

A DETERMINATION OF THAT PART OF THE CONTENT OF A COLLEGE
FRESHMAN MATHEMATICS COURSE DESIGNED TO PREPARE
STUDENTS FOR COURSES IN DEPARTMENTS OTHER THAN THE
MATHEMATICS DEPARTMENT AT THE UNIVERSITY OF KANSAS.

by

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TABLE OF CONTENTS

<u>Chapter</u>	<u>Page</u>
I. THE PROBLEM.	1
II. BACKGROUND OF THE PROBLEM.	4
III. RELATED LITERATURE.	17
IV. METHOD OF THE STUDY.	28
V. ANALYSIS OF TEXTBOOKS.	30
VI. ANALYSIS OF INTERVIEWS	35
VII. CONCLUSIONS.	42
The Mathematics Needed by Non-Mathematics and Non-Physical Science Majors in Courses Outside of the Mathematics Department. . . .	42
Proposed Content of That Part of a Fresh- man Mathematics Course Designed to Prepare General Students at the University of Kansas for Study of Non-Mathematics Courses. . . .	43
Limitations of the Study.	47
BIBLIOGRAPHY.	50
APPENDIX A: QUESTIONNAIRE GIVEN INSTRUCTORS PARTI- CIPATING IN THE STUDY.	53
APPENDIX B: TEXT MATERIALS USED IN THE ANALYSIS OF TEXTBOOKS	54

LIST OF TABLES

<u>Table</u>	<u>Page</u>
I. MATHEMATICS TOPICS FOUND IN COURSE TEXTBOOKS. . .	34
II. MATHEMATICS TOPICS FOUND IN INTERVIEWS.	38

CHAPTER I

THE PROBLEM

There is a growing tendency to introduce beginning courses in college mathematics which are of a type other than the traditional college algebra and trigonometry. This appears to be in part an extension of a movement which was begun in the high school in the early part of this century to improve the teaching of mathematics by making the work less formal and by eliminating the barriers between various branches of mathematics. It is also related to the recent emphasis on general education in college programs.

Early in the twentieth century, in an attempt to strengthen the high school students' mathematical preparation for college, some courses were designed to break down the compartmentalization of the algebra and geometry courses and replace them with "unified" courses. Later, as emphasis was placed on individual differences, other courses were designed to meet the students' mathematical needs in daily activities and the mathematical needs of adults. Whereas the first courses that differed from the traditional high school mathematics courses involved only a reorganization of the old content, the later courses introduced many new topics

and shifted the emphasis from mathematical principles themselves to applications to everyday affairs.

A decade or so after each of these developments in the high schools, similar questions and corresponding developments occurred at the college level. The earliest mathematics courses at the college level that differed from the traditional courses represented an attempt to integrate the material of the standard courses. More recently broader courses have been designed to contribute toward achievement of the objectives of general education at the college level.

At the present time, a great variety of mathematics courses other than the traditional ones are being offered in American colleges and universities. These courses range in level of difficulty from very elementary courses consisting mainly of a review of arithmetic to courses that appear to have been designed for students of highly superior ability and with a strong high school background in mathematics. Courses have been designed for various purposes: to provide a stronger background for future study of mathematics with little emphasis upon applications; to present the mathematics needed for a particular field of study--for example, social science or commerce; to develop ability to solve problems in everyday situations; and various combinations of the above. The content of these courses varies greatly according to the level of difficulty and the purpose the course is designed to serve.

One important reason for replacing the traditional mathematics courses at the freshman college level by broader content is to develop the mathematical understandings and skills the students need in other fields of study in college. Many methods have been used in attempts to determine the content for such courses. There seems to be no indication in available literature that the content of mathematics courses for university students not majoring in mathematics or physical science has been determined on the basis of a careful study of the mathematical needs in connection with non-mathematics courses.

The objectives of the present study are

1. to determine those mathematical skills and concepts which are desirable as preparation for non-mathematics course work for university students not majoring in mathematics or the physical sciences, and
2. to organize that part of a university mathematics course designed to develop these skills and concepts.

It is realized that there is a possibility that the resulting course content may not differ substantially from that which is included in many recently developed courses or even from that of traditional courses. Also, it may be found that the content in the resulting course would fit the needs of the mathematics and physical science majors although it is designed to meet the needs of other students.

CHAPTER II

BACKGROUND OF THE PROBLEM

A movement in the high schools which began in the early part of this century led to the development of some mathematics courses that differed from traditional courses. The earliest of these were the so-called integrated, unified, or fused courses.

E. H. Moore,^{1*} in his presidential address delivered before the American Mathematical Society at its annual meeting, December 29, 1902, focused attention on the need for improvement in the teaching of elementary mathematics. He urged that the work be made less formal and that the barriers be eliminated between mathematical subjects and also between mathematics and physics. He mentioned a paper which Perry had presented to a session of the British Association in 1901 and the appointment of a committee under Professor Forsythe of Cambridge to report upon improvements that might be effected in the teaching of elementary mathematics in England. Moore proposed a laboratory method of instruction in mathematics and physics with ". . . a principle purpose being as far as possible to develop on the part of every student the true spirit of research, and an appreciation, practical as

*Numbered references appear at the end of each chapter.

well as theoretic, of the fundamental methods of science."² He believed that this could best be achieved through the unification of mathematics and physics as well as elimination of the compartmentalization of algebra and geometry. Moore's recommendations received widespread attention, and integrated courses were developed in some high schools which were based upon logical interconnections among the various mathematical subjects.

T. Percy Nunn,³ in the preface of his text The Teaching of Algebra, states that under "Algebra" he includes some plane and spherical trigonometry and an exposition of the fundamentals of the calculus. He sought to present these subjects as a unified whole.

The earliest courses which differed from the traditional high school mathematics courses involved the reorganization of content rather than the introduction of new content or applications to every-day affairs. These courses apparently were designed more for the student who would continue his study of mathematics than for the general student.

