# THE RELATIONSHIP OF HIGH SCHOOL CALCULUS TO ACHIEVEMENT IN ANALYTIC GEOMETRY AND CALCULUS I AT KANSAS STATE UNIVERSITY

by 632

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# INTRODUCTION

General Background. Since the middle of the nineteenth century, calculus has been taught in a few high schools in the United States. However, it was not until after the 1957 launch of the Russian Sputnik that American education took such a critical look at the content of mathematics on the secondary level.

Since then, American education has increasingly focused its energies on training young people to meet the rapidly expanding demands of engineering, science, and mathematics. From recommendations of such groups as the Commission of Mathematics of the College Entrance Examination Board, the School Mathematics Study Group, and the University of Illinois Committee on School Mathematics, whole curriculums have been abandoned or reorganized. Algebra is being offered in the eighth grade with geometry in the ninth grade in many schools. Solid geometry and trigonometry are being incorporated into plane geometry and Algebra II rather than being full-year courses. Because of these factors, one semester or even a full year of elective time is available to students at the twelfth grade level for other topics in mathematics.

This elective time at the senior level has created definite problems for curriculum planners. Many educators feel that such topics as statistics, probability, elementary functions, analytic geometry, modern algebra, and computer programming would be more profitable to the student at the twelfth grade than would an introductory course in calculus. The Commission on Mathematics of the College Entrance Examination Board felt that calculus is a college-level subject and that a reasonable immediate goal for most high schools is a strong college-preparatory mathematics curriculum which prepares students to begin calculus when they enter college [2, 3].[1]

Statement of the Problem. The increase in more rigorous academic work at the secondary level has been of special concern to curriculum planners over the last twelve years. This study was conducted to determine if there was a significant difference in Analytic Geometry and Calculus I grades at Kansas State University between those who had completed high school calculus and those who had not completed a previous high school calculus course.

Hypothesis. There was no significant difference on Analytic Geometry and Calculus I grades if a student had completed at least one semester of calculus in high school when compared with those who had no previous high school calculus.

Importance of the Study. The writer believes that this research would aid both high school teachers and administrators in determining the content of a twelfth grade mathematics course.

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[1]The first coordinate of the ordered pair refers to the number of the article as listed in the bibliography. The second coordinate refers to the page number of the article from which the quotation or reference was taken.

Selection of Subjects. There were a total of 794 students who had taken the first course in calculus during the 1967-1968 year at Kansas State University. Of these, 587 had records of the needed variables. The subjects under study were then divided into two groups, those who had previous high school calculus (n = 37), and those who did not have a previous calculus course (n = 550). A random selection of 37 students was made from those not having high school calculus, using a table of random numbers [7, 237-243]. If a student's senior level mathematics instruction was questionable as to content (calculus vs. no calculus), that student's data was discarded from the study.

Limitations of the Study. The first limitation was that several students had no American College Testing Program (ACT) scores, although the American College Testing Program (ACT) scores were required of entering freshmen. Some students were transfer or foreign students, in which case no high school transcripts were available. Secondly, to the extent that course grades lack reliability, difficulty in accounting for the variance in the measures by any research methodology was anticipated. It would also appear that there were relevant determinants of student achievement which had been overlooked in this study. Some of these were teacher competence, course material, and motivation and social adjustment of the student which were not readily measurable at the time. A final limitation was that of obtaining translations of course names at the secondary level.

With such titles as Math V, Math 12, or Honors Math, it was sometimes difficult to determine whether or not calculus was offered as a part of the course.

Definition of Terms. The following list of terms was defined for clarification of the problem:

1. Analytic Geometry and Calculus I: A study of limits, their applications in definitions of a derivative and an integral, with emphasis in use to geometric situations.

2. Variable: "A quantity which can take on any of the numbers of some set" [8, 412].

3. Correlation Coefficient: (R) - "An index of relationship between two variables" [12, 72].

4. Standard Deviation: "The square root of the variance - the square root of the mean square, or simply the root mean square" [12, 51].

5. t-test: "A test of the hypothesis that the true means are equal" [9, 56].

