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The Prediction of Geometry Grades for Seven Linn County, Iowa, Schools

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THE PREDICTION OF GEOMETRY GRADES FOR SEVEN LINN COUNTY, IOWA, SCHOOLS

An Abstract of a Thesis

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Education

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by

Bernice Rosemary Barrow

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It was the purpose of this investigation (1) to determine the relative value of the Algebra I grade, the Iowa Tests of Educational Development quantitative thinking score, and the Iowa Tests of Educational Development composite score in predicting the geometry grade, and (2) to present the findings, using two predictor variables, that would provide the best possible estimate of success in geometry.

The study involved 219 students in seven schools in Linn County, Iowa, who were enrolled in geometry in 1966-67. Selection of the schools was made on the basis of information about the Algebra I and geometry textbooks used. This information was obtained from a questionnaire. Means and standard deviations for each of the predictor variables and the criterion were computed for all seven schools and for each school. Since the means obtained for two of the schools were generally lower and the standard deviations higher than for the other five schools on all variables, further statistical analysis was done grouping those two schools, the remaining five schools, all seven schools, and each school individually.

Correlations were computed between the geometry grade and each of the three predictor variables. Intercorrelations were found between the three predictors. Multiple R's were computed between geometry grades and two predictors. Regression equations based on each of these combinations were derived for the group of seven schools and double-entry expectancy tables were made to display these relationships.

The major findings and conclusions of this study were:

1. The algebra grade was the best single predictor of the geometry grade.

2. The ITED composite score was the poorest predictor of the geometry grade for all seven schools and for the subgroup of five schools. The poorest predictor for the subgroup of two schools was the ITED quantitative thinking score.

3. All correlations obtained for the subgroup of two schools were at least .10 higher than the correlations obtained for all seven schools and the subgroup of five schools.

4. The ITED quantitative thinking test did not predict geometry grades any better than it had predicted algebra grades.

5. The ITED composite score seemed to be a better predictor of the algebra grade than of the geometry grade for both the group of seven schools and the subgroup of five schools.

6. The multiple R's ranged from .59 to .99.

7. The best multiple predictor of the geometry grade for all seven schools and the subgroup of five schools was found by combining the algebra grade and the ITED quantitative thinking score.

8. The best multiple predictor of the geometry grade for the subgroup of two schools was the combination of the algebra grade and ITED composite score.

9. Correlations from this study involving "modern" algebra grades and "modern" geometry grades were generally in agreement with the results

of studies done a quarter of a century earlier, although the multiple correlations were somewhat lower than those obtained in previous studies.

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Entitled: THE PREDICTION OF GEOMETRY GRADES FOR SEVEN LINN COUNTY, IOWA, SCHOOLS

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CHAPTER I

THE PROBLEM

Individual talks with many mathematics teachers, counselors, and school administrators in Linn County, Iowa, seemed to indicate that there was a general agreement that not all students who attend the secondary school should be required to study geometry.[1] As mentioned by many of the mathematics teachers, counselors, and school administrators, some students do not possess the ability necessary to succeed in geometry, nor are they able to profit greatly from its content.

Several of the mathematics teachers who taught geometry expressed concern about the several students they had in each of their geometry classes who were failing. These students, they felt, had been potential failures at the start of the year in geometry. They expressed concern that more guidance had not been given to these "potential failures" when these students were electing their geometry class.

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[1] Joe Barker, Superintendent, North-Linn Community Schools, Troy Mills, Iowa; Earl Carrothers, mathematics teacher, Springville Community Schools, Springville, Iowa; Joe Cashman, Superintendent, Alburnett Community Schools, Alburnett, Iowa; Wilma Davidson, Counselor, Alburnett Community Schools, Alburnett, Iowa; Maurine Fralick, mathematics teacher, Central City Community Schools, Central City, Iowa; Henry Johnson, mathematics teacher, Center Point Consolidated Schools, Center Point, Iowa; Norman Russell, Principal, North-Linn High School, Coggon, Iowa; Robert Smola, Principal and Counselor, Central City Community Schools, Central City, Iowa; Clarence Thompson, mathematics teacher, North-Linn High School, Coggon, Iowa; and Ruth Walker, Counselor, Marion Independent Schools, Marion, Iowa.

All of the counselors who were contacted were aware of the problem these mathematics teachers expressed. The counselors expressed a desire for some valid procedure which could be used to predict success in geometry to use with these potential geometry students.

Statement of the problem. It was the purpose of this investigation (1) to determine the relative value of certain measures available at the time of the study for predicting the grade in "modern" geometry; and (2) to present the findings, using two predictor variables, that would provide the best estimate of success in geometry.

Specifically, this study was designed to answer the following questions:

1. Was the algebra grade an effective predictor of the geometry grade?
2. Was there a higher correlation between the Iowa Tests of Educational Development (ITED) quantitative thinking score and the geometry grade than between the ITED composite score and the geometry grade?[2]
3. Was the ITED quantitative thinking score or the ITED composite score a better predictor of the Algebra I grade than of the geometry grade?

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[2]This commonly used designation of the Iowa Tests of Educational Development, ITED, will be employed at various points throughout the thesis.

4. Was the combination of the algebra grade and the ITED quantitative thinking score a better predictor of the geometry grade than a combination of the algebra grade and the ITED composite score?

Importance of the study. Teachers, counselors, and administrators of a particular school system are always concerned with the continuing problem of estimating future performance of students based on available records. Similarly, when an individual is thinking about taking a particular course, his decision is usually governed by an estimate of his chance of success in the proposed course.

The investigator, as a geometry teacher, became quite concerned about the large number of students in the geometry class who did not have the adequate mathematics background as measured by the ITED quantitative thinking scores and the Algebra I grades to do satisfactory work in geometry. When checking to see what procedures were followed in helping a student decide whether or not to elect geometry, this writer found that essentially only one criterion, the successful completion of Algebra I, was used. Once this criterion was satisfied, the decision as to whether or not to study geometry was left to the student. The only objective factor on which the decision was based was the Algebra I grade. Could such a procedure be defended? Gorecki stated:

> The coefficient of correlation between final algebra numerical grades and plane geometry was high enough to be significant. This author [Gorecki] does not suggest, however, that passing a

> course in algebra automatically qualified a student for success in a plane geometry course.[3]

While conferring with other geometry teachers and counselors in neighboring schools in Linn County, Iowa, the investigator found that the problem of selection of students for geometry was also a problem of great concern to them. While conferring with these teachers and counselors, the investigator inquired as to what factors were taken into consideration when scheduling students for geometry. The most frequent replies were: nine, the desire of the student, a passing grade in Algebra I, and a conference with the counselor. Counselors were concerned when counseling students who were contemplating taking geometry, since they had no valid procedure that they could use with these students to predict their success in geometry. The best the counselors could do when a student asked his chances of probable success or of attaining a certain grade in geometry was to make an "educated guess" from a combination of the counselor's past experiences, and the student's past grades and test results. In a study done by Blick and Bramen on practices used in counseling students prior to enrollment in geometry, the investigators found:

> The estimate of the pupil's ability by the guidance director was used extensively in a greater percentage of small schools than medium and large schools. This practice was used extensively by

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[3] Audrey Gorecki, "The Lee Test of Geometric Aptitude: A Study of Its Use in Predicting Class Success and Its Use in Guidance in the Winona Public Schools" (unpublished Master's thesis, Winona State College, Winona, Minnesota, 1958), p. 34.

a greater percentage of senior high schools and six year high schools than four year high schools.[4]

In view of the foregoing, if counselors are to fulfill their role when counseling students who are contemplating taking geometry, they will need to use a procedure that considers algebra grade, ITED quantitative thinking score, and ITED composite score. These factors apparently are related to success in geometry as measured by geometry grades.

[4]David J. Blick and Shirley E. Bramen, "Some Practices Used in Counseling Students Prior to Enrollment in Elementary Algebra and Plane Geometry," School and Mathematics, LIV (January, 1954), 113.

CHAPTER II

REVIEW OF THE LITERATURE

Prior to 1930, only a few of the large number of predictive studies completed dealt with the prediction of success in high school geometry. After 1930, many studies have dealt with the prediction of success in geometry. Those studies which involved the prediction of algebra grades and/or geometry grades did not involve "modern" algebra or "modern" geometry as defined by this study. Although these studies did not involve "modern" algebra grades or "modern" geometry grades, these studies would show similar relationships between each of the predictor variables and geometry grades as would studies that involve the prediction of "modern" algebra grades and "modern" geometry grades as defined by this study. This investigator expected the findings of this study to show the coefficients of correlation and the multiple coefficients of correlation to be similar to the correlations found in previous studies.

I. PREDICTION OF SUCCESS IN ALGEBRA

Although the next two recent studies involved predicting success in algebra, they provided possible methods of approach for this study. Both studies developed prediction equations. Ivanoff, DeWane, and

Praem[1] used six variables--reading, arithmetic, language, and composite scores from the High School Placement Test, I.Q., and the eighth grade mathematics mark--in their prediction equation for algebra. The composite score correlated the highest, .699, with the algebra mark, while the I.Q. correlated the lowest, .510. Barnes and Asher[2] used ten predictor variables in their prediction equation for algebra. They used the seventh grade mathematics mark, the eighth grade mathematics mark, the seventh grade reading mark, the eighth grade reading mark, the raw score on the Otis Beta I.Q. test given during the eighth grade, the arithmetic and reading grade equivalents of the Iowa Every-Pupil Tests of Basic Skills given during the eighth grade, the grade equivalent on the arithmetic part and on the reading part of the Iowa Every-Pupil Tests of Basic Skills given during the seventh grade, and the raw score on the Orleans Algebra Prognosis Test given during the eighth grade.

The highest correlation, .5881, was between the algebra mark and the eighth grade mathematics mark. A regression equation using six of the ten predictor variables was obtained, and it had a multiple correlation of .6610. The variables used in the regression equation were:

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[1] John M. Ivanoff, Evermode T. DeWane, and O. Praem, "Use of Discriminant Analysis for Selecting Students for Ninth-Grade Algebra or General Mathematics," The Mathematics Teacher, LVIII (May, 1965), 412-416.

[2] Ward Ewing Barnes and John William Asher, "Predicting Student's Success in First Year Algebra," The Mathematics Teacher, LV (December, 1962), 651-654.

seventh and eighth grade mathematics marks, eighth grade reading mark, grade equivalent on the arithmetic and reading part of the Iowa Every-Pupil Tests of Basic Skills for the seventh grade, and the raw score on the algebra prognostic test given during the eighth grade.

II. PREDICTION OF SUCCESS IN GEOMETRY USING VARIABLES OTHER THAN ALGEBRA GRADES

Since 1930, numerous studies have dealt with predicting success in high school geometry. Most of these have not limited their attention to one factor but have studied the effect of a combination of factors on predicting success. There have been many studies directly related to predicting success in geometry that have not used algebra grades as one of their sources of data.

Lee and Hughes[3] were concerned with predicting success in algebra and plane geometry. A group of 213 geometry students was used. The study used the scores from the following variables for predicting first semester success in geometry: the Lee Test of Geometric Aptitude; the Hughes Trait Rating Scale, which was the pooled rating of a student on industry, accuracy, initiative, reliability, cooperation, and leadership given by all of the student's teachers of the previous semester; the geometry teacher's ratings on mathematical ability; the Kuhlmann-Anderson Intelligence Test score; and the Terman Group Test of Mental

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[3]J. Murray Lee and W. Hardes Hughes, "Predicting Success in Algebra and Plane Geometry," School Review, XLII (April, 1934), 188-196.

Maturity. Each of these factors was correlated with achievement in plane geometry as measured by the Orleans Plane Geometry Achievement Test and with the mark given by the geometry teacher at the end of the first semester.

The results showed that the Lee Test of Geometric Aptitude gave the best single prediction of achievement ($r = .63$). The best multiple predictor of the geometry mark was composed of the Kuhlmann-Anderson Intelligence Test, the Lee Test of Geometric Aptitude, and the trait ratings ($R = .67$). The mark received in geometry was predicted almost as well by using just the Lee Test of Geometric Aptitude and the Kuhlmann-Anderson Intelligence Test score ($R = .66$). Lee and Hughes found a correlation of only .36 between the geometry mark the pupil received and his achievement as measured by the Orleans Geometry Achievement Test.

