THE INFLUENCE OF HIGH SCHOOL CALCULUS ON STUDENT SUCCESS IN CALCULUS AT KANSAS STATE UNIVERSITY

by

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B. S., Kansas State University, 1965

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

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ACKNOWLEDGMENTS

The writer would like to acknowledge the assistance of the many people who helped make this study possible.

Special mention should be made of Dr. Russel Drumright of the College of Education and Dr. Lyle Dixon of the Department of Mathematics for their assistance, guidance, and encouragement throughout this study. The helpful criticism of Dr. Floyd Coppedge of the College of Education proved invaluable in the final stages of this study. The author is also grateful to Dr. Forest Whan of Kansas State University for his helpful suggestions concerning the questionnaire portion of this study and to Mrs. Lucille Asher, Kansas Mathematics Consultant, for her assistance.

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CHAPTER I

INTRODUCTION

The study of calculus has been traditionally omitted from the American high school curriculum. A review of the literature has shown that prior to the late 1950's a majority of mathematicians and educators agreed that the teaching of the elements of advanced analytic geometry and calculus should be part of the education provided by this nation's colleges and universities. It was their opinion that the average American high school student did not have the ability to understand the basic concepts necessary for an introductory calculus course.

However, after the launching of the first man-made satellite in late 1957, the literature indicated that a reversal of opinion on this matter seemed to have occurred. The relatively few advocates of a high school calculus course prior to that time were joined by many prominent mathematics educators. Whether this sudden change of opinion was due to public pressure for a strengthening of the high school mathematics curriculum or whether other reasons were responsible for this change is difficult to determine. Today mathematics educators in this country seem to be divided on the question of what mathematics course should be offered at the twelfth-grade level.

I. PURPOSE OF THE STUDY

This study had two primary purposes. The first of these was to determine whether a selected group of Kansas State University freshmen who had received credit for a high school calculus course achieved higher grades in Analytic Geometry and Calculus I than their classmates who did not have such a high school course. The second major purpose of this study was to gather information regarding the composition of the high school calculus courses which this particular group of students had taken.

Very little research can be found in the literature which attempts to evaluate the merits of including a calculus course in the high school mathematics curriculum. Therefore the results of this study will prove helpful to high school administrators and mathematics teachers who are attempting to determine whether their school should offer a calculus course.

II. STATEMENT OF THE PROBLEM

The problem of this study consists of two parts. One, the researcher wished to determine whether a high school calculus course had been beneficial to a selected sample of college calculus students. Second, the researcher desired to obtain information on the status of calculus in a selected sample of American high schools.

III. HYPOTHESES TO BE TESTED

The following hypotheses were proposed by the researcher at the outset of this study:

H_{01}: There was no significant difference in the achievement in Analytic Geometry and Calculus I between the selected group of students who had received credit for a high school calculus course (Group I) and their classmates who had not received credit for a high school calculus course (Group II).

H_{02}: There was no significant difference between the mean American College Test (ACT) standardized mathematics scores of the two groups involved in this study.

H_{03}: There was no significant correlation between the final grades earned in Analytic Geometry and Calculus I and the ACT standardized mathematics scores for either group.

H_{04}: There was no significant correlation between the high school calculus grades and the college calculus grades earned by the students in Group I.

IV. DEFINITION OF THE TERM "CALCULUS"

For the purposes of this study the writer defined the term "high school calculus" to include any course listed on the official high school transcript as calculus, analytic geometry, or mathematical analysis. Thus the students who were considered to have taken a high school calculus course had received credit for calculus, analytic geometry, or mathematical analysis.

V. DESIGN AND PROCEDURES OF THE STUDY

The students in this study included all of the Kansas State University entering freshmen who were enrolled in Analytic Geometry and Calculus I at the mid-point of the fall semester of 1965. The mid-semester class list, issued by the Admissions and Records Office, was used to determine the members of this population. The researcher chose to use the mid-semester list rather than the original class enrollment because a large number of freshmen usually withdrew from the introductory college calculus course during the first few weeks of the semester. The researcher also limited the population to entering college freshmen. Thus freshmen who had possibly received credit for a previous college mathematics course were eliminated from this study. By limiting the population in this manner the researcher hoped that the results of the study would not be biased by the performances of students who had taken a mathematics course since their high school graduation.

After the population had been chosen it was necessary to determine which of the students had received credit for a high school calculus course. This determination was made by reviewing the high school transcripts of all of the members of the original population. Since all Kansas State University students were required to submit a copy of their high school transcript to the Admissions and Records Office prior to their admittance to the university, the researcher was able to obtain the necessary information. Using the term "calculus" as previously defined in this report, the researcher was able to separate the original population into two distinct groups. It was the researcher's opinion that by defining calculus in the manner previously discussed he could best determine the members of the two groups. It should be noted that many students received credit for high school mathematics courses such as senior mathematics or advanced mathematics which might have included an introduction to the concepts of calculus. However, only the students who had specifically received credit for courses titled calculus, analytic geometry, or mathematical analysis were considered to have taken a high school calculus course. The researcher thus defined Group I as all of the students in the population who had received credit for a high school calculus course and Group II as the remaining students in the population who did not have credit for such a high school course.

Such information as the high school attended by each student in the population, the mathematics courses taken by each of these students, and the grades earned in these courses was obtained from the high school transcripts. The American College Test (ACT) standardized mathematics test scores were obtained from the files of the Kansas State University Counseling Center.

The researcher decided to use the final course grade as the indicator of the student's success in college calculus. These grades were obtained from the class grade sheets which were submitted to the Admissions and Records Office.

Once it had been decided to obtain more information about the course content of the high school calculus courses which the students in this study had taken, it was necessary to decide what method would be the most feasible for the gathering of such information. Since the schools were so scattered, it was decided that the questionnaire approach would be the most appropriate. A questionnaire was sent to the high school calculus teacher of each of the students in Group I. The names of the Kansas teachers were obtained from the files of the Kansas State Department of Public

Instruction. When the school records indicated that more than one teacher was responsible for teaching the calculus course, a copy of the questionnaire was sent to each teacher. The questionnaire was addressed to the head of the mathematics department when it was impossible to determine the calculus teacher's name.

Copies of the cover letter, questionnaire, and follow-up letter are included as Appendices A, B, and C of this report. The original cover letter and questionnaire were constructed by the researcher. The contents of this copy were then discussed with Dr. Drumright, Dr. Dixon, and Dr. Whan prior to the construction of the final form of the questionnaire. It was decided by the researcher to use Kansas State University stationery in hopes of assuring better return of the completed questionnaires. The questionnaire itself consisted of four pages and was divided into three main sections.

All of the items on the questionnaire specifically requested information pertaining to the 1964-65 school year. This was because the researcher had found that most of the students in this group had taken their high school calculus courses during that period.

The cover letter and questionnaire were designed to be as personal as possible. In keeping with this, each of the cover letters was personally signed by the researcher.

The name of the high school, the instructor's name, if possible, and the names of the teacher's former students who were involved in the study were also filled in by the researcher. Thus each teacher was able to determine which of his former students were included in this study.

A stamped, self-addressed envelope was included with the questionnaire. The questionnaires were sent on April 20, 1966. The recipients were requested to return the completed questionnaire no later than May 1.

Follow-up letters were sent on May 10 to the teachers who had not returned the questionnaires. This follow-up letter stressed the importance of the study and emphasized that another copy of the questionnaire would be sent if the original copy had been misplaced.

VI. THE ORGANIZATION OF THE REPORT

Chapter II is a review of the literature tracing the historical aspects of the movement to include a study of calculus in the American high school curriculum. In Chapter III the reader will find a review of the pertinent aspects of the two groups included in this study. A review of the results of the questionnaire portion of the study will be found in Chapter IV. The concluding chapter, Chapter V, contains the summary, conclusions, and recommendations.

CHAPTER II

REVIEW OF THE LITERATURE

Contrary to popular belief, the concept of adding an elementary calculus course to the American high school mathematics curriculum is not a recent one. If the old adage that curriculum changes in the American high schools take approximately fifty years to implant is correct, the advent of calculus at the secondary school level is about on schedule. This section of the paper will trace the concept of offering a study of calculus at the high school level from the Colonial Period to the present time.

I. HIGH SCHOOL CALCULUS FROM THE COLONIAL PERIOD TO 1900

The forerunners of our modern high schools during the Colonial Period offered mathematics courses that dealt primarily with integral numbers and the basic concepts of fractions and proportions.[1] Thus the topics of calculus were not taught during this period of American history because of the lack of the basic skills and concepts necessary for such a course. It must also be remembered that

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[1]Donald B. Tillotson, "The Relationship of an Introductory Study of Calculus in High School to Achievement in a University Calculus Course" (unpublished Doctor's dissertation, The University of Kansas, Lawrence, 1962), p. 5.

many of the aspects of calculus were still as yet unknown at that time.

During the early years of the Nineteenth Century American schools began to teach a few of the concepts of higher mathematics rather than stressing the more difficult manipulations of arithmetic.[1] Thus a few of the prominent mathematics educators in this country during that period recognized that high school students were capable of studying and understanding many mathematical concepts which were more abstract than arithmetical manipulations. This opinion of a few American mathematics educators probably convinced the officials of Central High School in Philadelphia, Pennsylvania, to offer a course in the theory of limits in 1845.[2] However, the time was not yet right for the beginning of a widespread movement to introduce such a course to the high school mathematics curriculum and so this particular school dropped the course from its curriculum after only a few years.