6. Variance: "The mean of the squared deviations from the mean" [12, 50].

7. Multiple Regression Equation: An equation used to predict the most likely measurement in one variable from the known measurements of several variables.

8. b Coefficients: "The partial regression coefficients in terms of the scores of the test" [4, 454].

9. c Coefficient: A constant that is calculated from the means of the variables. It is also referred to as the y-intercept.

10. F-test: "The ratio of 'between' variance to 'within' variance" [5, 147]. The F-test is used as a basis of deciding whether the sets could have arisen by random sampling from the same population.

11. Percentile Rank: "When a score in a collection of such scores is expressed as the percentage of scores in the collection that are below this score" [12, 17].

12. American College Testing Program, Inc. (ACT): ACT is a federation of state programs founded in 1959 and chartered under the laws of the state of Iowa as an independent, non-profit corporation. The ACT battery of tests consists of four subtests in English, Mathematics, Social Studies, and Natural Sciences. "These tests were developed to measure as directly as possible the abilities the student will have to apply in his college course work" [1, 8].

13. ACT College Bound Percentile Rank: On each of the four tests in the ACT battery, a raw score converted into percentile rank.

14. Advanced Placement: "A test taken for exemption from prescribed courses and placement in an elementary course which would otherwise have been required; or the award of college credit in recognition of achievement in covering the work ordinarily required in a course of college level, or both advanced placement and college credit" [3, 20].

## REVIEW OF RELATED LITERATURE

Using a 2 X 2 factorial design with 48 cases from each cell, Tillotson reported that no significant difference could be attributed to an introductory (2-12 weeks) study of calculus in high school on students' achievement in the first semester calculus course offered at the University of Kansas. Tillotson selected two criterion variables of achievement. One was the score on a common final examination administered to all students in the first semester course and the other was the numerical equivalent of the student's letter grade for the first semester calculus course at Kansas University during the 1961-1962, Fall term.

To control the factors of scholastic ability and general mathematical background statistically, two concommitant variables were employed. One was the normalized high school rank and the other was the score on a mathematics placement test. For the data in the 192 cases in the factorial design, two analyses of covariance were made, one for each criterion.

For the F-ratio to be significant, the calculated F must be at least 3.84 $\left[12, 322\right]$ at the 0.05 level of confidence. In the analysis of covariance based on the examination scores, the F-ratios obtained for the factors of preparation, level, and interaction were 2.40, 1.23, and 0.65, respectively. In the analysis which used the course grades for the criterion variable, the corresponding ratios were 0.194, 0.013, and 0.800. None of the F values were significant at the 0.05 level.

Tillotson then concluded that when adjustment was made for scholastic ability and general mathematical background, there was no evidence of any significant difference in achievement in the university course between the two groups, with and without high school calculus [13, 577-578].

McKillip, in his study on the effects of secondary school calculus on the students' first semester calculus grades at the University of Virginia, found that students who had one semester of calculus in high school did not earn grades in the first semester of college calculus significantly better than the grades which they would have been expected to earn without the effects of the high school calculus course. However, McKillip found that the subjects in his study who took two semesters of calculus in high school did earn grades in the first semester of college calculus significantly better than they would have been expected to earn without the effects of high school calculus.

McKillip used regression equations which were calculated, using as independent variables, grades in a college course previous to calculus, high school mathematics grade averages, high school class ranks, CEEB SAT-mathematical and SAT-verbal scores, and CEEB Mathematics Achievement Test scores. The criterion variable was the grade in the first semester of calculus at the University of Virginia. Based on data from 753 students who had taken essentially no calculus in high school, the predicted grade a student would earn without the effects of high school calculus was computed.

There were 83 students during the 1963-1964 academic year who had taken at least one semester of calculus in high school and who had not received advanced placement at the University of Virginia. These students were then grouped in three ways. One grouping was made according to the mathematical sequence of courses at the University of Virginia. Another was grouped by the number of semesters of calculus taken in high school, and a third group was by what type of high school the student graduated from, public or private.

Using the regression equations, McKillip predicted the grades the 83 subjects who had taken high school calculus would have earned had they not taken calculus in high school. The predicted grades were then subtracted from the actual grades received in the university calculus course and the resulting signed differences were tested for significance by a Wilcoxon Matched--Pairs Signed--Ranks test and by a t-test for the significance of the mean difference.