As the high school population increased, the needs of all students received greater consideration. In 1916, under the auspices of The Mathematical Association of America, The National Committee on Mathematics Requirements was organized

. . . for the purpose of giving national expression to the movement for reform in the teaching of mathematics, which had gained considerable headway in various parts of the country, but which lacked the power that coordination and united effort alone could give.⁴

The report of this committee states that it was instructed

. . . to undertake a comprehensive study of the whole problem concerned with the improvement of mathematical education and to cover the field of secondary and collegiate mathematics.⁵

The committee believed the work of the seventh, eighth, and ninth grades

. . . should be planned as a unit with the purpose of giving each pupil the most valuable mathematical training he is capable of receiving in those years, with little reference to courses which he may or may not take in succeeding years. In particular, college entrance requirements should, during these years, receive no specific consideration.⁶

In the chapter on mathematics for grades seven, eight, and nine, the following statement is made:

It is the opinion of the committee that all the material included in this chapter should be required of all pupils. It includes mathematical knowledge and training which is likely to be needed by every citizen. Differentiation due to special needs should be made after and not before the completion of such general minimum foundation.⁷

This unit of required material with little reference to courses to be taken in succeeding years represents a break from the traditional organization of courses. In a discussion of the mathematics for grades ten, eleven, and twelve, the report states,

The material for these years should include as far as possible those mathematical ideas and processes that have the most important applications in the modern world. As a result, certain material will naturally be included that at present is not ordinarily given in secondary school courses; as, for instance, the material concerning the calculus. On the other hand, certain other material that is now included in college entrance requirements will be excluded. . . .

During the years now under consideration an increasing amount of attention should be paid to the logical organization of the material, with the purpose of developing habits of logical memory, appreciation of logical structure, and ability to organize material effectively.⁸

Under college entrance requirements the committee emphasized that, in the selection of material for high school courses, its value as preparation for college mathematics need not be specifically considered. This committee believed that the high school courses should, however, prepare students for physical- and social-science college courses. In mentioning the results of a survey of the opinions of a number of college teachers in various fields conducted by the National Committee, the report says, "These results would seem to indicate that a modification of present college entrance requirements in mathematics is desirable from the point of view of college teachers in departments other than mathematics."⁹

Still further deviation from the traditional course material is recommended in the report of the Commission on the Place of Mathematics in the Secondary Schools in 1938 where the work suggested for the ninth grade is ". . . a composite course consisting of arithmetic, graphic representation, algebra, trigonometry, social mathematics, geometry, and logarithms."¹⁰ In the work beyond the ninth grade, the course material suggested in this report seemed to be designed to be practically useful and desirable for a large group of high school pupils as well as to meet the

needs of the college preparatory group.

The recommendations of the Commission on Post-War Plans¹¹ of the National Council of Teachers of Mathematics in 1945 recognized the general student and his mathematical needs. The Commission recommended¹² that high schools provide a double track in mathematics, algebra for some and general mathematics for the rest. Under the recommendations for grades ten to twelve the report includes the following statements:

Simple and sensible applications to many fields must appear much more frequently in the sequential courses than they have in the past.¹³

New and better courses should be provided in the high schools for a large portion of the school's population whose mathematical needs are not well met in the traditional sequence courses.¹⁴

The above named commission prepared a guidance report¹⁵ in 1947 to inform the high school students, teachers, and counsellors about the kind of mathematics that is best suited as preparation for various interests and vocational and educational plans. This report considers mathematics for personal use, mathematics used by trained workers, mathematics for professional workers, mathematics for various kinds of civil service workers, and mathematics as preparation for different college curricula.

The problem of developing high school courses in mathematics for the general student continues to receive much attention, but general agreement has not yet been reached regarding the content of such courses.

From some of the earliest studies¹⁶ that have been made to determine the effectiveness of courses thus far developed for the general student, it appears that the results are far from satisfactory.

In freshman college mathematics courses there have been developments which have followed those of the high schools by about a decade. As was the case in the high schools, the earliest courses which departed from the traditional courses were those of an integrated type. These were followed by courses designed to serve broader interests, with special emphasis on the needs of non-technical students.

F. L. Griffin, in writing about an experiment in correlating freshman mathematics in college in 1915, wrote,

Although there is some difference of opinion upon this point, it seems to the writer that a combination course which gives a preliminary bird's-eye view of the field, will, if worked out with sufficient care, prove to be not only the best final course for non-specialist students but also the best introductory course for specialist students. To be effective such a course must not be a mere collection of parts of the several subjects; it must correlate the topics and have a reasonable degree of unity and coherence. And, to meet the needs mentioned above, it must neither presuppose trigonometry nor omit integral calculus from the work of the first year.¹⁷

In the preface of Griffin's Introduction to Mathematical Analysis,¹⁸ the author discusses the disadvantages of the traditional plan of studying standard mathematics courses and then says that his unified course has been evolved to avoid these disadvantages. In his course it is possible for students to get some idea of differential and integral

calculus, trigonometry, and logarithms in the first semester. He also claims that specialist students acquire an excellent command of mathematical tools by first getting a bird's-eye view of the field, then proceeding to perfect their techniques.

Griffin's work was one of the earliest and best known attempts to unify the work of college mathematics although his text was not the first to be published in this field.

An indication of the extent of the movement toward unified courses by 1922 is shown in a report by J. W. Young¹⁹ on an investigation in which he collected information on the status of mathematics courses in colleges. Of 41 institutions reporting complete information he found 14 giving the unified type course in 1917-18, 27 in 1919-20, 23 in 1920-21, and 23 in 1921-22. These unified courses presented essentially the same material as the traditional ones and in most cases were designed to give students a broader understanding of important mathematical principles to serve as preparation for further study in mathematics.

