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THE NEED FOR AND NATURE OF ONE TYPE OF COURSE IN MATHEMATICS FOR GENERAL EDUCATION AT THE COLLEGE LEVEL

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THE NEED FOR AND NATURE OF ONE TYPE OF COURSE IN MATHEMATICS FOR GENERAL EDUCATION AT THE COLLEGE LEVEL

CHAPTER I

THE PROBLEM: ITS BACKGROUND AND DEFINITION

Introduction

In any discussion of general education the role of mathematics is likely to be considered. There is, however, a wide range of opinion as to just what is the place of mathematics in general education, especially at the college level. Those who are convinced of the need for including mathematics in the general education program at the college level are faced with the difficult question of what should be the nature of a course in mathematics for general education.

> In this scientific age no professional divining rod nor educational radar is needed to discover the merits of mathematics as a functional part of the college freshman program. To determine the most significant content of such a mathematics course is a problem that will require a great deal of careful thought.[1]

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[1]F. Lynwood Wren, "The Merits and Content of a Freshman Mathematics Course," <u>School Science and Mathematics</u>, LII (November, 1952), 602.

Among the possible types of courses in mathematics for general education at the college level is one which has as one of its chief objectives aiding students in further development of the functional competence in mathematics needed by all informed citizens. The study reported here was concerned with investigating the need for such a course at the college level and the nature of its content relating to functional competence. A specific statement of the problem will be postponed until some terms have been defined and certain background information has been given.

Definition of Terms

Since the terms "general education" and "mathematics for general education" were both used in the above introductory statement, it is necessary to indicate the meaning of these terms as used here. For the purposes of this study the term "general education" was used to mean those phases of non-specialized learning which are needed by every individual in becoming an informed, responsible citizen.

In line with this definition of general education the term "mathematics for general education" was used here to mean work dealing with mathematical concepts needed by every person in so far as he is able to master the ideas involved. It should be pointed out that in meeting his needs as an informed citizen, an individual may use mathematical concepts either directly or as a means of acquiring other learnings for which he has need. It will be at once apparent to the reader that, on the basis of the definition of "mathematics for general education" just given, there could be many different opinions as to what mathematical concepts are needed by everyone and hence many different kinds of courses in mathematics for general education at the college level.

As indicated above, the type of college course in mathematics for general education considered in this study was one concerned with further development of functional competence in mathematics. As used here the term "functional competence in mathematics" referred to an understanding of and an ability to use the basic mathematical concepts which are needed in everyday experience by all citizens. It should be pointed out that the ability of an individual to recognize his need to use a mathematical concept is itself a part of functional competence. Nobody can be aware of his need for using an idea about which he has little or no knowledge or understanding. The following section will include a statement as to just what mathematical concepts and abilities were considered in this investigation as essential for functional competence in mathematics.

Background of the Problem

The work of the Commission on Post-War Plans. The deficiencies in the mathematics background of military personnel during World War II called attention to the need for greater emphasis to be placed upon the development of basic mathematical abilities. In an effort to deal with the difficulty, the Board of Directors of the National Council of Teachers of Mathematics appointed in February, 1944, the Commission on Post-War Plans ". . . to plan mathematics programs for secondary schools in the post-war period."[2] The Commission on Post-War Plans was composed of thirteen high school and college teachers of mathematics. Most of the college teachers were persons who have worked and written in the area of mathematics education.

In 1945 the Commission on Post-War Plans presented thirty-four theses[3] concerning the improvement of mathematics instruction from the beginning of the elementary school through the last year of the junior college. The first thesis, which is the one most pertinent to the present study, was the following: "The school should guarantee functional competence in mathematics to all who can possibly achieve it."[4]

The Commission on Post-War Plans also prepared a

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[2]"The First Report of the Commission on Post-War Plans," The Mathematics Teacher, XXXVII (May, 1944), 226.

[3]"The Second Report of the Commission on Post-War Plans," The Mathematics Teacher, XXXVIII (May, 1945), 195-221.

[4]Ibid., p. 196.

Check List[5] of essentials for functional competence in mathematics which they presented for use by high school students. The introduction of the Check List to high school students included the following:

> How much mathematics is a "must" for every citizen? It's time to get that straightened out. Here is a Check List of twenty-nine questions. If you can say "yes" to nearly all of them you can feel pretty secure when it comes to dealing with the problems of everyday affairs.[6]

<u>The Check List</u>. The items on the Check List are the following.

1. Computation. Can you add, subtract, multiply, and divide effectively with whole numbers, common fractions and decimals?
2. Percents. Can you use percents understandingly and accurately?
3. Ratio. Do you have a clear understanding of ratio?
4. Estimating. Before you perform a computation, do you estimate the result for the purpose of checking your answer?
5. Rounding numbers. Do you know the meaning of significant figures? Can you round numbers properly?
6. Tables. Can you find correct values in tables; e. g., interest and income tax?
7. Graphs. Can you read ordinary graphs; bar, line and circle graphs? the graph of a formula?
8. Statistics. Do you know the main guides that one should follow in collecting and interpreting data; can you use averages (mean, median, mode); can you draw and interpret a graph?
9. The nature of a measurement. Do you know the meaning of a measurement, of a standard unit, or the largest permissible error, of tolerance, and of the statement that "a measurement is an approximation"?
10. Use of measuring devices. Can you use certain measuring devices, such as an ordinary ruler, other rulers (graduated to thirty-seconds, to tenths of an inch, and

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[5] "Guidance Report of the Commission on Post-War Plans," <u>The Mathematics Teacher</u>, XL (November, 1947), 318-19.

[6] <u>Ibid</u>., p. 318.

to millimeters), protractor, graph paper, tape, caliper micrometer, and thermometer?

11. Square root. Can you find the square root of a number by table, or by division?

12. Angles. Can you estimate, read, and construct an angle?

13. Geometric concepts. Do you have an understanding of point, line, angle, parallel lines, perpendicular lines, triangle (right, scalene, isosceles and equilateral), parallelogram (including square and rectangle), trapezoid, circle, regular polygon, prism, cylinder, cone, and sphere?

14. The 3-4-5 relation. Can you use the Pythagorean relationship in a right triangle?

15. Construction. Can you with ruler and compasses construct a circle, a square, and a rectangle, transfer a line segment and an angle, bisect a line segment and an angle, copy a triangle, divide a line segment into more than two equal parts, draw a tangent to a circle, and draw a geometric figure to scale?

16. Drawings. Can you read and interpret reasonably well, maps, floor plans, mechanical drawings, and blueprints? Can you find the distance between two points on a map?

17. Vectors. Do you understand the meaning of vector, and can you find the resultant of two forces?

18. Metric system. Do you know how to use the most important metric units (meter, centimeter, millimeter, kilometer, gram, kilogram)?

19. Conversion. In measuring length, area, volume, weight, time, temperature, angle, and speed, can you shift from one commonly used standard unit to another widely used standard unit; e.g., do you know the relation between yard and foot, inch and centimeter, etc.?

20. Algebraic symbolism. Can you use letters to represent numbers; i.e., do you understand the symbolism of algebra? Do you know the meaning of exponent and coefficient?

21. Formulas. Do you know the meaning of a formula? Can you, for example, write an arithmetic rule as a formula, and can you substitute given values in order to find the value for a required unknown?

22. Signed numbers. Do you understand signed numbers and can you use them?

23. Using the axioms. Do you understand what you are doing when you use the axioms to change the form of a formula or when you find the value of an unknown in a simple equation?

24. Practical formulas. Do you know from memory certain widely used formulas relating to areas, volumes, and interest, and to distance, rate, and time?

25. Similar triangles and proportion. Do you understand the meaning of similar triangles, and do you know how to use the fact that in similar triangles the ratios of corresponding sides are equal? Can you manage a proportion?
26. Trigonometry. Do you know the meaning of tangent, sine, cosine? Can you develop their meanings by means of scale drawings?
27. First steps in business arithmetic. Are you mathematically conditioned for satisfactory adjustment to a first job in business; e.g., have you a start in understanding the keeping of a simple account, making change, and the arithmetic that illustrates the most common problems of communications and everyday affairs?
28. Stretching the dollar. Do you have a basis for dealing intelligently with the main problems of the consumer; e.g., the cost of borrowing money, insurance to secure adequate protection against loss from the numerous hazards of life, the wise management of money, and buying with a given income so as to get good values as regards both quantity and quality?
29. Proceeding from hypothesis to conclusion. Can you analyze a statement in a newspaper and determine what is assumed, and whether the suggested conclusions really follow from the given facts or assumptions?[7]

In a later section of this paper there will be presented reviews of several studies which list many of the items included on the Check List as essential parts of general education in the area of mathematics.