In the six groups tested, the mean difference ranged from .126 to .376, for subjects who had one semester of calculu in high school. This was not a significant difference at the 0.05 level of confidence. Subjects who took two semesters of calculus in high school, public or private, had a mean difference of .755 to 1.184 which was significant at the 0.05 level [10, 5920].

Robinson studied the effects of two semesters of high school calculus on the students' first and second quarter calculus grades at the University of Utah. Based on this study th effect of two semesters of secondary calculus did significantly benefit the students' achievement in the university calculus courses.

Regression equations were calculated by the Wherry-Doolittle Test Selection Method, based on data on 1965, 1966, and 1967 graduates from five selected Utah high schools who had completed one semester of analytic geometry but no calculus in high school. The independent variables used were high school analytic geometry grade, average of high school mathematics grades, rank in the high school graduating class, ACT English score, and ACT mathematics score. The dependent variables were the grades received for the first two quarters of calculus at the University of Utah.

Five subgroups of students were identified, each containing twelve or more subjects, according to the mathematics sequence followed at the University of Utah and whether the student completed one or two semesters of calculus at the university. The regression equations were used to predict the grades for the first two quarters of calculus of the students who had completed analytic geometry and two semesters of calculus in high school. The predicted grades were subtracted from the grades actually received to obtain a set of signed differences which were tested for significance by the Wilcoxon Matched--Pairs Signed--Ranks Test and by a t-test for significance of the mean difference, both at the 0.05 level of confidence.

The three subgroups of students repeating the first quarter of calculus received grades whose mean differences were significant at the 0.01 level on both sides. The subgroup of students repeating analytic geometry as well as the first two quarters of calculus received grades for the second quarter of calculus whose mean difference was also significant at the 0.01 level on both tests. The subgroup of students repeating the first two quarters of calculus but not analytic geometry received grades in the second quarter of calculus whose mean difference was significant at the 0.05 level on the Wilcoxon test, but was not statistically significant on the t-test at the 0.05 level of confidence [11, 57-60].

## PRESENTATION AND ANALYSIS OF DATA

Table I gives the mean and standard deviation of each variable $X_2$ through $X_7$ according to whether the subject had completed a high school calculus course or not. Group I was composed of the subjects having completed a calculus course in high school while Group II was the section of the test population having no previous calculus course. Of particular importance was the means of the criterion variable $X_7$. The mean of the Analytic Geometry and Calculus I grade for Group I was higher than the mean for Group II. A t-test was run to determine if there was significant difference between the mean of Group I and the mean of Group II.

The t value was computed by the following formula [12, 166-167]:

TABLE I

MEANS AND STANDARD DEVIATIONS OF VARIABLES $X_2$, $X_3$, $X_4$, $X_5$, $X_6$, $X_7$ OF THOSE STUDENTS HAVING HIGH SCHOOL CALCULUS AND THOSE HAVING NO HIGH SCHOOL CALCULUS

| Variable | Group I High School Calculus | | Group II No High School Calculus | |
|---|---|---|---|---|
| | Mean | Standard Deviation | Mean | Standard Deviation |
| $X_2$ - Sex (Male = 1, Female = 0) | 0.97 | 0.16 | 0.86 | 0.34 |
| $X_3$ - High School Percentile Rank | 76.73 | 17.68 | 78.08 | 19.57 |
| $X_4$ - ACT Mathematics Score | 76.86 | 22.98 | 76.38 | 19.89 |
| $X_5$ - ACT English Score | 63.84 | 25.93 | 60.16 | 27.45 |
| $X_6$ - ACT Natural Science Score | 77.46 | 21.54 | 70.22 | 26.06 |
| $X_7$ - Analytic Geometry and Calculus I (Grade) | 2.22 | 1.32 | 2.19 | 1.14 |

$$t = \frac{M_1 - M_2}{\frac{SS_1 + SS_2}{n_1 + n_2 - 2} \quad \frac{1}{n_1} + \frac{1}{n_2}}$$

where M was the mean of the group, and n the size of the population sample. The sum of squares (SS) for each group was calculated by [12, 48]:

$$SS = \Sigma X^2 - \frac{(\Sigma X_i)^2}{n}$$

where $X_i$ is the numerical equivalent of the $i^{th}$ subject's grade in Analytic Geometry and Calculus I.

