OBJECTIVES OF MATHEMATICS INSTRUCTION
IN SEVEN TEXAS COLLEGES

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in partial fulfillment of the requirements
for the degree of
DOCTOR OF EDUCATION
May, 1958

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PREFACE

I gratefully acknowledge my indebtedness to '. James H. Zant, my adviser, for his guidance and construc- .ve criticism given throughout the study. I thank Dr. Harry ?obst and Dr. James E. Frazier for their valuable assistance 1d helpful suggestions.

I hereby express appreciation for the financial aid iven by The Danforth Foundation and the administration of uston-Tillotson College which made this study possible.

Thanks are due Mr. Alton P. Juhlin, head of the special ervices department of the library of Oklahoma State Univer- ity, who secured unpublished dissertations for me from other niversity libraries.

The cooperation of the mathematics teachers of Bishop, Huston-Tillotson, Jarvis, Prairie View, Texas, Texas Southern and Wiley made the completion of this study possible.

I am also indebted to the persons who have contributed to this investigation by giving of their thought and time in answering the questionnaire.

I am especially thankful for the constant encouragement understanding, and help of my wife, Bertha, and my children, Joan, Janet, James, Patricia, and Ronald.

J. H. M.

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CHAPTER I

THE PROBLEM

What are the objectives of freshman and sophomore math-
iatics courses for liberal arts colleges? Is there general
;reement among experts and teachers in the field of mathe-
itics education as to the relative values of these objective
› what extent are these objectives being realized in certain
.beral arts colleges in Texas? These questions stemmed
'om the writer's interest in the improvement of the college
ithematics curriculum, and the present study grew out of an
;tempt to answer these questions which were inherent in the
'oblem.

Statement of the Problem

The present study is an investigation of the objectives
f the lower division mathematics courses. In particular,
ie study is concerned with the objectives of freshman and
›phomore mathematics courses in the following Texas colleges
ishop College of Marshall, Huston-Tillotson College of
istin, Jarvis Christian College of Hawkins, Prairie View
and M College of Prairie View, Texas College of Tyler,
exas Southern University of Houston, and Wiley College of
arshall. In an effort to arrive at a solution of this

problem, the following steps were taken:

1. A list of objectives for freshman and sophomore mathematics courses was formulated.
2. The opinions of experts in mathematics education were obtained concerning the relative values of the objectives on the list.
3. The extent of agreement between the jury of experts and the mathematics teachers of the cooperating colleges was determined.
4. A test, constructed by the writer, was given to a sample of students in the seven schools.
5. Available teaching materials from these schools were examined to determine the extent of achievement of the stated objectives.

Need for the Study

Today colleges are not only attempting to adjust their mathematics programs to the large, heterogeneous enrollments, but are also faced with the task of re-examining their goals. Recent developments by the Russians in mathematics have focused criticism upon the mathematics programs in this country. Questions such as the following are asked: Can the mathematics objectives of the past be expected to hold top priority today? Is there substantial agreement among the curriculum makers and mathematics teachers in higher education on behavioral outcomes which should be expected of students who have taken certain mathematics courses? To what extent are the objectives which are said to be desirable being satisfactorily achieved?

This study was undertaken in an attempt to answer these questions. That such a study was needed was shown by the finding that college students and graduates are often deficient in mathematical requisites. Concerning this, wlan stated:

> It would be interesting and perhaps surprising to learn the small percentage of those in college mathematics who have had any clear conception of the meanings of the mathematical words and phrases they use in their daily work.[1]

writing about the present status of mathematics in our hools and colleges, Duren told of the concern of industry d the federal government with the deficiencies of the erican youth in mathematics. He stated:

> They [leaders in industry and government] began to realize that our economic welfare and our military security were dependent upon maintaining an expanding staff of technically trained men. They began to tell the public the facts about the degeneration in the learning of science and mathematics in the schools and about the poor showing which an American youth makes in these skills compared with a European, especially a Russian youth.[2]

At the present time many educators are questioning the equacy of the mathematics curriculum. Various committees ve been appointed to study the problem. Van Engen said:

> The Commission on Mathematics is not the only group to give thought to curriculum problems. The Committee on the Undergraduate Program of the Mathematical Association of America received its charge from the parent organization just prior to the activities of the Commission. The Secondary School Curriculum Committee of the National Council of Teachers of Mathematics came into being during the year 1955. Since then similar groups in high schools and colleges have been appointed to make studies at local levels.

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[1]F. S. Nowlan, "Objectives in the Teaching of College thematics," The American Mathematical Monthly, LVII (1950),

[2]William L. Duren, Jr., "School and College Mathematics, e Mathematics Teacher, XLIX (1956), 514.

> All of this committee activity, springing from various national and local sources, could only mean that there is a general dissatisfaction with the program of the first fourteen grades and that educators feel it is time to act.[3]

This study was needed because in it useful information ich had not been collected and analyzed previously was llected and analyzed.

This study is needed because no adequate investigation s been made of the mathematics programs and their objec- ves in the cooperating colleges.

In the search of the literature, it was found that veral studies of a similar nature had been made. None of ese studies, however, attempted to evaluate the mathematics ograms, nor did any study attempt to investigate the mathe- tics programs of those colleges whose students were pre- minantly Negro. Some related studies are described below.

Related Studies

In 1948, Kidd reported on research done on the objective mathematical training in the public junior college. He id that the purpose of his study was three-fold:

> . . . to describe the mathematical training being provided for students in the various curricula of the public junior college, to formulate and evaluate mathematical objectives in the training of these students, and to state implications of findings for the mathematic program in the junior college.[4]

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[3]H. Van Engen, "Plans for the Reorganization of College reparatory Mathematics," School Science and Mathematics, VIII (1958), 277.

[4]Kenneth P. Kidd, Objectives of Mathematical Training n the Public Junior College, Contribution to Education No. 94, George Peabody College for Teachers, (Nashville, 1948),

In 1957, Rowe[5] completed a study of "The General Mathe-
ics for Terminal Students in California Junior Colleges" which the mathematical objectives for these students were lected and analyzed.

Research has also been done on the aims of specific hematics courses such as calculus, trigonometry and algebra. C. MacDuffee[6] published an article dealing with the objecti a course in calculus. Schaaf[7] wrote about the aims in the ching of trigonometry. Brown[8], reporting on the general hematics program, stated that there had been little attempt evaluate the effectiveness of courses such as algebra, gonometry, and analytic geometry in terms of their objec-es.

The writer was unable to find any studies concerning the ainment in mathematics courses of certain goals, such as ls of appreciation and the development of attitudes, habits, interests. This is perhaps due to the difficulty of

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[5]Jack L. Rowe, "General Mathematics for Terminal Students California Junior Colleges" (unpub. Ed. D. dissertation, versity of Colorado, 1957) p. 110.

[6]C. C. MacDuffee, "Objectives in Calculus," The American hematical Monthly, LIV (1947), pp. 335-337.

[7]William L. Schaaf, "The Teaching of Trigonometry," Mathematics Teacher, XLV (1952), pp. 445-450.

[8]Kenneth E. Brown, General Mathematics in American Col-es, Contributions to Education No. 893 (New York, Bureau Publications, Columbia University, 1943), pp. 150-151.

suring these objectives. Some educators who agree with s view are quoted below.

Concerning this difficulty, Northrop said:

> I am also impressed by the fact that only a very small number of writers are bold enough to question whether or not the objectives of mathematics in liberal education have yet been clearly stated; or, if stated, whether or not they have been measured by means of tests and examinations. Of this small group of critics, some believe that significant tests will eventually be found, but have not been found to date. A very few suspect that significant tests may never be found.[9]

r, Davis, and Johnson realized the difficulty in quantify- the appraisal of certain aspects of the educational pro- m. In reporting on this, they said:

> A sound research and appraisal program demands that we use both qualitative and quantitative data. . . . In time it may be expected that many qualitative types of data in education will be reduced to quantitative data. It is not too much to hope that in due time most of the so called intangibles, such as interests, attitudes, appreciation, loyalties, and beliefs will be quantified. . . . It is the complex and not readily observed traits and qualities that are frequently the most difficult to quantify.[10]

Basic Assumptions

The present study assumes that the quality of the college hematics program can be improved if the teachers formulate e wisely the aims of the courses which they teach.

It is assumed in this study that mathematics courses

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[9]E. P. Northrop, "Mathematics in Liberal Education," American Mathematical Monthly, LII (1945), pp. 133-134.

[10]A. S. Barr, Robert A. Davis, and Palmer O. Johnson, ucational Research and Appraisal, (Chicago, 1953), p. 10.

th the same title, although given in different schools, ould generally have the same or similar aims. This is cessary if there is to be a free exchange of students ong the institutions, and if the registrars and other perns concerned are to be able to adequately evaluate the udents' transcripts.

Following other studies, such as the study by Madaus[11] d the study by Thomas[12], the writer assumed that the jury chnique of formulating the objectives was a valid procedure d, that a consensus thus established could be accepted as lidation. Thomas said, "The jury technique of research s the most practical, if not the only, technique to use selecting the elements which were to constitute the riterion." Madaus said, "The practicable method for conacting the study seemed to be the jury technique."

Definitions

Throughout this study, terms such as knowledge, abiliies, skill, interests, attitudes, critical thinking, and oncepts are used. Definitions of some of these terms are

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[11]Herbert S. Madaus, "Validation of Basic Principles nd Criteria for Evaluating the Organization and Adminisration of Student-Teaching Progress," (unpub. Ed. D. issertation, Oklahoma A and M College, 1957), p. 5.

[12]Archie C. Thomas, "The Development of a Criterion in he Measurement of Shorthand Transcription Production," unpub. Ed. D. dissertation, Oklahoma A and M College, 1951), . 12.

iven below.

Since mathematical training is just one facet of educa-ion, the definition of "mathematical objective" corresponds o that of "educational objective" as given by Bloom below.

> By educational objectives, we mean explicit formulations of the ways in which students are expected to be changed by the educative process. That is, the ways in which they will change in their thinking, their feelings, and their actions.[13]

The terms objective, goal, and aim are used inter-hangeably in this study to designate the "outcomes in terms f desirable characteristics that the educational product hould possess."[14]

Bloom[15] defines "knowledge" as that which includes hose behaviors and test situations which emphasize the emembering, either by recognition or recall, of ideas, aterial, or phenomena. He said that "abilities and skills" efer to organized modes of operation and generalized tech-iques for dealing with materials and problems.

Throughout the literature, "critical thinking," "reason-ng," and "deductive reasoning" mean essentially the same hing as "logical thinking" as defined by Smith and Tyler[16]

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[13]Benjamin S. Bloom, et al, Taxonomy of Educational Objectives, (New York, 1956), p. 20.

[14]Leo Brueckner, Encyclopedia of Educational Research, ed. Walter S. Monroe, (New York, 1950), p. 315.

[15]Bloom, p. 201.

[16]E. R. Smith and Ralph W. Tyler, Appraising and Recording Student Progress, (New York, 1942), p. 142.

ho said, "Logical thinking means distinguishing between conclusions which follow logically from given assumptions and conclusions which do not follow logically from given assumptions."

"Interests" emphasize liking an activity, while "appreciation" includes liking but emphasizes insight into the activity, understanding it, realizing its true value, and the like.

Johnson[17] defines attitudes as "an enduring emotional set or predisposition to react in a characteristic way toward a given person, object, idea, or situation."

In speaking of the term "concept" Sobel said:

> Although the literature reveals a lack of agreement concerning the exact meaning and nature of a concept, this difficulty may be avoided in the field of mathematics by operationally defining a student's concept of some particular term as the summation of a given set of responses which the student is expected to elicit at some given stage in his mathematical development. . . . Possession of the concept is assumed if the student is able to respond successfully.[18]

The Purpose of the Study

Specifically, the purpose of this study was:

1. To assist the seven cooperating colleges by bringing to the attention of their mathematics departments a list of objectives thought to be important by a jury of experts in the field of mathematics education.

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[17] Donovan A. Johnson, "Attitudes in Mathematics Classroom," School Science and Mathematics, LVII (1957), p. 113.

[18] Max Sobel, "Concept Learning in Algebra," The Mathematics Teacher, XLIX (1956), p. 426.

2. To determine the extent of the success of the teachers in realizing these objectives and to apprise the teachers of the findings.
3. To assist in the improvement of the mathematics curriculum of colleges similar to the colleges of this study by making the findings of this study available to them.

Scope and Limitation

While this study was undertaken for the purpose of ollecting and analyzing information which would contribute o the meeting of the needs mentioned above, it is not proosed that this investigation will establish the complete nd final solution of these needs.

The colleges included in this study are all those olleges in Texas which are accredited by the Southern Assoiation of Colleges and Secondary Schools, and which are ttended predominantly by Negroes. These colleges are mostly iberal arts colleges with teacher-training programs. Acording to the catalogues of these institutions, of the wenty-five mathematics teachers listed, two have doctor's egrees, seventeen have master's degrees, and six have achelor's degrees. This is not a fair indication of their ualification, for twenty of the twenty-three mathematics eachers who do not have the doctoral degree have done urther work toward advanced degrees.

The mathematics courses with which this study is conerned are restricted to the customary freshman and sophmore courses. These are: college algebra, trigonometry, eneral or basic mathematics, plane analytic geometry, and ifferential calculus.

No attempt is made in this investigation to compare r to contrast the mathematics programs or achievements of he cooperating institutions.

It is recognized that this investigation deals with nly one aspect of complete evaluation of the mathematics rograms of the colleges and is, therefore, limited to the valuation of the mathematics objectives and makes no laim of identifying other values or contributions.

Sources of Data

In order to accomplish the first step in the solution of the problem of this study, a survey was made of the iterature dealing with the aims of higher education in general and the objectives of mathematical training in articular. The literature surveyed included books and journals in education, mathematics textbooks, college and niversity catalogs, mathematical journals, and published and unpublished doctoral dissertations.