In the present study it will be assumed that the twenty-nine items on the Check List are valid essentials for functional competence in mathematics, and the problem will be stated on the basis of these essentials.

Statement of the Problem

The problem was that of determining the extent to

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[7] *Ibid.*, p. 318-19.

which there is need at the college level for a course in mathematics for general education which includes work designed to improve functional competence in mathematics and of investigating the nature of the content related to functional competence which should be included in such a course.

Specifically, answers to the following questions were sought:

1. To what extent do freshmen entering selected four year colleges in Oklahoma have an understanding of and an ability to use the essentials for functional competence in mathematics which were recommended as a part of the general education of all citizens by the Commission on Post-War Plans of the National Council of Teachers of Mathematics?

2. What are the implications of the results obtained in answering the first question as to (a) how great the need is for a college level general mathematics course which includes work designed to improve functional competence and (b) what mathematical concepts involved in the essentials for functional competence should be included in such a course in mathematics for general education?

Need for the Study

<u>In relation to college programs in Oklahoma</u>. At present a situation exists in the six state colleges[8] in

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[8]For a list of the six state colleges see page 10.

Oklahoma which makes the study especially timely. In the current general education programs at the six institutions mathematics is not required and is included only as one of several subjects in a group from which the student makes a selection. Since this very limited place of mathematics in the general education programs has been questioned at all of the six colleges, the problem is certain to be considered as plans for revision of the general education programs are made. At that time data from this study will be of value. Other Oklahoma colleges may also find the results of this investigation useful in connection with efforts to improve their general education programs.

<u>In relation to college programs outside of Oklahoma</u>. There is also a possibility that this study could have a more general value than its usefulness in Oklahoma. Since the role of mathematics in general education is being considered in all parts of the nation, data concerning the problem in one state could be useful as background material in studies being made elsewhere.

<u>In relation to high school programs</u>. The results of the study may perhaps be of interest to high school teachers and administrators, because the data give some indication of how well those students who do go on to college are prepared in areas usually covered in high school general mathematics courses. Such information would be of help in considering (1) the question of whether all high school students should

take general mathematics courses, (2) the need for revision of the traditional high school mathematics courses, and (3) the determination of the proper grade placement of high school mathematics courses.

Limitations of the Study

As to subjects. The subjects for the study were limited to freshmen entering the six state colleges in Oklahoma in the fall of 1955. The group of six state colleges is composed of the following institutions: Central State College, Edmond; East Central State College, Ada; Northeastern State College, Tahlequah; Northwestern State College, Alva; Southeastern State College, Durant; and Southwestern State College, Weatherford. The six state colleges were selected partly because of the above mentioned problem concerning the role of mathematics in their general education programs and partly because they are similar in size and function and draw students from the entire state.

As to method of evaluation of functional competence in mathematics. The evaluation of the subjects' functional competence in mathematics was limited to the results of the Davis Test of Functional Competence in Mathematics (Form AM),[9] which was designed to test the essentials for functional competence listed by the Commission on Post-War Plans

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[9]David John Davis, Davis Test of Functional Competence in Mathematics (Yonkers-on-Hudson, New York: World Book Company, 1951).

of the National Council of Teachers of Mathematics. The construction of the test was a part of the research done by David John Davis for his doctoral dissertation[10] at the University of Michigan. Davis stated that he began making preparations for the construction of the test when the Check List of essentials for functional competence in mathematics was published in 1945,[11] and he described the preparations as follows:

> In order to acquire the background necessary for the construction of the test, the writer examined and studied a vast array of tests, general mathematics books, a long range of issues of the Yearbook of the National Council of Teachers of Mathematics, copies of the Mathematics Teacher, and references pertaining to the construction and use of diagnostic and achievement examinations. In addition, he made a systematic study of radio programs and of newspaper articles and kept a record of the mathematics used therein. Furthermore, he examined telephone books and bills sent by stores and by public utilities to determine their rates and discounts, and visited banks, bus stations, stores, and insurance and electric light companies for information and ideas. For a final source of information, the writer and his wife kept a record of the applications of mathematics which they made in their daily activities.[12]

The procedure[13] followed by Davis in constructing the test is summarized briefly here. After organizing the information obtained from the sources described in the

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[10]David John Davis, "A Comparative Study of Achievement Levels of Twelfth Grade Pupils on a Test Designed to Measure Functional Competence in Mathematics" (unpublished Ph.D. dissertation, University of Michigan, 1950).

[11]*Ibid.*, p. 29.

[12]*Ibid.*, pp. 29-30.

[13]*Ibid.*, pp. 30-33.

above quotation, Davis prepared diagnostic tests to measure the objectives in each of the twenty-nine items of the Check List. He then selected the exercises for the tentative form of the final test from the exercises in the diagnostic tests. After trying the tentative form of the test with a few selected pupils, Davis submitted it along with the Check List to each member of his doctoral committee. Along with each exercise in the test there was presented the Check List objective which that item was designed to measure. Each committee member was asked to answer a list of questions regarding his opinions as to the validity and the difficulty of the test items. Davis then prepared the final form of the test as he used it in his study. This form of the test consisted of ninety items and required ninety minutes of time.

After the completion of Davis' work on constructing the test for use in connection with his dissertation, the test was revised further and in 1951 was published by the World Book Company in Form AM and Form BM, which are equivalent forms each consisting of eighty items. The time required for giving the present test is eighty minutes. According to the test manual[14] two preliminary forms of the Davis Test, each consisting of ninety items, were developed

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[14]"Manual of Directions," Davis Test of Functional Competence in Mathematics (Yonkers-on-Hudson, New York: World Book Company, 1951), p. 2.

and administered to 4,500 students in high schools in five states. From these test results difficulty and validity indices were determined for each test item. These statistical data were used in selecting the items for the two final forms of the test. "In selecting material for the final forms of the test, consideration was given not only to the statistical evidences of suitable difficulty and validity, but also to the construction of a test which, from a content standpoint, would correspond to the original outline or blueprint and which would, therefore, represent a balanced coverage of objectives."[15] The test manual contains middle-of-year and end-of-year percentile norms for grades nine through twelve.[16]

As to implications. The implications as to need for a college level course in mathematics for general education were limited to indications of need, as revealed by the Davis Test, for including at the college level a mathematics course which would provide additional opportunities for students to master the essentials for functional competence listed by the Commission on Post-War Plans. No effort was made to consider need for other types of courses in mathematics for general education. The same kind of limitation applied to comments concerning the content of the course,

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[15] Ibid.

[16] Ibid., p. 7.

which was discussed chiefly in so far as implications of the evaluation conducted in this study were concerned. Hence, the discussion of the nature of the course should not be interpreted as a complete description of all desirable content for a college level course in mathematics for general education.

Major Assumptions

Three major assumptions were made in the study.

1. It was assumed that the twenty-nine items on the Check List, which was prepared by the Commission on Post-War Plans, are valid essentials for functional competence in mathematics.

2. It was assumed that the performance of a college freshman on the Davis Test of Functional Competence in Mathematics revealed his functional competence in the mathematics covered by the items on the Check List.

3. It was assumed that it is desirable for a college to provide work in mathematics for general education which is designed to meet the needs of the students in view of the limitations of their previous experiences with mathematics.

Procedure

In this section a description of the procedure followed in carrying out the investigation will be presented, but no data as to results will be included here. The results of the study as well as interpretations, conclusions and recommendations will be presented in later chapters.

Selection of evaluation instrument. After the problem had been formulated it was necessary to select an evaluation instrument for use in determining the extent to which freshmen entering selected colleges in Oklahoma have an understanding of and an ability to use the essentials for functional competence in mathematics which were recommended as a part of the general education of all citizens by the Commission on Post-War Plans. Since in stating the problem the Check List developed by the Commission on Post-War Plans had been used as the specific statement of the meaning of functional competence in mathematics, it seemed desirable to use as the evaluation instrument the Davis Test of Functional Competence in Mathematics, which was designed to test the twenty-nine items on the Check List. Since this test has been described above, no further comment will be made about it at this point except to mention the use of a high school test with college students. Although the test was designed for grades nine through twelve, it was considered satisfactory for use with the college students since the group tested were entering freshmen. It was decided that the evaluation of functional competence with respect to the essentials included in the Check List would be limited to the results of the Davis Test.