In order for the t statistic to be significant, t needed to be at least 2.00 in two-tailed test at the 0.05 level of confidence with degree of freedom equal to 72 [12, 293]. The calculated t statistic equaled 0.117; therefore, there was no significance in the difference of the two means at the 0.05 level.

A seven by seven Pearson correlation coefficient matrix of the variables in this study is found in Table II. In order to show a significant correlation between any two variables in this study, the entry or matrix element needed to be at least equal to 0.232 for a two-tailed test at the 0.05 level of significance with degree of freedom equal to 72 [12, 301]. The asterisked entries show a significant correlation.

Of particular import was the correlation between whether a subject had high school calculus or not ($X_1$) and the subject's college calculus grade ($X_7$). The table value was 0.0110 which

TABLE II

INTERCORRELATION MATRIX OF THE SIX PREDICTOR VARIABLES AND ANALYTIC GEOMETRY AND CALCULUS I GRADES OF 1967-1968
N = 74

| Variable | | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ |
|---|---|---|---|---|---|---|---|---|
| lculus vs. no Calculus | $X_1$ | 1.0000 | 0.2731* | -0.0362 | 0.0113 | 0.0687 | 0.1498 | 0.0110 |
| c | $X_2$ | | 1.0000 | -0.0184 | -0.0474 | -0.1487 | 0.0976 | -0.1393 |
| gh School Percentile Rank | $X_3$ | | | 1.0000 | 0.4520* | 0.4247* | 0.4761* | 0.5317* |
| T Mathematics Score | $X_4$ | | | | 1.0000 | 0.6415* | 0.6409* | 0.5090* |
| T English Score | $X_5$ | | | | | 1.0000 | 0.5658* | 0.3740* |
| T Natural Science Score | $X_6$ | | | | | | 1.0000 | 0.3678* |
| alytic Geometry and Calculus I (Grade) | $X_7$ | | | | | | | 1.0000 |

*Significant at the 0.05 level (two-tailed test).

shows no significance at the 0.05 level of significance. It should be noted that a significant correlation is not in itself sufficient evidence to establish even a casual relationship between two variables [12, 80].

The method of data analysis was that of comparing two multiple regression models. A "full model" with six predictors and single criterion was formed, then a "restricted model," in which one of the predictor variables was discarded, was formed. The R-square (multiple coefficient of determination) reported for each model indicated that proportion of the criterion accounted for by the predictors included in that particular model. The F-statistic was then used to determine whether the full model accounted for a significantly larger proportion of the criterion variance than the restricted model. If the full model could account for a significantly larger proportion, then the discarded variable had a significant effect on the criterion variable. When the restricted model was constituted by dropping a grouping variable from the full model, the result was mathematically equivalent to the analysis of covariance with concommitant statistical control of the remaining predictor variables. Although this study was to determine whether high school calculus had a significant effect on a college calcalus I course, five other restricted models were formed to determine what, if any, of the criterion variance could be accounted for by the other predictors.

The F-ratio used in this study was calculated from the formula [12, 277]:

$$F = \frac{(R^2_{fm} - R^2_{rm})(N - u - 1)}{(1 - R^2_{fm})(u - v)} \quad \text{with df} = u - v,\ N - u - 1$$

where $R^2_{fm}$ was the multiple coefficient of determination of the full model, $R^2_{rm}$ was the multiple coefficient of determination of a given restricted model, u the number of predictors in the full model, v the number of predictors in the restricted model, and N the total number in the sample population. This equation was reduced to:

$$F = (110.11)(0.3915 - R^2_{rm}) \quad \text{with df} = 1,\ 67$$

for this study where $N = 74$, $u = 6$, $v = 5$, and $R^2_{fm} = 0.3915$.