The textbooks, syllabi, outlines, and bibliographies ised in the mathematics courses of the cooperating colleges served as sources of data for this investigation.

The tests and examinations prepared and administered by the teachers of mathematics in the cooperating colleges in the first term of the 1957-1958 school year served as further sources of data.

The questionnaires which were completed and returned by a competent jury of experts constituted another source of data.

Further information was received from the questionnaire sent to the mathematics instructors of the seven colleges.

The examination prepared by the writer and administered to a sample of students in the cooperating colleges yielded further information used in this study.

Summary of Chapter I

In this chapter the author has given a statement of the problem, the need for and purposes of the study, and the sources of data as well as the scope and limitations of the problem. Furthermore, a short discussion is found in this chapter concerning the research previously done in related studies, and certain terms, whose meanings might be in doubt, are clarified.

Chapter II, which follows, deals with the procedures and methodology employed in the collection and analysis of the data.

CHAPTER II

METHOD AND PROCEDURE

The purpose of this chapter is to give an explanation ' the steps taken by the writer in order to find a solution the problem of the study. The methodology and procedure r obtaining the necessary information are given in this apter. Included is a description of the methods used to rmulate a questionnaire, to select a jury of experts to dge the objectives of the questionnaire, and to prepare test administered to a sample of students. Also, this apter deals with the collection of the data from the estionnaire sent to mathematics teachers in the seven lleges and other sources.

Objectives from College Catalogs

A list of objectives was formulated from the many ob- ctives found in the search of published and unpublished terials. These sources included prefaces and introductions textbooks, articles in mathematical journals, college and iversity catalogs, and doctoral dissertations.

Two hundred college, junior college, and university talogs in the library of Oklahoma State University were amined for objectives of freshman and sophomore mathematics

ourses. Many of the catalogs did not set forth the objec-
ives of their mathematics courses. Some of the catalogs
ave the objectives in the form of course content while
thers gave the objectives explicitly for each course. The
bjectives given below which were gathered from these
atalogs are representative of all the objectives of the
ower division mathematics courses found in the two hundred
atalogs in the Oklahoma State University library.

The objectives of the Department of Mathematics of The
gricultural and Technical College of North Carolina, as
et forth in its catalog are the following:

1. To review and strengthen students in the basic fundamentals of mathematics in order that they may be adequately equipped for expressing or interpreting quantitative ideas in this and related areas.
2. To provide an opportunity for all students to increase their sense of utility of the subject matter by emphasizing the application of mathematical processes to problems involving personal and social living.
3. To equip the students whose interests and abilities lead to further study, research, and/or technology with an adequate mathematical background.
4. To contribute to the teaching efficiency of prospective secondary school mathematics teachers by insuring mastery of essential subject materials, and the development of a reasonable degree of skill, accuracy and speed in dealing with these materials.[1]

It was found in The University of Wyoming catalog
hat one of the three aims of teaching mathematics in college

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[1] Agricultural and Technical College of North Carolina ulletin, (Greensboro, 1954-1955), pp. 165-166.

s the following:

1. For its own sake
   a) For the intellectual and aesthetic pleasure it gives.
   b) In order to hear and read understandingly much that is said and written about today's problems.
   c) As one of the greatest contributors to the cultural life of the race.[2]

The catalog of Fresno State College outlines the mathe-atics courses, thus indicating the desired objectives in erms of mathematical ideas and concepts to be developed. n giving objectives for mathematics in general, the catalog f Fresno State College states:

> Mathematics serves as a part of general education, as an integral part of technical studies in physical science and engineering, as a foundation in other fields of study, and as a pure science for those interested in mathematics itself and for those who use it in some applied field such as statistics, economics, or actuarial work. A program of training is offered for teachers of mathematics in secondary schools.[3]

The aims of mathematics training in the lower division f the college as determined by the contents of the courses escribed in the Fresno State College catalog are:

> Trigonometry: Concept of a function, sine and cosine functions, tables and graphs, other trigonometric functions, identities and equations, trigonometric functions of angles, solution of triangles, logarithms.
>
> Analytic Geometry: Functions and their graphs, transformation of axes, straight line, curves including conic sections, parametric equations, polar coordinates

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[2] University of Wyoming Bulletin, (Laramie, 1955), p.330

[3] Fresno State College, General Catalog, (Fresno, 1957), . 226.

Differential Calculus: Limits, theory and technique of differentiation, differentials, law of mean, applications.[4]

The University of Chicago stated through its catalog that the major aims of its one-year course (Math. A, B, C) are:

. . . to train the student in the elements of scientifi discourse and their use in the statement, organization, and communication of ideas (logic, deductive theories); mathematical thinking (abstraction, symbolic expression structure of mathematical systems); and to supply him with certain concepts, facts, and methods basic to exact science (relations and functions, number systems, analytic geometry, trigonometry).

The major aim of Math. 150 (A, B, C) is to train the student in the fundamentals of differential and integra calculus; the course being organized around the concep of limit with the aim of giving the student good understanding of the concept and its place in calculus.[5]

At Florida Agricultural and Mechanical University, the objectives of "Introduction to College Mathematics" are:

. . . to explain (1) how the various branches of mathematics originated; and (2) how they have been and are now being used in the development of man's civilization. This includes the meaning and application of the sine, cosine, and tangent functions, the meaning and application of logarithms, and the fundamentals of mathematics of finance.

College Algebra: A review of elementary operations followed by a study of the function concept, logarithms quadratic functions and equations, equations of higher degree, and complex numbers.

Trigonometry: An elementary treatment of the trigonometric functions which continues with a graphical discussion of the right triangle and of the oblique triangle; applications.

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[4]Ibid., p. 228.

[5]The University of Chicago Catalogue, (Chicago, 1958-59), p. 68.

Analysis I: An introduction to the concepts of analytic geometry and calculus, embracing elementary treatment of the straight line and the circle, and differentiation and integration of simple algebraic forms.

Analysis II: Advanced algebra and trigonometry includes quadratic equations, progressions, the binomial theorem, logarithms, inequalities, mathematical induction, and complex numbers. Thorough treatment of the trigonometric functions and solutions of triangles with applications.

Analytic Geometry: Treats the straight line and conic sections in detail; rotation of axes, parametric equations, and polar coordinates. Recognizing a curve from its equation is emphasized.

Calculus I: Deals with the derivatives and differential of both algebraic and transcendental functions, application of maximum and minimum, parametric equations, and polar equations, curvature, the law of the mean and its application.[6]

The following aims of the Mathematics Department of rkansas Polytechnic College are found in its catalog:

The objectives of the department of mathematics are to assist the student in the acquisition of important information and work experience, in the cultivation of useful work habits and study skills, in an appreciation of the aesthetic values of mathematics and of the role it has had in the growth of our culture, and in the development of effective methods of thinking, salable skills, and certain hard-to-express intangibles represented by fairness of judgment and intellectual honesty.[7]

Northeastern Oklahoma A and M College[8] states in its atalog that mathematics study gives a basis for understanding the technical and scientific developments of modern times t is further stated here that mathematics develops intel-

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[6]Florida A and M University Catalogue, (Tallahassee, 955), pp. 123-124.

[7]Arkansas Polytechnic College Catalog, (Russellville, 955-56), p. 77.

[8]Northeastern Oklahoma A and M College Catalogue, Tahlequah, 1957-1959), p. 66.

ctual initiative, creates an ideal of clarity and precision reasoning, and increases the imaginative power of the udent in general.

From the catalog of Bennington College, a New England rls' school, come the following aims of two mathematics urses:

> College Algebra: Seeks to develop the student's power of analysis. Beginning with the concept of number the fundamental algebraic processes will be developed rapidly, emphasis being placed upon the role of definition. Extension of definition and an introduction to rigorous deductive methods of proof will be served by the close examination of Pascal's triangle and tentative statement of the Binomial Theorem will be derived and will serve as an introduction to proof by inductive methods. Such other topics as permutations, combinations and probability will be considered if time permits.
>
> Plane Trigonometry: From the initial definitions relating to the right triangle, extensions of definitions to ratios of angles of any size will be made. The course will develop through a study of the graphs of circular functions, solutions of trigonometric equations solutions of oblique triangles. (Students will be encouraged to relate their findings to problems encountere in everyday life.)[9]

Objectives from Mathematical Journals

Articles from mathematical journals such as <u>School</u> <u>:ience and Mathematics</u>, <u>The Mathematics Teacher</u>, and <u>The</u> <u>nerican Mathematical Monthly</u> were used as a source in the ompilation of objectives for the questionnaire. In disussing the qualities that our future scientists and matheaticians should have, Norton states the following:

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[9] <u>Bennington College Catalog</u>, (Bennington, 1955-56), . 29.

> Most authorities agree that the following traits, qualities, and characteristics are ones of particular value to individuals interested in scientific and mathematical endeavors. . . . They are: 1) Dependabilit 2) Goal directed activity, 3) Experimentation, 4) Human relationships, 5) Logical thinking, 6) Creativity, 7) Self-expression, 8) Patience, 9) Modesty, and 10) Alertness.[10]

Henderson and Dickman[11] list some ninety-seven needs f prospective students in the college of engineering. The ollowing needs, among others, are found in their article: oncept of an approximate number; concept of algebraic riables and constants; preparation and interpretation of atistical graphs; common special products; laws of exonents including negative and fractional exponents; solutio a pair of linear equations including solution by determinants; solution of a quadratic equation by factoring, by mpleting the square, and by the formula; addition, subaction, multiplication, and division of radicals and comple mbers; computation by means of logarithms; interpolation; ncept of locus; laws of sines, cosines, and tangents; and ncept of a vector.

Included among the aims given by Schaaf[12] are the

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[10]Monte S. Norton, "Developing Success Qualities in Our ture Scientists and Mathematicians," <u>School Science and thematics</u>, LVII (1957), p. 620.

[11]K. B. Henderson and Kern Dickman, "Mathematical Needs Prospective Students in the College of Engineering," e Mathematics Teacher, XLV (1952), pp. 89-93.

[12]W. L. Schaaf, "The Teaching of Trigonometry," pp. 446-48.

'ollowing:

1. To give a thorough working knowledge of trigonometry.
2. An insight into the usefulness of mathematics is gained from trigonometry far more than from any other course.
3. An introduction to the ideas of mathematically describing a periodic function.
4. An appreciation of the beauty in the marvelous combinations of which trigonometric functions are capable is a worthy aim.
5. To give training in functional thinking through graphical representation of functional relations.
6. To develop the power of quantitative and space perception and spatial imagination.
7. To develop mental habits of analysis, exactness, and logical organization.

MacDuffee[13] said that the first objective in a course n calculus has to be the basic techniques of differentiaion and integration and that our proper goal in the calculu s to develop the student's ability to interpret the physical orld in mathematical terminology. MacDuffee further stated hat the first course in calculus should be rigorous up to he capacity of the student to appreciate rigor.

Hassler is a good example of some of the earlier riters who emphasized some of the more intangible objecives. Hassler, writing in 1929, said:

> A knowledge of the history of the development of mathematical processes he is learning will kindle the pupil's interest in the subject matter. . . . A knowledge of the history of mathematics gives . . . an appreciation of the value of the subject and its inseparable and vital connection with the development of civilization.[14]

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[13]MacDuffee, p. 335.

[14]J. O. Hassler, "The Use of Mathematical History in 'eaching," <u>The Mathematics Teacher</u>, XXII (1929), p. 166.

Although Nowlan admitted that there were other worth-
hile objectives, he classified the major aims of mathematics
eaching under two main headings. He wrote:

> I do not underestimate the value of practical application in the teaching of mathematics, nor the necessity for the mastery of mechanical skills in numerical and algebraic operations. I assume that these are taken care of, as a matter of course, in our instruction.
>
> There are two main aims in the teaching of college mathematics, whether to liberal arts students or to students of engineering. These, in order of importance, are:
> 1. Training in precise thinking and a grasp of principles.
> 2. The acquisition of information and a mastery of certain technical skills.[15]

Fehr, when writing on the purposes of the study of
athematics, said that there are at least four fundamental
oals that should be attained. They are given below:

> First it should serve as a functional tool in solving our . . . problems.
> In the second place, mathematics serves as a handmaiden for the explanation of the quantitative situations in other subjects, such as economics, physics, navigation, finance, biology, and even the arts. . . .
> In the third place, mathematics, when properly concerned becomes a model for thinking, for developing scientific structure, for drawing conclusions, and for solving problems. . . .
> In the fourth place, mathematics is the describer of the universe about us.[16]

In the Fifteenth Year Book[17] of The National Council

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[15]Nowlan, p. 78.

[16]Howard F. Fehr, "Reorientation in Mathematics Education," Teachers College Record, LIV (1953), pp. 430-439.

[17]W. R. Reeve, Editor, Fifteenth Year Book, The National Council of Teachers of Mathematics, The Place of Mathematics in Secondary Education, (Bureau of Publications, Columbia University, 1940), p. 253.

f Teachers of Mathematics, the objectives are classified
nder the following headings:

1. Ability to think clearly.
2. Ability to use information, concepts, and general principles.
3. Ability to use fundamental skills.
4. Desirable attitudes.
5. Interests and appreciations.

Under "ability to think clearly", are found such
tivities as "gathering and organizing data," "drawing
onclusions," and "establishing and judging claims of proof".
ome of the attitudes which are considered desirable are:
a) Respect for knowledge, (b) Respect for good workmanship,
c) Respect for understanding, (d) Social-mindedness,
e) Open-mindedness.

