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A critical evaluation of the use of the Orleans Geometry Prognosis Test in the Lodi Union High School

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A CRITICAL EVALUATION
OF THE USE OF THE
ORLEANS GEOMETRY PROGNOSIS TEST
IN THE
LODI UNION HIGH SCHOOL

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CHAPTER I

INTRODUCTION

The high school course in plane geometry is reputed to have a high rate of failure and "drop-out" among its enrollees. The high percentage of failure with its resulting waste of time and effort as well as disappointment and frustration has motivated a number of attempts to discover or devise improved means of estimating the probability of success in this subject. Most of the reported research efforts were carried on during the past thirty-five years. Some of these attempts to improve prognosis have produced measuring instruments which have been standardized and are available for school use. However, none of these instruments has proved to be sufficiently reliable that it could be used as the sole, or even major, criterion for predicting individual success. All too frequently students with test scores which would indicate probable success do not achieve satisfactorily while others with scores predicting probable failure proceed to make satisfactory progress.

Because the prognostic tests which were standardized often resulted in inadequate predictions, a number of the more recent studies have attempted to predict success in geometry by using other measures of academic abilities or to combine the results of other measures of success or aptitude with the standardized prognosis tests. None of these has resulted in methods of predicting geometry success sufficiently accurate to warrant widespread adoption.

Statement of the Problem: During the period of this study approximately twenty per cent of the students enrolled in the plane geometry course in the Lodi Union High School failed. Students were admitted to the course if they had attained a grade of "B" for their third quarter of first year Algebra, or if their Algebra teacher recommended that they be allowed to enroll on a trial basis, or if the student was not recommended but he and his parents requested that he be allowed to enroll. The *Orleans Geometry Prognosis Test*[1] was given at the beginning of the geometry course so that students, teachers, counselors, and parents might have further insight into the student's liklihood of success.

It is the purpose of this study to evaluate the usefulness of the *Orleans Geometry Prognosis Test* as used in the Lodi Union High School and to determine if its use in conjunction with two other standardized measuring instruments would yield better prediction results. The additional

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[1]Joseph B. Orleans, *Orleans Geometry Prognosis Test* (Yonkers-on-Hudson: World Book Company, 1951).

prediction tests used were two sub tests of the *Differential Aptitude Test*[2] battery, the test of *Numerical Ability* and the test of *Abstract Reasoning*. The criterion of success used was the Seattle Plane Geometry Test.[3] Simple and multiple correlations were computed.

Importance of the Study: The place of the subject plane geometry in the high school curriculum is well established. Just which students should and which should not study the course is not well determined. It is generally accepted knowledge that many college students desiring to enter scientific studies must take H.S. mathematics in college. It is equally well known that: (1) some high school students study courses which do not properly challenge their ability while (2) others find themselves enrolled in a program requiring more ability than they possess. Although the resulting implications are similar for all areas of academic study, the concern here is primarily with regard to the course of plane geometry. When situation (1) above occurs, the major result is simple -- ability goes to waste, while undesirable study habits develop. When situation (2) occurs,

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[2]George K. Bennett, Harold G. Seashore, and Alexander G. Wesman, *Differential Aptitude Tests* (New York: The Psychological Corporation, 1947).

[3]Harold B. Jeffery and others, *Seattle Plane Geometry Test* (Yonkers-on-Hudson: World Book Company, 1951).

the results are somewhat more complex: (1) the student is disappointed and frustrated; (2) his parents usually feel that the student or someone else is at fault; (3) class progress is impeded while these students "clutch & grope"; and (4) the reputation of the subject as one "to avoid" grows.

A situation, not unusual in geometry classes, wherein twenty per cent of the students enrolled in a subject fail, seems to be unwarranted. If studies such as the present one can determine means of better recognizing ability so as to reduce the percentage of failures and at the same time discover the more able student earlier in the course, the time and effort expended will be justified.

Most of the studies reviewed in Chapter II of this report conclude that it should be possible to predict geometry achievement more accurately and recommend further research. If this study can only conclude that aptitude tests are inadequate as measures of prediction, the research should be useful.

<u>The chapter organization</u>. Chapter II of this report describes briefly the research and reference material available which has a pertinent relationship to this study.

Chapter III entitled Experimental Design, describes the manner in which the experimentation was carried out. The makeup of the sampling and the descriptions of each of the measuring devices are included in this chapter.

Chapter IV presents the statistical evaluation of the results of the experiment. Computations and references to statistical devices incorporated are included.

Chapter V summarizes the study, sets forth the conclusions reached and makes recommendations for the use of the results.

CHAPTER II

RELATED STUDIES

The difficulty of predicting a student's success in plane geometry was discussed in Chapter I. The summaries of related studies which follow further verify this premise. They also indicate the extent of the felt need to predict success more accurately. These accounts represent most of the recognized efforts to devise improved means of predicting success in geometry through experimental techniques. These studies have for the most part used one or more of four geometry aptitude tests and combined the results obtained on these with other predictive factors. The four tests are (1) the *Orleans Geometry Prognosis Test*[1] published in 1929 and revised in 1950; (2) the *Lee Test of Geometric Aptitude*[2] published in 1931; (3) the *Iowa Geometry Aptitude Test*[3] published in 1942; and (4) the *Stewart Davis Test of Ability in Geometry*[4] published in 1940. Other predictive

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[1]Joseph B. Orleans, *Orleans Geometry Prognosis Test* (Yonkers-on-Hudson: World Book Company, 1951)

[2]Doris M. Lee and J. Murray Lee, *Lee Test of Geometric Aptitude* (Los Angeles, California: California Test Bureau, 1931)

[3]Harry A. Greene and Harold W. Bruce, *Iowa Geometry Aptitude Test* (Iowa City, Iowa: Bureau of Educational Research and Service; State University of Iowa)

[4]Stewart-Davis, *Stewart Davis Test of Ability in Geometry*, (Boulder, Colorado: Bureau of Educational Research; University of Colorado, 1940)

factors commonly involved are previous school grades, mental test results, achievement test results, and teachers' ratings and estimates of ability.