Table III indicates the multiple correlation coefficient R, total variance ($R^2$) accounted for by the six predictor equations, amount each predictor could uniquely account for in the total variance ($R^2_{fm} - R^2_{rm}$), and the F-ratio for each restricted model. To show that the amount of the criterion variance accounted for by the restricted model was significantly less than that of the full model, the F-ratio needed to be at least 4.00 with degrees of freedom being 1 and 67 at the 0.05 level of significance [12, 322].

By discarding the grouping variable $X_1$ (calculus vs. no calculus), the $R^2$ was reduced from 0.3915 in the full model to 0.3877 in the restricted model. The calculated F-ratio was 0.418, which is statistically nonsignificant at the 0.05 level of confidence. This suggested that high school calculus made no significant contribution to the achievement in Analytic

TABLE III

MULTIPLE CORRELATION COEFFICIENT R, TOTAL VARIANCE $R^2$, UNIQUE CONTRIBUTION OF EACH PREDICTOR, AND F-RATIO FOR EACH RESTRICTED MODEL

| Model | Variable Omitted | R | $R^2$ | F-Ratio* | Unique Contribution to Criterion Variance** |
|---|---|---|---|---|---|
| Full | None | 0.6257 | 0.3915 | -- | -- |
| 1 | ($X_1$) Calculus vs. no Calculus | 0.6227 | 0.3877 | 0.418 | 0.0038 = 0.4 Percent |
| 2 | ($X_2$) Sex | 0.6131 | 0.3759 | 0.172 | 0.0156 = 1.6 Percent |
| 3 | ($X_3$) High School Percentile Rank | 0.5283 | 0.2791 | 12.380 | 0.1124 = 11.2 Percent |
| 4 | ($X_4$) ACT Mathematics Score | 0.5742 | 0.3297 | 6.800 | 0.0618 = 6.2 Percent |
| 5 | ($X_5$) ACT English Score | 0.6252 | 0.3909 | 0.070 | 0.0006 = 0.1 Percent |
| 6 | ($X_6$) Natural Science Score | 0.6253 | 0.3910 | 0.060 | 0.0005 = 0.0 Percent |

*Significant when $F \geq 4.00$ with df = 1, 67 at the 0.05 level of significance.

**$R^2_{\text{full model}} - R^2_{\text{restricted model}}$

Geometry and Calculus I, when the contribution of the other variables was statistically controlled.

The general form of the regression equation was:

$$Y = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + c.$$

The least squares criterion was used to determine the appropriate b values for each regression equation. Table IV lists the b-coefficients for each regression equation plus the value of c (the y-intercept). The multiple regression formula resulted in the following equation for the full model:

$$Y = 0.1605X_1 - 0.4780X_2 + 0.0261X_3 + 0.0210X_4$$
$$- 0.0016X_5 - 0.0016X_6 - 0.8257$$

where Y was the predicted grade in Analytic Geometry and Calculus I course.

The multiple correlation coefficient (R) between the predicted calculus grade and the earned grade was 0.6257 which indicates a significant relationship between the predicted calculus grade and the earned calculus grade. To be more rigorous, the F-ratio between the full model and an hypothetical restricted model where $R^2 = 0$, was $F = 7.18$ with degrees of freedom being 6 and 67 at the 0.05 level. In order to show a significant relationship one needed an F-ratio to be at least 2.25 at the 0.05 level of confidence [12, 322].

TABLE IV

b AND c COEFFICIENTS OF THE FULL AND THE RESTRICTED MODELS
N = 74

| Model | Discarded Variable | b Coefficients of Variables | | | | | | c Coefficient |
|---|---|---|---|---|---|---|---|---|
| | | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | |
| Full | None | 0.1605 | -0.4780 | 0.0261 | 0.0210 | -0.0016 | -0.0016 | -0.8257 |
| 1 | Calculus vs. no Calculus ($X_1$) | 0.0000 | -0.4162 | 0.0256 | 0.0205 | -0.0012 | -0.0010 | -0.7991 |
| 2 | Sex ($X_2$) | 0.0744 | 0.0000 | 0.0260 | 0.0211 | 0.0002 | -0.0032 | -1.2380 |
| 3 | High School Percentile Rank ($X_3$) | 0.0664 | -0.4622 | 0.0000 | 0.0246 | 0.0014 | 0.0043 | 0.3281 |
| 4 | ACT Mathematics Score ($X_4$) | 0.1003 | -0.4886 | 0.0286 | 0.0000 | 0.0048 | 0.0056 | -0.3026 |
| 5 | ACT English Score ($X_5$) | 0.1536 | -0.4563 | 0.0259 | 0.0201 | 0.0000 | -0.0021 | -0.8246 |
| 6 | ACT Natural Science Score ($X_6$) | 0.1524 | -0.4926 | 0.0257 | 0.0202 | -0.0020 | 0.0000 | -0.8171 |