Holzinger and Swineford[4] predicted achievement in geometry using spatial and general deductive factors. Most of the tests in their battery were specially devised at their laboratory with particular emphasis on improving the measure of the spatial factor. The test battery consisted of eight spatial tests and three additional tests--the Series Completion, the Woody-McCall Fundamentals, and the Word Classification--used to measure the general deductive factor. These additional tests

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[4]Karl J. Holzinger and Frances Swineford, "The Relation of Two Bi-Factors to Achievement in Geometry and Other Subjects," Journal of Educational Psychology, XXXVII (May, 1946), 257-265.

were used so that the spatial factor could be separated from, and studied independently of, the general deductive factor. The subjects were 174 pupils in five geometry classes that were taught by four different teachers. They found the following correlations:

		General	Spatial
1.	Series Completion	.857	----
2.	Woody-McCall Mixed Fundamentals	.473	----
3.	Word Classification	.416	----
4.	Visual Imagery	.502	.592
5.	Punched Holes--Verbal	.461	.625
6.	Punched Holes	.570	.654
7.	Cubes	.272	.509
8.	Figures	.442	.455
9.	Form Relations	.391	.552
10.	Pattern Perception	.523	.508
11.	Drawings	.503	.673

The best measure of the general deductive factor was the series completion. The visual imagery test, the punched holes test, and the drawings test appeared the best measures of the spatial factor. The other factor weights for the spatial factor were also substantial. The average intercorrelation of the eleven tests was .418.

The multiple correlation for the general factor and its best estimate from the entire battery was .903; the corresponding coefficient for the spatial factor was .897. The battery as a whole provided an excellent measure of these two factors. Nine months after the factor test battery was administered, an achievement test, the American Council Cooperative Plane Geometry Tests, was given. The correlation between the standardized geometry test and the best estimate of such ability from the entire test battery involving both factors was .768. When correlating the general and spatial factors with the mark received in geometry at the end of the year, the general factor correlated at .584 and the spatial factor at .227.

A comparison of an intelligence test and an achievement test in plane geometry was made by Hummer.[5] Her study involved 154 students. The Otis Group Intelligence Scale and the Columbia Research Bureau Plane Geometry Test were the measuring instruments. Her study showed a correlation of .58 between scores on the Otis Group Intelligence Test and on the Columbia Research Bureau Plane Geometry Test. Achievement in geometry, she found, can be differentiated only at the extremes of intellectual ability. Failure in geometry was likely to occur if the I.Q. was below a limit lying somewhere between 100 and 110.

Several studies using geometry prognosis tests have been done. In 1930, Perry[6] did a study using the Perry Prognosis Test, the Orleans

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[5] Vivian L. Hummer, "A Comparison of I.Q. and Achievement in Plane Geometry," School Science and Mathematics, XXVI (May, 1936), 496-501.

[6] Winona M. Perry, "Prognosis of Abilities to Solve Exercises in Geometry," Journal of Educational Psychology, XXII (November, 1931), 604-609.

Prognosis Test, the Hart Geometry Achievement Test, geometry grades, and I.Q. as measured by the Terman Group Test of Mental Ability. She found that the coefficient of correlation of the Orleans Prognosis Test with the I.Q. was .72. This was the highest correlation. According to Perry, both the Perry Prognosis Test ($r = .61$) and the Orleans Prognosis Test ($r = .66$) predicted achievement in geometry, as measured by the geometry grade, equally well. If achievement in geometry is measured by the Hart Geometry Achievement Test, the Orleans Prognosis Test predicted achievement better ($r = .78$) than the Perry Prognosis Test ($r = .63$).

Gibney's study[7] was concerned with those students who had a score below the critical score of twenty-four on the Lee Geometric Aptitude Test. Forty-nine of the 157 algebra students who were given the Lee Geometric Aptitude Test at Roosevelt High School in Chicago, Illinois, received a score below twenty-four. An experimental program was set up with these forty-nine students. They were segregated into two classes with a different teacher for each class. These two teachers adapted their instruction to the capacities and to the possible rate of progress of their students. At the completion of the experimental program, the Becker-Schrammel Plane Geometry Test was given. Of the forty-nine students who, according to the aptitude test, would probably have failed in a regular geometry class, only ten per cent failed.

[7]Esther F. Gibney, "Aptitude Tests in Relation to the Teaching of Plane Geometry," The Mathematics Teacher, XLII (March, 1949), 181-186.

The New York Rating Scale for School Habits was used by Orleans[8] to measure neatness, interest, ambition, persistence, honesty, initiative, reliability, and stability. The specific ability test in geometry consisted of nine lessons, each followed by an exercise based on the lesson and a summary test at the end. The achievement test used at the end of one semester was the Orleans Plane Geometry Achievement Test. Of the 235 pupils who took geometry, the mean I.Q. from the Otis Self-Administering Intelligence Test was 112.56.

These 235 pupils were from seven schools with from forty-four to seventy-nine pupils in each school. From his study, Orleans found:

1. Correlations between scores on a test of specific ability in geometry and marks representing achievement were in general higher ($r = .45$ to $r = .65$) than those between I.Q.'s and marks in achievement ($r = .51$ to $r = .54$).

2. Using 213 pupils, the combination of the prognosis test and the intelligence test was a slightly better predictor of geometry success ($R = .72$) than the prognosis test was alone ($r = .71$).

3. The range of I.Q.'s of a group of poor pupils segregated on the basis of the test of specific ability was wide enough to make Orleans feel that segregation on the basis of the I.Q.'s would do a grave injustice to a number of pupils.

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[8] Joseph B. Orleans, "A Study of Prognosis of Probable Success in Algebra and in Geometry," The Mathematics Teacher, XXVII (April, 1934), 165-180; (May, 1934), 225-246.

4. Even in a group of poor students who were given a modified geometry course at a much slower pace than was usual, there were some students who were not successful. He felt the very poor students should be eliminated at the beginning of the term. The test of specific ability seemed to predict the failure of these students.

5. The knowledge of the prognosis test scores by the teachers from the very start seemed to be helpful in the heterogeneous groups since the test results seemed to guide the teacher in the treatment of the pupil.

6. A study of the records of individual pupils who scored at the lower end of the distribution of the prognosis test scores over a period of several terms indicated the value of a test of specific ability for guidance.

Ling[9] tried a new approach in helping students decide whether or not to take geometry. All algebra students were given the Lee Test of Geometric Aptitude. Each algebra teacher gave a work habit grade to each algebra student which indicated the attitude the student took toward his responsibility for homework, class recitation, and the subject matter. This work habit grade, his algebra aptitude score, his geometry aptitude score, and all previous arithmetic achievement scores were written on a report card. Using this report card, one teacher did all of the counseling. Charts which showed the results of the previous five years and their relationships with the final geometry grades were

[9] Carmel Ling, "Shall They Take Geometry?" The Mathematics Teacher, XLVII (December, 1954), 567-558.

used as a basis of guidance. After counseling, each student was asked if he were going to take geometry. For those 125 students who indicated "yes," letters were sent to their parents telling them that their son or daughter should:

1. do very well in geometry if he continues as he has in the past.
2. be able to carry geometry in a successful manner if he will apply himself diligently.
3. experience difficulty with geometry but should pass with continuous effort.
4. have great difficulty in understanding geometry and will have trouble passing the course.[10]

Each parent who called the counselor was pleased to get the letter and wanted to know how he could help his child do better in geometry. Some parents also wanted to know whether their child should take geometry if the letter showed their child would have trouble with geometry.

III. PREDICTION OF SUCCESS IN GEOMETRY USING ALGEBRA GRADES

Particularly pertinent to this study were those investigations that used algebra grades as one of the variables in predicting success in geometry. Richardson,[11] with a group of 135 in 1933, conducted a study in which he investigated the factors that affected a student's success in geometry. The only prerequisite for taking plane geometry has been the completion of work in beginning algebra. In determining

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[10] *Ibid.*, 558.

[11] H. D. Richardson, "Predicting Achievement in Plane Geometry," *The Mathematics Teacher*, XXVIII (May, 1935), 310-319.

whether this method was satisfactory, a study was made by Richardson using the I.Q.'s resulting from the Terman Group Mental Test, the Orleans Geometry Prognosis Test scores, the first semester and second semester algebra grades, a teacher's estimate of the student's grades, the research office prognosis, the Iowa Algebra Prognosis Test scores, and a teacher's rating on studiousness.

These factors were correlated with geometry achievement as measured by first semester geometry grades. The lowest correlation (.34) was with the teacher's rating on studiousness. The highest correlation (.70) was with the second semester algebra grade, which was the best single predictor. Other correlations were .67 with the previous mathematics teacher's estimate of ability to learn geometry, .67 with scores on the Orleans Prognostic Tests of ability in geometry, .64 with the research office prognosis, .63 with first semester algebra marks, .50 with I.Q., and .50 with the Iowa Algebra Prognosis Tests scores. Richardson found that, using the multiple correlation technique, the second semester algebra grades and the geometry prognostic test scores together proved to be the best predictor of first semester grades in geometry, with a multiple R of .77.

Hamilton[12] did a study using marks in ninth grade algebra and ninth grade English. Hamilton chose algebra and English because he

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[12] J. Landon Hamilton, "A Method for Reducing Failures in Plane Geometry," Journal of Educational Research, XX (May, 1937), 700-702.

thought success in these two subjects was most closely related to success in geometry. He found a point average by transforming each semester's grade in algebra and each semester's grade in English into an appropriate numerical value such as A = 4, B = 3, C = 2, D = 1, and F = 0. An average of these four grades was found and was called the point average. The point average was considered as one grade for the four semesters of ninth grade work. This point average was correlated with marks or grades received in 10B geometry, and a correlation of .63 (N = 87) and .78 (N = 88) was found using two groups. A point average of 2.00 in ninth grade English and algebra was considered average.

Hamilton concluded from his study that students with a point average below 2.00 either were not ready for or were not capable of passing plane geometry. Students with a point average of 2.00 would be capable of passing geometry provided that they realized their handicap and were willing to put forth the extra effort needed to master geometry. He concluded that students with a point average above 2.00 were capable of mastering geometry and would pass without any undue difficulty.

In the first group of eighty-seven students in his study, there were twelve students who had an average below a C in algebra and ninth grade English. Eleven of these twelve students failed geometry and one received a D. In addition to the twelve students, seven other students failed geometry. Six of these seven students had a C average in algebra and ninth grade English, and one had a C+ average. Similar results were found for the second group of eighty-eight students in which eight of the students who averaged less than C in algebra and ninth grade English failed geometry.

In 1940-41, Davis and Henrick[13] did a study involving a group of 315. They determined the relative effectiveness of the score on the Stewart-Davis Test of Ability in Geometry, the I.Q. on the Otis Self-Administering Test of Mental Ability, the eighth grade arithmetic mark, and the second semester algebra mark in predicting achievement in geometry. Achievement in geometry was measured by an objective teacher-made achievement test in geometry and a standardized achievement test, the Orleans Plane Geometry Test.

It was found that the best single predictor of achievement in geometry was the Stewart-Davis Test of Ability in Geometry. This correlated at .88 with the Orleans Achievement Test and at .89 with a composite achievement score which was the average of two teacher-made tests and the Orleans Plane Geometry Achievement Test. The second best single predictor was the intelligence quotient, which correlated at .85 with the Orleans Achievement Test and at .86 with the composite achievement scores. The algebra mark correlated at .78 with the Orleans Achievement Test and at .87 with the composite achievement score. Marks in arithmetic had limited value ($r = .59$) in predicting achievement in plane geometry. The best predictor was a combination

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[13]Robert A. Davis and Marguerite Henrick, "Predicting Accomplishment in Plane Geometry," School Science and Mathematics, XLV (May, 1945), 403-405.

of the Stewart-Davis Test and algebra marks. This combination correlated at .89 with the Orleans Achievement Test and at .95 with the composite achievement score. A combination of the Stewart-Davis Test and the intelligence quotient correlated with the achievement test in geometry at .86 and at .91 with the composite achievement score. The combination of the Stewart-Davis Test and the intelligence quotient had about the same predictive value as the combination of the algebra mark and the intelligence quotient, which correlated with the achievement test at .85 and with the composite achievement score at .91.

Sanders,[14] with a group of eighty-three, studied the prediction of success in plane geometry using I.Q.'s from the Otis Intelligence Test, prognosis scores, eighth grade English marks, and first year algebra marks. He drew the following conclusions from the results of his study:

1. Algebra marks have no value in predicting success in plane geometry (r = .506). The higher the pupil's mark in first year algebra, the lower the prediction mark in plane geometry.
2. I.Q.'s and prognosis scores were not sufficiently reliable, as measured by the size of the correlation coefficient, for predicting success in plane geometry.
3. The correlation of the eighth grade English marks with geometry marks (.554) indicated that these grades would be a better predictor

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[14] C. R. Sanders, "A Study in Prognosis of Success in Plane Geometry" (unpublished Master's thesis, Louisiana State University, Baton Rouge, 1935).

of success in geometry than I.Q.'s (r = .502), prognosis scores (r = .40), or algebra grades (r = .506), but not sufficiently better to be significant.