Rogers.[5] The use of tests to determine mathematical ability was first tried by Rogers in 1916. She constructed and administered a group of six tests. The coefficients of correlation between the tests and achievement ranged from .34 to .76. In a report published seven years later in 1923, she concluded that more adequate aptitude tests which would measure the mathematical abilities were needed.

Orleans.[6] Referring to several reported studies of the use of intelligence test results and previous school grades as factors with which to predict success in geometry, Orleans stated that contradictory results had been found. In reporting upon his own studies, he indicated that a prognostic test which measures specific abilities is more valid.

Cooke and Pearson[7], three factors. A study by Cooke and Pearson encompassed a period of two school years and

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[5]Agnes L. Rogers, "Psychological Tests of Mathematical Ability and Educational Guidance," The Mathematics Teacher, 16:196-204, April, 1923.

[6]Joseph B. Orleans, "A Study of Prognosis of Probable Success in Algebra and in Geometry," The Mathematics Teacher, 27:166-180, April, 1934.

[7]Dennis H. Cooke and John M. Pearson, "Predicting Achievement in Plane Geometry," School Science and Mathematics, 33:872-78, November, 1933.

involved students in nine Mississippi schools. The problems were to determine the value of the _Orleans Geometry Prognosis Test_ and to discover the relative value for predicting success in geometry, of (1) the Orleans test; (2) the _Terman Test of Mental Ability_; and (3) teachers' marks in beginning Algebra; and of combinations of these three factors. Achievement was measured by use of the _Columbia Research Bureau Plane Geometry Test_. Data were assembled for nearly two hundred students. Simple, partial and multiple correlation coefficients were calculated. Regression equations and standard errors of estimate were derived.

The Orleans test was found to be only slightly more predictive than the Terman test or the teachers' algebra marks. Adding the second and third factors increased the accuracy of prediction only slightly. A coefficient of multiple correlation using all three predictive variables was found to be .747. Although significant, this was not considered sufficiently high to be used for individual prediction. The small number of students from each of the nine schools might be cause to doubt the validity of the results of this study.

Lee and Lee.[8] In 1932, Lee and Lee described the

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[8] J. Murray Lee and Dorris May Lee, "The Construction and Validation of a Test of Geometric Aptitude," _The Mathematics Teacher_, 25:197, April, 1932.

development of a plane geometry aptitude test. This was the Lee Test of Geometric Aptitude which was first used in and near Los Angeles in 1929. This test, published in 1931, has been used extensively and is popular with teachers of geometry. In their original study with the test conducted with students in five schools, the authors found correlations with a plane geometry achievement test to range from .613 to .720.

Lee and Hughes.[9] - five factors. The Lee Test of Geometric Aptitude was given to one hundred eight students at the beginning of a school year. The students were rated on the Hughes Trait Rating Scale and on geometric aptitude by geometry teachers. IQ's from the Kuhlman-Anderson Intelligence Test and from the Terman Group Test of Mental Ability were obtained. The students' achievement was measured by teachers' marks and the Orleans Plane Geometry Achievement Test. The best single predictor of success was the Lee Test of Geometric Aptitude. The best combination of two predictors was obtained by the addition of the Hughes Trait Rating Scale. Using more than two factors did not improve prognosis significantly. The highest correlations were from .60 to .75. These are high enough to be reliable only in group predictions and at the upper and lower extremes of ability.

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[9] J. Murray Lee and W. Hardin Hughes, "Predicting Success in Algebra and Geometry," School Review, 42:188-96, March, 1934.

Hamilton.[10]- two factors. In 1934, Hamilton averaged the English and algebra grades of ninth grade students in Charleston, West Virginia. He chose these subjects because algebra represents mathematical reasoning and English requires reading comprehension and an ability to use logical expressions. A grade point average of 2.00 which was equivalent to an average grade of "C" was established as a cutting score. Most of the failing geometry students had an English and algebra grade point average below 2.00. The cutting score was used the following year in counseling and programming students with respect to their enrolling in plane geometry. Through counseling, most of the students with scores below the cutting score decided against taking the course while those with a 2.00 average wanting to take geometry were cautioned that they must plan to put forth great effort. The percentage of students failing the course dropped from twenty-two to sixteen.

Richardson[11]- eight factors. Indicating that he was attempting to find a means of identifying those students who would find the study of geometry poorly suited to their needs

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[10] J. Landon Hamilton, "A Method for Reducing Failures in Plane Geometry," Journal of Educational Research, 30:700-02,

[11] J. D. Richardson, "Predicting Achievement in Geometry," The Mathematics Teacher 28:310-19, May, 1935.

and abilities, Richardson began a special study in 1932. In the first year of the study which involved one hundred twenty five students in Highland Park, Illinois, four predictive factors were used. These were (1) the Orleans Geometry Prognosis Test; (2) mental tests (tests used were not indicated); (3) first semester algebra grades; and (4) algebra teachers' estimates of ability to do geometry. Inconclusive evidence that the use of the prognostic test combined with other factors might offer additional predictive values prompted further study. In the second year, Iowa Algebra Aptitude Test scores, Terman Group Test of Mental Ability scores, and additional subjective ratings were added to make a total of eight factors. From the statistical analysis, the multiple correlation using the Orleans prognostic test and second semester algebra grades was calculated to be .805. This was lowered to .77 when computed to give the two predictive factors equal weight. This was considered sufficiently high to be useful in counseling during registration. However, Richardson cautioned that those responsible for advising students cannot afford to be too dogmatic or prescriptive, but neither afford to disregard facts. He also recommended that continuous studies on geometry prognosis be made.