In an article concerning the teaching of a first course
n calculus, Parker lists the following major objectives:

> 1. To give the student an understanding of the fundamental concepts of the calculus and a point of view relative to the historical background out of which these concepts grew.
> 2. To develop proficiency in the manipulative skills of differentiation and integration.
> 3. To develop the ability in making practical applications of the principle learned. . . .
>
> The concepts of a function, a variable, increment, limit, and continuity are absolutely necessary stepping-stones for the beginning student.[18]

In describing a plan for a program in mathematics for
iberal arts students, Allendoerfer wrote:

> In thinking of these students . . . First we have utility as a chief reason for their study of mathematics

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[18]James E. Parker, "The Teaching Objectives in a First ourse in Calculus," The Mathematics Teacher, XXXVII (1944), 347.

. . . second, mathematics is traditionally known as a logical subject, and its pursuit is supposed to improve the capacity of the mind for reasoning. And, finally, the student may hope to attain some understanding of the nature of mathematics and of its contribution to our culture.[19]

In describing the mathematics program at the University f Chicago, Northrop outlines the objectives as follows:

. . . the student should be taught to think deductively, to know what a deductive system is, to understand the relation between an abstract deductive system and its models, or concrete interpretations, and to have some appreciation of what rigor is and how it may be achieved Add to this the fact that he should learn, both for the skills themselves and for the part they will play in his later courses in science, how to understand and to deal with the problem of quantity and space, and the content of a year course in mathematics appropriate to a program of liberal education becomes fairly clear: It should include at least the study of logic, algebra, and geometry.[20]

Objectives from Dissertations

Among the published and unpublished dissertations some bjectives for the questionnaire were found. The abstracts f dissertations found in the library of Oklahoma State niversity were searched for usable objectives. The Special ervices Department of the library secured unpublished dis- ertations from other universities for the investigator.

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[19]C. B. Allendoerfer, "Mathematics for Liberal Arts tudents," The American Mathematical Monthly, LIV (1947), . 573.

[20]E. P. Northrop, "The Mathematics Program in the ollege of the University of Chicago," The American athematical Monthly, LV (1948), p. 2.

The dissertation by Banks[21] proved quite fruitful in his respect. In his study, Banks compared the relative ffectiveness of general mathematics and college algebra in mproving the ability to think critically. The responses hat Banks received from 213 colleges and universities ndicated that the ability to do critical or logical thinking s considered to be the most important contribution which he study of mathematics has to make to the education of the tudents who are not to specialize in mathematics.

In a study undertaken to aid in the clarification of he role of mathematics in the program of the community ollege, Bentz arrived at thirty-one critical mathematical equirements for the community college student. Among these hirty-one requirements, the following objectives were found:

1. Skill in computing with integers, common fractions
2. Familiarity with terms used in the identification of various numbers
3. Ability to interpret and express relationships by means of a chart, formula, or graph
4. Skill in setting up and solving simple equations to find the value of the unknown number
5. Ability to make a proper selection and use of a formula from memory or from a reference source
6. Ability to carry out an interpolation
7. Understanding of the usefulness of a system of coordinates
8. Understanding of the meaning of the more common symbols used in the field of mathematics
9. Ability to collect and tabulate accurately various kinds of numerical data
10. Understanding of the significance of such fundamental statistical measures as the arithmetic mean, median, mode, range, and standard deviation
11. Ability to use the slide rule and calculating machines to perform various fundamental operations

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[21]John H. Banks, Critical Thinking in College Freshman Mathematics, (unpub. Ph. D. dissertation, George Peabody College for Teachers, 1949), p. 15.

12. Understanding of the meaning of a logarithm and the ability to use it as a short cut in making calculations
13. Skill in the use of the sine, cosine, and tangent trigonometric ratios in determining distances and angles
14. Awareness of the importance of doing careful, accurate work and of checking results
15. Awareness of the importance of developing correct habits of a clerical nature in writing figures
16. Ability to deal intelligently with the matter of locus, investments, and the cost of borrowing money
17. Ability to make a selection of the significant facts in a given problem, and to apply the necessary techniques to bring about a satisfactory solution.[22]

Objectives from Textbooks

Textbooks for courses in freshman and sophomore mathe- atics were examined in order to find the objectives of the uthors. Forty-three textbooks were examined. Included mong these books were those used in the cooperating colleges f this study and some found in the library of this universit hese books have a wide range of publication dates--1904 to 956. The aims of the authors were determined by an analysis f the prefaces and introductions of the textbooks. While ome of the textbooks did not state the objectives of the uthors, others gave detailed objectives for the course.

Typical of some of the algebra textbooks is College lgebra, whose authors[23] stated that their book emphasizes

[22]Ralph Porter Bentz, "Critical Mathematical Require- ents for the Program of the Community College," Abstracts f Dissertations, (George Peabody College for Teachers, 1952 . 13.

[23]Committee of College Algebra, College Algebra (New ork, 1956), p. ix.

lgebraic7 technique, . . . and is sufficiently rich in terpretation and general problems to develop the student's wers of analysis. . . . Stress is laid upon concepts, the terial is presented with logical rigor, they say. The thors further state that in order to add to the cultural turity of the student, many brief yet complete historical etches of elementary mathematics are given.

Cooley and others give the cultural objectives of their xtbook to be the following:

1. To show how many of the fundamental ideas of mathematics have their sources in physical experience.
2. To show, how, from these ideas, mathematics builds broad logical theories which have wide application in the physical, biological, and social sciences, the arts, and philosophy.
3. To show that mathematics is a vast unified system of reasoning.
4. To acquaint the student with the logical structure of the mathematical system and thus provide him with a standard of exact reasoning which should help him to achieve a more critical attitude toward conclusions arrived at in other fields.
5. To show that science and philosophy are indebted to mathematics for many precise concepts, such as velocity, motion, and infinity.
6. To open the student's mind to the fact that the development of mathematics from ancient to modern times has been an important factor in the development of civilization.[24]

One of the general mathematics textbooks with a modern proach is Fundamentals of Mathematics. The author of the ok gives the following as the objectives of the book:

1. An appreciation of the natural origin and evolutionary growth of the basic mathematical ideas from antiquity to the present;

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[24]Hollis R. Cooley et al., Introduction to Mathematics, hicago, 1937), p. v.

2. A critical logical attitude, and a wholesome respect for correct reasoning, precise definitions, and a clear grasp of underlying assumptions;
3. An understanding of the role of mathematics as one of the major branches of human endeavor, and its relations with other branches of the accumulated wisdom of the human race;
4. A discussion of some of the simpler important problems of pure mathematics and its applications, including some which often come to the attention of the educational layman and cause him needless confusion;
5. An understanding of the nature and practical importance of postulational thinking.[25]

As the author further discusses the objectives of the extbook, he states:

> The author has intended to present a course in mathematics which will emphasize the distinction betweer familiarity and understanding, between logical proof and routine manipulation, between critical attitude of mind and habitual unquestioning belief, between scientific knowledge, and both encyclopedic collections of facts and mere opinion and conjecture, and which will give the student a wholesome appreciation of the nature and importance of mathematics.[26]

Another author, Dadourian, gave the objectives which e hoped his textbook would assist the student achieve. In he preface of the trigonometry book written by him is ound the following:

> In writing this book the author has had the following objectives: (1) To stimulate the student's interest and motivation, and to deepen his comprehension of the subject. To these ends, emphasis is laid on concepts, principles, and general methods; trigonometric functions are applied to simple problems of mensuration, mechanics, engineering and surveying; and the application of the functions to other fields is pointed out.

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[25]Moses Richardson, Fundamentals of Mathematics, New York, 1941), pp. v-vi.

[26]Ibid., p. vi.

> . . . (2) To reduce the need for memory work to a minimum. . . . To present proofs and solved problems in such a way as to reduce the amount of necessary verbal explanation to a minimum, to make analytical work orderly, concise and lucid; and thus to familiarize the student with a general method of procedure which is conducive to clear thinking, and to greater freedom from blunder, and to economy of time and effort.[27]

Rosenbach, Whitman, and Moskovitz[28] said that in their ·xtbook on trigonometry every effort was made to present ıe material in a manner that is clear and simple, yet ;imulating and rigorous. They have attempted to emphasize ıose topics which are generally recognized to be essential, ıatever the aims of the student or the objective of the ›urse.

Nathan and Helmer[29] wrote that one of the objectives ' analytic geometry should be the direct preparation for ıe study of calculus, engineering, and the physical and ›cial sciences. They say that a study of analytic geometry ın develop the student's powers of intuition and rigorous ıinking and can provide him with an example of a unified ›dy of thought. The examples and problems in the book ıbody applications to physics, chemistry, astronomy, ıgineering, and economics.

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[27]H. M. Dadourian, Plane Trigonometry, (Cambridge, 1941) ›. vii-viii.

[28]J. B. Rosenbach, E. A. Whitman, and David Moskovitz, lane Trigonometry, (New York, 1937), p. iii.

[29]David Nathan and Olaf Helmer, Analytic Geometry, New York, 1947), p. v.

Buchanan and Wahlin said in their textbook:

> Every mathematics instructor is aware of the urgent need to develop the brilliant student and at the same time to impart to the average student some feeling for mathematics as a living subject, one that has not only had a tremendous influence on the development of our civilization, but is vitally important in present-day affairs. In writing this book we have kept these needs in mind. . . .
>
> For the better students we have provided a sufficient number of more or less advanced exercises and also historical reports, . . . to challenge his ability and make him feel his efforts are worthwhile.[30]

Maxime Bocher[31], of Harvard University, stated that if alytic geometry is properly taught it is a difficult subject d that it should not be degraded to a course in graphics; at is, curve plotting, numerical problems, and the like. says, "The one aim should be to put the student into ssession of an instrument which he himself can use in oving new geometrical theorems or solving new problems."

In stating the objectives of his analytic geometry xtbook, Sisam stated the following in the preface:

> The course in analytic geometry has several major objectives, each of which has been fully considered in the preparation of this text. It should follow in a natural way from the student's previous work in mathematics, which it is expected to unify; it must acquaint the student with the methods, the spirit, and the essential facts of analytic geometry; and it should stress the particular types of geometric reasoning that the student will encounter most frequently in his later work.[32]

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[30]H. E. Buchanan and G. E. Wahlin, Elements of Analytic ometry, (New York, 1937), p. v.

[31]Maxime Bocher, Plane Analytic Geometry, (New York, 15), p. v.

[32]Charles H. Sisam, Analytic Geometry, (New York, 1936), iii.

Murnaghan, declaring that the aim of calculus is more ıan mechanical manipulations and techniques, also stated ıat his calculus book aims at meaning and understanding. e stated the following:

> The method used is radically different from that of the currently popular texts. Many teachers seem to feel and have no hesitation in expressing their feeling, that it is impossible to teach calculus correctly. The best one can do, they claim, is to give some idea of what the subject is about and to impart, by repeated drill and practice, proficiency in the manipulative details of the subject. The results obtained by this procedure are familiar; the ordinary student who has worked hard in the course can tell you the derivatives and the integrals of the most sinister-looking function, but he has no clear and confident understanding of what a derivative and an integral really are.[33]

Neeley and Tracey agree that differential and integral alculus should have two aims. They stated:

> The student who studies this subject because of his attraction to mathematics is not well equipped if he lacks a fair appreciation of the wide applications of the calculus in modern science and engineering. On the other hand, the student who is required to use the calculus in some chosen field of science can make more intelligent and extensive applications if he understands the underlying principles of the subject. Hence, whether mathematics is to be regarded as the queen of the sciences or as the tool of the scientists, the study of the calculus for the future teacher of mathematics and for the future engineer should differ only in the degree of emphasis placed on the theory and the applications.[34]

The oldest textbook that the writer examined was ritten in the first part of this century by Granville.

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[33]Francis P. Murnaghan, Differential and Integral alculus, (Brooklyn, 1947), pp. iii-v.

[34]J. H. Neeley and J. I. Tracey, Differential and ntegral Calculus, (New York, 1932), p. v.

ie two aims of the author were to sharpen the student's ntuition and to increase his analytic ability. In the reface of the calculus textbook by Granville, one finds:

> The present volume is the result of an effort to write a modern textbook on the calculus which shall be essentially a drill book. With this end in view, the pedagogic principle that each result should be made intuitionally as well as analytically evident to the student has been kept constantly in mind. . . . The object has not been to teach the student to rely upon his intuition, but in some cases to use this faculty in advance of the analytic investigation.[35]

In a study reported out of Teachers College, Columbia niversity, in 1943, Brown[36] found that a survey of the bjectives of general mathematics as given by the authors f more than fifty general mathematics textbooks indicates hat the aims of general mathematics courses fall into three ategories. They are given below:

1. To prepare the student for a profession, semi-rofession, or vocation in which mathematics is useful as tool and emphasis is placed on facility in mathematical anipulation as well as on understanding of the concepts nvolved.

2. To prepare students to be intelligent citizens, athematically. . . .

3. To attain both the above objectives by meeting the eeds of the large academic terminal mathematics group and

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35William A. Granville, Elements of the Differential nd Integral Calculus, (Boston, 1904), p. iii.

36Kenneth E. Brown, General Mathematics in American olleges, (New York Bureau of Publications, Teachers ollege, Columbia University, 1943), p. 61.

so to furnish an adequate preparation for the minority o wish to pursue further courses in mathematics.

After obvious duplications had been eliminated, the jectives given above were incorporated into a single list seventy-three general and specific objectives. This list pears as Appendix A of this study. The selection of the jectives was based upon the writer's opinion arrived at om an examination of the literature.

Selection of the Jury

These seventy-three objectives were put in questionnaire rm and sent to thirty-nine outstanding educators in the eld of mathematics. These thirty-nine educators made up e panel from which the jury of experts were selected.