The testing process. After the evaluation instrument had been chosen, the next step was to select the Oklahoma colleges which would be asked to participate in the study. The six state colleges were selected because they are institutions of the same type, are similar in size and collectively draw students from over the entire state. It was decided to request officials at each of the colleges to administer the Davis Test of Functional Competence in Mathematics to all entering freshmen during the first six weeks of the fall semester, 1955-56. In order to obtain the cooperation of the colleges and to make the necessary arrangements for the testing program, the writer visited five of the campuses in July, 1955, and had a personal interview in Norman with a representative of the sixth college. At five of the institutions the tests were administered by the person in charge of the college testing program and other faculty members whom he appointed to assist. The writer administered the test at the sixth school, Northwestern State College. A personal interview with the person in charge of the testing on each campus was used as a means of securing as nearly as possible uniform testing procedures at the several colleges. Furthermore, a copy of a letter of instructions was mailed to each person directing the testing near the time the test was to be given at his institution. Several long distance telephone calls were used in answering questions which developed in connection with the testing program and in making arrangements concerning test supplies. By the above mentioned means the writer was in close touch with the testing program as it was carried out on the several campuses. The persons administering the test were aware of the major purpose for which the results would be used while students taking the test assumed that it was a part of the total college testing program for freshmen.

At some of the colleges the test was given at the beginning of the semester as a part of the freshman orientation program, while at other institutions it was given during the first few weeks of the term. The testing had been completed at all colleges by the middle of the sixth week of the semester.

Although the colleges were requested to administer the test to all freshmen entering the institutions for the first time in the fall of 1955, it proved to be impossible to test all entering freshmen. At some of the colleges there was no opportunity to test students who entered after the first day of the orientation period at the beginning of the semester, while at other institutions, where a special session was held during the first six weeks of the semester for the purpose of giving the test, some students were unable to attend at the time set for the test. Since two periods of forty minutes each were required for the test, which can be given at two testing periods, some students were present for one part of the test but not for the other. Papers for students who took only one-half of the test could not be used in the study. A total of 1811 entering freshmen at the six colleges took the test. This group represented 80.2 per cent of all entering freshmen at the six institutions. The lowest percentage of entering freshmen included in the group tested at any college was 67.7, and at only one other institution was the percentage less than 80. Because a large proportion of the total group of entering freshmen took the test and because those taking the test were not selected in any way, the subjects were treated as a total population in dealing with the data.

Statistical treatment of test scores. The score made by a student on the test was the total number of questions answered correctly. A frequency distribution of the scores was made from which the mean, median, Q_1, Q_3, and the standard deviation were determined and a histogram was made. The corrected split-half reliability coefficient of the test for the group of subjects in this study was determined.

Comparison with norms. The scores were then compared with the norms for the test which are given for the end of grade twelve. In using the norms it was necessary to keep in mind the following limitation. Favorable comparison with the norms may not indicate that the subjects had adequate understanding of and ability to use the essentials for functional competence in mathematics covered by the test. The norms represent typical achievement for the group of high school seniors used in the process of standardizing the test, but this typical achievement may be far from desirable accomplishment. In view of the assumption made in this study that the items on the Check List prepared by the Commission on Post-War Plans are valid essentials for functional competence in mathematics, only those students who answered correctly all or nearly all of the questions on the test can be considered to have attained the most desirable level of achievement.

Comparison with minimum satisfactory score as determined by a group of judges. Although this entire study was made in the light of the assumption mentioned in the last paragraph, it was considered of interest to find out just which ones of the items on the Davis Test were thought to be essential for all college students by a small group of selected judges. The jury consisted of three superintendents of public schools, five high school principals, five college deans, three supervisors of student teachers of mathematics in teacher education institutions, five high school mathematics teachers and five college mathematics teachers. It should be noted that one-half of the jury members were administrators and one-half mathematics teachers. Also, if the jury is divided along different lines, one-half of the group were associated with public secondary schools and one-half with colleges. All of the judges were staff members of either public schools or colleges in Oklahoma. No attempt was made to select a random sample of mathematics teachers and administrators for the jury. Instead persons were chosen who were known personally by either the writer or some member of the committee directing the research and who were believed to be outstanding administrators or mathematics teachers. The nature of the task which the jury was to be asked to do made it desirable to have a select group of judges rather than a random sample of mathematics teachers and administrators. It was important to have judges who had the necessary background and interest to do carefully a rather difficult and time consuming piece of work.

Each judge was asked to indicate independently which items on the Davis Test he believed were essential as a part of the knowledge of the college student taking work in a variety of general education fields and in a major field not requiring extensive training in mathematics.[17] By determining the total number of items marked essential by each judge and finding the mean of these totals it was possible to arrive at some indication of a minimum satisfactory score on the test in the opinion of the group of judges. However, there was a fallacy in making use of the mean number of items considered essential as the minimum satisfactory score, because not all of the judges believed the same items

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[17]A copy of the letter sent to jury members and a sample of the reply form with instructions to the judges are included in the appendix.

to be essential. Furthermore, a student may have made the minimum score by answering correctly some items considered nonessential by most of the judges. In spite of the limitations just mentioned, the mean number of items considered essential by the jury members was used as the best available minimum satisfactory score with which to compare scores made by the subjects in this study. The minimum satisfactory score thus determined was compared with the mean score for the group of 1811 entering college freshmen, and the percentage of the subjects making a score equal to or greater than the minimum satisfactory score was computed also.

The number and percentage of the total group of judges considering each item essential was determined and the same information was obtained for the subgroup of mathematics teachers serving as judges and for the administrators. These results were examined for indications of agreement among the judges.

Item analysis. The next step was to make an item analysis in which the number and percentage of the subjects who answered each question correctly was determined. The items were then divided into seventeen groups, each group containing items which dealt with the same basic mathematical concept, and the average percentage of the subjects giving a correct response to the items in each group was computed. This average percentage for each group was used as an indication of the level of competence of the subjects on the concept tested by the items in that group. In addition, the average percentage of the judges marking the items in each group essential was computed.

Formulation of conclusions and recommendations. The results of the preceding steps were summarized and studied for possible answers to the questions raised in the statement of the problem, and a list of conclusions was made. On the basis of these conclusions certain recommendations were formulated and some suggestions were made as to other needed studies related to the work done in this investigation.

Review of Selected Related Literature

No attempt is made here to review all of the extensive literature concerning general mathematics at the college level. A few of the references which were most helpful in obtaining valuable background are included in the bibliography, although they are not summarized here. Only two types of studies which seem particularly important in connection with the present investigation are reviewed here. These are (1) studies which considered the problem of determining what mathematics is needed by all citizens or by college students and (2) studies which investigated the deficiencies of college freshmen in preparation on basic mathematics. Several of the studies in both groups had among their purposes consideration of the development of general mathematics courses at the college level.

<u>Studies concerning what mathematics is needed</u>. One of the rather extensive studies in the first group was done by Haggard,[18] who made a synthesis of twenty-three research studies concerning the mathematics needs of the general college student and his adult counterpart in society. The studies considered the specific mathematics used in the several areas of general education and in such areas as business administration, economics, retailing, pharmacy, nursing, office work and others. It was found that the twelve most important mathematical topics as revealed by the synthesis were:

1. Review and additional work in arithmetic.
2. Ratio and proportion, both algebraic and arithmetic.
3. Study of simple linear equations.
4. Business mathematics or mathematics of finance.
5. Graphs (cartesian coordinate) and charts.
6. Use of simple formulas.
7. Area of the common plane figures.
8. Volume and surface area of the common solids.
9. Right angle and the right triangle.
10. Study of simple quadratic equations.
11. Trigonometry up to and including the right triangle.
12. Fundamental properties of the circle.[19]

Haggard recommended that a course in cultural general mathematics on the college level be organized around

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[18] J. D. Haggard, "College Mathematics for the General Student" (unpublished Ed.D. dissertation, University of Missouri, 1951).

[19] <u>Ibid</u>., p. 89.

the subject matter included in the twelve topics, and he presented a proposed outline for such a course.