No mention is again found of any high school in the United States offering a course in the basic concepts of calculus before the early years of the Twentieth Century.[3]

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[1] Ibid., p. 5.

[2] Ibid., p. 6.

[3] Ibid.

It is important to remember that during the middle part of the Nineteenth Century the American high school as it is known today was just being founded. The mathematics curricula in these early schools consisted primarily of basic arithmetic and did not generally include topics of a more abstract nature. Thus during the infancy of the American high school the teaching of basic arithmetical concepts precluded any idea of introducing such abstract concepts as advanced analytic geometry and calculus.

In 1893 the Committee of Ten recommended that one year each of algebra, geometry, trigonometry, and advanced algebra be offered as high school mathematics electives.[1] However, no mention of a high school calculus course was made in the report of this committee. Even though the practical applications of the high school calculus course would have been of considerable value to students interested in such fields as surveying, navigation, and engineering, the respect for the rigor and usefulness of higher mathematical concepts that would have made such a course possible apparently was lacking in the mathematics curriculum of our secondary schools.

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[1]National Education Association, Report of the Committee of Ten on Secondary School Studies, pp. 104-116.

II. HIGH SCHOOL CALCULUS FROM 1900 to 1920

The movement to add a calculus course to the American high school curriculum apparently received its stimulus from European mathematicians and educators. Two Europeans prominent in this early movement were Felix Klein of Germany and John Perry of England.

Felix Klein was a noted German mathematician during the early part of the Twentieth Century. Mr. Klein, speaking at a school conference in Berlin in 1900, advocated a calculus course for the students who were attending his real gymnasium, a school equivalent of our American high schools. Mr. Klein enforced this view with the following statement:

> Thus one might begin with pupils of the age of fourteen or fifteen and develop the concepts of slope and area slowly. . . . It is essential to make it clear to the pupil that he is dealing with simple things that anyone can understand.[1]

The other prominent European instrumental in the early movement to include calculus in the high school curriculum was Professor John Perry of the Royal College of Science in London. Professor Perry was associated with the mechanics and mathematics departments at this college. His argument for the introduction of a high school calculus course was based on his experience in teaching a night course

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[1]Felix Klein, Elementary Mathematics From An Advanced Standpoint, Arithmetic, Algebra, Analysis. Translated by E. R. Hedrick and C. A. Noble, pp. 221-222.

to trade apprentices in London. Professor Perry was against the teaching of the traditional mathematics courses because he felt that they would be of little practical value to his students in later life. He felt that the applications of the concepts of calculus were of sufficient importance to necessitate the inclusion of a calculus course in the high school mathematics curriculum. He insisted that such topics as logarithms, algebraic formulae, and the methods of calculus could be introduced to high school boys. "Dexterity in all these," assured Professor Perry, "is easily learnt by all young boys."[1] Another basis for Professor Perry's argument for the teaching of the calculus at the high school level was his belief that such a course would improve the attitude of the students toward mathematics. Thus a new reason for the adoption of such a course was formulated. It was apparent that the professional price of the mathematicians of that era was beginning to show itself.

There are many reasons why this country's educators did not immediately follow the suggestions of Klein, Perry, and other European educators and introduce the study of calculus into the high school curriculum. Perhaps the best reason for this failure to immediately follow their advice was that our system of secondary education was not as

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[1]John Perry, "The Teaching of Mathematics," Discussion on the Teaching of Mathematics, pp. 8-9.

centralized as theirs. One must remember that the United States is composed of separate state governments, each with its own system of education and each with its own separate goals and purposes of education. It is also important to remember that the schools and universities in this country did not have the large bodies of accumulated materials which most of the European countries possessed at that time.

Perhaps one of the first American educators to become instrumental in the movement to include a calculus course in the high school curriculum was Professor E. H. Moore of the University of Chicago. In late 1902 Professor Moore stated:

> By emphasizing steadily the practical side of mathematics . . . it would be possible to give very young students a great body of the essential nature of trigonometry, analytic geometry and the calculus.[1]

These remarks were taken from Professor Moore's address to the American Mathematical Society convention held on December 2, 1902. His entire speech was later reprinted in various professional journals and is considered by many educators to have been the start of the American movement to include a calculus course in the high school curriculum.

Another early leader in this American movement was the prominent mathematician Professor David Eugene Smith of

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[1] Eliakim Hastings Moore, "On the Foundations of Mathematics," Bulletin of the Mathematical Society, IX (May, 1903), 415.

Teachers College, Columbia University. In 1908 Professor Smith read a paper before the Fourth International Congress of Mathematicians in which he outlined a twelfth-year calculus course for boys. One of the aspects of the course outlined by Professor Smith emphasized the applications of calculus to practical situations and to the problems of physics.

This American curriculum reform was further stimulated in 1912 when the International Congress of Mathematicians met at Cambridge University. The American delegates to this conference returned to this country after hearing of European success in introducing the study of calculus to secondary school students. The delegation, in their report to the National Council of the Teachers of Mathematics, advocated the teaching of the concepts of elementary calculus to boys of high ability, even if the boys were not planning to attend college.

In 1916 the American Mathematical Association sponsored a committee to assess the current trends in the high school mathematics curricula throughout the United States. The final report of the National Committee on Mathematics Requirements was the result of the work of this committee. This report outlined a theoretical high school mathematics curriculum and listed a course in calculus as a twelfth-grade elective. The report insisted that if such a course were to be offered it should be largely graphic and related to the topics studied in physics. The content of the course proposed by this committee is described in the following quotation:

> The elementary high school calculus course should include the following: general notion of derivatives, application of derivatives, simple inverse problems . . . integration, application of integration to simple cases of motion, area, volume and pressure.[1]

The committee stressed that it did not intend to imply that the introduction of calculus into the high school curriculum should rule out the teaching of other courses in mathematics. The committee further stated that there should be no sacrificing of high school algebra or geometry in order to teach a course in calculus.

The following statement by the National Committee on Mathematics Requirements summarizes their suggestions regarding the proposed course in calculus at the secondary school level:

> No formal study of analytic geometry need be presupposed beyond the plotting of graphs. It is apparent that the difficulties of the regular college calculus course are outside the scope of this course. . . . It should also be born in mind that the suggestion of including elementary calculus is not intended for all schools nor for all teachers nor all pupils in any school.[2]

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[1]National Committee on Mathematics Requirements, "Elective Courses in Mathematics for Secondary Schools," The Mathematics Teacher, XIV (April, 1921), 167.

[2]Ibid.

III. HIGH SCHOOL CALCULUS FROM 1920 TO 1950

A graduate research study undertaken by Noah Rosenberger during the early 1920's attempted to summarize the feeling of some of this country's mathematics educators toward the controversy of high school calculus instruction. The researcher concluded that in 1922 enough of the basic mathematical concepts were being taught in the junior high school to allow for a calculus course to be taught at the twelfth-grade level. Mr. Rosenberger summarized the major reasons which educators at that time used to justify the inclusion of calculus in the high school mathematics curriculum. He cited the important applications of calculus to engineering, physics, and mechanics as being the primary reason for its inclusion. Mr. Rosenberger also stated that some mathematicians felt that a study of calculus in the twelfth-grade would provide the ideal link between the previous school work in mathematics and the more pure forms of abstract mathematics. The researcher stated that the lack of a good high school textbook was perhaps the greatest hindrance to this movement during the early 1920's. He also indicated that there was a lack of qualified teachers who were capable of teaching a calculus course at the high school level. In concluding his report, the author proposed a framework for a high school calculus course. The course, as Mr. Rosenberger outlined it, followed many of the guidelines proposed by the National Committee on Mathematics Requirements discussed earlier in this report.[1]

It should also be noted that about the same time as Mr. Rosenberger's article appeared, quite a different argument for including a calculus course in the high school curriculum was proposed. This viewpoint, expressed by Miss Susie Farmer in an article in 1927, stressed the social and cultural advantages of the high school calculus course. She advocated teaching calculus to both boys and girls for the pure truth and beauty provided by the course, not for the more practical aspects of calculus. Miss Farmer's views are expressed in the following quotation:

> However, higher mathematics has contributed so much of practical and cultural value to civilization that the very existence of our social fabric depends upon it. . . . Even though calculus should not be of any practical value to any particular child, he should not be denied the privilege of enjoying its pursuit but should have as good a right to develop that ability as any other ability.[2]

Miss Farmer stressed that the high school calculus course should be taught in the way it was developed in the minds of men. According to the author of this 1927 article, the heuristic approach would provide students with the best

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[1]Noah Bryan Rosenberger, "The Place of Elementary Calculus in Senior High School Mathematics," The Mathematics Teacher, XV (March, 1922), 153-155.

[2]Susie B. Farmer, "The Place and Teaching of Calculus in Secondary Schools," The Mathematics Teacher, XX (April, 1927), 186-187.

understanding of the concepts of calculus. She stated that the pupils should be taught ideas, not notations or definitions, and that they should be shown concrete relationships rather than abstract ones. Miss Farmer proposed that the course proceed in the following order: functions, limits, differentiation (elementary, with practical applications), maxima-minima, integration, and infinitesimal calculus.[1]

Mr. W. F. Babcock, Professor of Mathematics at Woodmere Academy, Woodmere, New York, in 1927 sent a questionnaire to the heads of several college mathematics departments throughout the eastern United States. In summarizing the results of this study Mr. Babcock stated:

> I doubt if a student younger than eighteen years even understands analytic reasoning. I doubt the wisdom of beginning the calculus then.[2]

One of the early American high school mathematics teachers to attempt the teaching of a high school calculus course was Mr. Gordon Minick of the Columbia University experimental high school. Mr. Minick taught a high school calculus course which included such concepts as infinite progressions, mechanics, functions and their graphs, differentiation, and elementary integration. His course was taken

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[1] *Ibid*., pp. 188-201.