Essential criteria were established for the selection the experts of the jury who met some or all of the require- nts given below. The criteria were:

1. Extensive and recent experience in teaching college mathematics.
2. Scholarly publications in educational and/or mathematical journals.
3. The experts must have shown interest in mathematics education at the college level as evidenced by one or more of the following accomplishments:
    a) Publications in mathematical journals.
    b) Membership on special committees, such as the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America, and the Commission on Mathematics of the College Entrance Examination Board.
    c) Head of the department of mathematics in a leading college or university.
    d) Author of a modern textbook of mathematics for freshmen or sophomores.
    e) Mathematics instructor especially concerned with mathematics education.

In order to increase the validity of the objectives of
ie questionnaire, some experts were chosen from colleges
id universities similar to the cooperating institutions
' this study.

Table I below gives the names, locations, positions,
id some of the qualifications of the members of the jury.

That the jury members were well-qualified is seen by
ie fact that eighty-six per cent of them were members of
ither The Mathematical Association of America or The
ierican Mathematical Society. Kenneth E. Brown, Specialist
ı Mathematics in the United States Office of Education, also
; a member of the Research Committee of the National Council
' Teachers of Mathematics. C. B. Lindquist was recently
ppointed as Chief for Natural Sciences and Mathematics in
ıe United States Office of Education. Duren is Professor
f Mathematics and also Dean of the College of Arts and
ciences of Virginia University. Seidlin is Professor of
athematics and Dean of the Graduate School of Alfred Uni-
ersity. Fawcett is the Chairman of the Department of
lucation and Professor of Mathematics Education at Ohio
tate University. Jones, Gager, Price, and Pingry are
olding or have held offices in the National Council of
eachers of Mathematics. Twenty-two jurymen of the twenty-
ight have had one or more articles in the leading mathe-
atical journals of the nation. Twenty-five jury members
re teachers of college mathematics, and ten are chairmen
r heads of their departments of mathematics. Eight of

TABLE I

NAMES, LOCATIONS, AND EDUCATIONAL POSITIONS OF JURY MEMBERS

Name	Location	Position
A. Beaumont	U. of Washington	Executive Officer of Mathematics Department
neth E. Brown	U. S. Office of Education	Specialist for Mathematics
L. Duren, Jr.	U. of Virginia	Mathematics Professor, Dean, College of Arts and Sciences
old Fawcett	Ohio State U.	Head, Department of Mathematics Education
ard Fehr	Teachers College Columbia U.	Head, Mathematics Department
liam Gager	Florida U.	Professor, Mathematics
n R. Hatcher	Fisk University	Assistant Professor of Mathematics
H. C. Hildebrandt	Northwestern U.	Associate Professor
liam N. Huff	Oklahoma U.	Head, Mathematics Dept
llip S. Jones	U. of Michigan	Associate Professor
ston T. Karnes	Louisiana State	Head, Mathematics Dept
I. Layton	Stephen F.Austin	Head, Mathematics Dept
B. Lindquist	U. S. Office of Education	Chief, Natural Science and Mathematics
odore Love	Fisk University	Head, Mathematics Dept
C. MacDuffee	U. of Wisconsin	Professor of Mathemat
ce Meserve	New Jersey State Teachers College	Head, Mathematics Department
V. Newsome	New York U.	President
ert Pingry	U. of Illinois	Associate Professor

TABLE I (continued)

Name	Location	Position
obert Poe	Central State	Assistant Professor
. Vernon Price	U. of Iowa	Professor of Mathema
. B. Read	Wichita U.	Head, and Professor
oses Richardson	Brooklyn College	Professor
ack L. Rowe	Bakersfield Junior College	Head, Mathematics Department
illiam L. Schaaf	Brooklyn College	Associate Professor of Mathematics
oseph Seidlin	Alfred U.	Dean of Graduate School and Professor of Mathematics
. P. Vance	Oberlin College	Associate Professor of Mathematics
enry Van Engen	Iowa State Teachers College	Associate Professor of Mathematics
. Lynwood Wren	George Peabody College	Professor of Mathematics

he experts of this study are authors or co-authors of athematics textbooks. Fehr and Van Engen are members of he Commission on Mathematics of the College Entrance xamination Board, while Schaaf, Vance, Hildebrandt, Jones, nd Read have been editors of mathematical journals or ditors of departments in these journals. Hildebrandt, rown, and Fehr were considered to be specialists in mathe- atics education by Woodby.[37]

The consensus, therefore, of such a jury should be eadily accepted as representative of the best thinking in he United States with respect to the aims and objectives f mathematics instruction.

Data from Questionnaire and Other Sources

After the formulation of the questionnaire and the election of the jury members as described above, the eventy-three item questionnaire, accompanying letter, and elf-addressed return envelope were sent to thirty-nine xperts in the field of mathematics education. (Appendix A)

A four-point rating scale was placed at the top of the 'irst page of the mimeographed list of the seventy-three bjectives. The experts were asked to assign to each item value of "4", "3", "2", or "1" in the space provided, ccording to the following directions:

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[37]Lauren G. Woodby, "A Synthesis and Evaluation of Subject-Matter Topics in Mathematics for General Education" (unpub. Ph. D. dissertation, University of Michigan, 1952), p. 26.

<u>irections</u>: Please indicate your opinion of the value of each objective for freshman and sophomore mathematics courses by placing the number 4, 3, 2, or 1 before the statement of the objective according to the following scale:

<u>4</u> The objective is highly desirable.
<u>3</u> The objective is of considerable value.
<u>2</u> The objective is of slight value.
<u>1</u> The objective is of no value.

Nine weeks elapsed between the receiving of the first nd last completed questionnaires. Thirty-four, or eighty-even per cent, of the thirty-nine questionnaires were eturned. Two were returned unopened because the persons ad retired. Five persons did not respond at all, although follow-up card was sent to each. Of the thirty-four com-leted questionnaires, four were rejected as not being sable since the respondents admitted that they evaluated he items from a different frame of reference than that uggested in the directions. This gave twenty-eight ompleted questionnaires upon which to base the conclusions bout the desirable objectives.

In order to compare the opinions of the experts and he opinions of the mathematics instructors in the seven olleges of the study, the seventy-three-item questionnaire as sent to the mathematics instructors. The instructions or rating the items were the same as for the experts. The uestionnaire, accompanying letter (Appendix B), and self-ddressed, stamped envelope were sent to the heads of the athematics departments of the seven colleges with the nstruction to have each teacher of freshman and sophomore athematics complete the questionnaire. After many follow-up etters and long distance telephone calls, nineteen teachers, or one-hundred per cent of the teachers of lower division mathematics, completed and returned the questionnaires.

In order to obtain evidence of the achievement of the objectives, the investigator requested copies of the tests and examinations given during the first term of the school year 1957-1958.

A thorough search of the literature was made in an effort to find a standardized test which could be administered to a sample of students in the cooperating colleges. Correspondence was carried on between the Educational Testing Service and the writer. Sample tests were examined. One test which was thought to be suitable was found to be no longer available.

Since no suitable standardized test was available, a test was constructed by the writer. It was designed to measure to some extent the achievement of some of the objectives of the questionnaire by the students of the sample. The test items included many ideas from the questionnaire. A copy of the test appears as Appendix C in this study.

The thirty-five students of the sample were selected by their respective teachers as representative of those students who had completed freshman and sophomore mathematics courses in their school. These selected students were administered the test by their respective teachers.

The teachers of the cooperating colleges were asked to send to the writer syllabi, outlines, bibliographies, and lists of other teaching materials used in their freshman d sophomore mathematics courses. The investigator used is material in an effort to determine what attempts were de by these mathematics instructors to arrive at the sired goals.

Summary of Chapter II

The writer has given in this chapter the source of the jectives used in the questionnaire. These objectives were sembled and formulated from lists of objectives found in llege catalogs, mathematical journals, published and un-blished doctoral dissertations, and mathematics textbooks. is chapter has described the method of selection and the alifications of the members of a jury of experts who were ked to give their opinions concerning the relative merits ' seventy-three objectives. Also a description was given this chapter of other data used in this study, including llabi, outlines, bibliographies, and a test prepared by e writer and administered to a sample of students of the operating colleges.

Chapter III is concerned with the collection and the alysis of the data.

CHAPTER III

ANALYSIS OF DATA AND FINDINGS OF THE STUDY

The purpose of this chapter is to present and analyze e data. The data presented and analyzed include those om the questionnaire responses of the jury of experts and e mathematics teachers of the cooperating colleges. In dition to this, the chapter discloses the results from the st given to the sample of students in the colleges.

Data from the Questionnaire

In the covering letter sent with each questionnaire to e experts of the jury and the teachers of mathematics, it s suggested that the objectives should be those for the eshman and sophomore mathematics courses in liberal arts olleges. The writer recognized the fact that because of dividual differences each student would need a unique set f objectives, no matter what curriculum he followed. It s evident that this is impractical. As a compromise, the riter proposed to assemble a sufficiently broad list of jectives such that the seven cooperating colleges as well s similar institutions would receive benefit therefrom. hat all respondents did not respond from the frame of eference intended by the writer is shown by the comments f some of them.

Comments of Respondents

Provision was made for the respondent to the question-
.ire to make comments on the objectives if he desired to
› so. Several respondents availed themselves of the oppor-
ınity. Although the letter of transmittal suggested that
ıe proposed objectives were for liberal arts freshmen and
›phomores, respondent Albert E. Meder, Jr. commented that
; was difficult to complete the check list because it was
›t clear to him just what type of student these courses
ıd objectives were to serve. He asked the following
ıestions:

> Is this to constitute a list of objectives for <u>all</u> freshmen and sophomores? Or for all electing mathematics as a requirement for a liberal arts degree? Or as a prerequisite for future mathematical or scientific work? Or as an elective part of general education? Also, what entrance requirements are assumed?

ırthermore Meder suggested seriously that "having some good
lean intellectual fun" be added as an objective.

The comments of Duren are worthy of mention since they
re similar in many respects to some of the other comments.
uren, Dean of the College of Arts and Sciences and Professor
f Mathematics of the University of Virginia, made the
ollowing comments:

> I gave a low value to many subjects which I regard as high school subjects. If they are not learned in high school, it is my opinion that the students ought not to be in college mathematics which should be reserved for those who can take a form of mathematics in which

analytic geometry, calculus, and problem solving are given top priority. This does not imply that I think that trigonometry is not important. It just isn't right to assign it a high priority in college mathematics.

I also gave a low priority to some objectives which would be fine if you could achieve them, but should not be given high priority if you cannot. In teaching it is not noble to attempt the impossible. Hence I take a dim view of function theoretic rigor though it is good in itself. Also I take a dim view of developing the creative imagination because teachers who claim that a college mathematics course can do this are frauds.

You left out one big mathematical skill: The recognition of form. The old simplification problems, factoring problems, as well as the technique of integration, helped to develop it.

Jack L. Rowe, who completed a similar study as this st year, commented as follows:

I believe the opinions of respondents would be much more reliable if you were to tell just what kind or kinds of mathematics courses you had in mind for freshmen and sophomores. Do you mean objectives for freshman and sophomore calculus courses, business mathematics, trigonometry, advanced algebra, etc.--all of them, part of them, or any of them?

Are you implying that every freshman or sophomore should be exposed to some kind of mathematics course, and if so, what kind? Obviously, a person's opinion of desirable objectives would be different according to the particular point of view held.

Not all comments, however, were adverse. One of the perts who teaches in an Oklahoma college wrote:

Your questionnaire is fine. . . . I think your questions are of real value. However, you know my answers are prejudiced by my stronger feeling towards the theory or pure phase of mathematics.

Bruce Meserve of Montclair State Teachers College and B. Read of Wichita University both showed interest in the udy by requesting copies of the results of the study.

One of the teachers of the cooperating colleges stated ıat the study, so far, had given him some helpful suggestion

Treatment of Data

In scoring the opinions of the respondents, the writer ssigned weights of 4, 3, 2, and 1 to the responses accord- ıg to the directions of the questionnaire. The mean score ? each objective was obtained as follows: The sum of the eights of each objective was divided by the total number ? responses to the item. Example: Objective No. 1, "Skill ı solving verbal problems and checking solutions", was ıted "3" by respondent No. 1, "4" by respondent No. 2, 4" by respondent No. 3, and so on to respondent No. 28, who ıted it "4". Thus, the sum of 3 + 4 + 4 + . . . + 4 or 100 was ivided by 28, giving a mean score of 3.57 for objective ›. 1. This mean, when compared with the means of the other ›jectives, is interpreted as an index of the relative ex- ent to which an objective was recommended by the experts. ıch weighted mean may be interpreted by means of the ›llowing scale:

no value	slight value	considerable value	very great value
1	2	3	4

t is clear that if the mean of an objective differs slightly rom 4, the jury considered the objective to be of great alue; whereas, if the mean differs slightly from 1, the ıry considered the objective to be of little or no value.

The mean scores of all the seventy-three objectives re ranked in order of magnitude, the greatest being ranked rst. The rankings of the seventy-three objectives by the ry of experts are given in Table II, page 45.

When the seventy-three objectives are grouped into artiles, the objectives whose ranks range from one to 18½ ll in the first quartile. It seems reasonable to assume at these objectives are the ones considered to be more portant than the others. These highest ranking objectives e given in Table III on pages 47 and 48. The objectives e listed in order of importance, the most important objecve being given first.