4. The highest multiple correlation of .833 was found when all of the factors were used.

5. The correlation between the predicted marks and the actual marks of achievement in plane geometry was .30.

Sutton,[15] using a group of 145, studied the prediction of success in geometry using as predictor variables the average of the marks assigned in the eighth and the ninth grade, the I.Q. from the Otis Intelligence Test, the eighth grade arithmetic mark, the first year algebra mark, the standardized test scores in algebra, the biology mark, the age of the pupil, and the sex of the pupil. He found that the average of the eighth and ninth grade marks was the best predictor of success in geometry (r = .613). I.Q.'s were a poor predictor (r = .362). Eighth grade arithmetic marks (r = .494), marks assigned for biology (r = .502), and sex did not yield sufficiently high correlations to be used as single predictors. First year algebra grades (r = .559) and the standardized algebra test scores (r = .584) had a fair degree of correlation with plane geometry grades. Sutton

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[15] Robert Orren Sutton, "Who Should Study Geometry? A Study in Predicting Success in Plane Geometry" (unpublished Master's thesis, Louisiana State University, Baton Rouge, 1936).

found that age was a factor. The best ages for learning geometry were the years between fifteen and eighteen. The multiple R using I.Q.'s, arithmetic marks, algebra marks, and biology marks was .780. From the findings of his study, Sutton believed that teachers' marks of achievement measured factors other than achievement. Success in geometry seemed to depend upon the teacher and these other factors.

Cooke and Pearson[16] studied the relative prognostic value of the _Orleans Geometry Prognosis Test_, the _Terman Group Test of Mental Ability_, and the grade earned in beginning algebra to predict achievement in geometry as measured by the _Columbia Research Bureau Plane Geometry Test_ and the grade received in geometry. Their study involved nine high schools and 195 students. Two multiple regression equations were then derived. One used the _Columbia Research Bureau Plane Geometry Test_ score as the dependent variable, and the other used the mark received in geometry as the dependent variable. Their findings showed:

1. The highest correlation was between the teacher's mark in plane geometry and the teacher's mark in algebra ($r = .546$).

2. A combination of the three prognostic factors gave the most accurate prediction of achievement in plane geometry as measured by the _Columbia Research Bureau Plane Geometry Test_ ($R = .747$).

3. Neither of the prognostic instruments taken alone nor all of them in combination predicted achievement in plane geometry with sufficient

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[16]Dennis H. Cooke and John M. Pearson, "Predicting Achievement in Plane Geometry," _School Science and Mathematics_, XXXIII (November, 1933), 872-878.

accuracy to warrant their use as the final and only factors.[17] They felt that the following factors probably had some influence on achievement in geometry: a pupil's school habits, such as regularity of homework, attentiveness in the classroom, originality, initiative, and perseverance; external factors that influence a pupil's school work, such as opportunities for home study, number of hours of outside work, number of children in the family, and attitude of the parents toward school achievement.

Crane,[18] in 1941, did a study to find a reliable method of predicting achievement in plane geometry. She investigated the possibilities of using such factors as intelligence, age, social background, the pupil's attitude toward geometry, the estimate of the pupil's ability to do geometry successfully as predicted by the Orleans Geometry Prognosis Test, and the marks received in algebra, English, social studies, and foreign language. A multiple R of .686 was found when previous marks in algebra, English, social studies, and foreign language were correlated with geometry marks. By adding to these the Orleans Prognosis Test and I.Q., the multiple coefficient of correlation was raised to .733. The following coefficients of correlation (r) were

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[17] Cooke and Pearson felt the coefficients of multiple correlation should be greater than .75 to predict achievement in geometry with sufficient accuracy.

[18] Mary P. Crane, "The Prediction of Success in Plane Geometry," (unpublished Master's thesis, Wayne University, Detroit, 1941).

found: .659 with English marks, .635 with I.Q., .577 with algebra marks, and .501 with the Orleans Test. Her findings showed:

> Although the prognosis test alone could not be used to predict the teachers' marks in first semester geometry with any degree of success, when combined with intelligence and past marks a regression equation could be derived which actually did predict the teachers' marks in 48.3% of the cases. In 79.3% of the cases the predicted mark differed from the mark received by less than one full mark.[19]
>
> In trying to discover the "factors other than ability" which might be expected to influence achievement, we had no discernable success. So far as we were able to discover, motive, attitude, home environment, study conditions, or the education of their parents had little if any effect upon geometry achievement, for there seemed to be as many who succeeded under any particular condition as there were those who failed.[20]

From a study carried on by Lee and Lee,[21] with a group drawn from two previous studies, some conclusions were drawn pertaining to the relationship between algebra marks and geometry marks. Since there was a time interval of one year between the earlier studies and since two of the schools were used in both studies, there were complete records in both algebra and geometry for the 181 pupils. The variables used were the Lee Test of Algebraic Ability, the Lee Test of Geometric Aptitude, the Renfrow Geometry Test, scores from an algebra

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[19] Ibid., p. 37.

[20] Ibid.

[21] Dorris May Lee and J. Murray Lee, "Some Relationships Between Algebra and Geometry," Journal of Educational Psychology, XLII (October, 1931), 551-560.

achievement test, and first semester grades in algebra and geometry. Their findings revealed the following:

1. The correlation between the ability to do algebra and the ability to do geometry fell between .50 and .65.

2. The correlation between achievement in algebra and in geometry probably fell between .40 and .70.

3. The correlations between ability in algebra and ability in geometry were usually higher and more consistent than those of achievement in algebra and achievement in geometry.

4. About 40 per cent of the pupils showed differences between algebra and geometry with respect to both ability and achievement that could not be attributed to chance.

5. Some factor, other than ability and achievement, was entering into school marks in these two subjects.

6. Students who took geometry were a select part of the group that had taken algebra the year before.

7. Pupils receiving low marks in algebra did not, as a rule, take geometry.

8. Pupils were likely to receive a lower mark in geometry than they received in algebra.

9. It seemed more difficult to determine the failing point for a pupil in geometry than it was in algebra.

About the use of the algebra grade as a predictor of success in geometry, the Lees said, "Better guidance of a pupil in geometry is possible by using tests of ability to do geometry than by using the algebra record. The two, however, should be used together."[22]

IV. PREDICTION OF SUCCESS IN MATHEMATICS USING THE IOWA TESTS OF EDUCATIONAL DEVELOPMENT

Graham,[23] in a study for his master's thesis, arrived at a three-variable equation for predicting success in algebra using the score of Test 4, Quantitative Thinking, of the Iowa Tests of Educational Development, the composite score from the Iowa Tests of Educational Development, and the intelligence quotient from the Otis Quick-Scoring Mental Ability Test. His study involved 122 students from the same high school within a three-year span of time. Graham found the following correlations with algebra grades: quantitative thinking score .743, composite score .689, and I.Q. .702. The interrelationship of the variables showed that the quantitative score and the I.Q. correlated at .741, while the composite score and the I.Q. correlated at .740. The coefficient of multiple correlation using all of the variables was .78. Using two samples, Graham found his regression equation to be 64 per cent and 76 per cent accurate in the prediction of algebra grades.

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[22] Ibid., p. 196.

[23] Leslie Milton Graham, "A Study in Predicting Success in Algebra" (unpublished Master's thesis, Iowa State Teacher's College, Cedar Falls, 1957).

Robertson's study[24] used the scores from each test as well as the composite score of the Iowa Tests of Educational Development together with the grade point average obtained from marks in all classes in ninth and tenth grade as the variables to determine who could best succeed in science, mathematics, and foreign language as measured by the mark received in each subject. His study showed that the grade point average taken from teachers' marks in the ninth and tenth grades proved to be the best predictor of success as shown by marks received in elementary mathematics ($r = .72$) and advanced mathematics ($r = .68$). The next best predictor of success in mathematics was Test 3, Correctness and Appropriateness of Expression, of the ITED, with a correlation of .50 in advanced mathematics and a correlation of .54 in elementary mathematics. The third best predictor of success in advanced mathematics ($r = .48$) and elementary mathematics ($r = .47$) was the composite score of the ITED. The poorest predictor was the quantitative thinking score of the ITED. It correlated at .42 with marks received in advanced mathematics and at .43 with marks received in elementary mathematics. From his study, Robertson concluded, "The ITED may be used to determine the standing of the school in terms of the Tests' rather impressive norms, but they should not be used to predict academic success in mathematics, science, and foreign language."[25]

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[24] James R. Robertson, "Predicting Success at Highland High School from the Iowa Tests of Educational Development" (unpublished Master's thesis, University of Utah, Salt Lake City, 1959).

[25] Ibid., p. 36.

Slaichert's study[26] used four variables to predict academic achievement in plane geometry. The four were: intelligence quotient, score on the quantitative thinking test of ITED, score on the quantitative test of the American Council on Education Psychological Examination, and marks received in Algebra I. The correlations were .7534, .7079, .6683, and .5904 respectively. When all four variables were used, a multiple correlation of .8299 was obtained.

Busse,[27] in his master's thesis, reported a high positive correlation between separate test scores of the ITED and high school marks in the same field. The correlation of the quantitative thinking test with the sophomore mathematics grade was .58 (N = 110). The correlation of the other high school mathematics grades with the same test were: seniors, .78 (N = 97); juniors, .74 (N = 86); freshmen, .67 (N = 120); and the average, .69 (N = 214).

V. COUNSELING OF STUDENTS PRIOR TO ENROLLMENT IN GEOMETRY

Blick and Bramen[28] obtained their information about practices used in counseling students prior to their enrollment in geometry from a questionnaire sent to all secondary school principals in Connecticut

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[26] William M. Slaichert, "Predicting Academic Achievement in Plane Geometry" (unpublished Master's thesis, Iowa State College, Ames, 1947).

[27] Allen Busse, "The Correlation Between the Iowa Tests of Educational Development Score and High School Marks in the Same Field" (unpublished Master's thesis, State University of Iowa, Iowa City, 1952).

[28] Blick and Bramen, op. cit., pp. 107-115.

in 1952. The questionnaire included ten possible practices that could be used to predict success in geometry. Space was allowed for the insertion of any other practices that were being used. The results of this study shows:

1. The elementary algebra mark and the estimate of the pupil's ability by the algebra teacher were the practices used extensively in most of the schools. The general intelligence test scores and the estimate of the pupil's ability by the guidance director were also used extensively in a large percentage of the schools. Combinations of these four practices were used more often than a single practice was used.

2. The extensive use of the algebra mark and previous year's marks in all subjects decreased as the size of the schools decreased. A greater percentage of large schools used marks extensively than small schools.

3. A greater percentage of small and medium schools used the estimate of the pupil's ability by the algebra teacher more extensively than large schools.

4. General intelligence test scores were used more extensively by a greater percentage of medium and large schools than small schools.

5. The estimate of the pupil's ability by the guidance director was used extensively in a greater percentage of small schools than medium and large schools and sometimes in a greater percentage of medium and large schools than small schools. This practice was used extensively by a greater percentage of senior high schools and six-year high schools than four-year high schools.

6. The estimate of the pupil's ability by the geometry teacher was used extensively by small schools more often than by large schools.

7. A greater percentage of large schools <u>never</u> used the estimate of the pupil's ability to succeed in geometry by the secondary principal and rank in algebra class than did small schools. A much greater percentage of the senior high Schools <u>never</u> used the rank in algebra class than did the other schools.

8. Battery of aptitude tests scores were <u>never</u> used in a much greater percentage of medium and large schools than in small

schools. This practice was never used in a much greater percentage of six- and four-year high schools than in senior high schools.

9. The geometry aptitude test scores were not used, but it was indicated that they should be used in most of the schools.

10. Parent and pupil wishes and vocational and educational plans were considered the most important additional practices.

11. The six junior high schools that reported counseling for plane geometry used a combination of several practices. Elementary algebra mark, previous year's mark in all subjects, general intelligence test scores, estimate of pupils' ability by the algebra teacher and guidance director were used by all the six schools.[29]

Kraft[30] found the need for consistent and valid basic facts in guiding students of mathematics. In Cleveland, geometry students were given the Orleans Prognosis Test during their freshman year. By doubling this prognosis test score and adding the student's mental test rating as measured by a group test, a geometry aptitude index was established. Pupils with a geometry aptitude index of 145 and below, those within the lowest 10 per cent on the geometry aptitude index, were not encouraged to enroll in geometry classes. Pupils with a geometry aptitude index of 180 and above were counseled and urged to take geometry. For those students with a geometry aptitude index of 145 to 180, the counselor used additional evidence, such as previous success in schoolwork, especially in algebra, in counseling these students.