A second study in the area of the mathematics needed by college students was that of Leonhardy,[20] whose problem was to determine what basic mathematical concepts and processes are in the textbooks used in three areas of general education--natural science, social science, and the humanities. She found that "mathematics is used extensively in each of the areas of general education."[21] However, her statement as to the nature of the mathematics needed was that "the mathematics required for general education is relatively simple, for it is the arithmetic of the elementary school and certain concepts and processes from each of the four years of high-school mathematics."[22]

In an effort to determine what mathematics should be offered by the community college, Bentz[23] used the procedure of collecting descriptions of situations in which mathematics

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[20]Adele Leonhardy, "Mathematics Used in the Humanities, Social Science and Natural Science Areas in a General Education Program on the College Level," Science Education, XXXVI (October, 1952), 252-53.

[21]*Ibid*., p. 252.

[22]*Ibid*., p. 252.

[23]R. P. Bentz, "Critical Mathematics Requirements for the Program of the Community College" (unpublished Ph.D. dissertation, George Peabody College for Teachers, 1952), summarized by Kenneth E. Brown, "Research in Mathematics Education," The Mathematics Teacher, XLVII (January, 1954), 51-2.

was used or needed.

Questionnaires, personal interviews, and observations were used to secure these incident descriptions. The emphasis was on functional mathematics for the post high-school pupil. An analysis of the 327 usable incidents reported revealed the use or need of the following thirty-one mathematical concepts:

1. Skill in computing with integers, common fractions, and decimal fractions.
2. Ability to make mental calculations with reasonable speed and accuracy.
3. Familiarity with terms used in the identification of various numbers.
4. Knowledge of the principal units that are to be found in common usage.
5. Skill in changing from one set of units to another.
6. Understanding of the nature of and the ability to use the techniques of percentage.
7. Ability to interpret and express a relationship by means of a chart, formula, or graph.
8. Skill in setting up and solving simple equations to find the value of an unknown number.
9. Ability to make proper selection and use of a formula from memory or from a reference source.
10. Skill in setting up and making use of a proportion.
11. Ability to carry out an interpolation.
12. Ability to construct and interpret bar, circle and line graphs.
13. Understanding of the usefulness of a system of co-ordinates.
14. Understanding of the meaning of the more common symbols used in the field of mathematics.
15. Knowledge of the fundamental properties of the common figures as the square, rectangle, circle, triangle, rectangular solid, sphere, cylinder, cone, and cube.
16. Ability to make and use a scale drawing.
17. Ability to make use of the 3-4-5 right-triangle relationship and to apply the rule of Pythagoras.
18. Skill in making approximations of distances, areas, and volumes without the aid of the more precise measuring instruments.
19. Skill in making direct measurements with the protractor, scale, tape, micrometer, and other instruments.

20. Ability to collect and to tabulate accurately various kinds of numerical data.
21. Understanding of the significances of such fundamental statistical measures as the arithmetic mean, median, mode, range and standard deviation.
22. Ability to compute an average.
23. Ability to read intelligently the statistical generalizations in various types of publications.
24. Ability to construct a frequency table and a statistical graph.
25. Ability to use the slide rule and calculating machines to perform various fundamental calculations.
26. Understanding of the meaning of a logarithm and the ability to use it as a short cut in making calculations.
27. Skill in the use of the sine, cosine, and tangent ratios in determining distances and angles.
28. Awareness of the importance of doing careful, accurate work and of checking results.
29. Awareness of the importance of developing correct habits of a clerical nature in writing figures, organizing work, and identifying results.
30. Ability to deal intelligently with the matters of loans, investments, and the cost of borrowing money.
31. 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.[24]

<u>Studies concerning the deficiencies of college freshmen in preparation on basic mathematics</u>. In the second group of studies, those which investigated the deficiencies of college freshmen in preparation on basic mathematics, was Moore's dissertation on "The Mathematics of General Education for the Teacher."[25] An important part of this dissertation was concerned with determining the competence in mathematics of college freshmen in non-technical fields.

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[24] <u>Ibid</u>., p. 51.

[25] Vesper Dale Moore, "The Mathematics of General Education for the Teacher" (unpublished Ed.D. dissertation, University of Michigan, 1951).

Two tests, the Hundred Problem Arithmetic Test[26] and the Davis Test of Functional Competence in Mathematics,[27] were given to 328 freshmen in non-technical fields at Indiana State Teachers College during the school year 1949-50. The percentage of the group who solved each problem correctly was obtained for both of the tests. From his analysis of the data Moore reached the following conclusion: "Since these data indicate that the college freshmen were incompetent to solve various problems in simple arithmetic and many problems in the Davis Test of Functional Competence in Mathematics, it seems reasonable to conclude that there is need for some remedial work at the college level in arithmetic and on topics in mathematics for the common affairs in life. . ."[28]

In a study consisting of three parts Guiler investigated the difficulties encountered by college freshmen in

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[26] Raleigh Schorling, John R. Clark, and Mary A. Potter, Hundred-Problem Arithmetic Test (New York: World Book Company, 1944).

[27] David John Davis, Davis Test of Functional Competence in Mathematics (Yonkers-on-Hudson, New York: World Book Company, 1951).

[28] Moore, op. cit., pp. 91-92.

fractions,[29] in decimals,[30] and in percentage.[31] During the years 1938 to 1941 he gave the Christofferson-Rush-Guiler Analytical Survey Test in Computational Arithmetic to 925 freshmen enrolled in the School of Education in Miami University. The results showed that the percentage of the 925 college freshmen manifesting weakness in each of the fundamental processes with fractions was as follows: in addition of fractions 44.5 per cent, in subtraction of fractions 63.5 per cent, in multiplication of fractions 53.3 per cent, and in division of fractions 57.7 per cent.[32] The study of the percentage of the group manifesting weakness on each of the fundamental processes with decimals caused the author to conclude that "a large proportion of the college freshmen exhibited weakness in the handling of decimals."[33] Guiler reached a similar conclusion concerning the preparation of

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[29] W. S. Guiler, "Difficulties Encountered by College Freshmen in Fractions," Journal of Educational Research, XXXIX (October, 1945), 102-15.

[30] W. S. Guiler, "Difficulties Encountered by College Freshmen in Decimals," Journal of Educational Research, XL (September, 1946), 1-13.

[31] W. S. Guiler, "Difficulties Encountered in Percentage by College Freshmen," Journal of Educational Research, XL (October, 1946), 81-95.

[32] Guiler, "Difficulties Encountered by College Freshmen in Fractions," Journal of Educational Research, XXXIX (October, 1945), 103.

[33] Guiler, "Difficulties Encountered by College Freshmen in Decimals," Journal of Educational Research, XL (September, 1946), 3.

the college freshmen in the area of percentage, for he stated that "a large proportion of the college freshmen cannot be relied on to work effectively in situations in which percentage is involved."[34]

At Ohio State University Kinzer and Fawcett, who gave an arithmetic test of fifteen problems to freshmen enrolled in the first course in chemistry in the autumn quarter of 1945, found that of 1439 students tested, 534 solved fewer than one-third of the problems, 31 had no problems correct, 64 had only one problem correct, and 78 had only two problems correct.[35]

The investigations reviewed above seem to indicate need for further study in the area of the preparation of college freshmen on the essentials for functional competence in mathematics.

Overview of Following Chapters

In Chapter II the empirical data of the study are presented and analyzed, while Chapter III is devoted to a summary and the presentation of conclusions. In the final chapter recommendations are made on the basis of the study

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[34]Guiler, "Difficulties Encountered in Percentage by College Freshmen," Journal of Educational Research, XL (October, 1946), 83.

[35]J. R. Kinzer and H. P. Fawcett, "The Arithmetic Deficiency of College Chemistry Students," Educational Research Bulletin, XXV (May, 1946), 113-14.

as to (1) methods of providing and organizing one type of course in mathematics for general education at the college level and (2) other needed studies related to the present one. In addition there are included some implications growing out of the present investigation as to need for study of related problems at the high school level.

CHAPTER II

PRESENTATION AND ANALYSIS OF DATA

Introduction

In this chapter the empirical data of the study are presented and analyzed. These data are discussed in the following order: (1) the reliability of the test for the group of subjects in this study, (2) statistical treatment of test scores, (3) comparison of the performance of subjects in this study with norms, (4) comparison of the performance of subjects with minimum satisfactory score as determined by a group of judges, and (5) item analysis.