[2] W. F. Babcock, "Solid Geometry Versus Advanced Algebra," *The Mathematics Teacher*, XX (December, 1927), 479.

by students during the first semester of their senior year. It was Mr. Minick's position that the final semester of high school for the average mathematics student should consist of a review of algebra and trigonometry. However, for the very bright students he proposed a final course which would terminate with the indefinite integral and its physical applications.[1]

In 1934 a study of various colleges showed that the elements of analytic geometry and calculus were being introduced earlier in the students' schooling.[2] One of the principal reasons for the inclusion of calculus in the high school mathematics curriculum was the need for better student performance on the college entrance examinations. It should be noted that this argument for the introduction of calculus to the high school curriculum was advanced as early as the 1930's and was not a comparatively recent one. It has been reported that the College Entrance Examination Board's advanced mathematics test in 1935 had approximately one-sixth of its items devoted to the topics of analytic geometry and calculus.[3]

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[1]Gordon R. Minick, "Some Considerations Appertaining to the Content of High School Mathematics," The Mathematics Teacher, XXVII (January, 1934), 50.

[2]Ibid., p. 41.

[3]Commission on Examinations in Mathematics, "Report of the Commission on Examinations in Mathematics," The Mathematics Teacher, XXVIII (March, 1935), 161.

During the mid-1930's the value of the old mental discipline theory of education was seriously doubted. The economic depression of that same era seemed to further discourage the offering of most high school mathematics courses. During this period only a limited selection of pure or theoretical mathematics was offered at the secondary school level. The Progressive Movement in education, which emphasized practical mathematics such as consumer mathematics and business mathematics, hindered the movement to introduce the more abstract concepts of calculus to the high school mathematics curriculum. However, it should be noted that the Progressive Movement probably was responsible for the intuitive approach to mathematics which is today being advocated.

Thus during the period from 1900 to 1940 the movement to include a calculus course in the high school mathematics curriculum was initiated and then almost forgotten. With the rejection of the mental discipline theory and the coming of the economic depression, the entire high school mathematics curriculum was almost forgotten. The downfall of the theory of mental discipline, which stated among other things that mathematics was valuable in high school because it taught the student to reason analytically, made educators question the value of offering many forms of pure or theoretical mathematics.

In 1940 the Joint Commission of the Mathematics Association of America and the National Council of the Teachers of Mathematics recommended a senior-year course on "an introductory study of differentiation, with applications to slopes, maxima-minima, rates of change, velocity, acceleration, and related problems."[1] It was during this period prior to the outbreak of World War II that renewed interest was shown in the movement to include calculus in the high school mathematics curriculum. The military and industrial demands of World War II revealed certain basic deficiencies in the mathematics ability of the average American high school student. However, there was also a definite shortage of high school mathematics teachers who were qualified to teach a calculus course.

The very rapid technological developments immediately following the war increased the demands placed upon the secondary school mathematics program.

Another committee of the National Council of the Teachers of Mathematics, the Commission on Post-War Plans, in 1944 advocated a course similar to the one proposed by the Joint Commission in 1940. Thus during the period immediately following World War II the chief aim of education in

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[1]National Council of the Teachers of Mathematics, The Place of Mathematics in Secondary Education, pp. 97-98.

general and mathematics education in particular was to improve the education of all youth and to challenge the gifted.

IV. HIGH SCHOOL CALCULUS FROM 1950 TO THE PRESENT

Very little further progress was made in this movement until the early part of the 1950's. An article by Mr. William Duren in <u>The Mathematics Teacher</u> seemed to express the rather doubtful position that mathematics held in the high school curriculum during the late 1940's and early 1950's. Mr. Duren stated that during this time mathematics was poorly appreciated. It was difficult to justify mathematics and hard to get it taught. "Misfit teachers and football coaches," according to Mr. Duren, "were given the job of teaching mathematics."[1]

Mr. Duren's article did not imply that there were no advances in the movement to include calculus in the high school curriculum during the early 1950's. Mr. C. C. MacDuffee wrote of calculus courses which were being taught in high schools in the states of New York and Wisconsin during the 1951-52 school year. The enrollment in these courses was not limited to the academically gifted student, but the author wished to remind his readers that the below-average student rarely chose a fourth-year mathematics course

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[1]William L. Duren, Jr., "School and College Mathematics," <u>The Mathematics Teacher</u>, XLIX (November, 1956), 515.

so this limitation was not necessary. The author advocated teaching calculus and theoretical analytic geometry to high school students because of its value to college-bound students and because of its applications to the physical sciences. However, Mr. MacDuffee recognized the one reason why he felt that calculus was not being offered in more American high schools in 1952.[1] This reason was stated in the following manner:

> I believe that the main reason why many schools are not more favorable to the teaching of analytic geometry and the calculus is that they do not have teachers who feel capable of teaching it.[2]

In 1952 the College Entrance Examination Board appointed a committee known as the Commission on Mathematics. The work of this group eventually resulted in a plan which is today known as the Advanced Placement Program in Mathematics. In June, 1955, the commission recommended a mathematics curriculum for academically advanced college-bound high school students. The twelfth-grade course recommended by the commission consisted of an introduction to calculus including numerous applications. The suggested course content included such topics as analytic geometry, differential calculus with

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[1]C. C. MacDuffee, "What Mathematics Shall We Teach in the Fourth Year of High School?", The Mathematics Teacher, XLV (January, 1952), 1-5.

[2]*Ibid*., p. 3.

applications, and integral calculus with applications.[1]

In 1956 the Committee on the Undergraduate Program of the Mathematical Association of America reinforced the views of the Commission on Mathematics with the following statement:

> Especially able students in high school, but only a few of them, should have the opportunity to take calculus, possibly receiving college credit for it.[2]

The launching of the first man-made satellite by Russia in late 1957 brought a loud clammering from the American people for the bolstering of the high school mathematics program. This cry of the American people was met in several ways. The recent trend toward the adoption of modern mathematics is perhaps the best known solution to the quest for better programs in high school mathematics. The adoption of one of these modern mathematics programs could give the student a brief introduction to analytic geometry or calculus during the last part of his senior year in high school. A review of the work of the Illinois Committee on School Mathematics by the researcher showed that this committee did not allow for the teaching of calculus in its

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[1]E. P. Vance, Program Provisions for the Mathematically Gifted Student in the Secondary School, pp. 4-7.

[2]William L. Duren, Jr., "School and College Mathematics," The Mathematics Teacher, XLIX (November, 1956), 515.

mathematics curriculum outline. On the other hand, the School Mathematics Study Group did provide for the introduction of calculus near the end of the twelfth year.

The adoption of the multi-tract mathematics program has also recently favored the limited introduction of calculus to the high school curriculum. Under this plan the entire high school mathematics program of the above-average mathematics student is accelerated. In most cases this allows for an extra year in which the study of topics selected from the more advanced theoretical mathematics can be undertaken. As an example of this multi-tract system one can examine the Junior and Senior High School District 834 in Stillwater, Minnesota. This district has a three-tract system in mathematics. The decision as to which tract the student should follow is made in the eighth grade and is based upon teacher recommendation, followed by the Iowa Test of Basic Skills and the California Algebra Aptitude Test. When a student is accepted for the accelerated program he studies the first four years of high school mathematics in three years and spends the final year in high school studying a combination of college algebra, analytic geometry, and an introduction to calculus. This particular sequence is only one example of the multi-tract mathematics programs which are found in many American high schools. This program has probably caused an increase in the number of high school calculus courses being offered in the United States but it is important to remember that under this plan the enrollment in the course is limited to the brightest mathematics students and is not open to any high school student who desires to enroll.[1]

It is important to note that calculus is not the only course being considered as the ideal twelfth-grade course in mathematics. A recent study by O. Lexton Buchanan reported that 61 per cent of the respondents to a questionnaire sent to high school mathematics teachers opposed both a unit on calculus and a semester course in calculus at the high school level. A majority of college mathematics teachers from colleges which offered graduate degrees in mathematics favored a unit on limits in high school but opposed a unit on calculus, according to Mr. Buchanan's study.[2]

Mr. George Grossman, in a recent article in The Mathematics Teacher, stated that there were two reasons why a high school should offer a course in calculus. The first of these reasons, in order for the student to receive advanced placement when he enrolls in college mathematics,

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[1]William P. Keaveny, "Mathematics Program Outline for Junior and Senior High Schools," The Mathematics Teacher, LII (October, 1959), 450-51.

[2]O. Lexton Buchanan, "Opinions of College Teachers of Mathematics Regarding Content of the Twelfth-Year Course in Mathematics," The Mathematics Teacher, LVIII (March, 1965), 224.

is perhaps the more traditional according to that author.