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[29] Ibid., pp. 113-114.

[30] Ona Kraft, "Methods Used in the Selection of Pupils for the Study of Algebra and Geometry in Cleveland," The Mathematics Teacher, XXVIII (December, 1935), 236-239.

In one Cleveland school where the geometry aptitude index had been used with ninety-one students before they enrolled in geometry, 73 per cent of the students receiving A and B grades had a geometry aptitude index of 180 and above, 22 per cent were in the 145 to 180 geometry aptitude index range, and one pupil with a geometry index of 145 and below made a good grade. Although there was not a decrease in the number of failures after using the geometry aptitude index, the mathematics teachers felt that a larger percentage of those who passed geometry really understood geometry.

VI. SUMMARY

Douglas,[31] after reviewing the literature, stated that future achievement in geometry can best be predicted by using: (1) a good prognostic test, (2) the pupil's average mark in the previous year's school work, (3) the pupil's I.Q. rating, (4) the former teacher's estimate of the pupil's future success, (5) the pupil's mental age, and (6) the mark received in algebra. He listed these in the order of their validity for predicting geometry grades although there was little difference between variables one and two, variables three and four, and variables five, six, and seven. Douglas made the following statements:

1. Achievement in algebra and geometry may be predicted with a fair degree of accuracy only.

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[31] Harl R. Douglas, "The Prediction of Pupil Success in High School Mathematics," The Mathematics Teacher, XXVIII (December, 1935), 489-492.

2. Achievement cannot be predicted satisfactorily from any one variable for the purposes of homogeneous or ability grouping or definite advice relative to taking or not taking algebra or geometry.

3. Achievement is best predicted by a combination of the following variables--a good prognostic test, I.Q., and the average mark in the previous year or two years of school work.

Although these studies are old and might appear to show conflicting results, they were helpful in providing the necessary background and assistance needed for this study. Few studies pertaining to the prediction of success in geometry have been done within the last twenty years. This writer examined the Review of Educational Research, the Encyclopedia of Educational Research, and Research in Education to verify that no additional studies on the prediction of success in geometry had been carried out within the last quarter of a century. This writer attributes the lack of studies done in this area to the emergence of the "modern mathematics concept." The "modern mathematics concept" created a new interest in the techniques of teaching mathematics. Studies in mathematics within the last quarter of a century as reported in the Review of Educational Research, the Encyclopedia of Educational Research, and Research Studies in Education were mainly concerned with: the content of "modern" mathematics courses, programmed instruction, mathematics by television, comparisons and effectiveness of teaching techniques and of mathematics course work.

The review of the literature might appear to show conflicting results. In general, the studies showed the correlation of the algebra grade with the geometry grade to lie somewhere between .55 and .75. Most of the studies showed the algebra grade to be the best predictor of success in geometry as measured by the grade received in geometry. This writer does not believe the results of these studies to be in conflict, since certain factors may not have been controlled in the same manner when each of the studies was done. Before it is decided that these studies show conflicting results, the following questions should be considered:

1. Does one study use a large number of students and another use a small or inadequate number of students?

2. Does the geographical location have a bearing on the results of the study?

3. Did the teachers who assigned marks in algebra (or geometry) evaluate achievement in the same way?

4. Were the studies done in different size schools?

5. Was the algebra and geometry course content the same in all schools involved in the studies?

6. Did the algebra grades predict success in geometry as measured by achievement tests or geometry grades?

These studies were helpful in providing the necessary background and assistance needed for this study. If the present study, which involved "modern" algebra grades and "modern" geometry grades showed results similar to those of Lee and Lee's study, the coefficient of correlation for the algebra grade and the geometry grade would probably fall between .40 and .75. The ITED quantitative thinking score would probably correlate with the geometry grade so as to yield a coefficient which would fall between .58 and .71 as shown by the studies done by Slaichert and Busse. Unfortunately, the previous studies provided little background as to the correlation of the ITED composite score and the geometry grade.

The review of the literature also provided some of the techniques and procedures that were used in this study, such as correlations, intercorrelations, and multiple regression equations. Even though the studies done by Graham, Ivanoff, DeWane, and Praem, and Barnes and Asher were not concerned with the prediction of success in geometry but with the prediction of success in algebra, these studies suggested procedures and were helpful for the approach used in the present study.

CHAPTER III

PROCEDURE

The purpose of this study was: (1) to investigate the relative value of certain measures available at the time of the study for predicting the grade in "modern" geometry; and (2) to present the findings, using two predictor variables, that would provide the best possible estimate of success in geometry.

Selection of the variables. The independent variables used in this study were the 1965-66 Algebra I grade, the *Iowa Tests of Educational Development* quantitative thinking score, and the *Iowa Tests of Educational Development* composite score.[1] The dependent variable used was the first semester 1966-67 geometry grade. These variables were selected on the basis of the following considerations:

1. The Algebra I grade has been extensively employed in counseling students contemplating taking geometry. Many studies have utilized the Algebra I grade when predicting success in geometry. In all of the schools used in the study, Algebra I was a prerequisite for taking geometry. Therefore, the Algebra I grade was available for all the subjects.
2. The *ITED* was chosen because of its availability for the study. All schools employed in the study had scores available within the

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[1]For information regarding the *Iowa Tests of Educational Development*, see Appendix A.

last two years from the *ITED* for each of their students. The investigator found, in her search of the related literature, that few studies had been done on the validity of the *ITED* scores as predictors of success in geometry.

3. The quantitative thinking scores of the *ITED* reflected the general mathematical background of the student. Few studies had been done on the relationship of this score to the grade received in mathematics classes.

4. The composite score of the *ITED* was an overall measure of the general achievement of the student. Few studies had been done on the relationship of the student's overall general achievement to his success in geometry.

5. Several of the schools used in the study had just begun their "modern" mathematics programs when the subjects were in Algebra I. Because of this recent change to "modern" mathematics, first semester geometry grades were the only "modern" geometry grades available at the time information for this study was gathered.

6. An Algebra I standardized achievement test or a geometry achievement test had not been used in many of the schools involved in the study.

7. None of the geometry prognostic tests available at the time of this study used "modern" algebra and "modern" geometry terminology, nor did they predict success in "modern" geometry. Many of the schools involved in the study did not use a geometry prognostic test before their students took geometry.

Selection of the schools. The data for this study were obtained from seven of the sixteen public secondary schools in Linn County, Iowa. Four of the schools in the Cedar Rapids school district were eliminated from this study because they had a more complete guidance department than the remaining schools; and, consequently, probably more care had been taken in the selection of students for geometry. Only those students who did well in algebra had been advised to elect geometry. Each of these four schools had had counselors for a number of years. In these four schools, guidance had played a major role in helping students decide whether to elect geometry. The guidance departments were well developed, the counselors were specializing, and a standardized testing program was being used.

If data obtained from these four schools had been used, the major part of the study would have involved students from these schools since they had the largest enrollment. The enrollment of these four schools ranged from about one thousand to three thousand as compared with a range of enrollment of 72 to 568 in the seven schools used in the study.

Other schools were eliminated from the remaining group of twelve schools because of the type of geometry course being taught. Only data from those schools which taught from "modern" geometry textbooks were used. Five more schools were eliminated because they were not teaching from "modern" geometry textbooks. This left seven schools for inclusion in the study.

Gathering the data. First, a questionnaire with an accompanying letter and return envelope was sent to the algebra and/or geometry teacher in each of the twelve high schools surrounding Cedar Rapids in Linn County, Iowa.[2] These twelve schools were chosen because of their proximity to each other. The twelve schools were somewhat alike in their mathematics curriculum and in their guidance program. The main purpose of the questionnaire was to obtain information to be used to determine which schools taught "modern" algebra and "modern" geometry. The names of the algebra and geometry textbooks used, the number of years the present textbooks had been used in the school, the number of students enrolled in geometry, what per cent of the geometry students received grades of A, B, C, D, or F, and the factors taken into consideration when scheduling students for geometry were requested in the questionnaire. Eight schools returned the questionnaires within three weeks. At the end of the third week, another letter was sent to the same teachers in the remaining four schools.[3] This letter asked them to complete and

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[2]The letter and questionnaire appear in Appendix B.

[3]This letter appears in Appendix C.

return the questionnaire. Within a week, the remaining questionnaires were returned.

An analysis of the replies to the questionnaire showed two schools, which used the same geometry textbook, had replied differently as to whether they were teaching "modern" geometry.[4] Consequently, the reply on the questionnaire as to whether the course being taught was "modern" geometry or not could not always be taken at face value.

Since this problem had not been anticipated, some criteria for defining "modern" algebra and "modern" geometry had to be developed. The textbook content was used as the criterion for selecting the schools for this study.

After examining many "modern" geometry textbooks and "modern" algebra textbooks, this writer found not all "modern" algebra nor "modern" geometry textbooks included the same topics; and even when the topics treated were the same, the degree of emphasis varied. Therefore, a list of the characteristics of a "modern" geometry and a "modern" algebra textbook was made. The characteristics were then somewhat revised after a conference with Dr. Schurrer.[5] It was felt

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[4] According to the criteria the textbooks were judged against later, the textbooks were not "modern."

[5] Dr. Augusta Schurrer is presently a member of the mathematics faculty at the University of Northern Iowa, Cedar Falls, Iowa.

that a list of minimum characteristics must be included for a textbook to be called a "modern" geometry or a "modern" algebra textbook.

The characteristics of a presentation of Euclidean geometry which, for the purposes of this study, will be considered as "modern" are the following:

1. Emphasis on the axiomatic bases of geometry with concern for the clarification of those assumptions which were tacitly taken for granted by Euclid and the use of these in proof. Clarification of the assumptions of betweenness and separation (half-plane, half-line, rays, etc.).
2. A discussion of space as well as plane geometry.
3. An introduction to convex plane sets.
4. Substantial treatment of coordinate geometry.
5. Some work in elementary logic.

All of the above must be considered in a "modern" geometry course. The decision as to whether or not a school taught a "modern" geometry course was based solely on the content of the textbook used in the course. If the textbook did not possess all the characteristics indicated above, it was, for the purposes of this study, not considered to be "modern." It is realized that one and five will be included in varying degrees. It is also realized that even though these topics are found in a "modern" geometry textbook, it is the teacher's decision as to how thoroughly these will be taught.

The decision as to whether a school teaches a "modern" algebra course was again based entirely upon the content of the textbook used. For the purposes of this study, the characteristics of a first year algebra textbook which could serve as the basis for a "modern" course are the following:

1. A discussion of set and subset, and the application of these to the study of equations, inequalities, and coordinate geometry.

2. A presentation and application of field and order axioms for the rational and real number systems.

3. Some work in elementary logic.

4. An introduction to coordinate geometry and the use of its techniques to describe some of the basic plane figures (point, line, ray, angle) as well as an investigation of the geometric relations of parallelism, perpendicularity, betweenness, separation (half-plane, half-line) in plane and space figures.

A text which is called "modern" will include all of these. The extent to which they appear in a particular course is controlled not only by the choice of text, but also by the manner in which the text is used.

Seven schools' geometry textbooks met the criteria for "modern" geometry. Coincidentally, the same seven schools' algebra textbooks met the criteria used for "modern" algebra. Five schools were, therefore, eliminated because their algebra and geometry textbooks did not meet the criteria.

The size of six of the seven towns or school districts ranged from about 800 to 2600 as shown on page 41.

School	Population of Community[6]	High School Enrollment[7]	Number of Students Used in the Study
A	1227	104	18
B	2593	316	38
C	785	162	24
D	1236	180	16
E	198	72	16
F	1087	267	47
G	----	568	60

School G was a rural school and took in a portion of the outlying population of Cedar Rapids, Iowa. Therefore, no population figures were available for that school district. All seven of these schools were located within twenty-five miles of Cedar Rapids, Iowa, a city of approximately 101,000. Most of the parents of the students used in this study either farmed in the region around Cedar Rapids or worked in the city itself.

The high school enrollment of these seven schools ranged from 72 to 568. In many of these schools there were just one or two teachers teaching mathematics. Therefore, in some of the schools the same teacher might have been teaching both algebra and geometry. Three of the seven schools (B, C, and E) did not have a counselor. The other four

[6]From 1960 census.