Dissatisfaction with the traditional organization and presentation of mathematics continued. In 1937, J. S. Georges, in discussing the mathematics in junior college, wrote,

. . . In the traditional organization, and presentation of these branches of mathematics, not only do we lose sight of the unique functions of mathematics as a language affording a means of thought about form and quantity as no other language does, but actually replace the development of mathematical thought by manipulative skills. The acquisition of genuine understanding of the

fundamental concepts of mathematics is made incidental to the acquisition of skills and abilities to perform a large number of operations that are necessary only in the training of the specialist in the subject.²⁰

At about this time increasing emphasis was directed toward applications of mathematics. Georg Wolff, after discussing the work of the International Commission on Mathematical Education, wrote,

We no longer teach the difficult proofs of the Greek mathematics in their abstract imperceptible forms; we search for the relation of mathematics to the life of the practical man and his workshop, the merchant who needs to perform many calculations, and the engineer who performs his calculations and drawings by means of mechanical tools. In short, applied, live mathematics forms the central core of modern mathematical education. Instead of exact deduction we have many intuitively considered examples supplemented by numerous illustrations from many fields of applications.²¹

Further information concerning the status of the mathematics courses in 1938 is provided by the report of the Commission on the Place of Mathematics in the Secondary Schools which indicates that the materials offered in the junior college were essentially the traditional materials even though the course may be organized on the basis of a "unified" course. As to the needs of the terminal type junior college student, the report says,

The preparatory type of student is well provided with mathematics courses in the junior college, but comparatively little effort has been made to provide special courses to fit the needs of the terminal type of student who now takes no college mathematics, or at most 5 to 10 semester hours.²²

About ten years later, attempts still were being made to improve the mathematics offerings for the general student.

Henry Osner wrote the following about a junior college survey course in mathematics:

The basic subjects of algebra, geometry, and trigonometry are still required for technical students by most high schools; and these basic courses are followed by analytic geometry, advanced algebra, and calculus in the college. However, many schools are now using integrated courses in which certain subjects, including trigonometry, analytic geometry, algebra, differential and integral calculus, and differential equations (in various combinations) are taught as single courses. . . .

But it is in the nontechnical classes that most of the experiments are being made. . . .

Students in the technical fields will probably be offered all the mathematics they want, or have time for, in trigonometry, algebra, and calculus. Students with very little mathematical aptitude will probably take the very minimum of mathematics. Thus, the course which is really needed is one which is designed to meet the needs of students with moderate-to-fairly-high mathematical aptitude. Although it should require no preparation beyond elementary algebra and geometry at most, it should be of value to students who have had trigonometry and two years of algebra. Probably, it would be well to base most of the course on arithmetical principles, adding a few basic algebraic principles. To put it in the words of the National Council Report: "The junior college should offer at least one year of mathematics which is general in appeal, flexible in purpose, challenging in content, and functional in service."

Although theoretical mathematics can and should be included, the practical aspects should constitute the chief portion of the course. It is possible to solve most of the mathematical problems of daily life with nothing more than arithmetic and elementary algebra. Thus, it should be possible to base the course on these elementary subjects. Actually, of course, all mathematics is so inter-related that it is somewhat meaningless to speak of theoretical and practical mathematics as two different subjects.²³

In the report of the Harvard Committee on the Objectives of a General Education in a Free Society²⁴ is a

criticism of specialism as applied to the present college instruction and courses. This report mentions the fact that a student in search of a general course is commonly frustrated. It states further that the usual introductory courses are planned for the specialist and not for the student seeking a general education.

The size of the task of revising the mathematics curriculum to meet the new demands is shown by the statement with which C. B. Allendoerfer closes an article concerning mathematics for liberal arts students:

It is my position, therefore, that our standard freshman course needs radical revision if it is to meet the real needs of liberal arts students. Unfortunately, however, it is far easier to attack the present curriculum than it is to develop a second alternative to it. The preparation of a novel course, the publication of a suitable text, and its acceptance by our university authorities are no mean hurdles.²⁵

Raleigh Schorling, in discussing a report that was prepared for the President's Scientific Research Board by the Cooperative Committee, states the following about mathematics courses in junior college:

We need to provide science and mathematics courses for three very different types of students enrolled in the community college. It is assumed that the community college provides educational opportunities which otherwise might be inaccessible to a large number of educatable youth. In that case the three types of courses called for are: (a) courses that attempt to guarantee youngsters competence in mathematics and science as regards the content of general education for all who can possibly achieve it, (b) courses that provide certain science and mathematics competencies needed by students who have a desire to follow specific vocational interests, and (c) rigorous sequential courses in science and mathematics for

students who plan a career in science or mathematics. As a minimum it would seem that the community college should offer (1) at least a year of mathematics and of science which is general in appeal, flexible in purpose, challenging in content, and functional in outcome, (2) a one-year pre-vocational course consisting of units that correlate materials from mathematics, physics, and industrial arts, and (3) ample provision for the student with a major interest in science and mathematics.

Too often college courses are geared to the needs of the future specialists, to the neglect of the general student body whose main interest is in the science and mathematics of general education. This, in the judgment of the Cooperative Committee, is one of the main weaknesses of the science and mathematics programs in the colleges.²⁶

Thus we see that dissatisfaction with the traditional freshman college mathematics courses arose in the second decade of this century, that the first courses which differed from the traditional ones in an effort to improve the mathematics offerings involved chiefly a rearrangement of subject matter, and that interest in this kind of course gave way to an interest in a terminal type of mathematics course for the general student. There is at present a widespread movement among the colleges of this country to develop mathematics courses to fit general-education programs. There is lack of agreement as to the content and also as to the method of determining the content of a course for general freshman college students.

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CHAPTER III

RELATED LITERATURE

This chapter deals with the literature related to recent course offerings in various college freshman mathematics programs with particular emphasis upon the content of such courses together with the methods used in determining the content.