Goddeyne and Nemzek[12] - two predictive tests. In 1937, Goddeyne and Nemzek made the first reported study to determine the comparative value of the *Orleans Geometry Prognosis Test* (1929 edition) and the *Lee Test of Geometric Aptitude*. The two tests were given to two hundred tenth grade students in parochial schools in and around Detroit, Michigan. After a year's study, achievement was measured with the *Cooperative Plane Geometry Test*. The achievement scores were correlated with the prognostic test scores and with group mental test scores and algebra grades. The results showed that the Lee test was slightly superior to the Orleans test in this case. The prognostic tests were superior to the other factors. In addition, the Lee test was found to be easier to administer and score than the original edition of the Orleans test.

Davis and Henrick[13] - four factors. Davis and Henrick made a study in 1940-1941 to determine the relative effectiveness of the *Stewart-Davis Test of Ability in Geometry*, the *Otis Self Administering Test of Mental Ability*, eighth-grade arithmetic marks, and final marks in first year algebra.

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[12] Sister Loretta Marie Goddeyne and Claude L. Nemzek, The Comparative Value of Two Geometry Prognosis Tests in Predicting Success in Plane Geometry," *Journal of Social Psychology*, 20:283-87, November, 1944.

[13] Robert A. Davis and Marguerite Henrick, "Predicting Accomplishment in Plane Geometry," *School Science and Mathematics*, 45:403-05, May, 1945.

The criterion of achievement was a combination of teacher constructed achievement tests and the Orleans Plane Geometry Achievement Test. The best single predictor was the Stewart-Davis ability test, but it was not significantly better than the Otis mental ability test. The arithmetic marks had low predictive value. A combination of the Stewart-Davis test and algebra marks had the best predictive value, but only slightly higher than the combination of final algebra marks and intelligence quotients.

Kraft.[14] In Cleveland, Ohio during the period 1944-1946, Kraft used the Iowa Geometry Aptitude Test combined with students' "probable learning rates" (mental test ratings from group mental tests, Cleveland term) in an effort to establish a more effective system of counseling students who want to study geometry. She called the derived combination score the "geometry aptitude index". Use of the index was found to be a valuable aid to counseling. Combining the probable learning rate with the aptitude test made the results more impressive though only slightly more significant.

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[14] Ona Kraft, "Methods Used in the Selection of Pupils for the Study of Algebra and Geometry in Cleveland," The Mathematics Teacher, 39:236-39, May, 1946.

Harris[15] - comparison of two tests. Harris made a two year study in Austin, Texas in which she was attempting to improve means of decreasing the number of failures in geometry and at the same time to provide information which would help to group geometry students. Five predictive factors were used in the experiment (1) the Lee Test of Geometric Aptitude; (2) the Orleans Geometry Prognosis Test; (3) the California Short Form of Mental Maturity; (4) the California Arithmetic Test; and (5) the California Reading Test. The Lee and Orleans aptitude tests were found to be valuable for predicting success, for grouping and for discovering students with exceptional ability. The lower scores were not sufficiently reliable to use predictively without additional information. The Lee test correlated higher with achievement as determined by teachers' marks than did the Orleans test. The report did not indicate by what means the various teachers' marks were standardized so that an indicated grade would signify the same degree of achievement in each class.

Anglin[16] Four Factors. Anglin used four factors in

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[15]Margaret J. Harris, "A Study of the Value of Two Tests in Predicting Achievement in Plane Geometry," (unpublished Master's thesis, University of Texas, Austin, Texas, 1953), pp. 75-80.

[16]John B. Anglin, "A Study of the Value of Four Factors in Predicting Success in Plane Geometry", (unpublished Master's Thesis, North Dakota Agricultural College, Fargo, North Dakota, 1956) pp. 50-54.

his attempt to discover an accurate prediction of success in geometry: (1) Otis Quick-Scoring Mental Ability Test; (2) Lankton First Year Algebra Test; (3) Cooperative Mathematics Test; and (4) Cooperative Reading Comprehension Test. The Shaycroft Plane Geometry Test was used to measure achievement. The experiment was conducted in Alexandria, North Dakota. Single and three-variable multiple correlations were computed. The best single predictors were found to be the Cooperative mathematics test and the Lankton algebra test in that order. The best predictive combination were the Cooperative mathematics test combined with the Lankton algebra test. The results were not considered sufficiently significant to predict individual achievement. Anglin recommended that further research be carried out in search of more accurate predictive measures.

Summary. The studies reviewed here had one or both of two purposes in common: (1) to find a more accurate means of predicting a students chance to succeed in a course in plane geometry; and (2) to provide information for "grouping" geometry students. The majority of the studies used one or more geometry prognosis tests, mental tests, and scores or marks denoting various areas of academic achievement. Most of the studies used a standardized achievement test as the criterion of success. Teachers' marks were used in the others. The usual method of experimentation was to correlate the predictive factors with achievement, singly and in multiples.

The findings of the various studies were similar and may be summarized as: (1) achievement in plane geometry can be predicted with only a fair degree of accuracy by the use of the predictive measures studied; (2) the best predictors of success which were studied, are the geometry aptitude tests, algebra achievement and mental ability in that order; (3) combining the prognostic or aptitude test with either or both of ability in algebra and mental ability raised the predictive value somewhat as measured by the multiple correlation coefficient; (4) the predictive factors taken alone or in combination were not considered adequate to predict individual success, but were considered valuable in guidance and in providing for individual differences.