Reliability of the Test

In addition to the total score, which was the total number of items answered correctly, two part scores were determined for each subject. These part scores were the number of odd items answered correctly and the number of even items to which a correct response was given. From these part scores the corrected split-half reliability coefficient of the test for the group of subjects in this study was found to be .90. This was exactly the same as the corrected split-half reliability coefficient of the test for the group of 306 twelfth grade students used in determining the reliability of the test in the standardization process.[1]

Statistical Treatment of Test Scores

Since the score made by an individual on the Davis Test was the number of items answered correctly, the possible score was eighty. The range of scores made by the subjects in this study was from four to seventy-eight. A frequency distribution of the scores made by the 1811 entering college freshmen is presented in Table 1, and a histogram of the same information is shown in Figure 1. The mean of the scores was 30.8 and the standard deviation was 11.7. The median was 29.2. Fifty per cent of the group made scores between 22.3, Q_1 and 37.9, Q_3. Seventy-five per cent of the freshmen answered correctly less than one-half of the eighty test questions.

Comparison with Norms

No norms for college students were available with the Davis Test, but norms were given for the end of grade twelve. The use of these norms for the end of grade twelve was considered satisfactory, because the subjects in this study were entering college freshmen. Perhaps after a

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[1] "Manual of Directions," Davis Test of Functional Competence in Mathematics (Yonkers-on-Hudson, New York: World Book Company, 1951), p. 3.

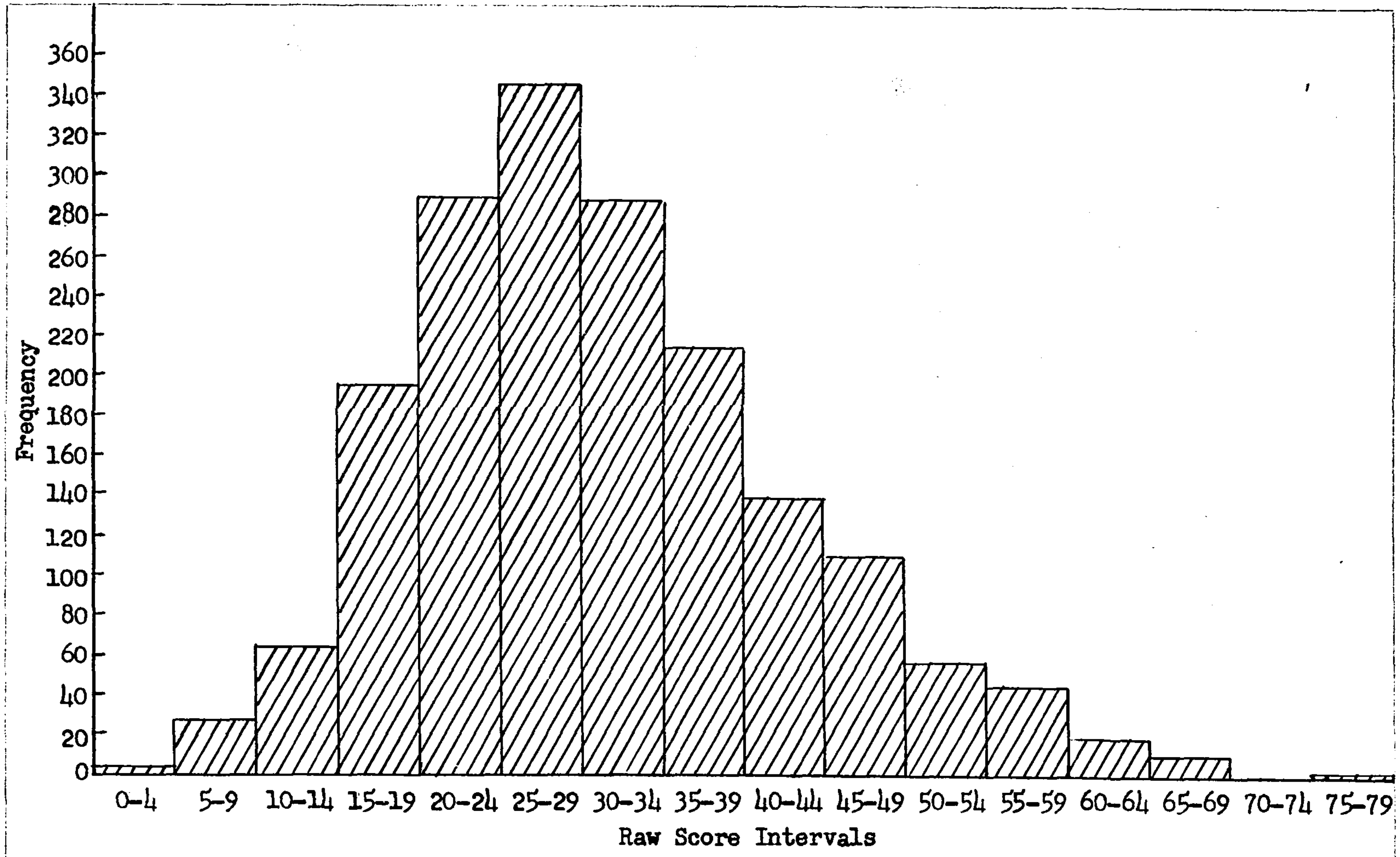

Figure 1.—Histogram of raw scores of 1811 entering college freshmen on the *Davis Test of Functional Competence in Mathematics*.

TABLE 1

FREQUENCY DISTRIBUTION OF SCORES FOR 1811 ENTERING COLLEGE FRESHMEN ON THE DAVIS TEST

Class Interval	Frequency
75-79	1
70-74	0
65-69	9
60-64	19
55-59	42
50-54	58
45-49	115
40-44	140
35-39	214
30-34	289
25-29	345
20-24	291
15-19	196
10-14	63
5- 9	27
0- 4	2

summer out of school these freshmen were somewhat less well prepared for the test than they would have been near the end of their senior year in high school.

The end-of-year percentile norms[2] given in the test manual were obtained from scores resulting from administering the test to 1371 high school seniors from thirty-one schools in nineteen states.[3] A comparison of the group of 1811 college freshmen tested in this investigation with the group of high school seniors used in the standardization

[2] *Ibid*., p. 7.

[3] *Ibid*., p. 6.

process is given in Table 2. It is evident from Table 2 that the performance of the college freshmen on the Davis Test was somewhat poorer than that of the high school seniors tested in the standardization process, but perhaps even more outstanding is the relatively poor performance of both groups, especially in view of the fact that the test was designed to measure concepts and abilities considered necessary for all citizens by the Commission on Post-War Plans of the National Council of Teachers of Mathematics. The norms represent typical achievement for the group of high school seniors used in the process of standardizing the test, but this typical achievement may be far from desirable accomplishment. The opinion that typical achievement of high school seniors on the Davis Test does not represent a desirable standard to be attained by others is reflected in the following statement which the author of the test made after analyzing the results of administering it to 2523 high school seniors. ". . . it is quite apparent that a relatively overwhelming proportion of these twelfth grade pupils were leaving high school with a very inadequate understanding and command of even the most simple essentials for functional competence in mathematics."[4]

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[4]David John Davis, "A Comparative Study of Achievement Levels of Twelfth Grade Pupils on a Test Designed to Measure Functional Competence in Mathematics" (unpublished Ph.D. dissertation, University of Michigan, 1950), p. 166.

TABLE 2

COMPARISON OF SCORES OF COLLEGE FRESHMEN WITH NORMS

	First Quartile	Median	Third Quartile
College Freshmen	22.3*	29.2	37.9
Norms for High School Seniors (end-of-year)	24.3	33.0	43.0

*All figures in this table are in terms of raw scores. Possible score is 80.