However, Mr. Grossman stated that another equally-important reason is to provide an enriched twelfth-grade mathematics education for the superior high school student. But the author reminded his readers that the study of calculus is not the only form of advanced mathematics that might be used to enrich the curriculum. Mr. Grossman insisted that the choice of the proper teacher to teach the enriched class was much more important than the choice of the subject matter to be taught.[1] He amplified his views in the following quotation:

> The first problem a school must solve when planning for its superior students is to get superior teachers. The second problem is what these teachers are to teach.[2]

Mr. Carl Allendoerfer was in favor of stressing the concepts of analytic geometry during the senior mathematics course in high school. He also favored a short unit of approximately six weeks' duration in calculus at the end of the senior year. It was his opinion that this short introductory course would provide a good transition to college mathematics.[3]

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[1]George Grossman, "Advanced Placement Mathematics--for Whom?", _The Mathematics Teacher_, LV (November, 1962), 561-66.

[2]_Ibid_., p. 564.

[3]Carl B. Allendoerfer, "The Case Against Calculus," _The Mathematics Teacher_, LVI (November, 1963), 482-85.

V. SUMMARY

The movement to include calculus in the high school curriculum has passed through several stages in the past seventy-five years. The American movement was stimulated by a similar movement in Europe during the early years of this century. However, since our schools are not organized as the European schools, the movement in this country did not progress as rapidly as it did in Europe. Prior to World War I the movement did not receive much support in this country. The supporters who did publicly advocate such a course in high school did so on the basis of the advantages which such a study would provide in physics and mechanics. In the period between the two world wars the movement was almost forgotten, primarily because of the effect of the economic depression and the Progressive Education movement.

Following World War II several national mathematics committees recommended that a high school calculus course be offered, but these recommendations were slow to be followed. The launching of Sputnik I probably gave impetus to the present movement to include calculus in the American High school curriculum. It is apparent that this most recent demand by the American people for a stronger mathematics program has more firmly implanted the study of calculus in the curricula of many high schools throughout this country.

CHAPTER III

PRESENTATION OF DESCRIPTIVE AND STATISTICAL DATA

This chapter of the report compares the performances of the students who had received credit for a high school calculus course (Group I) with the performances of the students who did not have such a course (Group II). A discussion of how the members of both groups were selected was given in Chapter I.

The original population consisted of 478 men and 41 women. After reviewing the high school transcripts of these 519 students, it was determined that 92 of them had received credit for a high school calculus course. A descriptive comparison of these two groups will be undertaken before the statistical testing of the null hypotheses stated in Chapter I is attempted.

I. A DESCRIPTIVE COMPARISON OF THE TWO GROUPS USED IN THIS STUDY

A description of Group I. This section of the report will describe several of the pertinent characteristics of the ninety-two students in the population who had received credit for a high school calculus course.

This group consisted of eighty-four men (91.3 per cent) and eight women (8.7 per cent). It should be noted that this percentage is considerably higher than the percentage of men who composed the entire entering freshman class of 1965 at Kansas State University (63.5 per cent).[1]

A total of eighty-one of these students (88.1 per cent) came from thirty Kansas high schools. This compares with 81.5 per cent of the entire entering freshman class of 1965 at Kansas State University who graduated from Kansas high schools.[2] The remaining eleven students came from ten out-of-state high schools. These out-of-state high schools represented eight different states. The particular high schools attended by the students in this group are listed in Table I.

By referring to the 1964-65 Kansas Educational Directory, published by the Kansas State Department of Public Instruction, it was possible to determine the sizes of the various Kansas high schools represented by the students in this group. The greatest percentage of Kansas students in this group (46.9 per cent) graduated from high schools with 1964-65 enrollments between 501 and 1,000 students. It should be noted that 7.4 per cent of the Kansas students came from high schools with one hundred or fewer students, whereas 21.0 per cent of the same group attended high schools with enrollments of more than one thousand students. A summary of

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[1]Kansas State University Office of Institutional Research.

[2]*Ibid*.

TABLE I

HIGH SCHOOLS REPRESENTED BY THE NINETY-TWO FRESHMEN ENROLLED IN ANALYTIC GEOMETRY AND CALCULUS I AT KANSAS STATE UNIVERSITY DURING THE FALL SEMESTER OF 1965 WHO HAD RECEIVED CREDIT FOR HIGH SCHOOL CALCULUS

High school	Location	Number of students
Augusta High School	Augusta, Kansas	3
Belleville High School	Belleville, Kansas	1
Center High School	Kansas City, Missouri	2
Central High School	South Bend, Indiana	1
Centre Rural High School	Lost Springs, Kansas	1
Chanel High School	Bedford, Ohio	1
Chaplain Kapaun Memorial High	Wichita, Kansas	1
Concordia High School	Concordia, Kansas	2
Corning High School	Corning, Kansas	2
Darien High School	Darien, Connecticut	1
Ellis High School	Ellis, Kansas	3
Emmett High School	Emmett, Kansas	1
Grainfield Rural High School	Grainfield, Kansas	1
Hamilton-Wenham High School	Hamilton, Massachusetts	1
Herington High School	Herington, Kansas	2
Highland Park High School	Highland Park, Illinois	1
Holyrood High School	Holyrood, Kansas	2
Humboldt High School	Humboldt, Kansas	3
Junction City High School	Junction City, Kansas	3
Lane County Community High	Dighton, Kansas	1
Leavenworth High School	Leavenworth, Kansas	9
Lincoln Northeast High School	Lincoln, Nebraska	1
Logan High School	Logan, Kansas	1
Lyndon High School	Lyndon, Kansas	2
McPherson High School	McPherson, Kansas	3
Maine-Endwell High School	Endwell, New York	1
Manhattan High School	Manhattan, Kansas	3
Parkview High School	Springfield, Missouri	1
Pratt High School	Pratt, Kansas	1
Ransom High School	Ransom, Kansas	1
Rose Hill High School	Rose Hill, Kansas	1
Shawnee Mission East High	Shawnee Mission, Kansas	9
Shawnee Mission North High	Shawnee Mission, Kansas	12
Shawnee Mission West High	Shawnee Mission, Kansas	7
Smith Center High School	Smith Center, Kansas	1
South Bend Central High	South Bend, Indiana	1
Wallace County Community High	Sharon Springs, Kansas	1
Wichita East High School	Wichita, Kansas	1
Wichita North High School	Wichita, Kansas	1
Wichita South High School	Wichita, Kansas	3

the school enrollments for the high schools represented by the Kansas students in this study is found in Table II.

TABLE II

1964-65 HIGH SCHOOL ENROLLMENTS (GRADES 9-12) FOR THE HIGH SCHOOLS REPRESENTED BY THE NINETY-TWO STUDENTS IN THIS STUDY WHO RECEIVED CREDIT FOR A HIGH SCHOOL CALCULUS COURSE

High school enrollment	Number of students
1-100 students	6
101-200	9
201-300	9
301-500	2
501-1,000	38
More than 1,000 students	17
No information available	11

It was also possible to determine the size of the towns represented by these ninety-two students. The city populations obtained for this portion of the study were based on the official 1960 United States census published in the 1965 World Almanac and Book of Facts. The largest number of students, twenty-eight, came from towns with populations between 5,001 and 10,000 people. Slightly more than 14 per cent of the students, all from Kansas, came from towns with populations of fewer than one thousand people. Most of the out-of-state students came from towns larger than 50,000, whereas most of the Kansas high school students in the group came from towns with populations of less than

10,000 people. Table III summarizes these findings.

TABLE III

POPULATION OF THE TOWNS IN WHICH THE NINETY-TWO STUDENTS IN THIS GROUP LIVED AT THE TIME OF THEIR ADMISSION TO KANSAS STATE UNIVERSITY

Hometown population	Number of students
1- 1,000 people	13
1,001- 2,500	7
2,501- 5,000	5
5,001-10,000	28
10,001-50,000	26
More than 50,000 people	13

It was found that most of the high school transcripts of these ninety-two students included their rank in their high school graduating class. This information was available for sixty-six of the students in this group. Thirty-six of the students (54.5 per cent of the students for whom the information was available) graduated in the upper one-fourth of their class, whereas 42.5 per cent of them graduated in the middle one-half. Thus only 3 per cent of these students graduated in the lower one-fourth of their high school class. The high school rank of all of the entering Kansas State University freshmen of 1965 was as follows: 47.2 per cent in the top one-fourth, 47.3 per cent in the middle one-half, and 5.5 per cent in the lower one-fourth.[1]

[1] Kansas State University Admissions and Records Office.

The researcher found that all of the students in this group had taken at least one year of high school algebra. Approximately 88 per cent of them had received credit for two years of high school algebra. More than 90 per cent of these students had taken a course in plane geometry, whereas 27.2 per cent had taken a trigonometry course prior to their high school calculus course. Thus a majority of the students in this group had taken two years of algebra, at least one semester of plane geometry, and many had taken a trigonometry course prior to their introductory high school calculus course.

The American College Test (ACT) standardized mathematics test scores were available for eighty-eight of the ninety-two students in Group I. The researcher chose to utilize the standardized mathematics test scores rather than the raw scores because of the statistical advantages which were afforded by the use of the standardized scores. By using the standardized scores it was possible to use statistical tests which are appropriate for use with normal populations.

The range of scores for the students in this group was from a low score of nineteen to a high score of thirty-five. The mean score for the eighty-eight students was approximately 28.3 points. The median score, the score of the student midway between the highest and lowest student in the ordered array of scores, was twenty-eight. The most frequently occurring score, the mode, was also twenty-eight. A discussion of the correlation between the student's ACT standardized mathematics score and his grade in Analytic Geometry and Calculus I will be found later in this chapter.

