	146	30	143	60
A,G,T,C,P	154	19	135	71
A,G,B,C,P	143	24	146	66
A,T,B,C,P	117	19	172	71
A,G,T,B,C	107	17	182	73
G,T,B,C,P	107	17	182	73
A,G,T,B,C,P	105	15	184	75

* Cell a contains those who received a good grade in chemistry and who possessed credit in all high school courses shown.

Cell b contains those who did not receive a good grade in chemistry and who possessed credit in all high school courses shown.

Cell c contains those who received a good grade in chemistry and who did not possess credit in all high school courses shown.

Cell d contains those who did not receive a good grade in chemistry and who did not possess credit in all high school courses shown.

TABLE Xa

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE X
(347 STUDENTS USED IN EACH COMPARISON INVOLVING FIRST TERM)
(316 STUDENTS USED IN EACH COMPARISON INVOLVING SECOND TERM)
(315 STUDENTS USED IN EACH COMPARISON INVOLVING THIRD TERM)

	Courses	Cell a*	Cell b	Cell c	Cell d
First Term Physics	P	232	86	9	20
	A,P	218	76	23	30
	C,P	210	74	31	32
	G,P	191	64	50	42
	A,G	194	71	47	35
	A,G,P	189	60	52	46
	A,C,P	197	65	44	41
	G,C,P	174	58	67	48
	A,G,C	175	61	66	45
	A,G,C,P	172	54	69	52
	A,G,T,P	139	43	102	63
Second Term Physics	P	230	63	10	13
	C	217	59	23	17
	G,P	191	44	49	32
	C,P	209	52	31	24
	G,C	180	40	60	36
	A,C	202	53	38	23
	G,C,P	176	37	64	39
	A,G,P	187	44	53	32
	A,G,C	176	40	64	36
	A,C,P	194	48	46	28
	G,T,P	141	29	99	47
	G,T,C	133	27	107	49
	A,G,C,P	172	37	68	39
	G,T,C,P	131	24	109	52
	A,G,B,C	124	24	116	52
	A,G,T,P	138	29	102	47
	G,T,B,P	95	16	145	60
	G,T,B,C	91	15	149	61
	A,G,T,C	130	27	110	49
	A,G,B,P	130	27	110	49

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TABLE Xa (continued)

OBSERVED CELL FREQUENCIES
FOR THE COMPARISONS SHOWN IN TABLE X
(347 STUDENTS USED IN EACH COMPARISON INVOLVING FIRST TERM)
(316 STUDENTS USED IN EACH COMPARISON INVOLVING SECOND TERM)
(315 STUDENTS USED IN EACH COMPARISON INVOLVING THIRD TERM)

	Courses	Cell a*	Cell b	Cell c	Cell d
	A,G,T,C,P	128	24	112	52
	G,T,B,C,P	89	14	151	62
	A,G,B,C,P	121	23	119	53
	A,G,T,B,P	93	16	147	60
	A,G,T,B,C	89	15	151	61
	A,G,T,B,C,P	87	14	153	62
Third Term Physics	A,P	214	59	24	18
	A,T,P	155	36	83	41
	A,G,T,P	139	30	99	47
	A,T,C,P	139	31	99	46
	A,G,T,C,P	127	26	111	51

* Cell a contains those who received a good grade in physics and who possessed credit in all high school courses shown.

Cell b contains those who did not receive a good grade in physics and who possessed credit in all high school courses shown.

Cell c contains those who received a good grade in physics and who did not possess credit in all high school courses shown.

Cell d contains those who did not receive a good grade in physics and who did not possess credit in all high school courses shown.

Date Due

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~~JAN 5 1964~~			

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