Comparison with Minimum Satisfactory Score

Since it was assumed in this study that the concepts and abilities included on the Check List prepared by the Commission on Post-War Plans were valid essentials for functional competence in mathematics, only those students who answered correctly all or nearly all of the questions on the test can be considered to have attained a desirable level of functional competence in mathematics. It was considered of interest, however, to obtain opinions from a group of selected judges as to what should be considered a minimum satisfactory score on the test. As was indicated in Chapter I, this minimum satisfactory score was arrived at somewhat indirectly. Each member of a selected group of thirteen administrators and thirteen mathematics teachers was asked to indicate independently which items on the

Davis Test he believed were essential as a part of the knowledge of the entering college freshman who would take college work in a variety of general education fields and in a major field not requiring extensive training in mathematics. In Table 3 there is presented a tabulation of the results obtained by determining the total number of items marked essential by each judge. From Table 3 the mean number of items marked essential by the judges was found to be

TABLE 3

NUMBER OF ITEMS ON THE DAVIS TEST CONSIDERED ESSENTIAL BY JUDGES

Number of Items Marked Essential*	Frequency		
	Mathematics Teachers	Administrators	Total
76	1	0	1
75	2	0	2
73	1	0	1
72	2	1	3
71	0	2	2
70	0	1	1
67	2	0	2
66	1	1	2
64	1	0	1
63	1	1	2
60	0	1	1
58	1	0	1
55	0	1	1
53	0	1	1
51	1	0	1
45	0	1	1
44	0	1	1
38	0	1	1
34	0	1	1
Total	13	13	26

*Total number of items on the test is 80.

sixty-two, and this figure was used as the minimum satisfactory score. At this point attention is again called to the earlier mentioned fallacies involved in making use of the mean number of items considered essential by the selected judges as the minimum satisfactory score on the test. In the first place, not all of the judges considered the same items essential, and secondly, a subject may have made the minimum satisfactory score by answering correctly some items considered nonessential by some or most of the judges. In spite of these limitations, the minimum satisfactory score as determined here was used as the best available one with which to compare the scores of the subjects. The reader may wish to return to a consideration of the limitations mentioned here after he reads a later paragraph dealing with some indications of agreement among judges.

The minimum satisfactory score of 62 is in sharp contrast with both the mean, 30.8, and the median, 29.2, for the group of college freshmen. Even Q_3, 37.9, for the group of subjects was 24 points below the minimum satisfactory score. In fact, only 21 or 1.16 per cent of the 1811 college freshmen made a score equal to or greater than the minimum satisfactory score as determined from the opinions of the judges. Furthermore, no judge considered the number of essential items to be as low as the mean or the median for the group of college freshmen, for 34 was the smallest number of items considered essential by any one of the 26 judges. The number of items considered essential by each of the other 25 judges was greater than the third quartile for the group of college freshmen.

The results presented in the last paragraph are more forceful when considered in connection with some indications of agreement among judges. Table 3 shows that the largest number of items marked essential by a mathematics teacher was 76, while 72 was the greatest number of items considered essential by an administrator. The smallest number of items marked essential by a mathematics teacher was 51, and the corresponding number for the administrators was 34. There was a difference of only approximately ten points between the mean number of items considered essential by the administrators and the corresponding mean number for the mathematics teachers. The means were 57.0 and 67.6 respectively.

Additional indications of agreement among judges can be observed from Table 4 which shows the number and percentage of the mathematics teachers, of the administrators, and of the total group of judges marking each test item essential.

From Column 6 of Table 4 it was determined that sixty of the test items were considered essential by 18, approximately 70 per cent, or more of the judges, while only two questions, Items 33 and 42, were considered nonessential by 18 or more of the judges. Only four additional questions, Items 40, 49, 54, and 71, were believed nonessential by as

TABLE 4

SUMMARY OF OPINIONS OF JUDGES CONCERNING ESSENTIAL ITEMS ON THE DAVIS TEST

Item Number	Number and Per Cent of Judges Marking Item Essential					
	Mathematics Teachers		Administrators		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
1	13	100.0	13	100.0	26	100.0
2	12	92.3	12	92.3	24	92.3
3	13	100.0	13	100.0	26	100.0
4	13	100.0	13	100.0	26	100.0
5	12	92.3	13	100.0	25	96.2
6	8	61.5	10	76.9	18	69.2
7	13	100.0	11	84.6	24	92.3
8	12	92.3	9	69.2	21	80.8
9	13	100.0	13	100.0	26	100.0
10	13	100.0	10	76.9	23	88.5
11	10	76.9	10	76.9	20	76.9
12	10	76.9	9	69.2	19	73.1
13	13	100.0	13	100.0	26	100.0
14	13	100.0	12	92.3	25	96.2
15	8	61.5	11	84.6	19	73.1
16	9	69.2	8	61.5	17	65.4
17	11	84.6	12	92.3	23	88.5
18	13	100.0	12	92.3	25	96.2
19	10	76.9	12	92.3	22	84.6
20	7	53.8	11	84.6	18	69.2
21	12	92.3	12	92.3	24	92.3
22	13	100.0	11	84.6	24	92.3
23	11	84.6	11	84.6	22	84.6
24	13	100.0	12	92.3	25	96.2
25	12	92.3	11	84.6	23	88.5
26	12	92.3	12	92.3	24	92.3
27	13	100.0	13	100.0	26	100.0
28	13	100.0	13	100.0	26	100.0
29	13	100.0	9	69.2	22	84.6
30	11	84.6	10	76.9	21	80.8
31	8	61.5	6	46.2	14	53.9
32	8	61.5	6	46.2	14	53.9
33	4	30.8	2	15.4	6	23.1
34	13	100.0	12	92.3	25	96.2
35	13	100.0	13	100.0	26	100.0
36	13	100.0	10	76.9	23	88.5
37	13	100.0	12	92.3	25	96.2
38	11	84.6	6	46.2	17	65.4
39	10	76.9	9	69.2	19	73.1
40	7	53.8	3	23.1	10	38.5

TABLE 4--Continued

Item Number	Mathematics Teachers Number	Mathematics Teachers Per Cent	Administrators Number	Administrators Per Cent	Total Number	Total Per Cent
	Number and Per Cent of Judges Marking Item Essential					
41	11	84.6	7	53.8	18	69.2
42	2	15.4	1	7.7	3	11.5
43	8	61.5	6	46.2	14	53.9
44	11	84.6	10	76.9	21	80.8
45	13	100.0	8	61.5	21	80.8
46	9	69.2	6	46.2	15	57.7
47	11	84.6	9	69.2	20	76.9
48	13	100.0	8	61.5	21	80.8
49	9	69.2	4	30.8	13	50.0
50	9	69.2	5	38.5	14	53.9
51	13	100.0	6	46.2	19	73.1
52	13	100.0	9	69.2	22	84.6
53	10	76.9	5	38.5	15	57.7
54	8	61.5	4	30.8	12	46.2
55	11	84.6	7	53.8	18	69.2
56	13	100.0	7	53.8	20	76.9
57	11	84.6	5	38.5	16	61.5
58	11	84.6	10	76.9	21	80.8
59	13	100.0	12	92.3	25	96.2
60	13	100.0	12	92.3	25	96.2
61	13	100.0	10	76.9	23	88.5
62	11	84.6	11	84.6	22	84.6
63	12	92.3	11	84.6	23	88.5
64	13	100.0	12	92.3	25	96.2
65	13	100.0	12	92.3	25	96.2
66	12	92.3	12	92.3	24	92.3
67	13	100.0	13	100.0	26	100.0
68	9	69.2	5	38.5	14	53.9
69	12	92.3	10	76.9	22	84.6
70	12	92.3	9	69.2	21	80.8
71	10	76.9	2	15.4	12	46.2
72	11	84.6	11	84.6	22	84.6
73	10	76.9	7	53.8	17	65.4
74	11	84.6	8	61.5	19	73.1
75	11	84.6	4	30.8	15	57.7
76	12	92.3	8	61.5	20	76.9
77	9	69.2	7	53.8	16	61.5
78	9	69.2	11	84.6	20	76.9
79	7	53.8	8	61.5	15	57.7
80	8	61.5	10	76.9	18	69.2

many as 13 judges. Hence, a total of only six items were considered nonessential by one-half or more of the judges.

Since the jury used was a group of selected mathematics teachers and administrators rather than a random sample, no conclusions can be drawn concerning possible opinions of a larger population. In spite of this limitation, the calculated decision to use a selected group was made in order to use judges who, in the opinion of the writer and of the committee directing the research, were well prepared and willing to make the necessary judgments, which required time consuming and somewhat difficult work. The advantages accruing from the use of such a select group appeared to outweigh those presented by employment of a random sample because of the relationship of the work of the jury to the thesis problem.