[7]From 1966-67 Educational Directory of Linn County, Iowa.

schools each had one counselor. The guidance program was just being developed in each of these four schools.

The questionnaires returned from these seven schools showed that School A gave no D or F grade to their students in geometry, School B gave no A grade to their students, and Schools C and F gave no F grade to their students as a geometry grade for the first semester. The criteria or procedures these seven schools used when scheduling their students for geometry were the following:

School	Factors
A	A passing grade in Algebra I and a conference with the counselor.
B	A passing grade in Algebra I.
C	None was listed
D	A passing grade in Algebra I and the desire of the student to enroll in geometry.
E	None.
F	A passing grade in Algebra I and the desire of the student to enroll in geometry.
G	A passing grade in Algebra I and the algebra teacher's approval.

After the questionnaires were analyzed, the writer secured the Algebra I grades, geometry grades, and ITED scores from the cumulative records of four schools. A letter; a dittoed form sheet, devised by the writer, for recording the data with the name of the students to be used in the study; and an addressed envelope for returning the information was sent to the principals of the remaining three schools.[8] Prompt replies containing the Algebra I grades, geometry grades, and ITED scores were obtained from these three schools.

Processing the data. The system of marking in Linn County during the period in which the data were gathered for the study was based upon the letters A, B, C, D, and F. To quantify the marks, a five-point transformation table, as shown below, was used.

Grade	A	B	C	D	F
Value	5	4	3	2	1

The school supplied either the year algebra grade or the semester grades for Algebra I. The algebra grade for the year was obtained, unless supplied by the school, by finding the average of the first semester and the second semester algebra grades.

The sums of scores, sums of squares, and the cross products for the four variables were computed. With these figures at hand, the means, standard deviations, Pearson Product Moment correlation coefficients, multiple correlation coefficients, and prediction equations using two predictor variables were computed. Double-entry expectancy tables were constructed using the same basic data because these should prove to be a more useful device than the multiple R for school counselors.

[8]The letter and form sheet appear in Appendix D.

Limitations of the study. This study did not attempt to treat all the factors involved in predicting success in geometry. No allowance was made for effort, personal interests, attitudes, or teacher-pupil relationships. Neither did this study attempt to study the criteria teachers used in grading, the methods used, and the materials covered in the algebra and geometry courses, nor the manner in which the ITED tests were administered. Since Test 4 of the ITED, Quantitative Thinking, was an aptitude measure rather than an achievement measure, the writer was aware that Test 4 did not possess curricular or content validity. The writer wanted to determine whether Test 4, as used in this study, possessed predictive validity.

CHAPTER IV

ANALYSIS OF THE DATA

Analysis of the collected data was approached by seeking answers to the following questions:

1. Was the algebra grade an effective predictor of the geometry grade?
2. Was there a higher correlation between the *ITED* quantitative thinking score and the geometry grade than between the *ITED* composite score and the geometry grade?
3. Was the *ITED* quantitative score (or the *ITED* composite score) a better predictor of the Algebra I grade than of the geometry grade?
4. Was the combination of the algebra grade and the *ITED* quantitative thinking score a better predictor of the geometry grade than a combination of the algebra grade and the *ITED* composite score?

I. GROUPING THE SCHOOLS PRIOR TO STATISTICAL ANALYSIS

Prior to the statistical analysis, the investigator found by checking the grades and scores obtained from School E that seven of the sixteen students, or 43 per cent, received a D in Algebra I. Of the twenty-nine D's and F's given in Algebra I in all seven schools, 27 per cent of these low grades were from School E. Similar results were found for School E for the geometry grades.

Also of concern to the investigator was that nine of the total twenty-nine D and F marks in Algebra I, or 35 per cent, came from

School F. The mean of the ITED quantitative thinking score of School F, Table I, was lower than that of any other school, except for School E and School G. School F exhibited a larger standard deviation than that of any of the other schools, except School E. School F also had a standard deviation for its ITED composite score larger than the other schools except for School E. In checking these ITED scores, the investigator found that there were twenty-one ITED quantitative thinking scores in the category 0 to 10. Of these twenty-one, seventeen were for pupils in Schools E and F. Nine of the thirteen scores in the category 0 to 10 for the ITED composite score were from the same two schools. Since the grades and scores of the students from these two schools were unusually lower than the grades and scores from the remaining five schools used in the study, this writer chose to do statistical analyses on the data from Schools E and F, on that from the remaining five schools, and on that from all seven schools, as well as for each individual school.

II. ALGEBRA GRADE AND ITED SCORES AS PREDICTORS OF THE GEOMETRY GRADE

Analysis of the data was made to determine the relationship between the algebra grade and the geometry grade, between the ITED quantitative thinking score and the geometry grade, and between the ITED composite score and the geometry grade. Table II, page 48, shows a comparison of the means and standard deviations for the subgroup of

TABLE I

MEANS AND STANDARD DEVIATIONS OF GEOMETRY GRADES, ALGEBRA GRADES, ITED QUANTITATIVE THINKING SCORES, AND ITED COMPOSITE SCORES FOR INDIVIDUAL SCHOOLS AND TOTAL

School	Number	Variable	Mean	Standard Deviation
A	18	Geometry Grade	3.72	.65
		Algebra Grade	3.36	.93
		Quantitative Thinking Score	18.11	3.65
		Composite Score	19.33	3.67
B	38	Geometry Grade	2.87	.80
		Algebra Grade	3.54	.82
		Quantitative Thinking Score	18.92	4.11
		Composite Score	19.92	4.20
C	24	Geometry Grade	3.71	.89
		Algebra Grade	4.02	.82
		Quantitative Thinking Score	17.71	4.56
		Composite Score	20.04	5.02
D	16	Geometry Grade	2.94	.90
		Algebra Grade	3.63	.70
		Quantitative Thinking Score	18.31	4.12
		Composite Score	19.56	4.54
E	16	Geometry Grade	2.63	1.17
		Algebra Grade	3.41	1.28
		Quantitative Thinking Score	12.38	7.01
		Composite Score	13.13	6.63
F	47	Geometry Grade	3.45	.87
		Algebra Grade	3.37	.81
		Quantitative Thinking Score	15.00	5.14
		Composite Score	18.51	5.95
G	60	Geometry Grade	3.22	.94
		Algebra Grade	3.13	.90
		Quantitative Thinking Score	15.00	3.87
		Composite Score	17.13	4.02
7 schools	219	Geometry Grade	3.24	.95
		Algebra Grade	3.42	.92
		Quantitative Thinking Score	16.76	5.02
		Composite Score	18.34	5.06

TABLE II

MEANS AND STANDARD DEVIATIONS OF GEOMETRY GRADES, ALGEBRA GRADES, ITED QUANTITATIVE THINKING SCORES, AND ITED COMPOSITE SCORES FOR SEVEN SCHOOLS, FIVE SCHOOLS, AND TWO SCHOOLS

School	Number	Variable	Mean	Standard Deviation
7 Schools	219	Geometry Grade	3.24	.95
		Algebra Grade	3.42	.92
		Quantitative Thinking Score	16.76	5.02
		Composite Score	18.34	5.06
5 Schools	156	Geometry Grade	3.24	.91
		Algebra Grade	3.43	.91
		Quantitative Thinking Score	17.74	4.30
		Composite Score	18.76	4.49
2 Schools	63	Geometry Grade	3.24	1.02
		Algebra Grade	3.38	.95
		Quantitative Thinking Score	14.33	5.79
		Composite Score	17.30	6.13

two schools, the subgroup of five schools, and all seven schools. As expected, the means for the algebra grade, ITED quantitative thinking score, and ITED composite score are lower for the subgroup of two schools than for the subgroup of five schools. Also, the standard deviations for the subgroup of two schools are larger than for the subgroup of five schools. This would probably indicate that the subgroup of two schools had more heterogeneous classes in geometry than the other five schools.

When the correlation coefficients (r) were found (Table III), the correlation of .82 between the algebra grade and the geometry grade for the subgroup of two schools was the highest correlation. The correlation coefficients for all seven schools, the subgroup of five schools, and the subgroup of two schools ranged from .38 to .82. The correlation of the ITED composite score and the geometry grade for all seven schools and the subgroup of five schools was the lowest correlation. The correlation for all seven schools was .47 and for the subgroup of five schools, .38. For all three groups of schools, the algebra grade and the geometry grade had the highest correlations. The subgroup of two schools was at least .10 higher on all correlations between each of the three predictor variables and the criterion. Consideration of the higher correlations and the larger standard deviations for the subgroup of two schools substantiated the belief that the subgroup of two schools had a more heterogeneous grouping of students in the geometry class than the other five schools used in this study. Heterogeneous grouping is mentioned by Douglas:

TABLE III

CORRELATION COEFFICIENTS BETWEEN THREE PREDICTOR INDEXES AND GEOMETRY GRADES[1]

Predictor Index	Correlation	SE_r
Algebra Grade		
7 schools	.65	.039
5 schools	.58	.053
2 schools	.82	.041
School A	.63	.142
School B	.73	.076
School C	.80	.074
School D	.66	.141
School E	.75	.109
School F	.66	.082
School G	.65	.075
ITED Test 4, Quantitative Thinking		
7 schools	.51	.050
5 schools	.50	.060
2 schools	.62	.078
School A	.34	.209
School B	.67	.089
School C	.86	.055
School D	.52	.237
School E	.74	.109
School F	.52	.106
School G	.45	.103
ITED Composite		
7 schools	.47	.053
5 schools	.38	.068
2 schools	.63	.076
School A	.60	.151
School B	.31	.147
School C	.79	.077
School D	.23	.219
School E	.87	.061
School F	.66	.082
School G	.35	.113

[1]The number of students in the study in each subgroup were:

7 schools--219
5 schools--156
2 schools-- 63
School A -- 18
School B -- 38
School C -- 24
School D -- 16
School E -- 16
School F -- 47
School G -- 60

> . . . the size of the coefficient is dependent upon the homogeneity of the group upon which it is based. The more heterogeneous the group, the greater the coefficient obtained, other things remaining equal.[1]

When comparing the individual schools, School C had the highest correlations between each of the three predictor variables and geometry grade, with correlations of .80 for algebra grades, .86 for the quantitative thinking score, and .79 for the composite score as shown in Table III. The coefficients of correlation for the various schools ranged from .23 to .87. The quantitative thinking score was a relatively inferior predictor of the geometry grade for School A ($r = .34$) and School G ($r = .45$). For Schools B, D, and G, the composite score was also a relatively inferior predictor of the geometry grade with coefficients of correlation of .31, .23, and .35 respectively. For School G, the only predictor of the geometry grade that was not inferior was the algebra grade ($r = .65$). It is sometimes contended that the algebra grade is the best predictor of the geometry grade. This seemed to be borne out by the data gathered for this study.

Reliability of the coefficients of correlation. An estimate of the reliability of a correlation coefficient was obtained (Table III, page 50) by computing the standard error (SE_r) by means of the formula:

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[1]Douglas, op. cit., p. 487.

$$SE_r = \frac{1 - r^2}{\sqrt{N}}$$

Using an r of .65 as an example and substituting:

$$SE_{.65} = \frac{1 - .65^2}{\sqrt{219}}$$

$$= \frac{.5775}{14.8}$$

$$= .039$$

Therefore, the chances are ninety-five in one hundred that the obtained r, .65, does not differ from the true r by more than $\pm$ .076 ($\pm$ 1.96 x .039). The .95 confidence-interval (5 per cent level of confidence), therefore, is .574 to .726. The .99 confidence-interval (1 per cent level of confidence) is .549 to .751.

Interrelationships among the variables. Although the purpose of this study was not to investigate the relationships between all pairs of the predictor variables, these intercorrelations are important in computing the multiple correlations. These intercorrelations are shown in Table IV. None of the intercorrelations was higher than the correlations between each of the three predictor variables and the criterion.

Multiple correlations. In addition to the correlation of the predictor variables and the criterion, multiple R's were computed between the geometry grade and two predictor variables.[2] These

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[2]The multiple correlation formula used in this study and an example of its use are found in Appendix E.