Unified courses are still offered in a considerable number of institutions. A description of one at Alma College follows:

Unified Course in Mathematical Analysis. This course is equivalent to the traditional courses in Algebra, Trigonometry, Elementary Analytic Geometry, and Calculus.¹

Another type of unified course is described in the Colgate University Catalogue:

Introductory Mathematics I. This part of the freshman mathematics course is based upon at least two years of secondary school mathematics. The fundamentals of algebra, analytic geometry, and elementary calculus are unified through the study of power, polynomial, and logarithmic functions.

Introductory Mathematics II. This part of the freshman mathematics course is a continuation of the first and includes the study of logarithmic, exponential, trigonometric, and implicit second degree functions with applications.²

E. P. Northrup³ has described a one-year course used in the College of the University of Chicago. This course is for persons who have had a minimum of a year of algebra and a year of geometry in high school. It was broken into four parts: logical structure, geometry, algebra, and coordinate geometry. Northrup stresses the point that the method of presentation of the material is of prime importance rather than the material of the course itself. The content of the course, however, is definitely not the content of traditional freshman college courses. Because of the emphasis on abstract thinking, this course obviously was designed for superior students. It contains little in the way of practical applications.

Another course which apparently demands more than an average amount of maturity is the one at Sarah Lawrence College. Following is a description of this course:

Mathematics I and II. These courses are designed to yield insight into the nature of mathematics and understanding of the fundamental concepts and methods involved. Various branches of the subject, algebra, geometry, theory of numbers, calculus, etc., are studied which illustrate the different types of axioms, abstract elements, methods of proof and their interrelationships. Many of the concepts introduced are related to the study of philosophy and the arts. The student will become aware of the logical attitude required and its application to correct reasoning in other fields of knowledge and thought. . . .⁴

A much more elementary course is described in the Bulletin of Information of the Kansas State Teachers College of Emporia. The description follows:

Fundamentals of Mathematics. The basic mathematical ideas and principles involved in the ordinary affairs of daily living. The review and extension of the fundamental operations of arithmetic as applied to practical and cultural problems. Elementary algebra and intuitive geometry needed for understanding and solving situations arising in everyday life. A principal objective is the development of an appreciation of the role and importance of mathematics in personal and community activities.⁵

In 1939, R. J. Hannelly⁶ made a survey of the junior college offerings in general mathematics and classified them as (1) tandem arrangement, (2) eclectic arrangement of chapters, (3) mathematical analysis, (4) job-analysis, and (5) cultural courses. He then proposed a plan for a junior college general mathematics course of seven units under the headings of functional thinking, probability, mathematics in the physical sciences, mathematics in the life sciences, mathematics in the social sciences, mathematics in the fine arts, and the nature of mathematics.

With the great interest in general education in colleges throughout the country in the past decade, there has arisen a demand for mathematics courses designed to contribute toward achievement of the goals of general education.

About 1940, Oklahoma Agricultural and Mechanical College⁷ began offering a course entitled "Practical and Cultural Mathematics" and required it of all students who did not major in the physical sciences or music. This course consisted of two types of subject matter, one showing the historical development of certain phases of mathematics and the other dealing with the fundamental meanings of certain

elementary mathematical concepts, such as number, the fundamental operations on numbers, elementary geometry, and some business mathematics. It was stated that these concepts were developed from a logical point of view.

In the fall of 1941 the University of Minnesota inaugurated a terminal course in mathematics. This was for non-specialists and was especially addressed to general students. The following is the catalogue description of the course:

Elementary Mathematical Analysis. A course for pre-medical and other students who desire a survey of college mathematics including trigonometry, algebra, and calculus with emphasis on fundamental ideas rather than on technical preparation for some more advanced courses in mathematics.⁸

In the General College of the University of Minnesota is another course which is removed still further from the traditional program and made more practical for general students. In the 1949-1951 catalogue of the General College is the following description of this course:

G. C. 8 - Applied Mathematics. A study of measurement and computation, with extensive slide rule work, precedes work with formulas--how to build them, and use them. A review of algebra, use of curves and graphs for presenting and relating data, variation as a means of developing formulas, and some elements of trigonometry are included. The student is given a background for applying mathematics to practical problems and for studying subjects in which elementary mathematics is used.⁹

An examination of college catalogs indicates a definite trend toward establishment of so-called general-mathematics courses at the freshman level. (A few of the institutions,

in addition to those already mentioned, that have developed courses of this type are: University of Michigan, University of Florida, Central Michigan College of Education, Pennsylvania State College, Cornell University, Florida State University, Western Michigan College of Education, and University of New Mexico.) The above description of the General College mathematics course at the University of Minnesota is fairly typical of the descriptions of a large number of these courses.

C. V. Newsom, in discussing the problem of providing an opportunity for a student to transfer from the general course to the program for majors makes some statements which have definite implications for the content of a general course. He writes:

The obvious solution to the difficulty just discussed calls for a revision of the traditional curriculum in college mathematics so that the general course under consideration would merely become a first course for all students. Interestingly enough, much of the material covered in the better general mathematics courses is not duplicated anywhere in the traditional sequence so that the student completing the general course will actually have a type of mathematical knowledge and understanding of mathematical concepts that the typical major in the field does not possess. This was called to my attention in a striking fashion two years ago when a group of senior students preparing to be high school teachers of mathematics called on me to inquire why they should not be given the opportunity to study the type of material that was taught in the general course. Professor E. P. Northrup of the University of Chicago has expressed the opinion that a course in mathematics that is fundamental in the general knowledge of the non-mathematicians should be just as fundamental in the general knowledge of the mathematician. Some have

expressed the thought that this point of view is intolerable because students taking the general course have mathematical ability less than that to be found among students majoring in mathematics. It is doubtful that this is true; at least, there is no evidence for such an attitude. In fact, a general course can and should be as difficult as the other courses in mathematics; even fundamental concepts of arithmetic can be presented from a mature viewpoint. It is noteworthy that in those institutions that offer a general course the impact of the new approach has generally left its mark on the traditional courses.¹⁰

There is little in the literature to indicate how the content of freshman college mathematics courses for general students has been determined. The examples which the writer has been able to locate will be discussed.