CHAPTER III

EXPERIMENTAL DESIGN

This experiment was designed to determine the degree of accuracy with which one can predict a student's success in geometry by the use of one or more of his scores from three aptitude tests. The criterion of success was the student's score obtained on a standardized achievement test taken after one semester of studying geometry. This portion of the report describing the design of the experiment is composed of four parts: (1) the selection of and a description of the sampling; (2) the method of instruction used in the classes; (3) a description of the measuring instruments used; and (4) the statistical design of the study.

Selection of students. The students used in the study were enrolled in eight plane geometry classes in the Lodi Union High School, Lodi, California. These classes were instructed by the investigator during the school years 1957-58 and 1958-59. Five of the classes were taught during the first and three during the second of each of the two school years. There was a total of fifteen classes of geometry taught in the school during the two year period. The sample was limited to the eight described because there were fewer variables present when all were under the same instructor.

The group was composed largely of sophomores (tenth year students) with a number of juniors and seniors. After eliminating from the study those students who were repeating the course and those for whom one or more of the test scores were not available, the final total group included one hundred sixty three. This included eighteen juniors (eleventh grade) and no senior (twelfth grade).

Method of instruction. The classes in which the students involved in this study were enrolled were taught in a manner which might be called "traditional." The format of the textbook *New Plane Geometry* by Welchons and Krickenberger[1] was followed closely. A geometry presented in this way is called demonstrative Euclidean geometry. Emphasis was placed upon the "formal proof" of theorems. Substantiation was required for most of the responses, written and oral, including statements in construction exercises. Students were required to be concise and complete in their responses. Although understanding in preference to rote memorization was stressed, a considerable portion of each student's study time was spent committing foundation material and theorems to memory. Emphasis was also placed upon logical deductive reasoning and the analytical approach to problem solving.

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[1]Welchons, A. M., and Krickenberger, W. R., *New Plane Geometry* (Boston: Ginn and Company, 1952).

The course was taught as a year course with classes meeting fifty-three minutes each day. A typical period was consumed by spending thirty-five to forty minutes in lecture-demonstration and discussion and the remainder in individual study. An examination was conducted (on the average) every two weeks with occasional short quizzes between. At the end of the first semester, the Seattle Plane Geometry (achievement) Test was given. During the years involved in the study, nearly twenty per cent of the students taking the course at the Lodi Union High School failed to receive passing grades for either or both semesters of the year in which they were enrolled. Scores made on the achievement test were only one of several factors considered in grade determination; however, these scores would correlate highly with grades.

Description of the tests used. The tests used as predictors of success were: (1) The Orleans Geometry Prognosis Test Revised Edition; (2) The Differential Aptitude Test of Numberical Ability;[2] and (3) The Differential Aptitude Test of Abstract Reasoning.[3] The test used as the criterion

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[2]George K. Bennett, Harold G. Seashore, and Alexander G. Wesman, Differential Aptitude Test of Numerical Ability (New York: The Psychological Corporation, 1947).

[3] George K. Bennett, Harold G. Seashore, and Alexander G. Wesman, Differential Aptitude Test of Abstract Reasoning (New York: The Psychological Corporation, 1947).

of success was the Seattle Plane Geometry Test.

The Orleans Geometry Prognosis Test, Revised Edition is a revision of a test first published in 1929 which was developed by Jacob S. Orleans and Joseph B. Orleans. The revised test has been shortened so that the testing time is thirty-nine minutes instead of the seventy minutes required for the original edition. The test was designed to measure those abilities needed to learn geometry by presenting eight lessons, a test on each, and a summary test. The eight lesson tests are (1) axioms; (2) reading angles; (3) kinds of angles; (4) complementary and supplementary angles; (5) understanding geometrical relationships; (6) bisection; (7) geometrical notation; and (8) geometrical problems.

The Differential Aptitude Test of Numerical Ability is one of a battery of eight aptitude tests which has been popular with educators, and especially with guidance personnel. Extensive research and evaluation of these tests show consistently significant relationship between plane geometry achievement and the tests of numerical ability and abstract reasoning.[4] Because basic numerical ability does not seem to be emphasized in the Orleans Geometry Prognosis Test, this test was chosen for use in this study. The items on the numerical

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[4]Bennett, G. K., Seashore, H. G., and Wesman, A. G., A Manual for the Differential Aptitude Tests (New York: The Psychological Corporation, 1952), pp. 42-53.

ability sub-test are

> designed to test understanding of numerical relationships and facility in handling numerical concepts . . . . The Numerical Ability test is a measure of the student's ability to reason with numbers, to manipulate numerical relationships and to deal intelligently with quantitative materials.[5]

The Differential Aptitude Test of Abstract Reasoning is another of the battery described in the preceding paragraph. "The Abstract Reasoning test is intended as a non-verbal measure of the students reasoning ability."[6] Each problem presents a series which requires the student to perceive an operating principle which governs the change in the figures. He demonstrates his recognition of the principle by choosing the diagram which would logically follow in the series. Abstract symbolism is used and

> Complexity is obtained from increasing conceptual difficulty . . . . It (the test) involves the ability to perceive relationships in abstract figure patterns -- generalization and education of principles from non-language designs.[7]

Because abstract reasoning is used extensively in geometry solutions and because of the non-verbal quality of this test it was chosen for use in this study. It was hoped that this test and the test of numerical ability described in the preceding paragraph would measure some of the abilities needed

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[5] Ibid. p. 6.

[6] Ibid. p. 6.

[7] Ibid. pp. 6-7.

for success in the study of geometry that are not measured by the Orleans prognosis test.