TABLE IV

COEFFICIENTS OF INTERCORRELATION FOR CERTAIN PAIRS OF PREDICTOR VARIABLES[1]

Predictor Variables	Correlation
Algebra grade and ITED Quantitative Thinking	
7 schools	.50
5 schools	.47
2 schools	.61
School A	.26
School B	.72
School C	.40
School D	.43
School E	.70
School F	.54
School G	.34
Algebra grade and ITED Composite	
7 schools	.50
5 schools	.54
2 schools	.45
School A	.41
School B	.41
School C	.64
School D	.52
School E	.75
School F	.54
School G	.31

[1]The number of students in the study in each subgroup were:
7 schools--219
5 schools--156
2 schools-- 63
School A -- 18
School B -- 38
School C -- 24
School D -- 16
School E -- 16
School F -- 47
School G -- 60

combinations and the multiple correlations obtained are found in Table V. A substantial relationship between the geometry grade and these combinations was found in all subgroups. The multiple correlations ranged from .65 to .99. The optimum prediction of geometry grades for the seven schools was attained by combining the algebra grade and the ITED quantitative thinking score (R = .68). For all seven schools this was only slightly better than the combination of the algebra grade and the ITED composite score (R = .67). For the subgroup of five schools, the combination of the algebra grade and the quantitative thinking score was the best predictor of the geometry grade (R = .63). The best predictor for the subgroup of two schools was the combination of the algebra grade and the composite score (R = .87). The multiple R of .99 obtained for School C by using the algebra grade and the ITED quantitative thinking score was considerably higher than the corresponding correlations for any other subgroup. This was the only multiple R that appreciably exceeded the correlations of the algebra grade and the geometry grade.

A comparison of all seven schools, the subgroup of five schools, and the subgroup of two schools showed that the multiple R's were higher than the correlations between each of the predictor variables and the criterion for all seven schools and the subgroup of five schools. These higher correlations were found among the ITED quantitative thinking score, the algebra grade, and the geometry grade. The multiple R for all seven schools was .68, and for the subgroup of five schools it was .63; while the correlation between the algebra grade and geometry

TABLE V

MULTIPLE R CORRELATION COEFFICIENTS BETWEEN TWO PREDICTOR VARIABLES AND GEOMETRY GRADES[1]

Predictor Variables	Correlation	SE_R
Algebra grade and ITED Quantitative Thinking		
7 schools	.68	.037
5 schools	.63	.048
2 schools	.77	.052
School A	.65	.150
School B	.77	.069
School C	.99	.033
School D	.66	.155
School E	.81	.096
School F	.69	.079
School G	.71	.066
Algebra grade and ITED Composite		
7 schools	.67	.037
5 schools	.59	.053
2 schools	.87	.031
School A	.84	.075
School B	.80	.060
School C	.89	.045
School D	.66	.156
School E	.88	.061
School F	.81	.052
School G	.67	.073

[1]The number of students in the study in each subgroup were:
7 schools--219
5 schools--156
2 schools-- 63
School A -- 18
School B -- 38
School C -- 24
School D -- 16
School E -- 16
School F -- 47
School G -- 60

grade for all seven schools was .65, and for the subgroup of five schools it was .58. The multiple R using the ITED quantitative thinking score and the algebra grade was lower for the subgroup of two schools than the correlation between the algebra grade and the geometry grade. The correlation between the algebra grade and the geometry grade was .82, while the multiple R was .77

Reliability of the multiple R coefficients of correlation. An estimate of the reliability of a multiple R correlation coefficient can be obtained by computing the standard error of R (SE_R) as shown in Table V, page 54, by means of the formula:[3]

$$SE_R = \frac{1 - R^2}{\sqrt{N - m}}$$ where m is the number of variables used.

Using a multiple R of .68 as an example and substituting, the following is obtained:

$$SE_{.68} = \frac{1 - .68^2}{\sqrt{219 - 3}}$$

$$= \frac{.5376}{14.7}$$

$$= .037$$

The .95 confidence-interval (5 per cent level of confidence), is .608 to .752. The .99 confidence-interval (1 per cent level of confidence) is .585 to .775.

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[3] J. P. Guilford, Fundamental Statistics in Psychology and Education (New York: McGraw-Hill Book Company, 1956), p. 399.

III. COMPARISON OF THE FINDINGS FROM THIS STUDY AND PREVIOUS STUDIES

As expected, the correlation of this study's algebra grade and geometry grade fell between what Lee and Lee found of .40 and .75. Using the correlations of all seven schools, the results of this study fit midway between those found by Richardson in his study. His first semester algebra grade correlated at .63, and his second semester algebra grade at .70, while this study's year algebra grade correlated at .65. This study showed a correlation of .10 higher than that found by Sutton and Cooke and Pearson and .10 lower than that found by Slaichert and Sanders when they correlated the algebra grade with the geometry grade. Crane's findings were similar to Richardson's. The coefficients determined in this study indicated that the algebra grade is the best predictor of the geometry grade. The results of this study using "modern" algebra and "modern" geometry grades were in agreement with the results of the studies done a quarter of a century earlier by Richardson, Cook and Pearson, Crane, and Slaichert using algebra and plane geometry as it was traditionally taught. This study's results were in disagreement with the conclusions reached by Sanders, that algebra grades have no value in predicting success in geometry.

The ITED quantitative thinking score for all seven schools correlated at .20 lower than was found by Slaichert in his study of the correlation of the quantitative thinking score with the geometry grade. The correlations were .51 for this study and .71 for Slaichert's study. Robertson found the ITED quantitative thinking score to be the poorest predictor of marks in advanced mathematics (.42) and marks in elementary mathematics (.43). Graham found the quantitative thinking score to be a good predictor of the algebra grade (.743). Busse found the quantitative thinking score correlating at .58 with the sophomore mathematics grades. This was just slightly higher than this study's .51 correlation.

In this study the geometry grade and the algebra grades correlated at almost the same level with the quantitative thinking score. This might indicate that the ITED quantitative thinking score did not predict the geometry grade any better than it predicted the algebra grade. Busse found that the quantitative thinking score predicted the algebra grade (r = .67) better than it predicted the sophomore mathematics grade (r = .58).

The correlation of the ITED composite score and the geometry grade was about the same as that obtained by Robertson. He found the composite score to be the third best predictor of the advanced mathematics grade (r = .48) and the elementary mathematics grade (r = .47).

When comparing the multiple R's used in this study involving "modern" algebra and "modern" geometry for all seven schools with those obtained a quarter of a century earlier involving traditional algebra and plane geometry, this study showed somewhat lower correlations. The results of this study showed the algebra grade and the ITED composite score combination to correlate at .67 with geometry grades. The combination of the algebra grade and the ITED quantitative thinking score correlated at .68. Richardson found a multiple R of .77 between the combination of second semester algebra grade and the Orleans Geometry Prognosis Test and the geometry grade. Using a combination of three prognostic tests, Cooke and Pearson found a multiple R of .747. Using four variables, algebra grade, ITED quantitative thinking score, I.Q., and the score from the American Council on Education Psychological Examination, Slaichert found a multiple R of .8299.

From the above, it can be seen that the results of this study involving "modern" algebra grades and "modern" geometry grades were not much different from the results of studies done twenty years ago involving traditional algebra grades and plane geometry grades.

IV. APPLICATIONS OF THE FINDINGS

An important part of this study was to provide applications of the findings that would be of practical value when counseling students who are contemplating taking geometry.

One such application was the preparation of double-entry expectancy tables. With only a small amount of explanation, counselors can easily understand and communicate the predictive data from the double-entry expectancy tables to students, parents, and other interested persons. The purpose of such tables was to provide the means of estimating, on the basis of specified prediction indexes, the probability that a student would achieve at a certain level in geometry. Double-entry expectancy tables were constructed using the total number of students in the study. In a similar manner, double-entry expectancy tables could be made for the other subgroups used in the study.

Table VI shows the data concerning each pupil's algebra grade, ITED quantitative thinking score, and geometry grade for the 1966-67 geometry students. Arbitrary groups of approximately ten standard score points were selected from the ITED scores for each cell. Since, in some cases, the two semester grades for algebra had to be averaged to get the year algebra grade, the transformed algebra marks were grouped to .5 for each cell. The number appearing in each cell is the number of students in each category row who earned the indicated standard score or grade. Table VI shows that seven students had a standard score between twenty-one and thirty on the quantitative test, had an A in algebra, and received an A in geometry. Only two students received scores between twenty-one and thirty on the quantitative thinking test, an A in algebra, and a C in geometry. The column totals show the relationship between algebra grades and geometry grades. For example, the first column total indicates that two students received an F in algebra, but only one of these received an F in geometry. The other student received a D in geometry.

The totals under the raw score column show the relationship between the ITED quantitative thinking standard score and the geometry grade received. Of those students receiving a standard score of twenty-one to thirty on the quantitative thinking test, thirteen received an

TABLE VI

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE QUANTITATIVE THINKING SCORE TO THE GEOMETRY GRADE FOR 219 STUDENTS

Quantitative Thinking Standard Score (ITED)		Year Algebra Grade									Raw Score
		(F) 1	1.5	(D) 2	2.5	(C) 3	3.5	(B) 4	4.5	(A) 5	
21-30	A							3	3	7	13
	B					2	4	3	7	4	23
	C				3	4	2	6	1	2	15
	D					1		1			2
	F										
11-20	A							2	2	5	9
	B				2	5	9	10	5	2	33
	C		1	6	9	27	12	18	2		75
	D	1		8	4	8	3				24
	F			2		2					4
0-10	A										
	B					2					2
	C			1		2	1	1	2		7
	D			7	1			1			9
	F	1		2							3
Column Total (by grade)											Grand Total
	A							5	5	12	22
	B				5	9	13	13	12	6	58
	C		1	7	9	33	15	25	5	2	97
	D	1		15	5	9	3	2			35
	F	1		4		2					7

A, twenty-three received a B, fifteen received a C, and two received a D in geometry. Again using Table VI, page 61, it can be shown that of the eighty-seven students who had received A or B in algebra, 61 per cent received A or B in geometry and 39 per cent received C or D in geometry. Of the twenty students with a 5.0 in algebra, 60 per cent received A in geometry and 40 per cent received B or C in geometry. Sixty-eight per cent of the fifty-three students who received a standard score of twenty-one to thirty on the quantitative thinking portion of the ITED received A or B in geometry, while 32 per cent received C or D in geometry.

Table VII exhibits the data from Table VI, page 61, after it has been interpreted as percentages. Table VII can be used by the counselor to help a student decide whether or not to take geometry. For example, if a student has a quantitative thinking standard score of thirteen on this ITED and C in algebra, his counselor, using Table VII, would indicate that of those who had approximately the same score and C in algebra, 12 per cent received B in geometry, 64 per cent received C, 19 per cent received D, and 5 per cent received F. The student's chances of receiving a grade higher than D would be estimated at 76 per cent. The student, with the counselor's help, could then decide whether he wanted to take geometry.

Because of the low cell frequencies, some of the percentages in Table VII may be misleading, since the percentages may appear higher than they actually are. In order to avoid this misconception the algebra grades and geometry grades were grouped into three

TABLE VII

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE QUANTITATIVE THINKING SCORE TO THE GEOMETRY GRADE EXPRESSED AS PER CENTS FOR 219 STUDENTS

Quantitative Thinking Standard Score (ITED)		Year Algebra Grade								
		(F) 1	1.5	(D) 2	2.5	(C) 3	3.5	(B) 4	4.5	(A) 5
21-30	A							23	27	54
	B				100	29	67	23	64	31
	C					57	33	46	9	15
	D					14		8		
	F									
11-20	A							7	22	71
	B				13	12	38	33	56	29
	C		100	38	60	64	50	60	22	
	D	100		50	27	19	12			
	F			12		5				
0-10	A									
	B					50				
	C			10		50	100	50	100	
	D			70	100			50		
	F	100		20						

categories: high, middle, and low. Grades of A and B were called "high," C was "middle," and D and F were called "low." The same categories were used for grouping the quantitative thinking and the composite standard scores. Similar double-entry expectancy tables, such as Table VIII, which used the total number of students in the study, could be made from the data for the other subgroups used in this study.

Table VIII shows the regrouping of the algebra grades, the geometry grades, and the quantitative thinking scores. Of the twenty-nine students who received low grades in algebra, 28 per cent received C in geometry and 72 per cent received D or F. Of the twenty-one students who scored ten or less on the quantitative thinking section of the ITED, approximately 10 per cent received A or B, 33 per cent received C, and 57 per cent received D or F in geometry.

Table IX, page 66, exhibits the data from Table VIII after the entries in the various cells have been interpreted as percentages.[4] This table may be interpreted in a manner similar to Table VII, page 63.

Prediction of the geometry grade may also be made by means of multiple regression equations. In this study, the regression equations

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[4]Double-entry expectancy tables similar to Tables VI through IX using the ITED composite score instead of the ITED quantitative thinking score may be found in Appendix E. The data exhibited in these tables, Tables XI through XIV, may be interpreted in a manner similar to the manner in which Tables VI through IX were interpreted.