Richtmeyer,¹¹ in 1937, determined a list of items which he felt should be included in the content of a course in functional mathematics at Central Michigan College of Education by means of a check list of 82 items prepared with the help of curriculum experts and college instructors and a questionnaire circulated among teachers and administrators who rated the items according to frequency of occurrence, difficulty of learning, and general importance.

Lee Emerson Boyer¹² made a study to determine the content for a college general mathematics course for prospective secondary school teachers. As a part of his study he analyzed the results of a number of research projects which had attempted to list the most important mathematical topics used in different fields of study. Most of these research projects were completed between 1920 and 1935.

The techniques used by the authors of the research projects are described and there seems to be little similarity from author to author. There also was lack of agreement in the results obtained. The topics listed for certain fields seemed to vary with each author and each technique. With his analysis of these projects he combined his analysis of textbooks, of articles in general reading, and of journals and magazines that appeal to professional people and generalists in education to select a list of topics. He then submitted it to a large number of persons teaching in various fields and to curriculum experts for rating in importance for prospective secondary school teachers. Those items ranking highest on these ratings were then included in his course. Boyer also made a special note of the fact that he had determined by correspondence that not one of the authors of four general mathematics textbooks which appeared on the market in the period of 1935-1939 based his work upon research.

Harold C. Trimble, in a discussion of mathematics for general education, tells about a mathematics course at Florida State College. The content for this course apparently was developed by the instructors of the course on the basis of what they considered to be the pupils' needs. There is no indication that any extensive research was made to determine the content. After the first year of operation, Trimble wrote the following concerning course content:

. . . The perfect course will not be concocted overnight and become applicable to all places at all times. Only by adopting clearly defined objectives to fit local situations at a point of time, and by proceeding to implement these objectives with teaching materials, can a beginning be made. Any strategy and any set of tactics which may be adopted should be subjected to continual scrutiny. Otherwise the temptations "to be tedious" and "to wreck the intellectual self-confidence of the pupil" may impair the effectiveness of the teaching. One more opportunity will be lost to give society more citizens who are quantitatively literate.¹³

In 1949, Kenneth E. Brown¹⁴ polled colleges (presumably the mathematics departments) listing courses in general mathematics as to the topics which they felt should be included in such a course with each topic's relative importance. On the basis of the results of this poll, Brown says arithmetic, algebra, and consumer problems should be emphasized for the students who do not expect to major in mathematics or its allied fields. Trigonometry, geometry, and statistics were considered important for cultural students. It is interesting to note that, in discussing possible general mathematics texts, Brown quotes twenty-one authors concerning the use of their books and the origin of the subject matter included in the texts. Of these, not one claimed that his book was the result of a thorough study to determine the content of the course. In some cases the text material had been in use for some years and had been revised from time to time as dictated by the instructors' experience. In some cases colleagues and students assisted in the preparation and revision of the texts.

Herbert H. Hannon¹⁵ conducted an investigation to determine the topical content for a course in mathematics for general education at Western Michigan College of Education. As a basis for his study, he chose twenty-seven topics suggested by previous studies, added two more topics, and then submitted the list to various groups for rating and addition of other topics. Included in his groups were graduates, students, and instructors connected with Western Michigan College of Education.

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CHAPTER IV

METHOD OF THE STUDY

In order to determine what mathematical skills and concepts are desirable for inclusion in a single mathematics course to serve students other than majors in mathematics and physical science at the University of Kansas, text materials in courses throughout the university which were considered to involve the use of some mathematics were examined and the views of instructors of those courses were sought. The deans of certain of the professional schools of the university whose students may begin their college work in the liberal arts college, and chairmen of a number of the departments within the liberal arts college were consulted to obtain a list of the particular courses in their area in which mathematics was being used. The required textbooks for these courses were examined for evidence of any uses of mathematics. A list of the mathematical topics was made for each text. Following the analysis of the textbooks the instructors were told, in an interview, of the purpose of the study and given a questionnaire. Appointments were made with these instructors for a time two or three days later when the answers to the questions were considered. At this

time the instructors were asked to elaborate upon any answers that were indefinite, and in cases where there were topics or concepts indicated in the texts but not listed by the instructors the instructors were asked about the use of these topics or concepts.

The results of the analysis of the textbooks were summarized by departments and by schools. The results of the interviews were analyzed in the same groupings as the analysis of the textbooks. The topics that emerged as being of value to the general student were arranged into an order for inclusion in a freshman mathematics course.

CHAPTER V

ANALYSIS OF TEXTBOOKS

The textbooks and certain other materials used in various courses throughout the university were examined for evidence of the use of mathematical skills and concepts. All elementary courses (except professional engineering courses) which have a mathematics prerequisite were included. Also included were courses which representatives of certain professional schools other than engineering, and chairmen of a number of departments in the liberal arts college, indicated as courses in which some mathematical principles or operations play a part.

This compilation resulted in a list of courses in the following schools and departments:

Professional Schools	Liberal Arts Departments
Business	Astronomy
Education	Bacteriology
Journalism	Chemistry
Pharmacy	Geography
	Home Economics
	Psychology
	Physical Science
	Physics

The chairmen of the departments of botany, entomology, geology, philosophy, physiology, political science, sociology and anthropology, and social work were consulted but in all cases stated that no mathematics was used in the elementary courses. In most cases it was mentioned that mathematics, especially statistics, is useful and even necessary for much of the advanced work in these departments. The chairman of the department of social work expressed the opinion that perhaps some elementary mathematics should be provided for graduate students in that department.