A review of the final grades in Analytic Geometry and Calculus I for the ninety-two students in this group follows. It was found that sixty-six of the students (71.8 per cent) earned grades of "C" or better in their introductory university calculus course. As would be expected, the largest number of students were in the "C" category (30.4 per cent), whereas an equal number of students (16.3 per cent) received grades of "A" and "F." One of the students received an incomplete at the end of the first semester but his grade was later changed to a "C." None of the students in this group withdrew from their university calculus course between the time the population was selected and the end of the semester. The final grade average for this group was found to be 2.141 on the four-point grading system. Thus the average student in this group earned slightly better than a "C" in his introductory college calculus course at Kansas State University. Table IV summarizes the grades earned by the members of this group.

A description of Group II. Group II consisted of all the members of the original population who did not

TABLE IV

GRADES EARNED IN ANALYTIC GEOMETRY AND CALCULUS I DURING THE FALL SEMESTER OF 1965 BY THE NINETY-TWO STUDENTS WHO HAD TAKEN A HIGH SCHOOL CALCULUS COURSE

Course grade	Number of students
A	15
B	23
C	28
D	10
F	15
Inc.	1*
Wd.	0

*Incomplete was later changed to a C.

receive credit for a high school calculus course. It should be noted that most of these students did receive credit for four years of high school mathematics. The five most common terminal mathematics courses for the students in this group were as follows: advanced mathematics, senior mathematics, college mathematics, Mathematics IV, and honors mathematics. The researcher was unable to determine whether these courses were partly devoted to the teaching of the fundamental concepts of calculus. As was previously discussed in this report, the researcher did not assume that any of the students in this group had been introduced to the concepts of calculus at the high school level.

This group was composed of 394 men and 33 women. Thus 92.3 per cent of the group were men while only 7.7 per cent were women.

It was determined that 367 of the students in this group (85.9 per cent) had attended Kansas high schools.

A total of 383 of the 427 students in this group (89.7 per cent) had ACT standardized mathematics scores available. The scores for the students in this group ranged from a low score of twelve to a high score of thirty-six, the highest possible standardized score for the test. The mean score for the group was 28.7 points, slightly higher than the mean score for the students in Group I. The median score was twenty-eight, whereas the mode was twenty-seven points.

A review of the final Analytic Geometry and Calculus I grades earned by the students in this group follows. It is important to note that fourteen of the members of the original group withdrew from their introductory calculus course between the time the population was determined and the end of the semester. Thus a group of 413 students was utilized for this portion of the study rather than the original group of 427 students. It was determined that 63.2 per cent of the students earned grades of "C" or better in their introductory college calculus course. The category containing the most students was again the "C" category with 30.3 per cent of the students in this group. There was a smaller number of "A"'s (11.1 per cent) than "F"'s (16.5 per cent) earned by this group of Kansas State University calculus students.

One of the students in Group II received an incomplete at the end of the semester but this grade was later changed to a "C." The final grade average for the 413 students in the group was 1.954 on the four-point grading system. Thus the average student in this group earned slightly below a "C" in his introductory college calculus course at Kansas State University. Table V summarizes the grades earned by the students in this group.

TABLE V

GRADES EARNED IN ANALYTIC GEOMETRY AND CALCULUS I DURING THE FALL SEMESTER OF 1965 BY THE 427 STUDENTS WHO HAD NOT TAKEN A CALCULUS COURSE IN HIGH SCHOOL

Course grade	Number of students
A	46
B	90
C	125
D	73
F	78
Inc.	1*
Wd.	14

*Incomplete was later changed to a C.

Summary. The percentages of men composing both groups were quite similar. Group I had a slightly lower percentage of men (91.3 per cent) than Group II (92.3 per cent). A slightly larger percentage of the students in Group I (88.1 per cent) attended Kansas high schools

(85.9 per cent of Group II attended Kansas high schools).

Since the researcher was primarily interested in the group of students who had received credit for a high school calculus course, he did not gather such information as high school size, population of the student's hometown, or the student's rank in his graduating class for the members of Group II. The comparisons drawn in the preceding paragraph indicated that the two groups were quite similar in two of the characteristics which were obtained for both groups.

Table VI compares the ACT standardized mathematics scores earned by the students in both groups. It should be noted that a larger percentage of these scores were available for Group I (95.7 per cent) than for Group II (89.7 per cent). Since there was a much larger number of scores available for Group II it was reasonable to find that the range of scores for the students in this group was greater than for the students in Group I. The mean score for Group II was slightly higher than for Group I, whereas the median and mode were the same for both groups.

Table VII compares the grades earned by both groups in Analytic Geometry and Calculus I. It should be noted that the students in Group I earned higher grades in their introductory college calculus course than the students in Group II. The grade average for group I (2.141) was slightly higher than the grade average of Group II (1.954).

TABLE VI

A COMPARISON OF THE AMERICAN COLLEGE TEST (ACT) STANDARDIZED MATHEMATICS SCORES FOR BOTH GROUPS IN THIS STUDY

	Students with high school calculus	Students without high school calculus
Total number of students	92	427
Number with scores available	88	383
Per cent with scores available	95.7	98.7
Range of scores	19-35	12-36
Mean score	28.3	28.7
Median score	28.0	28.0
Mode	27.0	27.0

TABLE VII

A COMPARISON OF THE GRADES EARNED IN ANALYTIC GEOMETRY AND CALCULUS I BY THE TWO GROUPS INCLUDED IN THE STUDY

Course grade	Per cent of students with high school calculus	Per cent of students without high school calculus
A	16.3	10.8
B	25.1	21.1
C	30.4	29.3
D	10.8	17.1
F	16.3	18.3
Inc.	1.1	0.2
Wd.	0.0	3.2

II. A STATISTICAL COMPARISON OF THE TWO GROUPS USED IN THE STUDY

A test of the first null hypothesis. It should be recalled from Chapter I that the first null hypothesis proposed by the researcher was as follows:

H_{01}: There was no significant difference in the achievement in Analytic Geometry and Calculus I between the selected group of students who had received credit for a high school calculus course (Group I) and their classmates who had not received credit for a high school calculus course (Group II).

The researcher chose to test this hypothesis using a form of Student's t-test.[1] The null hypothesis was tested against the alternative hypothesis that there was a significant difference in the performances of these two groups of students. A brief summary of the statistical test follows.

$$t = (\bar{X}_1 - \bar{X}_2)/S_{\bar{X}_1}$$

$\bar{X}_1$ = the mean grade received by the students in Group I (2.141)

$\bar{X}_2$ = the mean grade received by the students in Group II (1.954)

$S_{\bar{X}_1}$ = the standard deviation of the grades earned by Group I (1.294)

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[1] David B. Huntsberger, Elements of Statistical Inference, p. 148.

The calculated value of t was found to be 0.145. The region of rejection at the .05 level of confidence was determined to be $|t| > 2.00$.[1] Since the calculated value was not significant, the null hypothesis could not be rejected.

A test of the second null hypothesis. It should be recalled that the second null hypothesis proposed by the researcher was as follows:

> H_{02}: There was no significant difference between the mean American College Test (ACT) standardized mathematics scores of the two groups involved in this study.

The researcher again chose to use the same form of the t-test which was used to test the first null hypothesis. A brief review of the testing of this hypothesis follows.

$$t = (\overline{X}_1 - \overline{X}_2)/S_{\overline{X}_1}$$

$\overline{X}_1$ = the mean ACT standardized mathematics score for Group I (28.3)

$\overline{X}_2$ = the mean ACT standardized mathematics score for Group II (28.7)

$S_{\overline{X}_1}$ = the standard deviation of the ACT standardized mathematics scores of Group I (3.9)

After the necessary calculations were completed it was determined that t was equal to -0.103. The rejection region for this test was found to be $|t| > 2.00$ at the .05

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[1] H. C. Fryer, Concepts and Methods of Experimental Statistics, p. 566.

level of confidence.[1] It was thus apparent that the null hypothesis could not be rejected.

A test of the third null hypothesis. It should be recalled that the third null hypothesis proposed by the researcher was as follows:

> H_{03}: There was no significant correlation between the final grades earned in Analytic Geometry and Calculus I and the ACT standardized mathematics scores for either group.

In order that the above hypothesis could be tested, it was necessary to divide it into the following two sub-hypotheses:

> H_{03A}: There was no significant correlation between the final grades earned in Analytic Geometry and Calculus I and the ACT standardized mathematics scores for the students in Group I.

> H_{03B}: There was no significant correlation between the final grades earned in Analytic Geometry and Calculus I and the ACT standardized mathematics scores for the students in Group II.

The first sub-hypothesis will be tested at this time. The researcher chose to use the product-moment coefficient

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[1] Ibid.

of linear correlation (r) as the indication of the degree to which the scores were correlated.[1] The formula used to find this coefficient was as follows:

$$r = \sqrt{\frac{(\ X_iY_i\ -\ X_i\ Y_i/n)^2}{\left[X_i^2 - \frac{(\ X_i)^2}{n}\right]\left[Y_i^2 - \frac{(\ Y_i)^2}{n}\right]}}$$

X = the numerical equivalent of the grades earned in Analytic Geometry and Calculus I (A=4, B=3, C=2, D=1, F=0)

Y = the standardized ACT mathematics score

n = the number of students

After the appropriate mathematical calculations were performed, it was determined that r was equal to 0.74 for Group I. The researcher again used a form of the t-test to test the significance of this value of r.[2] The formula used in this test of significance was as follows:

$$t = r\sqrt{(n - 2)/(1 - r^2)}$$

It was determined that t was equal to 10.2 for Group I. The region of rejection at the .05 level of confidence was found to be $|t| > 2.00$, whereas it was $|t| > 2.70$ at the .01 level of confidence.[3] Thus the null hypothesis was rejected and the researcher concluded that he was 99 per cent certain that the correlation between the ACT standardized mathematics

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[1]Ibid., p. 226.