TABLE VIII

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE QUANTITATIVE THINKING SCORE TO THE GEOMETRY GRADE FOR 219 STUDENTS

Quantitative Thinking Standard Score (ITED)	Year Algebra Grade						
	Low			Middle		High	
21-30	Geometry Grade	A & B	0	A & B	9	A & B	27
		C	0	C	6	C	9
		D & F	0	D & F	1	D & F	1
11-20	Geometry Grade	A & B	0	A & B	16	A & B	26
		C	7	C	48	C	20
		D & F	11	D & F	17	D & F	0
0-10	Geometry Grade	A & B	0	A & B	2	A & B	0
		C	1	C	3	C	3
		D & F	10	D & F	1	D & F	1

TABLE IX

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE QUANTITATIVE THINKING SCORE TO THE GEOMETRY GRADE EXPRESSED AS PER CENTS FOR 219 STUDENTS

Quantitative Thinking Standard Score (ITED)	Year Algebra Grade							
	Low			Middle		High		
21-30	Geometry Grade	A & B	0	A & B	56	A & B	73
		C	0	C	38	C	24
		D & F	0	D & F	6	D & F	3
11-20	Geometry Grade	A & B	0	A & B	20	A & B	57
		C	39	C	59	C	43
		D & F	61	D & F	21	D & F	0
0-10	Geometry Grade	A & B	0	A & B	33	A & B	0
		C	9	C	50	C	75
		D & F	91	D & F	17	D & F	25

involved two predictors and the criterion.[5] The regression equations for the subgroups used in this study are shown in Table X. If a student who received an ITED quantitative thinking score of thirteen and an algebra grade of C was contemplating taking geometry, the multiple regression equation could be used in the following manner:

$X_1 = .54\ X_2 + .05\ X_3 + .59$ where X_1 is the predicted geometry grade, X_2 is the algebra grade after it has been quantified, and X_3 is the ITED quantitative thinking score.

$$X_1 = (.54)\ (3) + (.05)\ (13) + .59$$
$$= 1.62 + .65 + .59$$
$$= 2.86$$

Converting this value, 2.86, back into a letter grade using a five-point transformation table, this student would receive approximately a C in geometry. The correlation between the predicted value, 2.86, and the obtained value is .68. For this student, the chances are sixty-eight in one hundred that he will achieve a geometry grade somewhere between 2.17 and 3.55, ninety-five in hundred that his grade will be somewhere between 1.51 and 4.21, and ninety-nine in one hundred that it will be somewhere between 1.08 and 4.64. These confidence-intervals are based on a standard error of estimate of .69.

Any student contemplating taking geometry may be evaluated in a similar manner using the double-entry expectancy tables and/or the

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[5] An illustrative computation of the multiple regression equation is included in Appendix C.

TABLE X

MULTIPLE REGRESSION EQUATIONS PREDICTING THE GEOMETRY GRADE FROM TWO PREDICTOR VARIABLES

Subgroup	Regression Equation	R	$SE_{est.}$
7 schools (N=219)	$X_1 = .54\ X_2 + .05\ X_3 + .59$	.68	.69
	$X_1 = .57\ X_2 + .04\ X_4 + .68$	.67	.71
5 schools (N=156)	$X_1 = .44\ X_2 + .06\ X_3 + .62$	.63	.70
	$X_1 = .53\ X_2 + .02\ X_4 + 1.06$	.69	.74
2 schools (N= 63)	$X_1 = .65\ X_2 + .03\ X_3 + .62$	.77	.64
	$X_1 = .72\ X_2 + .005\ X_4 + .70$	.87	.50
School A (N= 18)	$X_1 = .40\ X_2 + .03\ X_3 + 1.76$	.65	.49
	$X_1 = .31\ X_2 + .07\ X_4 + 1.24$	.84	.35
School B (N= 38)	$X_1 = .47\ X_2 + .06\ X_3 - .06$	.77	.51
	$X_1 = .71\ X_2 + .002\ X_4 + .32$	.80	.48
School C (N= 24)	$X_1 = .59\ X_2 + .02\ X_3 + 1.07$	.99	.10
	$X_1 = .54\ X_2 + .01\ X_4 + 1.36$	.89	.38
School D (N= 16)	$X_1 = .89\ X_2 - .01\ X_3 - .01$	.66	.68
	$X_1 = .84\ X_2 + .002\ X_4 - .13$	.66	.68
School E (N= 16)	$X_1 = .42\ X_2 + .07\ X_3 + .34$	.81	.69
	$X_1 = .20\ X_2 + .12\ X_4 + .30$	.88	.55
School F (N= 47)	$X_1 = .47\ X_2 + .04\ X_3 + .92$	.69	.63
	$X_1 = .46\ X_2 + .06\ X_4 + .85$	.81	.51
School G (N= 60)	$X_1 = .59\ X_2 + .09\ X_3 - .11$	.71	.66
	$X_1 = .63\ X_2 + .04\ X_4 + .56$	.67	.70

Code:

X_1 = predicted geometry grade
X_2 = algebra grade after it has been quantified
X_3 = the ITED quantitative thinking score
X_4 = the ITED composite score

multiple regression equations if the data are available. Such an estimate of geometry success should be of help to counselors when helping students decide whether or not to take geometry. For the school administration, this estimate of geometry success should be helpful when screening students for ability grouped geometry classes.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY AND CONCLUSIONS

It was the purpose of this investigation: (1) to determine the relative value of the Algebra I grade, the Iowa Tests of Educational Development quantitative thinking score, and the Iowa Tests of Educational Development composite score in predicting the geometry grade; and (2) to present the findings, using two predictor variables, that would provide the best possible estimate of success in geometry.

The study involved grades and scores for 219 students who were enrolled in geometry in 1966-67 in seven secondary schools in Linn County, Iowa. Selection of the schools was made on the basis of information about the Algebra I and geometry textbooks used. This information was obtained from a questionnaire. Means and standard deviations for each of the predictor variables and the criterion were computed for all seven schools and for each individual school. Since the means obtained for two of the schools were generally lower and the standard deviations higher than for the other five schools on all variables, further statistical analysis was done grouping these two schools, the remaining five schools, all seven schools, and each school individually.

Correlations were computed between the geometry grade and each of the three predictor variables. Intercorrelations were found among the three predictors. Multiple R's were computed between geometry grades and two predictors. Regression equations based on each of these combinations were derived; and, for the group of seven schools, double-entry expectancy tables were made to display these relationships.

The writer recognizes that the findings of this study must be interpreted and applied with caution. The following is a summary of the findings and conclusions of this study.

1. The algebra grade was the best single predictor of the geometry grade with a correlation of .65, .58, and .82 for all seven schools, for the subgroup of five schools, and for the subgroup of two schools, respectively.

2. The ITED composite score was the poorest predictor of the geometry grade with r = .47 for all seven schools, and r = .38 for the subgroup of five schools. For the subgroup of two schools, the ITED quantitative thinking score was the poorest predictor (r = .62).

3. All correlations obtained for the subgroup of two schools were at least .10 higher than the correlations obtained for all seven schools and for the subgroup of five schools.

4. Since the geometry grade and the algebra grade correlated at almost the same level with the quantitative thinking score, this could be interpreted to indicate that the quantitative thinking test of the ITED did not predict the geometry grade any better than it had predicted the grade in algebra.

5. The _ITED_ composite score seemed to be a better predictor of the algebra grade than of the geometry grade for both the group of seven schools and the subgroup of five schools.

6. For the individual schools, School C correlated consistently higher on all three predictor variables with the geometry grade. Correlations of .80 for the algebra grade, .86 for the _ITED_ quantitative thinking score, and .79 for the _ITED_ composite score were obtained.

7. None of the interrelationships between pairs of predictor variables was higher than the relationships between the predictor variables and the geometry grades.

8. The multiple R's ranged from .59 to .99.

9. The best multiple predictor of geometry grades for all seven schools and for the subgroup of five schools was found by combining the algebra grade and the _ITED_ quantitative thinking score. The correlations were .68 and .63 respectively.

10. The best multiple predictor of geometry grades for the subgroup of two schools was the combination of the algebra grade and the _ITED_ composite score.

11. A multiple R of .99 was obtained for School C by using a combination of the algebra grade and the _ITED_ quantitative thinking score. This was the only multiple R which appreciably exceeded the correlation of the algebra grade with the geometry grade.

12. Correlations from this study involving "modern" algebra grades and "modern" geometry grades were generally in agreement with the results of studies done a quarter of a century earlier, although the multiple R correlations of this study were somewhat lower than the results of previous studies.

II. RECOMMENDATIONS

Tools of prediction, such as the multiple regression equation and the double-entry expectancy tables, should be more meaningful for any one school if the data used in building the tables and in determining the equation had been collected over a period of years in that school. After courses in "modern" algebra and "modern" geometry have been taught for several years, such tables could be made. These tables could help to identify those students likely to have trouble with geometry. Rather than barring these students from geometry classes, schools could give these students extra help or could place them in special classes which proceed at a slower pace.

This same study could be expanded so that it would take into account other factors that are available for the prediction of success in geometry, e.g., the algebra teacher's recommendation, the reading standard score from the ITED, the I.Q., and the cumulative grade point.

Further study could involve not only the textbooks used in the schools but, also, the type of material taught in the geometry class.

Such a study might also take into account the pupils' attitude toward geometry, their class participation, their self discipline in the geometry class, their interest, their opportunities for home study, the number of hours they work, the number of children in the family, the attitude of the parents toward school achievement, and other such factors which might influence the student's learning or the assignment of grades in geometry. Each pupil must be considered as an individual, as a complete person, rather than as a list of scores. Tests and grades are extremely useful and important, but unless they are supplemented by a knowledge of the interests, attitudes, and personal emotional adjustment of each student, all such tests and grades must fall short of their goal of perfect prediction.

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APPENDIX A

THE IOWA TESTS OF EDUCATIONAL DEVELOPMENT

As the test manual states:

> The Iowa Tests of Educational Development are a battery of nine objective tests designed to provide a comprehensive and dependable description of the general educational development of the high school pupil.[1]

The individual tests in the battery are as follows:

	Title of Test	Items	Time in Minutes
1.	Understanding of Basic Social Concepts	90	55
2.	Background in the Natural Sciences	90	60
3.	Correctness and Appropriateness of Expression	103	60
4.	Ability to Do Quantitative Thinking	53	65
5.	Ability to Interpret Reading Materials in Social Studies	80	60
6.	Ability to Interpret Reading Materials in Natural Sciences	81	60
7.	Ability to Interpret Literary Materials	80	50
8.	General Vocabulary	75	22
9.	Use of Sources of Information	65	27

The whole battery of tests is a measure of general achievement. Tests 3 through 8 are intended to measure the pupils' ability to do

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[1] How to Use the Test Results. Manual accompanying the Iowa Tests of Educational Development (Chicago: Science Research Associates, 1967), p. 6.

critical thinking. The tests are not concerned with what the pupil has actually learned, but with how well he can use what he has learned in interpreting and evaluating the material presented.

Of special interest to this study is Test 4, Quantitative Thinking. The reliability of this test for grade 10 is .883. The authors offer no numerical index for the validity. They say:

> There is no single measure which educators will accept as a criterion against which the test scores may be correlated. Each user must carefully study for himself the test descriptions, outlines, and illustrative exercises presented earlier in this manual. The content validity of the tests will depend on the extent to which the tests assess skills that the user believes should be measured.[2]

The material in this test, Test 4, is arranged in practical problem situations which require a general informational background as well as varied mathematical experience from the elementary and the high school level. The material in this test includes:

1. Operations with fractions
2. Per cent
3. Volume
4. Area
5. Angular relationships
6. Evaluation of formulas
7. Roots and powers
8. Curve fitting

---

[2] *Ibid.*, p. 63.

9. Operations with signed numbers

10. Cost and profit

11. Interpretation of verbal statements

12. Rate

13. Linear interpolation

14. Units of measurement

15. Ratio and proportion

16. Averages

17. Variability

18. Symbolic representation

19. Solution of equations

20. Verbalization of decimals; place value

21. Number series

22. Approximate computation and computational shortcuts

23. Graphical representation

24. Table reading

25. Graph reading

Another score from the ITED of importance to this particular study is the composite score of Tests 1 through 8. According to the test manual:

> The standard composite score on Tests 1-8 is not a simple average of the standard scores on the separate tests. It is obtained by finding the sum of the standard scores on Tests 1-8, and then changing this sum into a standard score by means of a table similar to those used in transforming the raw scores on the separate tests.[3]

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[3] Ibid., p. 35.