The Seattle Plane Geometry Test is one of the tests in the Evaluation and Adjustment Series of high school tests published by the World Book Company. It was designed to measure the achievement of students in the high school course of beginning plane geometry at the end of one semester of study and thus provides normative criteria for this study. The decision to use an achievement test as a criterion of success was reached after considering these points: (1) the investigator had previously observed a high degree of agreement between the achievement test scores and his own estimates of success; (2) it is difficult to determine a comparative standard of achievement when it (achievement) is represented by teacher assigned grades; and (3) grades usually reflect some degree of subjectivity which is not a part of the achievement (geometrical) under consideration here.

The time required for administration of the test is one class period. The authors indicate that the test measures "not only understanding and knowledge of the facts of geometry, but also acquisition and application of skills, facts and methods."[8] The test is said to measure in four areas:

Harold B. Jeffery, and others, The Seattle Plane Geometry Test Manual of Directions (Yonkers-on-Hudson: World Book Company, 1951), p. 1.

(1) vocabulary; (2) construction; (3) computation; and (4) reasoning. The objectives of the course as taught at the Lodi Union High School would be classified into these same areas.

The statistical design of the study. The *Differential Aptitude Test* scores of the students were obtained from their cumulative school records. The Orleans prognostic test scores and the Seattle achievement scores were obtained from tests given in the geometry classes. Product-moment linear correlations between each set of prediction test scores and the achievement test scores were calculated first. In the second stage of analysis, multiple correlation coefficients using three variables were computed. In the final stage of analysis, the regression equation for four variables was developed as well as the four-variable multiple correlation coefficient. Except for very high and very low scores, the correlation coefficient was not large enough to make the regression equation much better than a crude prophesy.

CHAPTER IV

RESULTS OF THE ANALYSIS

A general description of the method of research employed in this study was given in Chapter III. The experimental computations, the results of these statistical analyses, and the significance of these results will be presented in this section of the report.

Single correlations. After the scores made by the 163 plane geometry students on the four tests were placed in tabular form, the zero order product moment coefficients of correlation were computed. The coefficients (r's) obtained indicate the degree of relationship between each of the predictive tests and the achievement test. In the tables and appendices which illustrate calculations as well as in the account describing the results of the calculations, reference to the various tests is made by the use of numerals and numerical subscripts (see Table 1). The tests and the numbers assigned to them are as follows: (1) Seattle Plane Geometry Test; (2) Orleans Geometry Prognosis Test; (3) Differential Aptitude Test of Numerical Ability; and (4) Differential Aptitude Test of Abstract Reasoning.

The zero order correlation coefficients were computed

TABLE I

THE ZERO-ORDER COEFFICIENTS OF CORRELATION BETWEEN THE CRITERION TEST (1) AND THE THREE TESTS OF PREDICTION (2), (3) AND (4), AND THE INTER-CORRELATIONS*

r				
	1	2	3	4
1	---	.546	.299	.309
2	---	---	.348	.351
3	---	---	---	.391

*Numerical designation of the tests used in the study

Name of test	Reference number
Seattle Plane Geometry Test	1
Orleans Geometry Prognosis Test	2
Differential Aptitude Test of Numerical Ability	3
Differential Aptitude Test of Abstract Reasoning	4

by using the formula $r = \frac{N\Sigma XY - \Sigma X(\Sigma Y)}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$

By the use of this formula, calculation was made from raw or obtained scores. Appendix C shows the obtained values used in the formula for each of the correlations of the predictive tests with the achievement test and the inter-correlations.

The correlations, as shown in Table 1, between predictive tests and achievement test were: (1) between the Orleans Geometry Prognosis Test and the Seattle Plane Geometry Test, $r = .546$; (2) between the Differential Aptitude Test of Numerical Ability and the Seattle Plane Geometry Test, $r = .299$; and (3) between the Differential Aptitude Test of Abstract Reasoning and the Seattle Plane Geometry Test, $r = .309$. From Garrett's[2] table of significance of correlation coefficients, these values are all considered significant at the one per cent level. However none is sufficiently high to permit predicting individual success or failure with any high degree of confidence. The standard error of estimate ($\sigma est_{(1)}$) for predicting Seattle achievement test scores from the Orleans prognostic test scores is 10.25, (approximately twice the standard error of estimate of the Seattle test itself). This means that two-thirds of the predicted scores will be within plus or minus 10.25 points

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[1] Henry E. Garrett, Statistics in Psychology and Education, (New York: Longmans, Green and Company, 1947), p. 292.

[2] Ibid. pp. 190-91.

of the best estimate. Ten Points on the Seattle test can easily amount to a change in percentile ranking of as much as twenty, a rather broad span. In view of this, even the scores on the Orleans test which correlate highest with the achievement test can hardly be used alone for more than a guess of a student's liklihood of success.

Multiple correlation with three variables. The second stage of analysis was the calculation of the correlation between each pair of the three predictive tests and the achievement test. The method of computation used is that described by Garrett[3] in which the multiple correlation coefficients are calculated using the formula:[4]

$$R_{1(23)} = \sqrt{1 - \frac{\sigma^2_{1.23}}{\sigma^2_1}}$$

In addition to the inter-correlations (Table 1, p. 25), this method requires the following values: (1) the mean, and standard deviation (σ) of each series of scores; (2) the first order partial coefficients of correlation; and (3) the partial σ's. The formulas used for these computations are listed in Appendix A. The resulting statistics are listed in Tables II and III. Numerical subscripts refer to the tests as indicated in Table 1, page 25.

The coefficient of multiple correlation between the

[3] Ibid. pp. 404-25.