[2]Ibid.

[3]Ibid., p. 566.

scores and the grades earned in Analytic Geometry and Calculus I was not due to chance.

The researcher used the same method for testing H_{03B} as was employed to test H_{03A}. It was determined that the product-moment coefficient of linear correlation between the ACT standardized mathematics scores and the grades earned in Analytic Geometry and Calculus I by the students in Group II was $r = 0.35$.

The test for significance was again identical to that employed for testing H_{03A}. The t value calculated for thus null hypothesis was $t = 7.3$. The region of rejection for the .05 level of confidence was $|t| > 1.98$ and $|t| > 2.62$ for the .01 level of confidence.[1] Thus this null hypothesis was also rejected by the researcher at the .01 level of confidence.

A test of the fourth null hypothesis. It will be recalled that the final null hypothesis proposed by the researcher was as follows:

> H_{04}: There was no significant correlation between the high school calculus grades and the college calculus grades earned by the students in Group I.

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[1] Ibid.

The researcher again chose to find the product-moment coefficient of linear correlation (r) for the analysis of this hypothesis. The reader is referred to page 45 for a discussion of this coefficient of correlation.

After the appropriate mathematical calculations were performed, it was determined that the product-moment coefficient of correlation between the high school calculus grades and the college calculus grades was $r = 0.58$.

Again the researcher chose to use the same form of the t-test which was employed to test H_{03}. The reader is asked to refer to pages 45 and 46 for a discussion of this technique. The calculated value of t was determined to be 6.10. The region of rejection for this test was found to b $|t| > 2.00$ at the .05 level of confidence and $|t| > 2.71$ at the .01 level of confidence.[1] Thus this null hypothesis was also rejected and the researcher concluded that he was 99 per cent certain that the correlation between the high school calculus grades and the college calculus grades earned by the students in Group I was not due to chance.

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[1] *Ibid.*

CHAPTER IV

REVIEW OF THE QUESTIONNAIRE RESULTS

A summary of the questionnaire technique employed in this study was undertaken in Chapter I. The following paragraphs further amplify this technique.

The questionnaire used in this study was divided into three parts. The first part contained six items which concerned the calculus which the recipient had taught during the 1964-65 school year. The second section concerned the background and teaching experience of the recipient. The final part included an item concerning the high school calculus grades for the recipient's students who were included in the study. The questionnaire was concluded with an open-end item in which the teacher was asked to make any comments which he felt would be of value to this study.

A total of forty-two questionnaires were sent to the forty different high schools represented by the students in this study. Thirty of these schools were located in Kansas and ten of them were out-of-state schools.

Twenty-five of the questionnaires had been returned by May 1, the date specified in the cover letter as the final date for the return of the completed questionnaires. Four of these were returned blank or with the notation that the teacher was no longer at the high school. In all, eighteen of the Kansas teachers and three of the out-of-state teachers had submitted the completed questionnaires prior to May 1.

Follow-up letters were sent on May 10 to the seventeen teachers who had not returned the questionnaire. This follow-up letter stressed the importance of the study and emphasized that another copy of the questionnaire would be sent if the original copy had been misplaced. This follow-up letter resulted in the return of five additional questionnaires from Kansas teachers and one from an out-of-state teacher.

Thus thirty-one (73.8 per cent) of the questionnaires were returned. The Kansas teachers in the study returned a much higher per cent (81.3 per cent) than did the out-of-state teachers (50.0 per cent). The questionnaires which were returned involved sixty-eight of the ninety-two students included in this study (73.9 per cent).

Since the questionnaire was divided into three sections, the results of each will be discussed and analyzed in the following pages.

I. ANALYSIS OF PART ONE

The first part of the questionnaire was concerned with the calculus courses which the recipients taught during the 1964-65 school year.

Since the researcher desired to know how many students were being taught calculus in the high schools involved in this study, the first item asked the teacher to check how many sections (a section was defined on the questionnaire as a class which met for one period a day) of calculus were held and not the number of sections offered. The item was worded in this way to eliminate the possibility of a teacher listing sections which did not meet the school's minimum number for acceptance and were thus cancelled. The most frequent reply to this item was that the school held no sections of calculus during the first semester and one section during the second semester of the 1964-65 school year. Exactly one-half of the teachers responding to this item replied that this situation was true in their schools. Six of the teachers responded that their schools held one section of calculus each semester. The largest number of sections held during the 1964-65 school year was eight, two having been offered during the fall semester and six during the spring term.

The second item in this section of the questionnaire concerned the number of sections of calculus that the recipient taught during the 1964-65 school year. As was anticipated, the most frequent responses were the same as for item one. It should be noted that in only two schools did more than one teacher teach the calculus courses offered. In these high schools the calculus sections were taught by two teachers.

Item three asked for the number of students enrolled in the sections that were held during the 1964-65 school year. Analysis of the results revealed that the largest reported class size was twenty-seven students while the smallest class had an enrollment of only two students. The average class size was sixteen students. The teachers reported that the calculus classes were composed of approximately 80 per cent boys. Table VIII summarizes the responses to this item.

TABLE VIII

CALCULUS SECTION ENROLLMENTS BY SEMESTER FOR THE 1964-65 SCHOOL YEAR AS REPORTED BY CALCULUS TEACHERS FROM TWENTY-SIX HIGH SCHOOLS

Section enrollment	Fall semester	Spring semester
1- 5 students	1 section	4 sections
6-10 students	1 section	5 sections
11-15 students	4 sections	7 sections
16-20 students	7 sections	10 sections
21-25 students	1 section	5 sections
26-30 students	0 section	4 sections

The fourth item in this section of the questionnaire was an open-end item requesting the teacher to list the prerequisites for enrollment in his high school calculus course. It was the purpose of this item to determine if the sections being surveyed had limited enrollments and if so, how the students were selected for enrollment in the courses. As the researcher had predicted, the most predominant pre-requisite was the successful completion of certain basic mathematics courses. An analysis of the number of schools reporting specific pre-requisite mathematics courses is found in Table IX. This table shows that the most common mathematics pre-requisite was the successful completion of Algebra I and II, trigonometry, and plane geometry. A combination of Algebra I and II with either plane geometry or trigonometry was also commonly reported by these high schools.

TABLE IX

MATHEMATICS PRE-REQUISITES FOR THE CALCULUS COURSES OFFERED BY TWENTY-SIX HIGH SCHOOLS

Pre-requisite mathematics courses	Number of schools
Alg. I and II, Trig., P. Geom.	9
Alg. I and II, Trig.	6
Alg. I and II, P. Geom.	6
Alg. I, P. Geom.	1
Alg. I and II	1
College Alg. and Trig.	1
Three years college prep. math.	1
No response	1

The non-mathematical pre-requisites for the high school calculus courses were more varied. One teacher replied that the student must have been enrolled in an "honor" section in his lower mathematics courses. Another added that the student must have been recommended by his mathematics teacher for enrollment in the high school calculus course. One school limited enrollment to high school seniors. Two schools reported that the students must have maintained at least a "B" average in their previous mathematics courses, whereas another required only a "C" average. Twenty-one of the reporting schools listed no other pre-requisites than the mathematics pre-requisites listed in Table IX and discussed in the previous paragraph.

The fifth item asked the teachers to check the particular topics which were studied in the high school calculus courses which they taught. The six topics listed in item five were taken from the list of suggested topics in Advanced Placement Program: Course Descriptions, published by the College Entrance Examination Board in 1962. The last item on the check-list was an open-end item which allowed the teacher to list additional topics. It should be noted that at least one-half of the courses surveyed included topics related to analytic geometry, derivatives of algebraic functions, applications of derivatives, integration, and applications of integration. Table X summarizes the responses to this item.

Only a few additional topics were listed under the heading "other topics" in item five. One teacher reported that his calculus course included the study of matrices as well as units on sets and mathematical logic. Another

TABLE X

TOPICS STUDIED IN THE CALCULUS COURSES OF THE TWENTY-SIX HIGH SCHOOLS IN THIS STUDY

Topic	Schools reporting coverage
Analytic geometry	24
Derivatives of algebraic functions	20
Applications of derivatives	19
Integration	17
Applications of integration	13
Transcendental functions	5
Other topics (see text)	5

teacher reported that her course included a study of complex numbers and quadratics in addition to the other topics specified in item five. Another reported that his course included a review of the various number systems. Two teachers reported that their calculus courses included the study of vectors and parametric equations.

The final item in part one of the questionnaire asked the teacher to indicate the text which he had used for his calculus course during the 1964-65 school year. The books included on this check-list were the ones approved for use by the Kansas Department of Public Instruction. A space was provided on the questionnaire for the listing of additional texts which were used by the schools. The use of sixteen different texts was reported by the twenty-six high schools participating in this study. Two schools reported that they had used three different texts for the course and four reported that they had used two separate texts. A list of the texts used by the schools in this study is found in Table XI.