TABLE II

RANKINGS OF THE SEVENTY-THREE OBJECTIVES BY EXPERTS

Objective Number	Rank	Frequency of Response in Categories of Value				Weighted Rating	Mean Weighted Rating
		1	2	3	4		
1	14.5	0	2	8	18	100	3.57
2	14.5	3	0	3	22	100	3.57
3	60	1	10	11	5	74	2.74
4	68	4	13	11	0	63	2.25
5	35	0	6	7	15	93	3.32
6	6	1	0	7	20	102	3.64
7	18.5	2	1	5	20	99	3.54
8	46	1	6	10	11	87	3.11
9	22	1	2	7	18	98	3.50
10	72	11	9	5	2	52	1.93
11	6	0	3	4	21	102	3.64
12	4	1	0	6	21	103	3.68
13	65.5	3	14	9	2	66	2.36
14	18.5	0	3	7	18	99	3.54
15	64	4	6	15	3	73	2.61
16	49.5	2	4	12	10	86	3.07
17	58	1	10	10	7	79	2.82
18	9.5	0	2	7	19	101	3.61
19	59	1	8	15	4	78	2.79
20	28	0	1	14	13	96	3.43
21	40	0	6	10	12	90	3.21
22	69.5	7	12	6	3	61	2.18
23	46	0	8	9	11	87	3.11
24	14.5	1	1	7	19	100	3.57
25	52	0	7	15	6	83	2.96
26	62	5	7	6	9	73	2.70
27	42	2	2	13	11	89	3.18
28	42	1	4	12	11	89	3.18
29	52	2	5	13	8	83	2.96
30	65.5	4	12	10	2	66	2.36
31	49.5	4	2	10	12	86	3.07
32	73	18	8	2	0	40	1.43
33	52	1	7	12	8	83	2.96
34	46	0	4	17	7	87	3.11
35	18.5	0	2	9	17	99	3.54
36	55.5	1	10	8	9	81	2.89

TABLE II (continued)

jective umber	Rank	Frequency of Response in Categories of Value				Weighted Rating	Mean Weighted Rating
		1	2	3	4		
37	31	0	3	11	14	95	3.39
38	14.5	0	2	8	18	100	3.57
39	31	0	5	7	16	95	3.39
40	9.5	0	0	11	17	101	3.61
41	42	0	4	15	9	89	3.18
42	71	7	12	8	1	59	2.11
43	29	0	3	10	14	92	3.41
44	6	1	2	3	22	102	3.64
45	24.5	1	1	9	16	94	3.48
46	33	1	1	12	13	91	3.37
47	27	1	1	10	15	93	3.44
48	37.5	1	3	11	12	88	3.26
49	9.5	1	0	8	19	101	3.61
50	2	0	1	4	22	102	3.78
51	1	0	0	4	23	104	3.85
52	3	1	0	4	22	101	3.74
53	22	0	0	13	13	91	3.50
54	37.5	1	4	9	13	88	3.26
55	18.5	0	2	9	17	99	3.54
56	12	0	1	9	17	97	3.59
57	24.5	1	1	9	16	94	3.48
58	31	1	1	12	14	95	3.39
59	46	1	3	16	8	87	3.11
60	34	0	1	16	10	90	3.33
61	26	1	2	8	17	97	3.46
62	22	1	2	7	18	98	3.50
63	61	3	7	13	5	76	2.71
64	67	5	14	5	4	64	2.29
65	69.5	3	17	8	0	61	2.18
66	39	1	5	7	13	84	3.23
67	9.5	0	1	9	18	101	3.61
68	51	1	8	9	10	84	3.00
69	63	1	12	11	4	74	2.64
70	36	1	2	13	12	92	3.29
71	55.5	4	5	9	10	81	2.89
72	46	0	6	13	9	87	3.11
73	57	0	9	14	5	80	2.86

TABLE III

OBJECTIVES CONSIDERED TO BE HIGHLY DESIRABLE BY THE EXPERTS

ɔjective Number	Objective
51	Habit of evaluating the conclusion in light of the basic assumptions and given data.
50	Habit of dissatisfaction with incompleteness, ambiguity, and incoherent arguments.
52	Habit of solving problems independently, and th development of confidence in one's own ability.
12	Skill in making mathematical generalizations and discoveries.
6	Ability to translate word statements into equations.
11	Skill in formulating problems.
44	Attitude of suspending judgment until sufficien evidence is available.
18	Ability to prove simple theorems.
40	Ability to apply mathematics to other fields.
49	Habits of orderliness, accuracy, neatness, exactness of expression, concentration and organization.
67	Understanding limit, continuity, function, derivative.
56	Expansion of student's interest in mathematics
1	Skill in solving verbal problems and checking solutions.
2	Skill in arithmetical and algebraic fundamentals.

TABLE III (continued)

jective umber	Objective
24	Ability to define certain mathematical terms.
38	Ability to use mathematical symbols, such as $>$ and $\rightarrow$.
7	Ability to solve simple linear equations.
35	Ability to find the equation of a line given two points on the line.
14	Skill in the use of positive, negative and fractional exponents.
55	Attitudes of curiosity, creativeness and research.

In so far as the aims in the first quartile are concerne
ıe opinions of the experts seem fairly consistent. Twenty-
ıree of the twenty-seven experts who scored objective no. 51
ıve it a score of "4", and the other four experts gave it a
ɔore of "3". Twenty-two of twenty-seven experts gave item
ɔ. 50 a score of "4", whereas four gave it a score of "3",
ıd only one scored it "2". Item no. 52 was rated "4" by
ıenty-two experts, "3" by four experts, and "1" by one
ɾpert. General agreement is further shown by the ratings
.ven objectives no. 2 and no. 44, where 81.5 per cent of the
ɾperts rated each "4". Also, 75.0 per cent of the experts
ɔnsidered objectives no. 11 and no. 12 to be of "great
ılue", while 71.4 per cent of the experts considered objec-
.ves no. 6 and no. 7 to be of "great value". Of the six-
ɔen highest ranking objectives, each was given a rating of
ɾreat value" by more than 60 per cent of the experts. Nine
' these sixteen top ranking objectives were not rated of
ıo value" by any of the experts.

Objective no. 7 was rated "4" by twenty experts, yet it
ıiled to be included in the first quartile because it had a
ınk of only 18.5. Three other objectives which had the
ıme rank of 18.5 might be included in the first quartile.
ıese objectives were no. 35, no. 14, and no. 55, which were,
ɔspectively, "Ability to find the equation of a line, given
ıo points on the line," "Skill in the use of positive,
ɔgative, and fractional exponents," and "Attitudes of
ıriosity, creativeness, and research."

In his comments on the questionnaire, Professor C. B. ad of Wichita University said,

> It is almost impossible to rate a concept as of no value, even though it is relatively far less important than another. . . . It is quite a different question: Are these stressed in your own courses?

This hesitation by the experts to give a low rating to objective is seen throughout the ratings of the seventy-ree objectives. Nevertheless, some of the experts did nsider certain objectives to be of "no value". This made ssible the differentiation between important objectives d unimportant objectives.

The nineteen lowest ranked objectives, grouped in the urth quartile, are considered by the experts to be rela-vely unimportant. They are listed in Table IV, page 51, order of value as determined by the ratings of the experts, e objective of least value being placed last.

TABLE IV

OBJECTIVES CONSIDERED BY THE EXPERTS
TO BE OF SLIGHT OR NO VALUE

jective umber	Objective
36	Ability to find the equation of a circle, given three points of the circle.
71	Knowledge of the relations between the roots and the coefficients of equations.
73	Knowledge of permutation and combination formul
17	Ability to rationalize the denominators of fractions, such as 1/(1-2i).
19	Ability to transform equations by translating and rotating axes.
3	Ability to use logarithms.
63	Knowledge of the history of our number system.
26	Ability to do certain simple geometric constructions.
69	Understanding of the rigorous proofs of the basic theorems of calculus.
15	Ability to solve systems of equations by determinants.
13	Ability to use synthetic division.
30	Ability to solve oblique triangles.
64	Concept of geometric terms such as medians and incenter.
4	Ability to use slide rule or calculating machi
22	Ability to use the law of tangents.
65	Concept of simple spherical trigonometry.
42	Ability to use the multinomial theorem.
10	Ability to solve cubic equations.
32	Ability to use a surveyor's transit.

The three objectives in the fourth quartile which no expert considered to be of "great value" were "Ability to use slide rule or calculating machine," "Ability to use a surveyor's transit," and "Concept of simple spherical trigonometry Only two of the lower quartile objectives received more ratings of "no value" than they did of any other ratings. These two objectives were no. 10 and no. 32, which were, respectively, "Ability to solve cubic equations," and "Ability to use a surveyor's transit." Only one expert considered "Ability to use the multinomial theorem" to be of "great value", whereas seven considered it to be of "no value" and twelve experts considered this objective to be of only "slight value." The final rankings of these lower quartile objectives were largely determined by the number of experts who rated them of "slight value" and of "considerable value."

Those objectives which were considered to be of "slight value" by ten or more of the twenty-eight members of the jury are the following, with the number of experts who rated the objective "2" being given in parentheses: "Ability to use slide rule or calculating machine"(13), "Ability to use synthetic division"(14), "Ability to rationalize the denominators of fractions, such as 1/(1-2i)" (10), "Ability to use the law of tangents"(12), "Ability to solve oblique triangles"(12), "Ability to find the equation of a circle, given three points of the circle"(10), "Ability to use the multinomial theorem" (12), "Concept of geometric rms such as median and incenter"(14), "Concept of simple herical trigonometry"(17), and "Understanding of the gorous proofs of the basic theorems of calculus"(12).

As stated in Chapter II, the same questionnaire which s sent to the jury of experts was also sent to the mathe-tics teachers in the cooperating colleges. The results d analysis of this questionnaire follow.

The Ratings of the Objectives by the Teachers

The questionnaires which were returned by the mathe-tics instructors were analyzed in a manner similar to ose from the experts. The rankings of the seventy-three jectives by the instructors and the mean weighted ratings e given in Table V, which follows on pages 54 and 55.

TABLE V

RANKINGS OF THE SEVENTY-THREE OBJECTIVES BY MATHEMATICS INSTRUCTORS IN THE SEVEN TEXAS COLLEGES

Objective Number	Rank	Frequency of Responses in Categories of Value				Weighted Rating	Mean Weighted Rating
		1	2	3	4		
1	4.5	1	0	1	17	72	3.79
2	4.5	1	0	1	17	72	3.79
3	47.5	0	1	13	5	61	3.21
4	72	1	12	5	1	44	2.32
5	34.5	0	2	8	9	64	3.37
6	10.5	1	0	2	16	71	3.74
7	4.5	1	0	1	17	72	3.79
8	40	0	3	7	9	63	3.32
9	34.5	1	1	7	10	64	3.37
10	68	3	4	9	3	50	2.63
11	64	1	6	8	4	53	2.79
12	53.5	2	1	9	7	59	3.15
13	65	2	5	8	4	52	2.74
14	10.5	0	0	5	14	71	3.74
15	67	2	5	9	3	51	2.68
16	40	0	2	9	8	63	3.32
17	40	0	2	9	8	63	3.32
18	30	0	3	5	11	65	3.42
19	62	2	3	10	4	54	2.84
20	30	0	2	7	11	65	3.42
21	40	0	2	9	8	63	3.32
22	62	0	5	11	3	54	2.84
23	15	0	0	6	13	70	3.68
24	17.5	1	1	2	15	69	3.63
25	40	1	2	6	10	63	3.32
26	26	1	2	7	9	62	3.26
27	32.5	0	0	11	7	61	3.39
28	4.5	0	1	2	16	72	3.79
29	53.5	1	2	10	16	59	3.15
30	45	0	3	8	8	62	3.26
31	53.5	0	4	9	6	59	3.15
32	73	6	8	4	0	34	1.90
33	53.5	1	3	8	7	59	3.15
34	59	1	5	7	6	56	2.95

TABLE V (continued)

bjective Number	Rank	Frequency of Response in Categories of Value				Weighted Rating	Mean Weighted Rating
		1	2	3	4		
35	15	0	1	4	14	70	3.68
36	40	0	2	9	8	63	3.32
37	30	1	2	4	12	65	3.42
38	47.5	1	3	6	9	61	3.21
39	59	2	4	6	7	56	2.95
40	23	2	0	3	14	67	3.53
41	26	0	1	8	10	66	3.47
42	70	2	9	5	3	47	2.47
43	45	1	2	7	9	62	3.26
44	15	1	1	1	16	70	3.68
45	20	0	0	8	11	68	3.58
46	20	0	0	8	11	68	3.58
47	20	0	0	8	11	68	3.58
48	10.5	0	1	3	15	71	3.74
49	4.5	1	0	1	17	72	3.79
50	10.5	1	0	2	16	71	3.74
51	1	1	0	0	17	69	3.83
52	4.5	1	0	1	17	72	3.79
53	10.5	1	0	2	16	71	3.74
54	17.5	1	0	4	14	69	3.63
55	23	1	1	4	13	67	3.53
56	23	0	1	7	11	67	3.53
57	26	0	2	6	11	66	3.47
58	28	0	3	4	11	62	3.44
59	50	0	3	10	6	60	3.16
60	26	0	1	8	10	66	3.47
61	50	0	4	8	7	60	3.16
62	57	1	3	9	6	58	3.05
63	59	1	3	11	4	56	2.95
64	62	1	7	5	6	54	2.84
65	69	4	4	9	2	47	2.49
66	32.5	1	1	6	10	61	3.39
67	40	0	5	3	11	63	3.32
68	71	4	5	6	3	44	2.44
69	66	5	3	4	7	51	2.69
70	56	1	4	5	8	56	3.11
71	36	0	1	10	7	60	3.33
72	10.5	0	0	5	14	71	3.74
73	50	1	3	7	8	60	3.16

It is seen from an examination of Table V, pages 54 and , that the following objectives will fall into the first artile, thus indicating that the teachers consider these jectives to be very important. These objectives, in order rank, are: 51, 1, 2, 7, 28, 49, 52, 6, 14, 48, 50, 72, , 35, 44, 24, and 54.

The objectives considered by the teachers to have little no value in the freshman and sophomore mathematics courses e grouped in the fourth quartile. They are as follows, th the objective of lower rank preceding that of higher nk: 32, 4, 68, 42, 65, 10, 15, 69, 13, 11, 19, 22, 64, , 39, 63, 62, and 70.