[4] Ibid. p. 407.

TABLE II

MEANS AND STANDARD DEVIATIONS

OF THE FOUR TEST VARIABLES

Test**	Mean	σ
1	6.13*	12.23
2	34.29	15.13
3	-.976*	8.12
4	-.724*	7.41

* After subtraction of constants
** For numerical designation see Table 1, p.25.

TABLE 3

THE THREE-VARIABLE PARTIAL COEFFICIENTS OF CORRELATION AND PARTIAL STANDARD DEVIATIONS

The partial coefficients of correlation

Test 1 partialed out	Test 2 partialed out	Test 3 partialed out	Test 4 partialed out
$r_{23.1} = .230$	$r_{14.2} = .149$	$r_{12.3} = .494$	$r_{12.4} = .491$
$r_{24.1} = .226$	$r_{13.2} = .130$	$r_{14.3} = .219$	$r_{13.4} = .203$
$r_{34.1} = .330$	$r_{34.2} = .319$	$r_{24.3} = .249$	$r_{23.4} = .246$

The partial standard deviations

$\sigma_{1.23} = 10.11$	$\sigma_{1.24} = 10.08$	$\sigma_{1.34} = 11.40$

For numerical designations, see Table 1, p. 25.

two predicting tests (2) and (3) and the criterion test (1) indicated by $R_{1(23)}$ was calculated to be .567. $R_{1(24)}$ = .57 and $R_{1(34)}$ = .372. These are all considered significant at the one per cent level; however with the single correlations, the relationships are not sufficiently strong to allow the combination of scores on the predictor tests to be used as the sole criterion for prediction of individual student success. The scores on tests (3) and (4), although showing significant relationship to scores on test (1), are together only of limited predictive value. Each, when combined with test (2) scores, add only slightly to its value as a predictor.

Multiple correlation with four variables. In order to determine the maximum possible value of the tests of prediction, the multiple regression equation and multiple correlation coefficient using all four variables were computed. The regression equation in deviation and in score form and the formulas used to calculate them are listed in Appendix B. In score form the resulting equation is:

$$X-M_1 = .4(X_2 - M_2) + .14(X_3-M_3) + .17(X_4-M_4)$$

The coefficient of multiple correlation for all four variables was calculated using the formula: $R_{1(234)} = \sqrt{1 - \frac{\sigma^2_{1.234}}{\sigma^2_1}}$ [5]

[5] Ibid. p. 424.

The σ_{est_x} (standard error of estimate) was computed using formula number (9), Appendix B.

The coefficient of multiple correlation ($R_{1(234)}$) was found to be .59 and the σ_{est_x} to be 9.9. The combination of all three tests of prediction is little better than the Orleans test alone. Attempting to predict individual achievement from these scores along would be unjustified. Garrett[6] states, "For r's of .80 or less . . . predictions of individual scores based upon the regression equation are little better than 'guesses'." It should be borne in mind that when success in a course is being measured by the use of a standardized achievement test, such a test is quite certain not to measure some of those factors which have been objectives of the course. Also, the test is likely to be measuring achievement in some areas which have not been objectives of the course. In other words, any achievement test, standardized on students taught by many teachers in many schools may lack validity when used as a measure of achievement in courses taught by one specific instructor. However, teachers' grades are not likely to be superior as a criterion when calculating the correlation between prediction and achievement if the objectives of the achievement test under consideration parallel those of the course.[7]

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[6] Ibid. p. 336.

[7] See chapter III, p. 22.

However, because of the significant coefficients of correlation, these scores may be useful when considered in conjunction with other indicators of achievement. It should be possible to choose most of those students for whom the study of geometry will be especially difficult and those who will need additional topics to challenge their ability.

Summary. This chapter described the experimental computations and the results of the statistical analysis. The significance of these results was also considered.

The computation of single and three and four variable multiple correlation coefficients indicated significant relationship at the one per cent level in all cases. However, the coefficients of correlation were not found to be sufficiently high to be useful to make accurate predictions of individual success in geometry.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary. This study was undertaken in an attempt to evaluate the use of the *Orleans Geometry Prognosis Test* in the Lodi Union High School. It was sought to determine the degree to which the Orleans test is predicting success and the amount by which prediction could be improved by combining its results with either or both of two other aptitude tests. Two tests whose predictive value in combination with a standardized geometry aptitude test had not been previously reported were chosen. These tests, the *Differential Aptitude Test of Numerical Ability* and the *Differential Aptitude Test of Abstract Reasoning*, were reported by their authors to correlate significantly with achievement in geometry. It was hoped they might measure some of the mental capacities required for success in geometry that were not being measured by a test such as the *Orleans Geometry Prognosis Test*. If so, it seemed that a combination of test results might be more useful for predicting individual success than the results of any one test.

Scores from the three aptitude tests and from the *Seattle Plane Geometry Test* (achievement test) were obtained and tabulated for a sample of one hundred sixty-three geometry students. These students were enrolled in eight classes taught by the same instructor during the school years 1957-58 and 1958-59. Linear and three and four variable multiple correlations were calculated. The multiple regression equation for the use of the results of all three predictive tests was developed as well as the standard error of estimate.

The correlations obtained were all found to be significant at the one per cent level.[1] However, the largest coefficient of correlation, the four-variable multiple, was only .59 and was not much larger than the simple correlation between the Orleans prognosis test and achievement measured by the Seattle test (.546). Although useful in group predictions, the standard error of estimate is so large (9.94) that even the results of all three tests are not sufficient criteria for making accurate individual predictions. It will, however help to determine if a student's chances for success are great or small and should therefore be useful in counseling individual students.[2]

<u>Conclusions</u>. The results of this study and of those reported in Chapter II seem to bear strong evidence that a rather large portion of the qualifications necessary for a student to be successful in the study of plane geometry is

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[1]See Table I, p. 25, and Table III, p. 29.