## SUMMARY AND CONCLUSIONS

<u>Summary</u>. It was the purpose of this study to determine if there was a significant difference in the first semester calculus grade at Kansas State University between those students who had at least a one-semester high school calculus course and those students who had no previous calculus course.

Information was collected on 794 students who had taken Analytic Geometry and Calculus I during the 1967-68 school year at Kansas State University. Of these students, 37 had the records necessary for the six predictor equation and had taken calculus in a high school course. Then 37 students were randomly selected from the 550 students who had the necessary records and who had no previous calculus course.

Once the sample population was determined, two multiple regression models were calculated. The independent variables for these models were whether a subject had taken a high school calculus course or not ($X_1$), sex ($X_2$), high school percentile rank ($X_3$), ACT Mathematics Score ($X_4$), ACT English Score ($X_5$), and the ACT Natural Science Score ($X_6$). The grade in the first semester calculus course at Kansas State University was the dependent variable ($X_7$).

The multiple coefficient of determination ($R^2$) was reported for each model to indicate that proportion of the criterion accounted for by the predictors. Six restricted models with five predictors were formed by discarding each of the independent variables. The F-statistic was used to show if the discarded predictor variable accounted for a significant amount of the variance at the 0.05 level of confidence.

Conclusions. Based on the available evidence, the null hypothesis is retained. There was no significant relationship between whether the student studied high school calculus or not as to the achievement in Analytic Geometry and Calculus I at Kansas State University.

Based on this study, a high school offering calculus would need to justify its offering on grounds other than the contribution to achievement as measured by course grade in the first semester calculus course at Kansas State University. In considering the results of this study, it must be realized that the population was restricted to Kansas State University students and the group having previous high school calculus was relatively small ($n = 37$).

Other Findings. Although the high school calculus variable ($X_1$) indicated no significant effect on the criterion variable, high school percentile rank ($X_3$) and the ACT Mathematics Score ($X_4$) did indicate a significant contribution to the criterion variable at the 0.05 level. This implied that high school percentile rank and ACT Mathematics Score would be good predictors of the Analytic Geometry and Calculus I grade at Kansas State University.

Observations and Recommendations for Further Research. It is the writer's opinion that the reliability of calculus grades is questionable. Having taught calculus and associated with others at Kansas State University who have also taught the course, the criterion variable of calculus grades appears to be a criterion of questionable merit. Of the subjects having a high school calculus course, 27 percent received a grade of D or less while 21.6 percent of those having no previous calculus course received D or less. In both groups 8.1 percent were in the upper 20 percent of their graduating class. Research could be used in this area to determine the consistency at which grades were determined as compared to what the student actually acquired academically.

The writer would also suggest that Kansas high schools consider using a standard transcript form. The diversity of transcript forms made this research difficult. Many transcripts were difficult to decipher and some were illegible and confusing. The transcripts of students attending high school in the eastern part of the United States seemed to be most efficient and systematic.

Finally, it needs to be established, if possible, what criterion can be used to predict college mathematics scores effectively. In this study only 39.15 percent of the variance in the calculus grade was accounted for. More research needs to be done in this area in order to aid advisors and curriculum planners in guiding students with their mathematical training prior to the first calculus course at the university level.