A list of required text materials for each course was obtained from the chairman of the department or the instructor in each course. A preliminary examination was made of the textbooks* of the courses considered, to learn what mathematical skills and concepts were involved and a tentative list of topics was prepared. This list was revised as it seemed advisable when the textbooks were examined, and tabulations made of the occurrence of these topics in the texts. The resulting list included the following topics:

1. Fundamental Processes of Arithmetic: The four fundamental operations applied to whole numbers, fractions, and decimals; extraction of square roots.
2. Percentage: Understanding of the concepts and terminology; computation involving the various "cases."
3. Simple Geometry: Similar triangles; concept of tangent to a curve; asymptote; interpretation of three dimensional line drawings.

*A list of the text materials analyzed appears in Appendix B.

4. Ratio, Proportion, and Variation: Arithmetic and algebraic examples.
5. Linear Equations: Solution of linear equations in one unknown; substitution in formulas and the solving of formulas for one unknown in terms of others; the formulation of equations.
6. Simultaneous Linear Equations: Solution of pairs of linear equations in two unknowns.
7. Quadratic Equations: Solution of quadratic equations in one variable with numerical coefficients.
8. Powers, Roots, and Radicals (other than the computations included in I and 9): The meaning and use of powers and roots; expressing numbers as positive and negative powers of 10.
9. Logarithms: Meaning of a logarithm; properties of logarithms; computations involving multiplication, division, raising to a power, and extraction of roots.
10. Approximate Computation: Significant digits.
11. Trigonometry: Definitions of sine, cosine, and tangent of acute angles; solution of right triangles; inverse sine; sine curve; radian measure.
12. Graphs and Tables (other than statistical): Understanding functional relationships expressed in graphical and tabular form; constructing graphs and tables to express functional relationships.
13. Permutations; Combinations; and Probability, including the Normal Probability Curve: Applications of the most elementary principles.
14. Statistics: Arrangement and interpretation of data; measures of central tendency; measures of dispersion; correlation; construction and interpretation of statistical graphs.
15. Vectors: Addition of vectors.
16. Conic Sections: Simple properties of the ellipse, including eccentricity; meaning of the expression, "rectangular hyperbola."

17. Symbols: Meaning of Σ , ΔX , $<$, $>$, and $|a|$.
18. Miscellaneous Terms: Discontinuity; slope of a curve; angle of inclination of a line.

As each textbook was examined, each mathematical topic that was found was tabulated but once regardless of the number of times it appeared in the text. Table I shows the mathematics topics which are included in textbooks of elementary courses of professional schools and of certain departments of the liberal arts college. For any given topic it can be seen which schools and departments make use of that topic in their textbooks. For example, logarithms are used in the textbooks of elementary courses in the schools of business, education, and pharmacy and in the departments of astronomy, bacteriology, chemistry, and physics.

CHAPTER VI

ANALYSIS OF INTERVIEWS

In individual conferences, instructors of the courses which are referred to on page 30 were informed of the purpose of this study by the writer after he had made the analysis of textbooks used in their courses. They were asked to fill out a questionnaire concerning the use of mathematics in their courses. The questionnaire is given in appendix A. Within a few days after the questionnaire had been given to each instructor the author met with him to discuss his answers to the questions. In those cases where answers appeared to be incomplete or not clear, the instructor was asked to furnish additional information or to explain his answer. In each case in which the instructor did not give all of the mathematical topics which had been found in the textbook which he used, he was asked about the omitted items.

A tabulation was made to show the mathematical topics which the instructors indicated were used in their courses. These topics differ in some respects from those resulting from the analysis of textbooks.

There were a number of cases in which a topic appeared in the textbook of a course but in which the instructor of

the course indicated that the material was presented in such a way that the item was not involved. The principle of addition of vectors, for example, was found in the textbooks of three courses, whereas instructors stated that this principle was not used in the courses. The terms "discontinuity," "slope of a curve," and "angle of inclination of a line," which appeared in the textbook analysis, were likewise ruled out by the instructors. The expression "rectangular hyperbola," which was found in the textbook of an economics course, was said by the instructor not to be used in the course. Logarithms appeared more frequently in the textbooks than in the replies of the instructors.

Some mathematical principles in addition to those found in the analysis of textbooks were mentioned in the interviews. Instructors indicated several applications of simple geometry which had not been found in the textbooks of the courses. These included theorems about parallel lines cut by a transversal, exterior angles of a triangle, complementary and supplementary angles, and angles whose sides are mutually parallel or perpendicular. Under trigonometry was added the law of sines, law of cosines, and the identities $\tan A = \frac{\sin A}{\cos A}$ and $\sin^2 A + \cos^2 A = 1$. The process of solving certain quadratics by disregarding the linear term was added to the topic of approximate computation. The following new topics were added to those included in Table I:

19. Fundamental Operations of Algebra: The four fundamental operations; functional notation; converting word problems to formulas. (There obviously is some overlapping between this item and the item of Linear Equations.)
20. Binomial Theorem.
21. Progressions: Arithmetic and geometric.
22. Slide Rule: Use in multiplication, division, and extraction of square roots.

In tabulating the results of the interviews, a topic was included for a school or a department even if it were mentioned only by a single instructor. No attempt was made to weight a topic according to the number of instructors mentioning it or according to the emphasis given it by instructors. The results of the interviews are presented in Table II.