[2]See Conclusions, p. 34

not being measured by the criteria which are being used for this purpose. Of the numerous tests and achievement evaluations examined in this and the other studies, the best estimate of a student's chance to succeed seems to be obtained from the combination of a standardized geometry aptitude test and the student's success in first year algebra. Combining the results of the *Differential Aptitude Tests of Numerical Ability* and *of Abstract* Reasoning with the *Orleans Geometry Prognosis Test* as reported in this study does not seem to predict much better than the prognostic test alone. Apparently most of the geometric aptitudes or abilities measured by the *Differential Aptitude Tests* considered here are also being measured by the *Orleans Geometry Prognosis Test*.

This study, as well as the related studies reviewed, seems to indicate that some ability factors which have not been measured or otherwise determined, contribute significantly to the success of a geometry student. The degree to which success depends upon these indeterminate qualities may be greater than suggested by some of the authors of geometry aptitude tests. A growing awareness to the importance of these less tangible abilities such as intellectual curiosity and persistence, as determinants of academic achievement is evidenced in recent research. The studies by Silovsky[3] and Rowland[4] are examples of these.

It must be concluded that aptitude for the study of plane geometry is a difficult quantity to assess. Anyone who has the responsibility of screening, or counseling, applicants for admittance to the course should be cognizant of this conclusion. He should consider the motivation of students of doubtful aptitude who aspire to enroll. If they are strongly motivated, this study produces no evidence upon which to base a denial of their right to enter the course.

Recommendations. Because the Orleans Geometry Prognosis Test provides useful supplemental information regarding a student's liklihood of success in studying plane geometry, it is recommended that its use be continued. Although the results of this study indicate that the prognostic test is not a good individual student predictor, scores well above or below the mean will usually help to determine if a students chances for success are great or small.

There is no evidence in this study to indicate that

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[3] George L. Silovsky and Kenneth E. Anderson, "A Study of the Relationships of Non-Academic Correlates to Achievement - Participants and Non-Participants in the National Merit Scholarship Testing Program," School Science and Mathematics, 527:191-198, March 1960.

[4] J. Kenneth Rowland, "A Psychometric Study of Student Attitudes as a Measure of Academic Motivation," (unpublished Doctor's thesis, College of the Pacific, Stockton, California, 1958), 81 pp.

the practice of considering a grade of "B" or better in first year Algebra an automatic recommendation for enrollment in geometry is unwise. Use of the *Orleans Geometry Prognosis Test* to gain additional information upon which to base a recommendation to enroll in geometry for those students with "C" Algebra achievement is recommended.

It is not recommended that the *Differential Aptitude Tests of Numerical Ability and of Abstract Reasoning* be used in determining a student's eligibility to enroll in geometry unless there is reason to believe that his algebra achievement and prognostic test scores are not valid samples of his abilities.

Recommendations for further study. If further research on geometry prognosis is to be attempted, it is recommended that consideration be given to attributes which encourage academic success other than those which can be measured by tests of specific ability. This study and others reviewed herein have indicated that a considerable portion of the attributes which a student needs to possess in order to succeed in the study of plane geometry are not measured by tests of academic ability which have been used.

BIBLIOGRAPHY

A. BOOKS

Bennett, George K., Harold G. Seashore, and Alexander G. Wesman, A Manual for the Differential Aptitude Tests. New York: The Psychological Corporation, 1952. 78PP.

Garrett, Henry E., Statistics in Psychology and Education. New York: Longmans, Green and Company, 1947. 487 pp.

Good, C. V., A. S. Barr, and D. E. Scates, The Methodology of Educational Research. New York: D. Appleton-Century Company, 1941. ___pp.

Jeffery, Harold B., S. L. Merriam, C. T. Smith, R. E. Bennett, and Roy D. Kellogg, Seattle Plane Geometry Test Manual of Directions. New York: World Book Company, 1951. 7pp.

Lacey, Oliver L., Statistical Methods in Experimentation. New York: The MacMillan Company, 1953. 249 pp.

Orleans, Joseph B., Orleans Geometry Prognosis Test Manual of Directions. New York: World Book Company, 1951. 12 pp.

Welchons, A. M., and W. R. Krickenberger, New Plane Geometry. Boston: Ginn and Company, 1956. 568 pp.

Whitney, Frederick L., The Elements of Research. New York: Prentice Hall, Inc., 1942. 497 pp.

B. PERIODICAL ARTICLES

Brown, Kenneth E., "Status of Mathematics Education in Public Secondary Schools," The Bulletin of the National Association of Secondary School Principals, 38:56, May 1954.

__________, "The White House Conference on Education and Its Implications for Mathematics Teachers," The Mathematics Teacher, 49:296, April, 1956.

Cooke, Dennis H., and John M. Pearson, "Predicting Achievement in Plane Geometry," School Science and Mathematics, 33:872-78, November 1933.

Davis, Robert A., and Marguerite Henrick, "Predicting Accomplishment in Plane Geometry," School Science and Mathematics, 45:403-05, May, 1945.

Goddeyne, Sister Loretta Marie and Claude L. Nemzek, "The Comparative Value of Two Geometry Prognosis Tests in Predicting Success in Plane Geometry," Journal of Social Psychology, 20:283-87, November, 1944.

Hamilton, J. London, "A Method for Reducing Failures in Plane Geometry," Journal of Educational Research, 30:700-02, May, 1937.

Kraft, Ona, "Methods Used in the Selection of Pupils for the Study of Algebra and Geometry in Cleveland," The Mathematics Teacher, 39:236-39, May, 1946.