Relationship between the Opinion of the Jury of Experts and the Opinion of the Mathematics Teachers of the Cooperating Colleges

To determine the relationship between the opinions of e experts on the one hand and the opinions of the teachers the cooperating colleges on the other hand concerning the lative merits of the seventy-three objectives, the product-ment method of correlation was used. The product-moment thod of determining the coefficient of correlation as scribed by Garrett[1] is given in Appendix D of this study. th the use of Garrett's formula and the data found in ble VI (Appendix D), the coefficient of correlation of the

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[1]Henry E. Garrett, Statistics in Psychology and Education, (4th ed., New York, 1953), p. 139.

pinions of the experts and the teachers is also calculated
n Appendix D.

It was found in this calculation that the coefficient
f correlation, r, was equal to .78, and that the confidence-
nterval at the ninety-five per cent level was .67 to .86.
hat is, the fiduciary probability is .95 that the interval
67 to .86 contains the true r.

The magnitude of this coefficient of correlation indi-
ated that a substantial positive relationship existed
etween the opinions of the experts and the opinions of the
athematics teachers of the Texas colleges. Garrett wrote
he following concerning the size of r and the degree
elationship:

> It is customary in mental measurement to describe the correlation between two tests in a general way as high, marked or substantial, low or negligible. While the descriptive label applied will vary somewhat in meaning with the author using it, there is a fairly good agreement among workers with psychological and educational tests than an . . . r from $\pm.70$ to ±1.00 denotes high to very high relationship; r from $\pm.40$ to $\pm.70$ denotes substantial to marked relationship.[2]

The high positive relationship as shown by the co-
fficient of correlation was an indication that the
athematics teachers of the cooperating colleges knew what
bjectives were important as judged by the jury of experts.

In spite of the over-all high coefficient of correlation
few of the rankings and ratings indicated distinct and
ide differences between the two groups of experts and

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[2]Ibid., p. 173.

achers. Some indications of these differences follow:

Objective No. 28, dealing with the ability to solve ght triangles was ranked 4.5 by the teachers, while the perts of the jury ranked it only 42. An explanation of is may be found in the comments of some of the experts who nsider trigonometry to be a high school subject. The achers ranked Objective No. 48, "Appreciation of mathematics d its role in the development of civilization," 10.5, while e experts ranked it 37.5. The teachers gave Objective . 72 a rank of 10.5; the experts ranked it 46.

On the other hand, the teachers gave a low rank of .5 to Objective No. 12, compared to a rank of 4 by the perts. This objective was concerned with making mathemat- al generalizations and discoveries. Objective No. 11, kill in formulating problems," received a rank of 6 by the perts, but only 64 by the teachers. Likewise, Objective . 67 was ranked 9.5 by the experts and 40 by the teachers. is might be explained by the fact that calculus is not ught as freshman and sophomore mathematics courses in all ven colleges.

Both groups rated the following objectives in the first artile: 51, 1, 2, 7, 49, 52, 6, 14, 50, 35, 44, and 24.

Both groups judged the following objectives to be of ttle or no value by placing them in the fourth quartile: 2, 4, 42, 65, 10, 15, 69, 13, 19, and 64.

It is beyond the scope of this investigation to analyze
l factors responsible for the differences between the
achers' ratings and those of the experts.

Teaching Materials

Although the heads of the mathematics departments of the operating colleges were asked to send descriptions of studer ojects being carried on in their schools, no report or ntion of such projects was received. It might be inferred at no such project exists. The existence of in-school or t-of-school projects might be an indication of attempts achieving certain objectives, such as No. 12, "Skill in king mathematical generalizations and discoveries," No. 40, bility to apply mathematics in other fields," No. 45, timulation of the imagination," No. 55, "Attitude of riosity, creativeness, and research," and other objectives aling with skills, knowledge, appreciation, and habits. is possible that projects are not needed to achieve these jectives. Further study is needed along this line.

Syllabi and outlines of courses were requested. Five lleges sent outlines, while two colleges stated that the uthern Association of Colleges and Secondary Schools required that outlines of courses remain in the office of the ean. The analysis of the outlines which were received was one from the standpoint of searching for evidences of the jectives in the outlines. Most of the objectives of the iestionnaire were also found in the outlines. Examples of)jectives in the outlines follow:

1. Some essentials of logic--hypothesis, conclusion, necessary and sufficient conditions.
2. Solving linear and quadratic equations.
3. Systems of equations.
4. Negative, zero, and fractional exponents.
5. Interpolation, and computation with logarithms.

The aim of one course in Differential Calculus as given ı the outline is "To introduce the student to the vast field ' analysis. More specifically, the student is introduced) the fundamental concepts of continuity, limits, derivative .so great effort is exercised in showing how these concepts ıy be utilized in solving problems in Algebra, Physics, and ıgineering." The objective of a course in Plane Analytical ›ometry in this college is "To assist students in making ›od preparation for the calculus." One of the aims of ·igonometry is "To prepare the student for more advanced ›urses in mathematics." An outline from one of the other)lleges states that Analytic Geometry contributes to the)ility of the student to reason.

The bibliographies contained in the outlines consisted f the ordinary textbooks. No biographies of mathematicians, ıthematical magazines, or books on mathematics which might ıcrease the student's interest were reported.

It is generally agreed that teachers' examinations sually reflect their ideas of what is of value in the ›urses. Tests and examinations given in the first term f this year were sent to the writer from five of the seven chools. In analyzing the tests, the writer used the intro-pective method. By closely studying a test, an attempt was ade to determine what objectives the teacher was trying to valuate. Upon examination of each question of the tests, he writer asked himself what concepts, knowledge, and athematical abilities were necessary to answer the questions orrectly. The writer was interested also in determining rom the tests what attitudes, habits, skills, and appreci-tions the teacher was attempting to evaluate. In this nalysis of the tests, the writer found the following: Al-hough the objective "Checking" received a high ranking by he teachers who answered the questionnaire, only a few est questions included it. All verbal problems of the ests were "type" problems not likely to create interest r enthusiasm for mathematics. One such typical verbal roblem was: A sixteen foot ladder makes an angle of 60° ith the wall of a house. What angle does the ladder make ith the level ground?

Upon considering all examinations from the five schools, he writer found that arithmetical and algebraic fundamentals ere stressed more than other objectives. One teacher ated these objectives of no value on the questionnaire, tating that these were more properly high school aims. evertheless, tests from this school revealed that funda-entals were the things considered important in the courses. either the ability to use logarithms nor an understanding f the meaning of them received a high ranking from the xperts or the teachers. Nevertheless, the examinations re-uired this skill and this concept in many problems. On he other hand, objectives numbered 44, 49, 50, 48, 51, 52, nd 53, dealing with intangibles such as appreciations, abits, and attitudes, were not in evidence on the tests, lthough they were ranked highly by the teachers of the even colleges. This does not mean that the objectives ere neglected in class instruction; because they are not eadily adaptable to the usual methods of testing, they are issing from test questions.

In most cases, the low ranking objectives were not ound on the tests. These objectives included "Ability to se the slide rule," "Ability to solve cubic equations," Skill in formulating problems," "Skill in making generali-ations and discoveries," "Ability to use synthetic divisio Ability to use complex numbers," "Ability to transform quations by rotation or translation," "Ability to use the aw of tangents," and "Ability to use the surveyor's ransit." In addition to these were the following objec-ives which were not discernible from a study of the tests: Ability to add or subtract vectors," "Ability to use the ultinomial theorem," "Knowledge of the history of our umber system," "Concept of spherical trigonometry," Understanding of the sine of a number," "Concept of group, ield, and set," "Understanding of rigorous proofs in alculus," "Knowledge of the relations between the roots nd the coefficients of equations," and "Knowledge of permutation and combination formulas."

Only one college of the seven offered College Geometry during the first term of the 1957-58 school year. The examination for this course consisted of elementary constructions and definitions usually found on high school tests. Examples of items on the test are: At a point on a line construct a perpendicular to the line. Define circle, square, congruent triangles, and perpendicular bisector of a line segment.

The grades achieved by the students were sent with the tests to the investigator. Of the 1888 grades recorded, 1145 were 60 or less, based on maximum grade of 100. Ninety of these grades were zero and seventy-nine were 100. The arithmetic mean of the 1888 grades was 61.3. According to two catalogs from these Texas colleges, a grade of 61.3 is a failing grade.

Data from Test Administered to a Sample of Students

The test devised by the writer was administered to thirty-five students of the seven colleges. Based upon a score of 100 per cent for all answers correct, the thirty-five students achieved an average grade of 43.9 per cent. Item No. 1 on the test dealt with exponents. This objective No. 14, was ranked in the first quartile by the teachers. Twelve students, or 34.3 per cent, failed to answer this question correctly. Item 2 on the test was a simple verbal

roblem requiring the use of the elementary formula: Dis-
ance equals Rate times Time, or elementary reasoning. No
tudent worked this problem. Item 3, like Objective No. 35,
equired the ability to find the equation of a line, given
wo points on the line. Twenty-nine, or 82.9 per cent, of
he students answered this correctly. Item 4 was designed
o determine the acquisition of the ability to do logical,
ritical or constructive thinking. Only four students gave
he correct answer to this item. This objective No. 57, and
o. 61, though not ranked in the first quartile by the ex-
erts or the teachers, was deemed to be of considerable
alue by both groups. Item 5 of the College Mathematics
est was a verbal problem dealing with the ability to solve
he right triangle and to know the definition of the sine
f X. Fifteen students failed to answer Item 5 correctly.
tem 6, a verbal problem dealing with the ability to use
he law of sines and the ability to solve oblique triangles,
as not attempted by eight of the students. Fourteen stu-
ents answered it correctly. Rated of considerable value
y both the experts and the teachers, Objective No. 60,
Understanding the meaning of logarithms" was tested in
tem 7. Only six students answered this item correctly.
n order to be able to answer Item 8 correctly, one needs
o know the definitions of the trigonometric functions.
ight of the thirty-five students answered correctly. To
nswer Item 9, the student needs to have achieved Objective
o. 13, "Ability to use synthetic division." Twenty-one

students answered this correctly. Eighteen students did not know that the cosecant of an angle is equal to the secant of the complement of the angle. If the student is to achieve Objective No. 15, "Ability to solve systems of equations by use of determinants," it is necessary that he be able to solve a problem similar to Item 11. Thirteen students succeeded in doing this.

If the roots of a quadratic equation are equal, the discriminant equals zero. Twenty-five of the thirty-five students answered this correctly in Item 12. Since Objectiv No. 33 is not recommended highly be experts or teachers, it is surprising that the students made such a high score on Item 13, which dealt with complex numbers. Only five students failed to answer this question correctly. Only nine students were able to recognize a rational integral equation Item 15 of the test is concerned with Descartes' Rule of Signs. Only four students, or eleven per cent, were able to give the correct answer to this item. Item 16 was included in the test in order to evaluate the achievement of Objective No. 71, "Knowledge of the relations between the roots and the coefficients of equations." Only three of the thirty-five students answered this question correctly. Item 17 of the test is used to determine the achievement of Objective No. 20, "Ability to find the maximum and minimum of simple functions." Eleven students were able to answer this item correctly. Item 18 is an Analytic Geometry question. In order to successfully answer this question, the student needs to know the equations of the straight line Twenty-four students successfully answered this question. Objective No. 31 was rated of considerable value by the jury of experts and the teachers of the cooperating colleges Item 19, related to Objective No. 31, requires a familiarity with inverse trigonometry functions. Seventeen of the thirty-five examinees answered Item 19 correctly. The binomial theorem, considered to be important by both the jury of experts and the teachers, was considered in Item 20. Twenty-four of the thirty-five students were able to answer the question of this item correctly. The ability to interpolate in tables is evaluated by Item 21. Nineteen, or 54.3 per cent, of the thirty-five students answered Item 21 correctly. In typing the multiple choices to Item 22, the correct answer was omitted. Because of this, Item 22 was omitted from the analysis of the test. Twenty-five students were able to solve the analytic geometry problem in Item 23, which dealt with parallel lines and their equations.

The students were asked to indicate on the test paper names of the mathematics courses that they had completed. It was found that all thirty-five students had completed College Algebra, Trigonometry, and Plane Analytic Geometry. Thirty students had completed Differential Calculus, and four of them were taking Calculus at the time of the test. Several students indicated that they had completed more dvanced mathematics courses, such as Integral Calculus, heory of Equations, Solid Analytic Geometry, and Differentis quations. In analyzing the results of the College Mathe- atics Test, the investigator recognized that there were everal weaknesses in the procedure. Other than for a mini- um of two years of college mathematics, the students did ot have a common mathematics background. Factors such as ntelligence of the students, number of years of high school athematics, grades on entrance and placement tests, and the ntentions of the students to make mathematics their major r minor were not considered in the analysis of the results of the test.

In drawing conclusions from the data of this College Mathematics Test, the investigator recognized the weaknesses mentioned above and acted accordingly.

Summary of Chapter III

In this chapter, the data from the questionnaires returned by the jury of experts and the teachers of the cooperating colleges have been presented and analyzed. Moreover, data obtained from tests and examinations given during the first term of this school year, data obtained from a sample of students, and data from outlines and syllabi of the mathematics courses were presented and analyzed in this chapter.

It was found that there was substantial agreement between the jury and the teachers concerning the relative values of certain objectives. On the other hand, there was some disagreement concerning certain objectives. The coefficient of correlation between the opinions of the jury and the teachers was .78. This coefficient of correlation was significant at the five per cent level. The high coefficient of correlation indicated agreement between the jury and the teachers.