The deficiency named by most instructors was lack of ability to handle the fundamental operations of arithmetic. This appeared in spite of the fact that students who enter the liberal arts college with a conspicuous deficiency in arithmetic are required to take a course in remedial arithmetic. Other deficiencies which were indicated on many of the questionnaires are: applications of principles of mathematics to general problems, expressing functional relationships, logarithms, fundamental operations of algebra, and use and understanding of ratio and proportion. Some instructors in chemistry listed logarithms as a deficiency of their students, when actually the prerequisites of the chemistry course under consideration did not include a course in which the use of

TABLE II

MATHEMATICS TOPICS FOUND IN INTERVIEWS

Mathematics Topics (Described on pages 31, 32, 33 and 37.)	Professional Schools				Liberal Arts Departments							
	Business	Education	Journalism	Pharmacy	Astronomy	Bacteriology	Chemistry	Geography	Home Econ.	Psychology	Phys. Science	Physics
1. Fund. Processes of Arith.	X	X	X	X	X	X	X	X	X		X	X
2. Percentage	X	X	X	X		X	X	X	X		X	X
3. Geometry, Simple	X				X		X	X			X	X
4. Ratio, Proportion, and Variation	X	X	X	X	X	X	X	X	X	X	X	X
5. Linear Equations	X		X	X			X	X		X		X
6. Simult. Lin. Eq's.	X			X								X
7. Quadratic Eq's.	X						X					X
8. Powers, Roots, and Radicals	X				X	X	X	X			X	X
9. Logarithms	X			X			X			X		X
10. Approx. Comput'n.	X						X					X
11. Trigonometry				X	X			X				X
12. Graphs and Tables	X	X		X	X		X	X		X	X	X
13. Permutations, Combinations, and Probability	X	X								X		
14. Statistics	X	X	X	X	X		X	X	X	X	X	X
16. Conic Sections					X							
17. Symbols	X						X			X		X
19. Fund. Operations of Algebra	X			X	X						X	X
20. Binomial Theorem	X											
21. Progressions	X							X				
22. Slide Rule	X						X	X				

logarithms was taught. Other deficiencies as stated by from one to three instructors were the following: recognizing functional relations, exponents, graphs, percent, use of simple algebraic symbolism, trigonometry (from physics instructors), solving equations--linear and quadratic, significant digits, binomial theorem (from business school instructor), accuracy, and ability to analyze a problem.

Most of the suggestions for correcting deficiencies involved the giving of more problems to students in mathematics courses. In many cases instructors stated that there should be more applications to the field of interest to the person making the suggestion. In addition to the suggestion for more problems the following are quoted:

A comprehensive and intensive first term college course covering arithmetic, algebra, geometry, trigonometry, with two class hours per credit hour, and stout problem assignments from day to day. It might be helpful to have teachers from physical science departments participate in the course. (From an instructor in chemistry.)

Give an all around mathematics course stressing basic arithmetic.

A separate course of mathematics for consumers or mathematics for business world. (From an instructor in business.)

Much more mathematics in the secondary schools.

Assign secondary mathematics classes to mathematics teachers rather than to those whose main interest lies in a different field, such as, coaching.

Teach teachers mathematics and less about how to teach something of which they are ignorant.

Long range planning - consider entire school system. Leadership in such planning must come from educational institutions. (From an instructor in business.)

More emphasis on logarithms and the binomial theorem and encourage continuing of mathematics training or perhaps taking it more slowly so training over a longer period of time established the technique.

More emphasis on uncovering those with arithmetic deficiencies and give remedial course to more students.

Under the question, "How is mathematics used in your course?", practically all instructors stated that the use was in solving problems pertaining to their courses. Other uses were in deriving formulas in physics, in deriving statistical formulas in education, and in statistical analysis of data in business and education.

About two-thirds of the instructors indicated that greater use could be made of mathematics if the students were better prepared. In telling how greater use could be made, most instructors indicated that they desired not more mathematics courses but greater ability to apply the mathematics already covered in previous courses. With this greater ability, less time would be taken to review or reteach the necessary mathematics and more material could be covered. A few instructors stated that greater use could be made of statistical techniques if the student were prepared. One instructor mentioned, as an advantage of better preparation in mathematics, extension of the literature that a student could read. One instructor in chemistry stated that greater use of mathematics could be possible if students understood quadratic or higher-

degree algebraic equations.

Excluding the departments of astronomy, chemistry, and physics, the mathematics indicated as most needed at the graduate level was statistics. Instructors in business named the following: calculus, differential equations, partial differential equations, mathematical theory of investment, statistics, and compound interest. Calculus and differential equations were also indicated for graduate study in educational statistics and in psychology.

Although parts of textbooks were omitted by instructors in some courses, it was indicated that no part was omitted for any reason pertaining to the mathematics involved.

CHAPTER VII

CONCLUSIONS

THE MATHEMATICS NEEDED BY NON-MATHEMATICS AND NON-PHYSICAL SCIENCE MAJORS IN COURSES OUTSIDE OF THE MATHEMATICS DEPARTMENT

The following conclusions appear to be warranted concerning the mathematical needs of general students at the University of Kansas:

1. For a vast majority of the students who are not majors in mathematics or physical science, the mathematics needed for successful completion of their undergraduate program is quite elementary.
2. An understanding of the fundamental operations of arithmetic is necessary in a large number of university courses.
3. A majority of students do not possess sufficient arithmetical maturity to enable them to gain maximum benefit from a large number of university courses.
4. Much of the material normally presented in traditional college algebra and trigonometry courses is not used in courses outside of those in the mathematics and physical science departments and is not used in the elementary

courses in astronomy, chemistry, and physics. Those parts of trigonometry which involve secants, cosecants, and cotangents and many of the more advanced topics are not used by students who are not majoring in mathematics or physical science. Very little of the usual algebraic material concerning simultaneous linear equations and quadratic equations and none of the work on theory of equations is used in other courses by these students.

5. There is a definite need in many courses in departments throughout the university of understanding of elementary statistics.
6. In a considerable number of departments more mathematics is needed for advanced work than is needed for elementary courses. An understanding of elementary statistics is necessary for advanced work in most departments.