Item Analysis

The first phase of the item analysis was determining the number and percentage of the subjects who answered correctly each item on the Davis Test. The results of this analysis are presented in Table 5, from which it can be seen that the largest per cent of the group of 1811 freshmen answering any item correctly was 84.7 for Item 3, and the smallest per cent was 1.9 for Item 24. It is interesting to note that each of these items deals with an application of arithmetic to a business problem. Item 3, which

TABLE 5

NUMBER AND PER CENT OF 1811 COLLEGE FRESHMEN ANSWERING CORRECTLY EACH ITEM ON THE DAVIS TEST

Item Number	Number of Correct Responses	Per Cent	Item Number	Number of Correct Responses	Per Cent
1	1518	83.8	41	544	30.0
2	1327	73.3	42	374	20.7
3	1534	84.7	43	794	43.8
4	1504	83.0	44	705	38.9
5	1081	59.7	45	444	24.5
6	1250	69.0	46	599	33.1
7	810	44.7	47	846	46.7
8	856	47.3	48	731	40.4
9	1130	62.4	49	674	37.2
10	995	54.9	50	456	25.2
11	1120	61.8	51	430	23.7
12	948	52.3	52	374	20.7
13	993	54.8	53	397	21.9
14	848	46.8	54	408	22.5
15	924	51.0	55	342	18.9
16	481	26.6	56	222	12.3
17	898	49.6	57	169	9.3
18	736	40.6	58	139	7.7
19	1031	56.9	59	1056	58.3
20	855	42.2	60	76	4.2
21	1275	70.4	61	1254	69.2
22	359	19.8	62	773	42.7
23	260	14.4	63	845	46.7
24	35	1.9	64	744	41.1
25	1374	75.9	65	919	50.7
26	978	54.0	66	617	34.1
27	999	55.2	67	720	39.8
28	783	43.2	68	513	28.3
29	593	32.7	69	507	28.0
30	349	19.3	70	460	25.4
31	860	47.5	71	384	21.2
32	391	21.6	72	521	28.8
33	282	15.6	73	308	17.0
34	1451	80.1	74	244	13.3
35	1288	71.1	75	234	12.9
36	1000	55.2	76	176	9.7
37	973	53.7	77	201	11.1
38	835	46.1	78	300	16.6
39	691	38.2	79	95	5.2
40	621	34.3	80	124	6.8

the largest percentage of the students answered correctly, asked what the annual premium is on a $10,000.00 life insurance policy on which the premium rate is $22.85 per $1,000.00.[5] Question 24, which was answered correctly by fewer of the students than any other item, was the following:

> A typewriter can be bought for $60 cash or, on the installment plan, for a $10 down payment and $5 each month for 12 months. If you bought this typewriter on the installment plan, the yearly rate of interest you would pay is most nearly 2%, 6%, 10%, 15%, 40%.[6]

In Table 6 there is shown a frequency distribution of the items on the Davis Test based on the percentage of the college freshmen answering each item correctly. From a study of Table 6 it is apparent that in addition to Item 24, which was mentioned above, six other questions were answered correctly by 10 per cent or less of the subjects. These six questions were Items 57, 58, 60, 76, 79, and 80.[7] In contrast, no questions were answered correctly by more than 85 per cent of the college freshmen, and only four items received correct responses from more than 75 per cent of the group. Furthermore, a total of fifty-seven items were answered correctly by only 50 per cent or less of the

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[5]David John Davis, Davis Test of Functional Competence in Mathematics (Yonkers-on-Hudson, New York: World Book Company, 1951), p. 2.

[6]*Ibid.*, p. 4.

[7]Statements of these and other test items can be found in the appendix where a copy of the Davis Test is included.

TABLE 6

FREQUENCY DISTRIBUTION OF THE ITEMS ON THE DAVIS TEST BASED ON THE PER CENT OF THE COLLEGE FRESHMEN ANSWERING EACH ITEM CORRECTLY*

Per Cent Intervals	Items in Each Class Interval Based on Per Cent of Correct Responses to Each Item
96-100	
91-95	
86-90	
81-85	1, 3, 4
76-80	34
71-75	2, 25, 35
66-70	6, 21, 61
61-65	9, 11
56-60	5, 19, 59
51-55	10, 12, 13, 15, 26, 27, 36, 37
46-50	8, 14, 17, 20, 31, 38, 47, 63, 65
41-45	7, 28, 43, 62, 64
36-40	18, 39, 44, 48, 49, 67
31-35	29, 40, 46, 66
26-30	16, 41, 68, 69, 72
21-25	32, 45, 50, 51, 53, 54, 70, 71
16-20	22, 30, 42, 52, 55, 73, 78
11-15	23, 33, 56, 74, 75, 77
6-10	57, 58, 76, 80
1- 5	24, 60, 79

*This table should be read in the following manner. Between 81 and 85 per cent of the college freshmen answered correctly Item 1, Item 3, and Item 4.

subjects. Hence, of the eighty items there were only twenty-three which received correct responses from more than 50 per cent of the freshmen.

The reader may find it of interest to examine the facts presented in Table 5 and Table 6 in light of the information given in Table 4 concerning the opinions of the selected group of judges as to how essential knowledge of the concept covered in each test item is for the college student. From Column 1 and Column 6 of Table 4 it can be seen that twenty-five of the twenty-six judges considered the most frequently missed question, Number 24, to be essential as a part of the knowledge of the college student, and that exactly the same number of judges believed Item 60, which was in second place for receiving incorrect responses, to be essential.

Additional information as to just which items on the Davis Test were considered most essential by the judges can be obtained from Table 7 in which is shown a frequency distribution of the test items based on the percentage of the judges marking each question essential. From Table 7 it is apparent that all except six of the eighty test items were considered essential by more than 50 per cent of the judges and that fifty-five questions were considered essential by more than 70 per cent of the jury members.

A comparison of Table 7 with Table 6 reveals that among the fifty-seven items answered correctly by only 50

TABLE 7

FREQUENCY DISTRIBUTION OF THE ITEMS ON THE DAVIS TEST BASED ON THE PER CENT OF THE JUDGES MARKING EACH ITEM ESSENTIAL*

Per Cent Intervals	Items in Each Class Interval Based on Per Cent of Judges Marking Each Item Essential
96-100	1, 3, 4, 5, 9, 13, 14, 18, 24, 27, 28, 34, 35, 37, 59, 60, 64, 65, 67
91-95	2, 7, 21, 22, 26, 66
86-90	10, 17, 25, 36, 61, 63
81-85	19, 23, 29, 52, 62, 69, 72
76-80	8, 11, 30, 44, 45, 47, 48, 56, 58, 70, 76, 78
71-75	12, 15, 39, 51, 74
66-70	6, 20, 41, 55, 80
61-65	16, 38, 57, 73, 77
56-60	46, 53, 75, 79
51-55	31, 32, 43, 50, 68
46-50	49, 54, 71
41-45	
36-40	40
31-35	
26-30	
21-25	33
16-20	
11-15	42
6-10	
1- 5	

*This table should be read in the following manner. Between 46 and 50 per cent of the judges marked essential Item 49, Item 54, and Item 71.

per cent or less of the college freshmen there were thirty-three questions which were considered essential by more than 70 per cent of the judges. In terms of number of judges, this means that these thirty-three frequently missed items were each considered essential by 19 or more of the 26 judges. Furthermore, all except six of the fifty-seven items, which were answered correctly by only fifty per cent or less of the subjects, were considered essential by more than fifty per cent of the judges.

In the second phase of the item analysis, the test questions were divided into seventeen groups, each of which contained items which dealt with the same basic mathematical concept, and the mean percentage of the freshmen giving the correct response to the items in the group was computed. Also the mean percentage of the judges marking the items in the group essential was determined. The results of this phase of the item analysis are summarized in Table 8.

Although some of the items required knowledge of more than one of the concepts covered in the test, each item was placed in the group which, in the opinion of the writer, represented the central concept tested by the item. Each item was thus placed in only one group. Some of the groups contained only one or two items, because these questions did not belong in any of the other groups.