It was found that the examination and test questions submitted by the teachers did include most, but not all, of the highly recommended objectives. Only three questions, however, pertaining to objectives which were ranked in the fourth quartile by the teachers were found in the test questions. These pertained to concepts of geometric terms, mathematical induction, and inverse trigonometric functions. Of the 1888 scores earned by the students on the tests and examinations, 1145 were not greater than sixty. This was an indication that the objectives which the teachers were attempting to evaluate were not being fully realized.

Low scores were made by the students who took the test constructed by the writer. This was an indication that some of the objectives which were generally considered to be important were not being adequately realized.

The outlines of the mathematics courses, the college catalogs of the seven schools, and the textbooks used in the courses were analyzed by the writer. These were found to contain many of the same or similar objectives which were on the questionnaire sent to the experts and the eachers.

Chapter IV, which follows, will summarize the study, raw conclusions, and make recommendations based on the 'indings of the study.

CHAPTER IV

GENERAL SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The aim of this chapter is to re-state the problem and the purposes of the study, to review the procedure of the investigation, to summarize the findings, to draw conclusions, and to make recommendations.

The Problem and the Purpose of the Study

The problem of this investigation was to determine what objectives are desirable for freshman and sophomore courses in seven Texas colleges, and to ascertain to what extent these objectives are being achieved. The position was taken in this study that the first step in the development of an effective mathematics program is that of determining the objectives of mathematical training that are most valuable. The purpose of this study has been to formulate a list of objectives of mathematical instruction whereby the seven colleges cooperating in the study could be benefited by an awareness of the desirable objectives and the realization of their success or failure in attaining these objectives. The present study also proposed to assist institutions similar to the seven of this study by making the findings of this study available to them.

Method and Procedure

In order to arrive at a solution of the problem, the following steps were taken:

1. A list of objectives for freshman and sophomore mathematics courses was formulated.
2. The opinions of a jury of experts and the opinions of the mathematics teachers in the colleges of the study were determined by the questionnaire method.
3. The extent of agreement between the jury of experts and the mathematics teachers was determined
4. A test devised by the investigator was given to a sample of students of the seven colleges, and teaching materials, including outlines and syllabi, tests and examinations, and grades from these tests were analyzed with the idea of determining the objectives of the courses and the extent of realization of these objectives.

The objectives of the questionnaire were obtained from a search of the literature on mathematical education.

Criteria for the selection of the jury included some or all of the following accomplishments by the members:

1. Extensive and recent experience in teaching college mathematics.
2. Scholarly publications.

3. Interest in college mathematics education shown by one or more of the following:
    a. Publications in mathematical journals.
    b. Membership on national or regional committees dealing with the teaching of mathematics.
    c. Head of the mathematics department in a leading college.
    d. Author of a modern mathematics textbook for freshmen or sophomores.
    e. Mathematics instructor especially concerned with mathematics education.

Outlines of courses, catalogs, and tests given in the first term of this year were analyzed to determine more fully the objectives of the individual institutions of the study.

A test, constructed by the writer and administered to a sample of thirty-two students, was designed to measure to some extent the achievement of some of the objectives of the questionnaire.

Analysis of Data and Findings

The twenty-eight members of the jury of experts rated each of the seventy-three objectives of the questionnaire with respect to their importance. A numerical value of 4, 3, 2, or 1 was assigned to an objective if the expert thought it to be highly desirable, of considerable value, of slight value, or of no value, respectively. The mean weighted rating was obtained for each objective, as described in Chapter III, and ranked according to size. Those objectives of high rank were then taken as those considered desirable by the jury, while those of low rank were taken as those considered to be of little or no value. Using the same procedure, the same seventy-three objectives were rated by all teachers of freshman and sophomore mathematics in the cooperating colleges. The product-moment method was then used to determine the coefficient of correlation between the opinions of the jury of experts and the opinions of the teachers. The coefficient of correlation was found to be .78, thus showing a definite agreement concerning the relative values of most of the objectives.

Both experts and teachers rated most highly those objectives which are intangible, such as Objective No. 51, "Habit of evaluating the conclusion in light of the basic assumptions and the given data," and Objective No. 52, "Habit of solving problems independently, and the development of confidence in one's own ability."

The experts and teachers gave lowest ratings to those objectives dealing with "Ability to use the surveyor's transit," "Ability to use the slide rule and calculating machine," and "Concepts of spherical trigonometry."

The experts and teachers were generally agreed on what was highly desirable and what was of no value; the disagreements were mostly in the middle rankings where the scale used did not differentiate sharply between objectives of considerable value and those of slight value. Objectives numbered 1, 2, 6, 7, 14, 24, 35, 49, 50, 51 and 52 were given top rankings by both groups, while objective numbers 4, 10, 13, 15, 19, 22, 32, 42, 63, 64, and 65 were ranked low by both groups.

The tests made and administered by the teachers in the first term of this year did not reveal attempts to measure attitudes, appreciations, habits, and interests of the students. The scores from these tests further revealed that the objectives which the teachers were evaluating were not being fully achieved.

That a large proportion of the desirable objectives were not being realized was shown by the low scores made by the sample of students on the test constructed by the writer. The mean score for all thirty-five students was 44.7.

Conclusions

On the basis of the evaluation of data obtained in this study, and with the recognition of the limitations inherent in the study, the following conclusions appear to be warranted for the objectives of freshman and sophomore mathematics courses in the colleges of the study:

1. Consensus of opinions of mathematical educators regarding the importance of objectives can be determined, and this consensus can be used as a guide to determine the proper objectives for

mathematics courses.

2. Substantial agreement exists between the jury of mathematical experts and the group of teachers in the cooperating colleges as to the relative importance of objectives.
3. As a general rule, the objectives concerned with habits, appreciations, and attitudes are judged to be of great relative importance.
4. In general, the objectives concerned strictly with mathematical manipulations are judged to be relatively unimportant.
5. Objectives which logically should be realized in high school courses are judged relatively unimportant for college courses.
6. A careful analysis of the tests given by the classroom teachers reveals that the tests are limited to the measurement of the achievement of only a few of the recommended objectives. The test items are usually concerned with the objectives of mathematical skills and knowledge, while attitudes, habits, appreciations, and interests--the most important goals according to the experts and teachers--are not included.
7. The low scores made by the students who took the test constructed by the writer indicate that some of the recommended objectives are not being fully realized.

Recommendations

The following recommendations are supported by the findings and conclusions of this study:

1. It is very important that the mathematics teachers of the cooperating colleges incorporate in the daily instruction and tests more aspects of the development of desirable habits, attitudes, appreciation, and interests.
2. Objectives which should properly be attained in high school should be omitted or passed over quickly.
3. Rigorous proofs in calculus should not be stressed.
4. Recommendations for further study along the following lines are made:
   a. Evaluation of the attainment of the objective of mathematical training.
   b. The attainment of objectives in the colleges of the study compared with the attainment in other colleges.
   c. Ways and means by which instruction may be best organized to accomplish the given objectives.

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APPENDIX A

OBJECTIVES FOR FRESHMAN AND SOPHOMORE MATHEMATICS COURSES

Directions: Please indicate your opinion of the value of each objective for freshman and sophomore mathematics courses by placing the number 4, 3, 2, or 1 before the statement of the objective according to the following scale:

4 The objective is highly desirable.
3 The objective is of considerable value.
2 The objective is of slight value.
1 The objective is of no value.

___ 1. Skill in solving verbal problems and checking solutions.
___ 2. Skill in arithmetical and algebraic fundamentals.
___ 3. Ability to use logarithms.
___ 4. Ability to use slide rule or calculating machine.
___ 5. Ability to construct and interpret tables and graphs.
___ 6. Ability to translate word statements into equations.
___ 7. Ability to solve simple linear equations.
___ 8. Ability to solve quadratic equations by two methods.
___ 9. Ability to solve simple systems of linear equations.
___10. Ability to solve cubic equations.
___11. Skill in formulating problems.
___12. Skill in making mathematical generalizations and discoveries.
___13. Ability to use synthetic division.
___14. Skill in the use of positive, negative, and fractional exponents.
___15. Ability to solve systems of equations by determinants.
___16. Ability to work with numbers of the form $\sqrt{3}$.
___17. Ability to rationalize the denominators of fractions, such as $1/1-2i$.
___18. Ability to prove simple theorems.
___19. Ability to transform equations by translating and rotating axes.
___20. Ability to find maxima and minima of simple functions.
___21. Ability to use the laws of sines and cosines.
___22. Ability use the law of tangents.
___23. Ability to change radians to degrees and vice versa.
___24. Ability to define certain mathematical terms precisely.
___25. Ability to solve problems involving arithmetic and geometric progressions.
___26. Ability to do certain simple geometric constructions.
___27. Ability to interpolate and extrapolate in tables.
___28. Ability to solve the right triangle.
___29. Ability to find the mean, median, and standard deviation of statistical data.
___30. Ability to solve oblique triangles.
___31. Familiarity with inverse trigonometric functions.
___32. Ability to use a surveyor's transit.
___33. Ability to add, multiply, and divide complex numbers.
___34. Ability to add and subtract vectors.
___35. Ability to find the equation of a line given two points on the line.

___36. Ability to find the equation of a circle, given three points of the circle.
___37. Ability to differentiate functions such as $(1-3x^2)^5$.
___38. Ability to use mathematical symbols, such as $\rightarrow$ and $<$.
___39. Ability to use mathematical induction.
___40. Ability to apply mathematics in other fields.
___41. Ability to use the binomial theorem.
___42. Ability to use the multinomial theorem.
___43. Ability to solve simple inequalities.
___44. Attitude of suspending judgment until sufficient evidence is available.
___45. Stimulation of the imagination.
___46. Appreciation of the beauty of mathematics.
___47. Appreciation of the power and economy of mathematics.
___48. Appreciation of the important role that mathematics has played in the development of civilization.
___49. Habits of orderliness, accuracy, neatness, exactness of expression, concentration, and organization.
___50. Habit of dissatisfaction with incompleteness, ambiguity, and incoherent arguments.
___51. Habit of evaluating the conclusion in light of the basic assumptions and the given data.
___52. Habit of solving problems independently, and the development of confidence in one's own ability.
___53. Habit of checking mathematical operations.
___54. Attitudes of cooperation, open-mindedness and tolerance.
___55. Attitudes of curiosity, creativeness, and research.
___56. Expansion of student's interest in mathematics.
___57. Acquisition of the skills and habits involved in critical and constructive thinking.
___58. Foundation for further and higher mathematics.
___59. Understanding statistical measures, such as mean.
___60. Understanding of the meaning of logarithms.
___61. Knowledge of fundamental logical principles.
___62. Knowledge of some direct and indirect methods of proof.
___63. Knowledge of the history of our number system.
___64. Concept of geometric terms such as median and incenter.
___65. Concept of simple spherical trigonometry.
___66. Understanding of the meaning of the sine of a NUMBER.
___67. Understanding limit, continuity, function, derivative.
___68. Concepts of group, field, and set.
___69. Understanding of the rigorous proofs of the basic theorems of calculus.
___70. Concepts of polar coordinates.
___71. Knowledge of the relations between the roots and the coefficients of equations.
___72. Knowledge of values of trigonometric functions of certain special angles such as, $\sin 30^\circ = \frac{1}{2}$.
___73. Knowledge of permutation and combination formulas.

Please use back of sheet for comments.

NAME ______________________________

APPENDIX A

211 Thatcher Hall
Oklahoma State University
Stillwater, Oklahoma
October 22, 1957

Under the direction of Dr. James H. Zant of Oklahoma State University, I am conducting a study to determine the objectives of freshman and sophomore mathematics courses. Also, I hope to ascertain how well these objectives are being attained in certain liberal arts colleges in Texas.

One phase of the study is the appraisal by competent persons in the field of mathematics education of a list of objectives formulated from the literature. The desirable objectives are to be determined by an analysis of the opinions and suggestions obtained from the questionnaire.

I would appreciate your assistance in the completion of the study by filling in the enclosed questionnaire and returning it to me. A stamped, self-addressed envelope is enclosed for your convenience.

Yours truly,

James H. Means

JHM/bem
enclosures

APPENDIX B

211 Thatcher Hall
Oklahoma State Universit
Stillwater, Oklahoma
February 7, 1958

Dear Fellow-Teacher:

This is to request your participation and help in a doctoral study being made at Oklahoma State University. It is a study of the objectives of college mathematics courses through differential calculus. On the enclosed questionnaire, please express your opinion about each objective according to the directions on the questionnaire.

Although all objectives on the questionnaire may or may not apply to the courses that you teach, in grading the objectives, please think of yourself as a teacher of all the mathematics courses through differential calculus.

Your thoughtful response and the return of the attached instrument will be very much appreciated.

The results of the study will be summarized and the information will be available to you as soon as the study is completed.

Again, I thank you very much for your help.