PROPOSED CONTENT OF THAT PART OF A FRESHMAN
MATHEMATICS COURSE DESIGNED TO PREPARE GENERAL
STUDENTS AT THE UNIVERSITY OF KANSAS FOR STUDY
OF NON-MATHEMATICS COURSES

The results of this study indicate that a rather elementary freshman college mathematics course would give a vast majority of the non-mathematics and non-physical science majors of the University of Kansas the mathematics needed for successful completion of their undergraduate programs. Such a course should include the following topics, which might well be organized in the way indicated:

1. Arithmetic.

Addition, subtraction, multiplication, and division of integers, fractions, and decimals, and extraction of square roots with emphasis on applications of these operations in problem situations and with attention to basic understandings as well as to the development of skill in performing operations.

2. Review of Fundamental Operations of Algebra.

The four fundamental operations applied to simple algebraic expressions; construction of formulas. The relationship between arithmetic and algebra should be stressed at every point.

3. Geometry.

A brief review of the important properties of similar triangles; concept of tangent to a curve; concept of a curve becoming asymptotic to a line; interpretation of three-dimensional line-drawings; and a review of the properties of figures involving parallel lines cut by a transversal, exterior angles of a triangle, complementary and supplementary angles, and angles whose sides are mutually parallel or perpendicular.

4. Percentage.

The language of percentage, review of the basic types of problems, applications representing many different fields.

5. Linear Equations.

Solution of linear equations in one unknown; substitution

in formulas and the solving of formulas for one unknown in terms of the others; the setting up of equations. Applications should be from many different fields.

6. Simultaneous Linear Equations.

Include only pairs of linear equations in two unknowns.

7. Quadratic Equations.

Solution of quadratic equations in one variable with numerical coefficients. Show that when an approximate result is desired the equation may be solved by omission of one of the terms under certain conditions.

8. Powers, Roots, and Radicals.

The meaning and use of powers and roots; expressing numbers as positive and negative powers of 10. In presenting this topic the instructor must present a sound basis for the understanding of logarithms.

9. Logarithms.

Meaning of a logarithm; properties of logarithms; computations involving multiplication, division, raising to a power, and extraction of roots. The computations should be performed by applying the properties of logarithms. Use of significant digits should be taught in connection with logarithms.

10. Slide Rule.

The slide rule as a mechanical means of computing by logarithms. Use in multiplication, division, and extraction of square roots.

11. Trigonometry.

Definitions of sine, cosine, and tangent of acute angles and general angles; solution of right triangles; inverse sine; sine curve; radian measure; law of sines; law of cosines; and the identities $\tan A = \frac{\sin A}{\cos A}$, $\sin^2 A + \cos^2 A = 1$, $\sin (180^\circ - A) = \sin A$, and $\cos (180^\circ - A) = -\cos A$.

12. Ratio, Proportion, and Variation.

Arithmetic and algebraic examples.

13. Graphs and Tables (other than statistical).

Understanding functional relationships expressed in graphical and tabular form; constructing graphs and tables to express functional relationships. Applications should be from a variety of fields.

14. Permutations, Combinations, and Probability.

Applications of the most elementary principles.

Acquaintance with the normal probability curve and its most common applications in statistical work.

15. Statistics.

Arrangement and interpretation of data; measures of central tendency--arithmetic mean, median, and mode--with advantages and limitations of each; measures of dispersion--range, average deviation, and standard deviation--with the proper uses for each; meaning of correlation and its use; construction and interpretation of various kinds of statistical graphs.

This list of topics includes all of the topics in Table II of the preceding chapter except binomial theorem, conic sections, and progressions. These topics have been omitted because they are relatively advanced topics which are used in courses taken only by a small portion of the student body. The miscellaneous symbols listed in Table II do not appear here as a separate topic because these symbols should be introduced as the need for them arises.

This proposed content might well be included in a one-semester course for students with a nominal amount of high school preparation in mathematics. For students with greater mathematical preparation the content might be modified by eliminating some of the simpler topics in arithmetic, algebra, and geometry or by spending less time on these topics.

LIMITATIONS OF THE STUDY

In designing a first year college mathematics course to serve the needs of courses in other departments of the university, no consideration is given to the question of whether the present courses throughout the university are properly organized and taught to achieve valid educational objectives. This study, however, in no way implies that the status quo should be maintained. As improvements are made in the entire university program, instruction in mathematics should continue to contribute to the effectiveness of the entire program.

This study is concerned only with determination of that part of the content of a college mathematics course which is designed to prepare students better to understand the mathematical concepts included in courses in other departments throughout the university; it is not concerned with content designed to achieve other objectives of a first-year course in college mathematics. Because of this limitation, the content suggested by this study should not be considered as including all the topics of an entire first-year course in college mathematics.

This investigation is restricted to a single university. Although in many respects this institution appears to be typical of a large number of American universities, the possibility exists that certain of the findings resulted from local factors and caution must therefore be used in applying the results of this study to courses on other campuses.

Because this study involves the use of questionnaire-and-interview techniques as one of two bases for determining desirable content of a course, results are subject to the limitations that are inherent in these techniques. Although great care has been exercised in using these techniques, it is conceivable that in some cases the responses of instructors were influenced by preconceived notions with respect to the importance of mathematics. It is possible that criteria in addition to those used in the study would be useful in determining the content of the course under consideration.

For example, it might be helpful to know what the attitude of both current and former students would be regarding mathematical needs in courses throughout the university.

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APPENDIX A
QUESTIONNAIRE GIVEN INSTRUCTORS PARTICIPATING
IN THE STUDY

What topics or understandings in mathematics should be prerequisite to your course? Please include topics from elementary arithmetic as well as any more advanced topics.

In what ways are your students deficient in mathematics as they begin your course?

Do you have any suggestions as to how these deficiencies could be corrected? If so, how?

How do you use mathematics in your course?

If the students were better prepared in mathematics, could greater use be made of mathematics in your course? If so, how?

What mathematical topics are needed at the graduate level in your field?

Do you omit any parts of your adopted text? If so, which parts? Why?

APPENDIX B

TEXT MATERIALS USED IN THE ANALYSIS
OF TEXTBOOKS

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