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# APPENDIX

# DATA COLLECTION MATERIAL

| Identification Number | Variable 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 72 | 77 | 70 | 93 | 1 |
| 2 | 1 | 1 | 98 | 94 | 91 | 63 | 0 |
| 3 | 1 | 1 | 82 | 16 | 47 | 24 | 0 |
| 4 | 1 | 1 | 82 | 86 | 84 | 90 | 2 |
| 5 | 1 | 1 | 45 | 86 | 54 | 73 | 3 |
| 6 | 1 | 1 | 79 | 96 | 93 | 98 | 2 |
| 7 | 1 | 1 | 83 | 77 | 37 | 54 | 3 |
| 8 | 1 | 1 | 75 | 90 | 67 | 43 | 3 |
| 9 | 1 | 1 | 73 | 95 | 81 | 89 | 2 |
| 10 | 1 | 1 | 61 | 46 | 27 | 44 | 1 |
| 11 | 1 | 1 | 51 | 77 | 75 | 79 | 0 |
| 12 | 1 | 1 | 45 | 81 | 88 | 60 | 0 |
| 13 | 1 | 1 | 96 | 89 | 62 | 90 | 2 |
| 14 | 1 | 1 | 89 | 97 | 84 | 98 | 4 |
| 15 | 1 | 0 | 97 | 91 | 18 | 94 | 3 |
| 16 | 1 | 1 | 92 | 90 | 91 | 54 | 4 |
| 17 | 1 | 1 | 87 | 77 | 58 | 95 | 3 |
| 18 | 1 | 1 | 88 | 77 | 14 | 54 | 3 |
| 19 | 1 | 1 | 38 | 38 | 58 | 95 | 3 |
| 20 | 1 | 1 | 69 | 69 | 47 | 72 | 3 |
| 21 | 1 | 1 | 75 | 38 | 21 | 85 | 1 |
| 22 | 1 | 1 | 18 | 52 | 19 | 50 | 0 |
| 23 | 1 | 1 | 55 | 57 | 47 | 54 | 1 |

| Identification Number | Variable 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 24 | 1 | 1 | 83 | 21 | 24 | 30 | 1 |
| 25 | 1 | 1 | 78 | 66 | 74 | 93 | 2 |
| 26 | 1 | 1 | 98 | 62 | 75 | 63 | 4 |
| 27 | 1 | 1 | 85 | 98 | 96 | 93 | 4 |
| 28 | 1 | 1 | 80 | 99 | 94 | 91 | 4 |
| 29 | 1 | 1 | 99 | 98 | 84 | 99 | 3 |
| 30 | 1 | 1 | 83 | 96 | 93 | 99 | 4 |
| 31 | 1 | 1 | 90 | 97 | 84 | 98 | 2 |
| 32 | 1 | 1 | 76 | 77 | 37 | 90 | 2 |
| 33 | 1 | 1 | 73 | 98 | 46 | 85 | 2 |
| 34 | 1 | 1 | 60 | 97 | 93 | 98 | 2 |
| 35 | 1 | 1 | 60 | 97 | 84 | 98 | 3 |
| 36 | 1 | 1 | 99 | 99 | 98 | 99 | 4 |
| 37 | 1 | 1 | 63 | 43 | 47 | 79 | 0 |
| 38 | 0 | 0 | 86 | 89 | 62 | 73 | 2 |
| 39 | 0 | 1 | 99 | 99 | 93 | 99 | 2 |
| 40 | 0 | 1 | 26 | 52 | 30 | 23 | 2 |
| 41 | 0 | 1 | 68 | 77 | 67 | 98 | 3 |
| 42 | 0 | 1 | 84 | 94 | 84 | 95 | 2 |
| 43 | 0 | 1 | 54 | 40 | 27 | 18 | 0 |
| 44 | 0 | 1 | 83 | 85 | 84 | 91 | 3 |
| 45 | 0 | 1 | 66 | 21 | 7 | 63 | 1 |
| 46 | 0 | 1 | 96 | 77 | 97 | 85 | 2 |
| 47 | 0 | 1 | 86 | 57 | 47 | 24 | 1 |
| 48 | 0 | 0 | 70 | 92 | 46 | 90 | 3 |
| 49 | 0 | 1 | 80 | 61 | 5 | 60 | 2 |