Yours truly,

James H. Means

JHM

enclosures

APPENDIX C

COLLEGE MATHEMATICS TEST

Student's Name ______________________________

List here all college mathematics courses you have complete

____

____

DIRECTIONS: Place the appropriate letter A, B, C, D, or E in the parenthesis at the right of each question. (This is a test to determine how well certain objectiv have been achieved. In order that a clear, true pictu may be had, you are asked to do your best on this test

1. Which of the following is the largest?

(A) $27^{-2/3}$ (B) 10^{-1} (C) $4^{-3/2}$ (D) $10/99$ (E) $(3/2)^0$

( )

2. An automobile went up a hill at a speed of 10 miles an hour and down the same distance at a speed of 20 miles an hour. The average speed for the round trip was: (A) $12\frac{1}{2}$ m.p.h. (B) 13 2/3 m.p.h. (C) $14\frac{1}{2}$ m.p.h. (D) 15 m.p.h. (E) none of these. ( )

3. The points (6,12) and 0,-6) are connected by a straight line. Another point on this line is (A) (3,3) (B) (2 (C) (7,16) (D) (-1,-4) (E) (-3,-8) ( )

4. The contradictory of the statement, "All men are honest is (A) No men are honest (B) All men are dishonest (C) Some men are dishonest (D) No men are dishonest (E) Some men are honest. ( )

5. If X is an acute angle such that $\tan X = K/2$, $\sin X = (?)$

(A) $K/(2+K)$ (B) $2/\sqrt{4-K^2}$ (C) $K/\sqrt{4-K^2}$ (D) $2/\sqrt{4+K^2}$

(E) $K/\sqrt{4+K^2}$ ( )

6. A plane flies 120 miles on a course 60° west of south. It then takes a course 70° east of south until it is directly south of its starting point. Its distance (in miles) from the starting point is (A) $120\sin 20^\circ$ (B) $120\sin 50^\circ\cos 70^\circ$ (C) $120\sin 50^\circ\sin 70^\circ$ (D) $120\sin 50^\circ$ (E) $120\sin 50^\circ\csc 70^\circ$ ( )

7. If $\log_{10}5 = 0.70$, $\log_5 10 = (?)$
(A) 0.30 (B) 0.70 (C) 1.40 (D) 1.43 (E) 1.70 ( )

8. Trigonometric functions are (A) units of length (B) abstract numbers (C) equations of condition (D) identities (E) pure imaginaries ( )

9. The work of dividing a polynomial in x by x-r may be shortened by using (A) Horner's method (B) synthetic division (C) Descartes Rule of Signs (D) The Remainder Theorem (E) Transformation ( )

10. $\sec(90° - \theta) = (?)$ (A) $\cos\theta$ (B) $\cot\theta$ (C) $\csc\theta$ (D) $\sin\theta$ (E) $\sec\theta$ ( )

11. The value of the determinant $\begin{vmatrix} 0 & 1 & 3 \\ 1 & -1 & 0 \\ 2 & 0 & -2 \end{vmatrix}$ is
(A) -8 (B) -4 (C) 0 (D) 4 (E) 8 ( )

12. What is the value of the discriminant of a quadratic equation whose roots are equal?
(A) -16 (B) -2 (C) 0 (D) 36 (E) 48 ( )

13. Rationalizing the denominator of $\sqrt{3}/(2+i)$ makes use of (A) synthetic division (B) polar coordinates (C) Remainder theorem (D) graphs (E) conjugate complex numbers ( )

14. Which of the following is a rational integral equation?
(A) $x^{\frac{1}{2}} = 3$ (B) $3e^x = 4$ (C) $\log x = 42$ (D) $x^{18} = 1$
(E) $x^2 + 2x^{3/2}x - 1 = 0$ ( )

15. According to Descartes Rule of Signs $x^6 + 4x^4 - 3x^2 + 6 = 0$ has (A) at least two positive roots (B) at most two imaginary roots (C) at least two negative roots (D) at most two negative roots (E) only one imaginary root ( )

16. In the equation $x^4 - 8x^3 + 42x - 12 = 0$, the sum of the products of the roots taken two at a time is
(A) -42 (B) -8 (C) 0 (D) 8 (E) 42 ( )

17. The curve $y = f(x)$ with derivatives $f'(x)$ and $f''(x)$ has a maximum at $x = c$ if (A) c is a root of $dy/dx = 0$ (B) c is a root of $d^2y/dx^2 = 0$ (C) c is a root of $f(x) = 0$ (D) c is a root of $f'(x) = 0$ and for b and d arbitrarily near c, $f'(d) > 0$ for $d > c$ and $f'(b) < 0$ for $b < c$ (E) $f'(c) = 0$ and $f''(c) < 0$. ( )

18. Which one of the following would you use to find most quickly the equation of a line with slope m, going through the point (x_1, y_1)?

(A) $(y-y_1)/x-x_1) = (y_1-y_2)/(x_1-x_2)$ (B) $Ax+By = C$

(C) $y = mx+b$ (D) $y-y_1 = m(x-x_1)$ (E) $y_1 = mx_1$

( )

19. The principal value of $\text{Arcsin}(-\sqrt{3}/2)$, expressed in radians is (A) $\pi/3$ (B) $\pi/4$ (C) $\pi/6$ (D) $-\pi/3$ (E) $-3\pi/2$ ( )

20. The fifth term in the expansion of $(1+y)^{10}$ is

(A) y^5 (B) $(1+y)^5$ (C) $210y^4$ (D) $210y^5$

(E) $252y^5$ ( )

21. The mantissa for log2670 is 0.4265; the mantissa for log2680 is 0.4281. The logarithm of 267.3 is equal approximately to (A) 2.4260 (B) 2.4270 (C) 2.4276 (D) 2.4286 (E) 3.4270 ( )

22. What are the coordinates of the foci of the ellipse

$4x^2+9y^2 = 36$? (A) $(\pm 65,0)$ (B) $(\pm 5,0)$ (C) $(\pm\sqrt{5}$

(D) $(0,\pm\sqrt{5})$ (E) $(0,\pm 5)$

23. The equation of a line through (2,4) and parallel to $3x+2y = -1$ is (A) $3x+2y-14 = 0$ (B) $2x+3y-16 =$ (C) $2x+3y-8 = 0$ (D) $2x-3y-8 = 0$ (E) $2x-3y-16 = 0$ ( )

APPENDIX D

TABLE VI

TABLE FOR THE CALCULATION OF THE COEFFICIENT OF CORRELATION

jec- ve mber	Score of Experts X	Score of Teachers Y	Deviation from Mean of X x	Deviation from Mean of Y y	x^2	y^2	xy
	3.57	3.79	.42	.51	.1764	.2601	.2
	3.57	3.79	.42	.51	.1764	.2601	.2
	2.74	3.21	-.41	-.07	.1681	.0049	.0
	2.25	2.32	-.90	-.96	.8100	.9216	.8
	3.32	3.37	.17	.09	.0289	.0081	.0
	3.64	3.74	.49	.46	.2401	.2116	.2
	3.54	3.79	.39	.51	.1521	.2601	.1
	3.11	3.32	-.04	.04	.0016	.0016	-.0
	3.50	3.37	.35	.09	.1225	.0081	.0
	1.93	2.63	-1.22	-.65	1.4884	.4225	.7
	3.64	2.79	.49	-.49	.2401	.2401	-.2
	3.68	3.15	.53	-.13	.2809	.0169	-.0
	2.36	2.74	-.79	-.54	.6241	.2916	.4
	3.54	3.74	.39	.46	.1521	.2116	.1
	2.61	2.68	-.54	-.60	.2916	.3600	.3
	3.07	3.32	-.08	.04	.0064	.0016	-.0
	2.82	3.32	-.33	.04	.1089	.0016	-.0
	3.61	3.42	.46	.14	.2116	.0196	.0
	2.79	2.84	-.36	-.44	.1296	.1936	.1
	3.43	3.42	.28	.14	.0784	.0196	.0
	3.21	3.32	.06	.04	.0036	.0016	.0
	2.18	2.84	-.97	-.44	.9409	.1936	.4
	3.11	3.68	-.04	.40	.0016	.1600	-.0
	3.57	3.63	.42	.35	.1764	.1225	.1
	2.96	3.32	-.19	.04	.0361	.0016	-.0
	2.70	3.26	-.45	-.02	.2025	.0004	.0
	3.18	3.39	.03	.11	.0009	.0121	.0
	3.18	3.79	.03	.51	.0009	.2601	.0
	2.96	3.15	-.19	-.13	.0361	.0169	.0
	2.36	3.26	-.79	-.02	.6241	.0004	.0
	3.07	3.15	-.08	-.13	.0064	.0169	.0
	1.43	1.90	-1.72	-1.38	2.9584	1.9044	2.3
	2.96	3.15	-.19	-.13	.0361	.0169	.0
	3.11	2.95	-.04	-.33	.0016	.1089	.0
	3.54	3.68	.39	.40	.1521	.1600	.1
	2.89	3.32	-.26	.04	.0676	.0016	-.0
	3.39	3.42	.24	.14	.0576	.0196	.0

TABLE VI (continued)

jec- ve mber	Score of Experts	Score of Teachers	Deviation from Mean of X	Deviation from Mean of Y			
	X	Y	x	y	x^2	y^2	xy
	3.57	3.21	.42	-.07	.1764	.0049	-.02
	3.39	2.95	.24	-.33	.0576	.1089	-.07
	3.61	3.53	.46	.25	.2116	.0625	.11
	3.18	3.47	.03	.19	.0009	.0361	.00
	2.11	2.47	-1.04	-.81	1.0816	.6561	.84
	3.41	3.26	.26	-.02	.0676	.0004	-.00
	3.64	3.68	.49	.40	.2401	.1600	.19
	3.48	3.58	.33	.30	.1089	.0900	.09
	3.37	3.58	.22	.30	.0484	.0900	.06
	3.44	3.58	.29	.30	.0841	.0900	.08
	3.26	3.74	.11	.46	.0121	.2116	.05
	3.61	3.79	.46	.51	.2116	.2601	.23
	3.78	3.74	.36	.46	.3969	.2116	.28
	3.85	3.83	.70	.55	.4900	.3025	.38
	3.74	3.79	.59	.51	.3481	.2601	.30
	3.50	3.74	.35	.46	.1225	.2116	.16
	3.26	3.63	.11	.35	.0121	.1225	.03
	3.54	3.53	.39	.25	.1521	.0625	.09
	3.59	3.53	.44	.25	.1036	.0625	.11
	3.48	3.47	.33	.19	.1089	.0361	.06
	3.39	3.44	.24	.16	.0576	.0256	.03
	3.11	3.16	-.04	-.12	.0016	.0144	.00
	3.33	3.47	.18	.19	.0324	.0361	.03
	3.46	3.16	.31	-.12	.0961	.0144	-.03
	3.50	3.05	.35	-.23	.1225	.0529	-.08
	2.71	2.95	-.44	-.33	.1936	.1089	.14
	2.29	2.84	-.86	-.44	.7396	.1936	.37
	2.18	2.49	-.97	-.79	.9409	.6241	.76
	3.23	3.39	.08	.11	.0064	.0121	.00
	3.61	3.32	.46	.04	.2116	.0016	.01
	3.00	2.44	-.15	-.84	.0225	.7056	.12
	2.64	2.69	-.51	-.59	.2601	.3481	.30
	3.29	3.11	.14	-.17	.0196	.0289	-.02
	2.89	3.33	-.26	.05	.0676	.0025	-.01
	3.11	3.74	-.04	.46	.0016	.2116	-.01
	2.86	3.16	-.29	-.12	.0841	.0144	.03

Let $\overline{X}$ and $\overline{Y}$ denote the means of the X's, and Y's, respectively,

$$\overline{X} = \frac{\Sigma X}{N} = \frac{229.93}{73} = 3.15$$

$$\overline{Y} = \frac{\Sigma Y}{N} = \frac{239.7}{73} = 3.28$$

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}} = \frac{11.3832}{\sqrt{(17.762)(12.147)}} = \frac{11.3832}{14.68} = .775$$

The formula for determining r, the coefficient of correlation, is given by Garrett as:

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}}$$

(coefficient of correlation when deviations are taken from the means of the two distributions)

in which x and y are deviations from the actual means and Σx^2 and Σy^2 are the sums of the squared deviations in x and y taken from the two means. Using Table VI in this Appendix, the coefficient of correlation was calculated as shown above.

In testing the reliability of the obtained coefficient of correlation, the method suggested by Garrett was conside appropriate. Garrett stated:

> A mathematically more defensible method of testing the significance of an r, especially when the coefficient is high, is to convert r into R. A. Fisher's z-function and find the SE of z. The function z has two advantages over r: (1) its sampling distribution

is approximately normal and (2) its SE depends only upon the size of the sample N, and is independent of the size of r.[1]

With data from Table VI and the formula $SE_z = 1/\sqrt{N-3}$, the reliability of the coefficient of correlation is obtained:

$$SE_z = 1/\sqrt{73-3} = .119 \text{ or } .12$$

$$z = 1.05 \quad \text{(Table C in Garrett's book)}^2$$

The .95 confidence-interval for the true z is .81 to 1.29 (that is, $1.05 \pm 1.96(.12)$ or $1.05 \pm .24$). Converting the z's back into r's, a confidence-interval of from .67 to .86 is obtained. Thus, the fiduciary probability is .95 that this interval contains the true r.

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[1]Henry E. Garrett, p. 198.

[2]Ibid., p. 426.

VITA

James Horatio Means

Candidate for the Degree of

Doctor of Education

hesis: OBJECTIVES OF INSTRUCTION IN FRESHMAN AND SOPHOMORE MATHEMATICS COURSES IN SEVEN SELECTED COLLEGES IN TEXAS

ajor Field: Education

iographical:

Personal data: Born in Pine Bluff, Arkansas, the son of Lewis H. and Rebecca Means.

Education: Attended the public schools of Pine Bluff, Arkansas, and was graduated from Merrill High School in 1929; received the Bachelor of Science degree, with a major in Mathematics, from Arkansas Agricultural, Mechanical, and Normal College in 1933; received the Master of Science degree, with a major in Mathematics, from the State University of Iowa in January, 1937; attended the graduate schools of the University of Michigan and the University of Texas; completed the requirements for the Doctor of Education degree in May, 1958.

Professional experience: Served as a teacher of mathematics and science for four years in the practice high school of Arkansas A. M. and N. College; served one year as teacher of mathematic and science in West Kentucky Industrial College, Paducah, Kentucky; has taught in the Mathematics and Physics Department of Huston-Tillotson College since 1938.

Professional organizations: Elected to membership in the following organizations: The Mathematics Association of America, The American Mathematical Society, Pi Mu Epsilon, Phi Delta Kappa, Alpha Kappa Mu Honor Society, and The National Institute of Science.