Lee, J. Murray, and W. Hardin Hughes, "Predicting Success in Algebra and Geometry," School Review, 42:188-96, March, 1934.

Lee, J. Murray, and Dorris May Lee. "The Construction and Validation of a Test of Geometric Aptitude," The Mathematics Teacher, 25:193-203, April, 1932.

McDaid, Elmer W., "Determining Individual Needs Through a Guidance-Counseling Testing Program," The Bulletin of the National Association of Secondary School Principals, 38:89, May, 1954.

Orleans, Joseph B., "A Study of Prognosis of Probable Success in Algebra and in Geometry," The Mathematics Teacher, 27:165-180, April, 1934.

Reeve, William D., "The Problem of Varying Abilities Among Students in Mathematics, "The Mathematics Teacher, 49:70-71, February, 1956.

Richardson, H. D., "Predicting Achievement in Plane Geometry," The Mathematics Teacher, 28:310-319, May, 1935.

Rogers, Agnes L. "Tests of Mathematical Ability," The Mathematics Teacher, 16:193-205, April, 1923.

Silovsky, George J., and Kenneth E. Anderson, "A Study of the Relationships of Non-Academic Correlates to Achievement -- Participants and Non-Participants in the National Merit Scholarship Testing Program," School Science and Mathematics, 527: 191-198, March, 1960.

C. PUBLICATION OF A LEARNED ORGANIZATION

Reeve, William D., and others, "The Teaching of Geometry," The Fifth Yearbook of the National Council of Teachers of Mathematics, New York: Bureau of Publications, Teachers College, Columbia University, 1930. 206 pp.

D. UNPUBLISHED MATERIALS

Anglin, John G, "A Study of the Value of Four Factors in Predicting Success in Plane Geometry." Unpublished Master's thesis, North Dakota Agricultural College, Fargo, North Dakota, 1956.

Harris, Margaret Jane, "A Study of the Value of Two Tests in Predicting Achievement in Plane Geometry." Unpublished Master's thesis, The University of Texas, Austin, Texas, 1953.

Rowland, J. Kenneth, "A Psychometric Study of Student Attitudes as a Measure of Academic Motivation." Unpublished Doctor's thesis, College of the Pacific, Stockton, California, 1958.

APPENDIX

APPENDIX A

FORMULAS USED TO CALCULATE THE ZERO-ORDER AND THREE-VARIABLE MULTIPLE CORRELATIONS

(References are to pages in Garrett[1])

(1) Zero-order Coefficients of Correlation 292

$$r = \frac{N\Sigma XY - \Sigma X(\Sigma Y)}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$$

(2) Partial Coefficients of Correlation 407

$$r_{12.3} = \frac{r_{12} - r_{13}\, r_{23}}{\sqrt{1 - r_{13}^2}\ \sqrt{1 - r_{23}^2}}$$

(3) Standard Deviation from Original Scores 62

$$\sigma = \sqrt{\frac{\Sigma X^2}{N} - M^2}$$

(4) Partial σ's 407

$$\sigma_{1.23} = \sigma_1 \sqrt{1 - r_{12}^2}\ \sqrt{1 - r_{13.2}^2}$$

(5) Three-variable Coefficient of Multiple Correlation 407

$$R_{1(23)} = \sqrt{1 - \frac{\sigma_{1.23}^2}{\sigma_1^2}}$$

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1 Henry E. Garrett, Statistics in Psychology and Education, (New York: Longmans, Green and Company, 1947).

APPENDIX B

FORMULAS USED TO CALCULATE THE FOUR-VARIABLE MULTIPLE CORRELATION AND THE REGRESSION EQUATION

(References are to pages in Garrett[2])

(6) Partial Correlation Coefficients of the Second Order 415

$$r_{12.34} = \frac{r_{12.3} - r_{14.3}\, r_{24.3}}{\sqrt{1 - r^2_{14.3}}\ \sqrt{1 - r^2_{24.3}}}$$

(7) Partial σ's 417

$$\sigma_{1.234} = \sigma_1 \sqrt{1 - r^2_{12}}\ \sqrt{1 - r^2_{13.2}}\ \sqrt{1 - r^2_{14.23}}$$

(8) Partial Regression Coefficients 420

$$b_{12.34} = r_{12.34} \frac{\sigma_{1.234}}{\sigma_{2.134}}$$

(9) Standard Error of Estimate 422

$$\sigma_{est\, X_1} = \sigma_{1.234}$$

(10) Four-variable Multiple Correlation Coefficient . 424

$$R_{1(234)} = \sqrt{1 - \frac{\sigma^2_{1.234}}{\sigma^2_1}}$$

(11) Regression Equation 419

$$\bar{X}_1 = b_{12.34} X_2 + b_{13.24} X_3 + b_{14.23} X_4$$

Deviation form -- $\bar{X}_1 = .4(X_2) + .14(X_3) + .17(X_4)$

Score form -- $X - M_1 = .4(X_2 - M_2) + .14(X_3 - M_3) + .17(X_4 - M_4)$

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1 *Ibid.*

APPENDIX C

THE NUMERICAL VALUES USED TO COMPUTE THE SINGLE-ORDER COEFFICIENTS OF CORRELATION

r	ΣXY	ΣX	ΣY	ΣX^2	ΣY^2
r_{12}	50742	5589	999	228992	30511
r_{13}	3840	-118	999	9015	30511
r_{14}	3866	-159	999	10906	30511
r_{23}	1530	5589	-159	228992	10906
r_{24}	2373	5589	-118	228992	9015
r_{34}	3951	-118	-159	9015	10906

N = 163