| Identification Number | Variable 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 50 | 0 | 0 | 86 | 67 | 37 | 33 | 4 |
| 51 | 0 | 1 | 48 | 57 | 67 | 12 | 2 |
| 52 | 0 | 1 | 65 | 62 | 62 | 73 | 3 |
| 53 | 0 | 1 | 58 | 57 | 46 | 67 | 0 |
| 54 | 0 | 1 | 89 | 77 | 58 | 72 | 3 |
| 55 | 0 | 1 | 97 | 77 | 97 | 85 | 4 |
| 56 | 0 | 1 | 83 | 85 | 7 | 68 | 2 |
| 57 | 0 | 1 | 72 | 86 | 62 | 75 | 2 |
| 58 | 0 | 1 | 90 | 92 | 84 | 85 | 2 |
| 59 | 0 | 1 | 99 | 97 | 75 | 85 | 4 |
| 60 | 0 | 1 | 78 | 97 | 75 | 98 | 2 |
| 61 | 0 | 1 | 89 | 97 | 75 | 63 | 3 |
| 62 | 0 | 1 | 76 | 97 | 58 | 72 | 2 |
| 63 | 0 | 1 | 21 | 18 | 15 | 9 | 0 |
| 64 | 0 | 1 | 99 | 85 | 94 | 91 | 3 |
| 65 | 0 | 1 | 38 | 72 | 16 | 33 | 0 |
| 66 | 0 | 1 | 80 | 77 | 75 | 85 | 2 |
| 67 | 0 | 0 | 90 | 86 | 84 | 98 | 1 |
| 68 | 0 | 1 | 85 | 77 | 58 | 72 | 3 |
| 69 | 0 | 1 | 99 | 99 | 96 | 81 | 4 |
| 70 | 0 | 1 | 94 | 77 | 37 | 72 | 2 |
| 71 | 0 | 1 | 92 | 90 | 99 | 99 | 1 |
| 72 | 0 | 1 | 92 | 85 | 59 | 84 | 3 |
| 73 | 0 | 1 | 77 | 77 | 58 | 95 | 2 |
| 74 | 0 | 0 | 94 | 91 | 83 | 72 | 4 |

THE RELATIONSHIP OF HIGH SCHOOL CALCULUS
TO ACHIEVEMENT IN ANALYTIC GEOMETRY AND
CALCULUS I AT KANSAS STATE UNIVERSITY

by

TED PRICE BROWNING

B. S. E., Northeastern State College, 1968

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AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

College of Education

KANSAS STATE UNIVERSITY
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1970

Since the middle of the nineteenth century, calculus has been taught in a few high schools in the United States. However, it was not until after the 1957 launch of the Russian Sputnik that American education took such a critical look at the content of mathematics on the secondary level. Since then, upon recommendations of various groups and committees, whole curriculums have been abandoned or reorganized. Today, certain courses have been combined into one course, while others have been dropped completely. Still others are being offered at a lower grade level than before. Because of these and other factors, one semester or even a full year of elective time is available at the twelfth grade level.

The purpose of this study was to investigate whether at least one semester of high school calculus could account for a significant difference in achievement in Analytic Geometry and Calculus I at Kansas State University. This could aid both high school teachers and administrators in determining the content of a twelfth grade mathematics course for their high school curriculum.

The data for this study was obtained from the university records of each student and from the records kept by the Department of Mathematics at Kansas State University. A multiple regression technique was used to develop the prediction equations. The six predictor variables were whether a student had high school calculus or not, sex, high school graduating percentile rank, ACT Mathematics Score, ACT English Score, and the ACT Natural Science Score. The criterion variable was the numerical equivalent of the student's letter grade for the university course, with a withdrawal from the course being recorded as a zero.

A restricted model, formed by deleting one of the six predictor variables, was compared to the full model using the F-ratio in a standard analysis of regression procedure. The F-ratio obtained was not statistically significant at the five percent level. This suggests that high school calculus made no significant contribution to the achievement in Analytic Geometry and Calculus I, when the contribution of the other variables was statistically controlled.

Pending further investigation, it would seem that curriculum planners should use other considerations in deciding whether or not to offer a course in high school calculus than that of contributing to student success in a first semester university calculus course.