TABLE XI

TEXTS USED IN THE 1964-65 CALCULUS COURSES TAUGHT BY THE TWENTY-SIX SCHOOLS IN THIS STUDY

Text and author	Number of schools
Analytic Geometry and Introduction to Calculus by Schock	7
Modern Introductory Analysis by Dolciani	5
Elements of Calculus and Analytic Geometry by Thomas	4
Principles of Mathematics by Allendoerfer and Oakley	3
Temac Programmed Calculus	3
Senior Mathematics by Mallory and Tehr	2
Analytic Geometry by Middlemiss	2
Analytic Geometry by Rider	2
Elementary Mathematical Analysis by Herberg	1
Mathematical Analysis by Camp	1
Matrix Algebra by Fuller and Bechtel	1
Elements of Analytic Geometry by Hart	1
Analytic Geometry by Rees	1
SMSG Analytic Geometry	1
Fundamentals of the Calculus by Richmond	1
Introductory Calculus by Borrow	1

II. ANALYSIS OF PART TWO

Part two of the questionnaire requested information pertaining to the background and qualifications of each of the high school calculus teachers. It consisted of a series of five items from which the researcher hoped to determine such things as the educational level of the teachers, their teaching experience, and their professional education affiliations. An analysis of the results of this section of the questionnaire follows.

The first item in part two asked the teacher to check how many years of experience he had received in teaching high school mathematics prior to the 1964-65 school year. An analysis of the responses to this item revealed that three of the teachers in the study had no previous experience in teaching high school mathematics prior to the year in question. However, it was reported that eleven of the teachers had received more than eleven years of prior teaching experience. It should be noted that about one-half of the participating teachers had taught high school mathematics for nine years or more. Table XII summarizes the responses to this item.

Item two requested the teacher to check how many semesters of experience he had obtained in teaching a high school calculus course prior to the 1964-65 school year. It should be noted that this item requested the number of semesters of experience rather than the number of years. It was the researcher's opinion that since some of the high school calculus courses were only one-semester courses, this item would be the least confusing to the respondents.

It was interesting to note that while only three teachers reported having no previous experience in teaching

TABLE XII

HIGH SCHOOL MATHEMATICS TEACHING EXPERIENCE PRIOR TO THE 1964-65 SCHOOL YEAR AS REPORTED BY THE TWENTY-SEVEN TEACHERS PARTICIPATING IN THIS STUDY

Mathematics teaching experience	Number of teachers
No previous experience	3
1-2 years	4
3-5 years	4
6-8 years	2
9-11 years	3
13 years	2
14 years	1
16 years	1
18 years	1
20 years	1
23 years	1
27 years	1
28 years	1
35 years	1
40 years	1

high school mathematics prior to the 1964-65 school year, twelve reported that they had taught a calculus course for the first time during that year. Thus nine of the teachers who were teaching a high school calculus course for the first time during the 1964-65 school year had obtained previous experience in teaching high school mathematics. For example, one beginning calculus teacher reported that she had obtained twenty-six years of experience in teaching high school mathematics prior to her first attempt at a high school calculus course.

Several teachers reported that they had taught calculus at the college level. One teacher reported five years of experience in teaching college calculus at Kansas State University. Another reported seven semesters of experience as a college calculus teacher at Bowdoin College. One teacher had taught college calculus for three years at the University of Connecticut. Table XIII summarizes the responses to this item.

TABLE XIII

HIGH SCHOOL CALCULUS TEACHING EXPERIENCE PRIOR TO THE 1964-65 SCHOOL YEAR AS REPORTED BY THE TWENTY-SEVEN TEACHERS PARTICIPATING IN THIS STUDY

Calculus teaching experience	Number of teachers
No previous experience	12
1-2 semesters	4
3-5 semesters	2
6-8 semesters	5
10 semesters	2
12 semesters	1
Many years	1

Item three requested the teacher to check what college degrees he had completed prior to the 1964-65 school year. This check-list included Bachelor of Arts, Bachelor of Science, Master of Arts, Master of Science, and "other degrees." It was intended to request information on all of the degrees held by the teachers and not just the highest degree earned. However, after the questionnaires had been returned it was apparent that a few of the teachers had not interpreted the item in this manner and so the responses were analyzed on the basis of the highest college degree held during the 1964-65 school year.

Four of the teachers reported that they held a Bachelor of Arts degree during the 1964-65 school year while seven listed a Bachelor of Science degree as their highest college degree. Seven of the high school calculus teachers participating in the study held a Master of Arts degree and nine held a Master of Science degree during the 1964-65 school year. Thus sixteen of the twenty-seven teachers (59.3 per cent) held college degrees above the Bachelor's degree at the time they were teaching the students who were included in this study.

The fourth item requested information on the teacher's affiliation with professional education organizations. It was the purpose of this item to determine whether most of the high school calculus teachers maintained membership in the National Council of the Teachers of Mathematics as well as the local, state, and national teachers associations. More than one-half of the teachers reported that they did belong to the National Council of the Teachers of Mathematics during the year in question. One of the respondents was also a member of the Mathematical Association of America. Most of the teachers belonged to the National Education Association and all but one of them maintained membership in their state teachers association.

The fact that more than two-thirds of the teachers participating in this survey belonged to a national association of mathematics teachers probably indicates that these teachers were interested in the position of mathematics in the high school curriculum. A summary of the responses to this item is found in Table XIV.

TABLE XIV

MEMBERSHIP IN PROFESSIONAL EDUCATION ORGANIZATIONS AS LISTED BY THE TWENTY-SEVEN TEACHERS PARTICIPATING IN THIS STUDY

Organization	Number of teachers
State Teachers Association	26
National Education Association	23
National Council of the Teachers of Mathematics	18
Local Teachers Association	7
Kansas Association of the Teachers of Mathematics	5
Honorary Education Societies	3
Mathematical Association of America	1

The final item in part two asked the high school calculus teacher to check how many undergraduate and graduate college semester hours of calculus he had received prior to the 1964-65 school year. The researcher realized that some of the teachers had probably attended colleges that were arranged on the trimester system rather than the semester system. Thus a formula for the conversion of quarter credit hours to semester credit hours was included in the discussion of this item on the questionnaire.

The smallest number of undergraduate hours of college calculus reported by the participants in this study was between eleven and fifteen semester credit hours. More than 80 per cent of the teachers reported that they had earned between eleven and twenty undergraduate credit hours of college calculus prior to the 1964-65 school year. Almost one-half of the teachers reported that they did not have any graduate credit in college calculus. Only two reported that they had more than twenty graduate hours of calculus prior to the year in question. Table XV summarizes the responses to this item.

TABLE XV

SEMESTER CREDIT HOURS OF COLLEGE CALCULUS EARNED PRIOR TO THE 1964-65 SCHOOL YEAR AS REPORTED BY THE TWENTY-SEVEN PARTICIPATING HIGH SCHOOL CALCULUS TEACHERS

Semester credit hours of college calculus	Number of teachers
No undergraduate hours	0
1- 5 undergraduate hours	0
6-10 undergraduate hours	3
11-15 undergraduate hours	10
16-20 undergraduate hours	12
More than 20 undergraduate hours	2
No graduate hours	12
1- 5 graduate hours	3
6-10 graduate hours	4
11-15 graduate hours	5
16-20 graduate hours	1
More than 20 graduate hours	2

III. ANALYSIS OF PART THREE

Part three of the questionnaire consisted of only three items. The first of these listed the recipient's former students who were included in this study. Since all of the final high school course grades were not obtainable from the Admissions and Records Office, the researcher asked the teachers to supply these final calculus grades in the space provided on the questionnaire.

The second item concerned the recipient's desire to obtain a summary of the results of this study. The researcher was pleased that a high per cent of the participating teachers desired such a summary.

The final item on the questionnaire was an open-end item in which the researcher asked the teacher to include any additional information which he felt might be of value to this study. One-third of the responding teachers supplied comments to this item. Most of these comments concerned changes which the teacher had made in his high school calculus course since the 1964-65 school year. One teacher reported that he had found "most high school students are not quite ready for such a course." Two teachers reported that the course had as its main goal the successful completion of the College Entrance Examination Board's Advanced Placement Examination. One reported that her class was an enriched class but that "unfortunately we have too many students--they skim too low." Several teachers indicated that they were extremely interested in this study and that they were anxious to obtain a summary of the results.

CHAPTER V

SUMMARY AND CONCLUSIONS

I. SUMMARY

The question of which mathematics courses should be offered at the twelfth-grade level is one which has plagued educators for many decades. The idea that calculus should be offered at that point in a student's education is not a relatively recent one. However, the researcher found that this idea has come to the public's attention only during the last few years.

The researcher desired to determine whether a selected group of students who had taken a high school calculus course earned higher grades in their introductory calculus course than their classmates who hadn't taken such a course. He selected a population, divided it into two groups, and compared the performances of each group.

The researcher found that a selected group of Kansas State University freshmen who had received credit for a high school calculus course (Group I) did not earn significantly higher grades in Analytic Geometry and Calculus I than their classmates who did not receive credit for a high school calculus course (Group II). He also found that the students in Group I did not score significantly higher than those in Group II on the mathematics portion of the American College Test (ACT).

It was determined, however, that there was a significant correlation between the ACT standardized mathematics scores and the grades earned in Analytic Geometry and Calculus I by the students in both groups. The researcher also found a significant correlation between the grades which the students in Group I earned in their high school calculus courses and the ones which they earned in Analytic Geometry and Calculus I.

The researcher also desired to determine the status of calculus in several selected high schools. A questionnaire was sent to the high school calculus teachers of all of the students included in Group I of this study. The data collected from this portion of the study are analyzed in Chapter IV of this report.