The average reliability of grade 10 for Tests 1-8 of the ITED which are included in the composite is .98.[4]

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[4]Manual for the School Administrator. Manual accompanying the Iowa Tests of Educational Development (Chicago: Science Research Associates, 1965), p. 29.

APPENDIX B

March 13, 1967

Dear ____________:

I am working on my thesis for my master's degree at the State College of Iowa. My topic is the relationship of algebra grades to geometry grades.

I have been teaching geometry in Central City, Iowa, and have become quite concerned about the method of guiding algebra students into geometry. Algebra has always been a perequisite, and in many cases the grades have been used as the determining factor in guiding students into geometry. Is there a high relationship between algebra and geometry grades?

I have chosen the twelve schools surrounding Cedar Rapids in Linn County for my study since these schools are the types of schools and in the same geographical area that I am most concerned with. I would appreciate your help for my study by filling out the enclosed questionnaire and returning it to me by March 24, 1967.

If you would like a summary of my findings, I would be more than happy to send you a summary.

Thank you for your help.

Yours truly,

Rosemary Barrow

(Mrs.) Rosemary Barrow

Name of School ______________________________

1. How many students are enrolled in geometry this year? __________

2. How many geometry classes are there in your school? __________

3. What geometry textbook is used in your school? __________

____

4. Is it a modern or traditional geometry textbook? __________

5. If modern, about how many years, including this year, has your school been using this textbook? __________

6. What Algebra I textbook is used in your school? __________

____

7. Is it a modern or traditional algebra textbook? __________

8. If modern, about how many years, including this year, has your school been using this textbook? __________

9. What type of grading is used in your geometry classes: A,B,C, or A,B,C,D, or A,B,C,D,F? __________

10. About what percentage of the geometry students at the end of the first semester this year (1967) received the following grades?

    A __________ B __________ C __________

    D __________ F __________

11. When your school is scheduling for geometry, what factors that could be quantified are taken into consideration? __________

12. What years does your school give the <u>Iowa Tests of Educational Development</u> (<u>ITED</u>)? ______________________

13. Would you like to receive a summary of the findings of my study?

____

APPENDIX C

April 3, 1967

Dear ___________,

About three weeks ago I sent you a one-page questionnaire that I asked you if you would fill out for me so that I may use the information in my thesis study. As of today, I have not received your questionnaire.

I, being a teacher also, realize how busy we all are with preparations, classes, grading, etc., but I would appreciate it if you would take the couple minutes necessary to fill out my questionnaire. Before I am able to continue with my thesis, I must have the results of all the questionnaires, since my study is limited to only twelve schools.

Thank you for your help.

Yours truly,

Rosemary Barrow

(Mrs.) Rosemary Barrow

APPENDIX D

May 15, 1967

Dear ____________,

I am working on my thesis for my Master's degree at the State College of Iowa. My topic involves the prediction of geometry grades using the algebra grade, the Iowa Tests of Educational Development Test 4 score, and the Iowa Tests of Educational Development composite score. I have selected your school as one to be included in my study.

If permissible, I would like to obtain data on your sophomores who are currently enrolled in geometry. I realize that you are busy with year end-activities, but I would appreciate it if you would fill out the enclosed dittoed form and mail it back to me in the enclosed envelope as soon as possible. I will be happy to pay you for your time that it takes to fill out the dittoed form. Please bill me at the above address.

I will greatly appreciate your help.

Yours truly,

Rosemary Barrow

(Mrs.) Rosemary Barrow

Name of Student (All 1967 geometry students)	1st Semester Algebra Grade (1966)	2nd Semester Algebra Grade (1966)	Year Algebra Grade (1966)	1st Semester Geometry Grade (1967)	ITED Raw Score Quantitative Thinking (latest)	ITED Raw Score Composite (latest)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						

APPENDIX E

AN ILLUSTRATIVE MULTIPLE CORRELATION PROBLEM INVOLVING THREE VARIABLES[1]

The formula for finding the multiple correlation involving the geometry grade, algebra grade, and the ITED quantitative thinking score is:

$$R_{1.23} = \sqrt{\frac{r^2_{12} + r^2_{13} - 2\, r_{12}\, r_{13}\, r_{23}}{1 - r^2_{23}}}$$

where:

r_{12} = correlation of geometry grade and algebra grade

r_{13} = correlation of geometry grade and ITED quantitative thinking score

r_{23} = correlation of algebra grade and ITED quantitative thinking score

Using the correlations of the seven schools as an example and substituting $r_{12} = .65$, $r_{13} = .51$, and $r_{23} = .50$:

$$R_{1.23} = \sqrt{\frac{.65^2 + .51^2 - 2\,(.65)\,(.51)\,(.50)}{1 - .50^2}}$$

$$= \sqrt{\frac{.4225 + .2601 - .3315}{1 - .25}}$$

$$= \sqrt{\frac{.3511}{.75}}$$

$$= \sqrt{.46813}$$

---

[1] Based on J. P. Guilford, Fundamental Statistics in Psychology and Education (New York: McGraw-Hill Book Company, 1956), p. 393.

$= .684$

$= .68$

The formula for the multiple correlation which involves the geometry grade, algebra grade, and ITED composite score is:

$$R_{1.24} = \sqrt{\frac{r^2_{12} + r^2_{14} - 2\, r_{12}\, r_{14}\, r_{24}}{1 - r^2_{24}}}$$

where:

r_{12} = correlation of geometry grade and algebra grade

r_{14} = correlation of geometry grade and ITED composite score

r_{24} = correlation of algebra grade and ITED composite score

APPENDIX F

TABLE XI

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE COMPOSITE SCORE TO THE GEOMETRY GRADE FOR 219 STUDENTS

Composite Standard Score (ITED)		Year Algebra Grade									Raw Score
		(F) 1	1.5	(D) 2	2.5	(C) 3	3.5	(B) 4	4.5	(A) 5	
21-33	A							1	4	10	15
	B				3	2	6	9	8	3	31
	C			1	2	9	3	7	1	2	25
	D				1	2	2				5
	F										
11-20	A							4	1	2	7
	B				2	7	7	4	4	3	27
	C		1	6	6	23	12	17	3		68
	D	1		11	3	7	1	1			24
	F	1		1		2					4
0-10	A										
	B										
	C				1	1		1	1		4
	D			4	1			1			6
	F			3							3
Column Total (by grade)											Grand Total
	A							5	5	12	22
	B				5	9	13	13	12	6	58
	C		1	7	9	33	15	25	5	2	97
	D	1		15	5	9	3	2			35
	F	1		4		2					7

TABLE XII

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE COMPOSITE SCORE TO THE GEOMETRY GRADE EXPRESSED AS PER CENTS FOR 219 STUDENTS

Composite Standard Score (ITED)		Year Algebra Grade								
		(F) 1	1.5	(D) 2	2.5	(C) 3	3.5	(B) 4	4.5	(A) 5
21-33	A							6	31	66
	B				50	15	55	52	61	20
	C			100	33	70	27	42	8	14
	D				17	15	22			
	F									
11-20	A							15	16	40
	B				18	18	35	15	50	60
	C		100	33	55	59	60	65	34	
	D	50		61	27	18	15	5		
	F	50		6		5				
0-10	A									
	B									
	C				50	100		50	100	
	D			57	50			50		
	F			43						

TABLE XIII

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE COMPOSITE SCORE TO THE GEOMETRY GRADE FOR 219 STUDENTS

Composite Standard Score (ITED)	Year Algebra Grade						
		Low		Middle		High	
21-33	Geometry Grade	A & B	0	A & B	11	A & B	35
		C	1	C	14	C	10
		D & F	0	D & F	5	D & F	0
11-20	Geometry Grade	A & B	0	A & B	16	A & B	18
		C	7	C	41	C	20
		D & F	14	D & F	13	D & F	1
0-10	Geometry Grade	A & B	0	A & B	0	A & B	0
		C	0	C	2	C	2
		D & F	7	D & F	1	D & F	1

TABLE XIV

RELATIONSHIP OF THE ALGEBRA I GRADE AND THE COMPOSITE SCORE TO THE GEOMETRY GRADE EXPRESSED IN PER CENTS FOR 219 STUDENTS

Composite Standard Score (ITED)	Year Algebra Grade						
		Low		Middle		High	
21-33	Geometry Grade	A & B	0	A & B	37	A & B	78
		C	100	C	47	C	22
		D & F	0	D & F	16	D & F	0
11-20	Geometry Grade	A & B	0	A & B	22	A & B	46
		C	33	C	59	C	49
		D & F	67	D & F	19	D & F	5
0-10	Geometry Grade	A & B	0	A & B	0	A & B	0
		C	0	C	67	C	67
		D & F	100	D & F	33	D & F	33

APPENDIX G

AN ILLUSTRATIVE CALCULATION OF THE REGRESSION EQUATION[1]

The formula for the regression equation predicting the geometry grade and using the algebra grade and the ITED quantitative thinking score is:

$$X_1 = a + b_{12.3} X_2 + b_{13.2} X_3$$

where:

$$a = M_1 - b_{12.3} M_2 - b_{13.2} M_3$$

$$b_{12.3} = \left(\frac{\sigma_1}{\sigma_2}\right)\left(\frac{r_{12} - r_{13}\, r_{23}}{1 - r^2_{23}}\right)$$

$$b_{13.2} = \left(\frac{\sigma_1}{\sigma}\right)\left(\frac{r_{13} - r_{12}\, r_{23}}{1 - r^2_{23}}\right)$$

σ_1 = standard deviation of the geometry grade

σ_2 = standard deviation of the algebra grade

σ_3 = standard deviation of the ITED quantitative thinking score

r_{12} = correlation of geometry grade and algebra grade

r_{13} = correlation of geometry grade and ITED quantitative thinking score

r_{23} = correlation of algebra grade and ITED quantitative thinking score

X_1 = predicted geometry grade

X_2 = algebra grade

X_3 = ITED quantitative thinking standard score

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[1] Based on J. P. Guilford, Fundamental Statistics in Psychology and Education (New York: McGraw-Hill Book Company, 1956), pp. 393-395.

Using the information from the seven schools as an example and substituting $\sigma_1 = .95$, $\sigma_2 = .92$, $\sigma_3 = 5.02$, $r_{12} = .65$, $r_{13} = .51$, $r_{23} = .50$, $M_1 = 3.23744$, $M_2 = 3.42237$, and $M_3 = 16.76255$:

$$b_{12.3} = \left(\frac{.95}{.92}\right)\left(\frac{.65 - (.51)\ (.50)}{1 - .50^2}\right)$$

$$= \left(\frac{.95}{.92}\right)\left(\frac{.3950}{.75}\right)$$

$$= \frac{.37525}{.69}$$

$$= .54384$$

$$= .54$$

$$b_{13.2} = \left(\frac{.95}{5.02}\right)\left(\frac{.51 - (.65)\ (.50)}{1 - .50^2}\right)$$

$$= \left(\frac{.95}{5.02}\right)\left(\frac{.185}{.75}\right)$$

$$= \frac{.17575}{3.765}$$

$$= .046679$$

$$= .05$$

$$a = 3.23744 - (.54384)\ (3.42237) - (.046679)\ (16.76255)$$

$$= 3.23744 - 1.86122 - .78246$$

$$= .59376$$

$$= .59$$

$$X_1 = .54\ X_2 + .05\ X_3 + .59$$

The formula for the regression equation involving the algebra grade and the ITED composite score is:

$$X_1 = a + b_{12.4} X_2 + b_{14.2} X_4$$

where:

$$a = M_1 - b_{12.4} M_2 - b_{14.2} M_4$$

$$b_{12.4} = \left(\frac{\sigma_1}{\sigma_2}\right)\left(\frac{r_{12} - r_{14} r_{24}}{1 - r^2_{24}}\right)$$

$$b_{14.2} = \left(\frac{\sigma_1}{\sigma_2}\right)\left(\frac{r_{12} - r_{14} r_{24}}{1 - r^2_{24}}\right)$$

σ_1 = standard deviation of the geometry grade

σ_2 = standard deviation of the algebra grade

σ_4 = standard deviation of the ITED composite score

r_{12} = correlation of the geometry grade and the algebra grade

r_{14} = correlation of the geometry grade and the ITED composite score

r_{24} = correlation of the algebra grade and the ITED composite score

X_1 = predicted geometry grade

X_2 = algebra grade

X_4 = ITED composite standard score