II. CONCLUSIONS

It was apparent that the students in this study who had received credit for a high school calculus course did not earn significantly higher grades in their introductory calculus course than their classmates who did not have a high school calculus course. Since there was no significant difference in the performances of the two groups on the ACT mathematics test, the researcher concluded that the high school calculus courses which the students in this study had taken did not significantly aid them in earning higher grades in their college calculus course.

The researcher also concluded that on the basis of the performances of the students selected for this study, the mathematics portion of the ACT battery was a good predictor of success in introductory college calculus. It was also concluded, on the basis of the students selected for this study, that the high school calculus grade was also a good predictor of student success in college calculus at Kansas State University.

III. RECOMMENDATIONS

This study was limited to student performance in the introductory college calculus course. A follow-up of this study in which the researcher surveys student performance in the more advanced college calculus courses might report much different results.

This report leaves the question of what course should be offered at the twelfth-grade level still unresolved. Although the students in Group I did not earn significantly higher grades in their introductory college calculus courses, they did earn higher grades. On this basis, the researcher would like to recommend that the high school include a calculus course in its curriculum if it has a teacher who is qualified to teach it and students who are capable of pursuing its study.

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BIBLIOGRAPHY

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APPENDIX A

Kansas State University

Manhattan, Kansas

Director of Institutional Research
Anderson Hall

April 20, 1966

The attached questionnaire is part of a study to determine the effect of high school calculus on the success of freshmen enrolled in Analytic Geometry and Calculus I at Kansas State University during the fall semester of 1965.

This questionnaire is being sent to all teachers of calculus, analytic geometry, and mathematical analysis in your high school because at least one former student is included in the study. The list of your former students who are included in the study will be found in Part III of the questionnaire. If you were not responsible for teaching one of the previously mentioned courses to these students, please forward this questionnaire to the correct teacher or return it unanswered in the enclosed stamped, self-addressed envelope.

Please return the completed questionnaire in the enclosed stamped, self-addressed envelope before May 1. If you desire a summary of the results of this study, please so indicate on the questionnaire.

Sincerely,

Tom Rawson

Enclosure

QUESTIONNAIRE

High School ____________________

Instructor's Name _______________

PART I

Part I is concerned with the calculus, analytic geometry, or mathematical analysis courses which you taught during the 1964-65 school year.

1. How many different sections (hours per day) of calculus, analytic geometry or mathematical analysis did your school hold during each semester of the 1964-65 school year?

First Semester	Second Semester
_____ No sections	_____ No sections
_____ 1 section	_____ 1 section
_____ 2 sections	_____ 2 sections
_____ 3 sections	_____ 3 sections
_____ 4 sections	_____ 4 sections
_____ 5 sections	_____ 5 sections
_____ More than 5 sections	_____ More than 5 sections

2. How many of the above did <u>YOU</u> teach during each semester of the 1964-65 school year?

   I taught _____ sections during the first semester and _____ sections during the second semester.

3. How many different students were enrolled in the sections that <u>YOU</u> taught each semester of that year?

   First semester _____ Boys
   _____ Girls

   Second semester _____ Boys
   _____ Girls

4. What were the prerequisites or other requirements in your high school for enrollment in the above-mentioned courses? (Please include information on the means of selection for enrollment, prerequisites for the course, etc.)

5. Which of the following topics were covered in the course?

_____ Analytic geometry
_____ Derivatives of algebraic functions
_____ Applications of derivatives
_____ Integration
_____ Applications of integration
_____ Transcendental functions
_____ Other topics (Please specify)

6. What text did you use for the course during the 1964-65 school year?

_____ Elements of Calculus and Analytic Geometry by Thomas
_____ Analytic Geometry by Fuller
_____ A First Course in Calculus Including Analytic Geometry by Lynch
_____ Elementary Mathematical Analysis by Herberg
_____ Modern Introductory Analysis by Dolciani
_____ Analytic Geometry and an Introduction to Calculus by Schock
_____ Analytic Geometry by Cell
_____ Other (Please specify)

Part II

Part II pertains to your background as a teacher of calculus, analytic geometry or mathematical analysis during the 1964-65 school year.

1. How many years of experience in teaching high school mathematics did you have prior to the 1964-65 school year?

_____ No previous experience
_____ 1 - 2 years
_____ 3 - 5 years
_____ 6 - 8 years
_____ 9 - 11 years
_____ More than 11 years (Please specify)

2. How many semesters of experience in teaching calculus, analytic geometry or mathematical analysis did you have prior to the 1964-65 school year?

_____ No previous experience
_____ 1 - 2 semesters
_____ 3 - 5 semesters
_____ 6 - 8 semesters
_____ More than 8 semesters (Please specify)

3. What college degree did you hold during the 1964-65 school year?

_____ B A
_____ B S
_____ M A
_____ M S
_____ Other (Please specify)

4. To what professional organizations did you belong during the 1964-65 school year?

_____ Kansas State Teachers Association
_____ National Education Association
_____ National Council of Teachers of Mathematics
_____ Other (Please specify)

5. Approximately how many undergraduate and graduate semester hours of college calculus, analytic geometry and/or mathematical analysis did you have prior to the 1964-65 school year. (Please convert credits from universities on the quarter system to semester credit hours by dividing by 3 and multiplying by 2.)

No	undergraduate hours _____	graduate hours_____
1 - 5	undergraduate hours _____	graduate hours_____
6 - 10	undergraduate hours _____	graduate hours_____
11 - 15	undergraduate hours _____	graduate hours_____
16 - 20	undergraduate hours _____	graduate hours_____
Over 20	undergraduate hours _____	graduate hours_____

Part III

Part III is concerned with your former students who are included in the study.

1. Please include the final course grades for the students listed below who are included in this study.

Student's Name	First Semester Grade	Second Semester Grade
1.	( )	( )
2.	( )	( )
3.	( )	( )
4.	( )	( )
5.	( )	( )
6.	( )	( )
7.	( )	( )
8.	( )	( )
9.	( )	( )
10.	( )	( )
11.	( )	( )
12.	( )	( )
13.	( )	( )
14.	( )	( )
15.	( )	( )

2. I (do do not) desire a summary of the results of this study.

3. If you have any additional information that you feel would be of interest in this study please feel free to comment in the space below.

APPENDIX B

Kansas State University

Manhattan, Kansas

Director of Institutional Research
Anderson Hall

May 10, 1966

You were recently sent a questionnaire which is part of a study to determine the effect of high school calculus on freshmen enrolled in a college calculus course. In a preliminary analysis of the returned questionnaires I was unable to locate yours. If your high school is to be included in this study the questionnaire must be returned no later than May 20.

If I have misplaced your returned questionnaire or if through some oversight it has been lost, another copy will be sent to you upon request.

Sincerely yours,

Tom Rawson

Tom Rawson

APPENDIX C

Calculus Course Description

The course in calculus and analytic geometry at Darien High School covers every topic suggested by the check list of topics outlined in the "Advanced Placement Program: Course Descriptions" published by the College Entrance Examination Board in 1962. The students were prepared for this course by starting the study of secondary school mathematics in grade eight.

Specifically the course covered the following:

1. Analytic geometry:
   Properties of lines; conic sections including translation and rotation of axes and the directrix-focus property; polar coordinates

2. Derivatives of algebric functions:
   Definition and properties of limits; continuity; slope of curve and rates of change; definition of derivative; differentials; Chain Rule; Rolle's Theorem; Mean Value Theorem; parametric equations

3. Application of the derivative:
   Curve plotting; related rates; maxima and minima, motion

4. Integration:
   The indefinite integral; Fundemental Theorem of Integral Calculus; definite integral; trapezoidal rule

5. Application of Integration:
   Area; distance; volume; work; length of plane curve; average value of function

6. Transcendental Functions:
   Differentiation and integration of trigonometric, exponential and logarithmic functions.

Text: "Elements of Calculus and Analytic Geometry", George B. Thomas, Jr., Addison-Wesley Publishing Co., 1959. Except for chapter seven titled "Applications of Integration to Physics", the complete text was covered.

Class hours: Classes met five times per week at 47 minutes per class. About 75 minutes of homework was assigned for each class period.

John O'Meara
Mathematics Teacher

THE INFLUENCE OF HIGH SCHOOL CALCULUS ON STUDENT SUCCESS IN CALCULUS AT KANSAS STATE UNIVERSITY

by

THOMAS MICHAEL RAWSON

B. S., Kansas State University, 1965

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
Manhattan, Kansas

1967

This study had two primary purposes. The first was to determine if a high school calculus course helped a selected sample of students attain higher grades in Analytic Geometry and Calculus I at Kansas State University. The second purpose was to ascertain the status of calculus in the curricula of certain selected high schools.

This study was carried out using both a review of student records and a questionnaire. Information pertaining to both the high school and college performances of the students was obtained from their high school and college transcripts. This information was used in fulfilling the first goal of the study. A questionnaire was sent to selected high school calculus teachers to satisfy the second purpose listed in the first paragraph of this abstract.

The researcher found that the group of students who had received credit for high school calculus did not achieve significantly higher grades in Analytic Geometry and Calculus I than did their classmates who did not have such a high school course.

The researcher also found that the students who had received credit for a high school calculus course did not score significantly higher on the mathematics portion of the American College Test (ACT). However, the researcher did find significant correlations between these ACT scores and the grades which the students earned in Analytic

Geometry and Calculus I at Kansas State University. The researcher also found a significant correlation between the grades earned in the high school calculus courses and those earned in Analytic Geometry and Calculus I at Kansas State University.