The mean percentage of the freshmen giving correct responses to the items in each group ranged from 73.7 to

TABLE 8

SUMMARY OF ITEM ANALYSIS AND OPINIONS OF JUDGES BY GROUPS OF ITEMS

Group Number	Group Title	Item Numbers	Per Cent of Freshmen Giving Correct Response to Each Item	Mean Per Cent of Freshmen Giving Correct Response to Items in Group	Per Cent of Judges Marking Each Item Essential	Mean Per Cent of Judges Marking Items in Group Essential
I	Problems involving finding a per cent of a number	1	83.8		100.0	
		2	73.3	73.7	92.3	98.1
		4	83.0		100.0	
		13	54.8		100.0	
II	Consumer problems involving per cents but also requiring some other knowledge	7	44.7		92.3	
		8	47.3		80.8	
		10	54.9	37.9	88.5	90.8
		18	40.6		96.2	
		24	1.9		96.2	
III	Consumer problems not involving per cents	3	84.7		100.0	
		5	59.7		96.2	
		6	69.0		69.2	
		9	62.4		100.0	
		11	61.8		76.9	
		12	52.3		73.1	
		14	46.8		96.2	
		15	51.0	51.5	73.1	84.1
		16	26.6		65.4	
		17	49.6		88.5	
		19	56.9		84.6	
		20	47.2		69.2	
		21	70.4		92.3	
		22	19.8		92.3	
		23	14.4		84.6	

TABLE 8--Continued

Group Number	Group Title	Item Numbers	Per Cent of Freshmen Giving Correct Response to Each Item	Mean Per Cent of Freshmen Giving Correct Response to Items in Group	Per Cent of Judges Marking Each Item Essential	Mean Per Cent of Judges Marking Items in Group Essential
IV	Reading and interpreting graphs	25	75.9	57.7	88.5	93.6
		26	54.0		92.3	
		28	43.2		100.0	
V	Reading and interpreting tables	27	55.2	32.0	100.0	66.1
		29	32.7		84.6	
		30	19.3		80.8	
		31	47.5		53.9	
		32	21.6		53.9	
		33	15.6		23.1	
VI	Use of formulas	35	71.1	35.6	100.0	73.1
		37	53.7		96.2	
		46	33.1		57.7	
		48	40.4		80.8	
		54	22.5		46.2	
		55	18.9		69.2	
		57	9.3		61.5	
VII	Solution of linear equations	34	80.1	58.1	96.2	88.5
		36	55.2		88.5	
		44	38.9		80.8	
VIII	Basic algebraic simplification	41	30.0	39.4	69.2	62.5
		43	43.8		53.9	
		47	46.7		76.9	
		49	37.2		50.0	

TABLE 8--Continued

Group Number	Group Title	Item Numbers	Per Cent of Freshmen Giving Correct Response to Each Item	Mean Per Cent of Freshmen Giving Correct Response to Items in Group	Per Cent of Judges Marking Each Item Essential	Mean Per Cent of Judges Marking Items in Group Essential
IX	Basic geometric concepts	38	46.1		65.4	
		39	38.2		73.1	
		40	34.3		38.5	
		45	24.5		80.8	
		50	25.2	29.0	53.9	68.9
		51	23.7		73.1	
		52	20.7		84.6	
		53	21.9		57.7	
		56	12.3		76.9	
		62	42.7		84.6	
X	Measurement	63	46.7		88.5	
		66	34.1		92.3	
		71	21.2	24.6	46.2	73.1
		76	9.7		76.9	
		77	11.1		61.5	
XI	Use of approximate numbers	58	7.7		80.8	
		59	58.3		96.2	
		68	28.3	25.5	53.9	75.7
		69	28.0		84.6	
		73	17.0		65.4	
		74	13.5		73.1	

TABLE 8--Continued

Group Number	Group Title	Item Numbers	Per Cent of Freshmen Giving Correct Response to Each Item	Mean Per Cent of Freshmen Giving Correct Response to Items in Group	Per Cent of Judges Marking Each Item Essential	Mean Per Cent of Judges Marking Items in Group Essential
XII	Ratio and proportion	61	69.2		88.5	
		64	41.1		96.2	
		65	50.7	45.9	96.2	93.1
		67	39.8		100.0	
		72	28.8		84.6	
XIII	Estimating answers	70	25.4	19.2	80.8	69.3
		75	12.9		57.7	
XIV	Drawing conclusions	78	16.6	10.9	76.9	67.3
		79	5.2		57.7	
XV	Writing number involving decimal in numerals when given in verbal form	60	4.2	4.2	96.2	96.2
XVI	Finding the median of six test scores	80	6.8	6.8	69.2	69.2
XVII	Knowledge of right triangle definition of trigonometric functions	42	20.7	20.7	11.5	11.5

4.2, but only in Group I was the mean percentage greater than 60, and in only three other groups (III, IV, and VII) did it exceed 50. In twelve groups the mean percentage of the subjects answering correctly was less than 40. Attention is called to the fact that consideration should be given to the percentage of the freshmen answering correctly each item in a group as well as to the mean for the group, because of the effect of extreme cases on the mean and because some very striking deficiencies may be obscured if only the mean is considered. For example, in Group II using only the mean of 37.9 per cent does not point out that Item 24 was answered correctly by only 1.9 per cent of the freshmen.

For all groups of items, except Group XVII which contained only one item, the mean percentage of judges marking the items in the group essential was between 62.5 and 98.1. Reference to Column 6 of Table 8 indicates that within some of the groups there was considerable variation in the percentage of the judges who considered each of the several items essential. For example, in Group V the range is from 23.1 per cent to 100 per cent. Since all of these items deal with reading and interpreting tables it is possible that some of the items were marked nonessential not because the judge thought knowledge of how to read and interpret tables was nonessential but because he thought the material used in the particular table was unimportant and poorly selected. One judge made a comment to that effect in regard to some of the questions testing reading of tables. The same situation perhaps existed with other groups of items.

The data which have been presented and analyzed in this chapter will serve as a basis for drawing conclusions in Chapter III and for making recommendations and discussing further implications in Chapter IV.

CHAPTER III

SUMMARY AND CONCLUSIONS

In this chapter a brief summary of the study will be made and conclusions will be drawn on the basis of the several phases of the investigation. At the close of the chapter, a list of all the conclusions will be presented.

Problem

The purpose of the study was to determine the extent to which there is need for a college-level course in mathematics for general education which has as one of its chief purposes the improvement of functional competence in mathematics and to investigate the nature of the content related to functional competence which should be included in such a course. The term "functional competence in mathematics" as used here meant an understanding of and an ability to use the basic mathematical concepts which are needed in everyday experience by all citizens. The mathematical concepts and abilities which were considered necessary were those included in the Check List of essentials for functional competence in mathematics which was prepared by the Commission on Post-War Plans of the National Council of Teachers of

Mathematics. In order to accomplish the purpose stated above, answers to the following two specific questions were sought.

1. To what extent do freshmen entering selected four-year colleges in Oklahoma have an understanding of and an ability to use the essentials for functional competence in mathematics which were recommended as a part of the general education of all citizens by the Commission on Post-War Plans of the National Council of Teachers of Mathematics?

2. What are the implications of the results obtained in answering the first question as to (a) how great the need is for a college-level general mathematics course which includes work designed to improve functional competence and (b) what mathematical concepts involved in the essentials for functional competence should be included in such a course in mathematics for general education?

Procedure and Results

In order to find an answer to the above questions, the writer had the Davis Test of Functional Competence in Mathematics administered to 1811 entering college freshmen at the six state colleges in Oklahoma in the fall of 1955 and studied the results. Both a statistical treatment of scores and an item analysis were used. The Davis Test was selected because it was constructed to test the concepts covered in the above mentioned Check List.

Since it was assumed in this study that the concepts and abilities included on the Check List were valid essentials of functional competence in mathematics and that the performance of a college freshman on the Davis Test revealed accurately his functional competence in the mathematics covered by the items on the Check List, only those students who answered correctly all or nearly all of the eighty items on the test can be considered to have attained a desirable level of functional competence in mathematics. It was found, however, that the achievement of most of the freshmen was far below this desirable level. In fact, only one of the 1811 students answered correctly as many as seventy of the eighty test questions, while 75 per cent of the students gave correct responses to less than one-half of the test items.

When the scores of the college freshmen were compared with the end-of-year percentile norms for high school seniors, it was found that the performance of the college freshmen was somewhat poorer than that of the high school seniors. However, the data in Table 2 indicated that the performance of both groups was relatively poor in view of the fact that the test was designed to measure concepts and abilities considered necessary for all citizens by a national committee of mathematics teachers.

One possible reason for the consistently poor performance of both the above mentioned groups is that many high school students take only one year of mathematics and relatively few take more than two years. It is a common practice for high school students to take this limited amount of mathematics work during their first and second years of high school. Hence, much of the material has been forgotten by the time the students finish high school. Furthermore, the amount of forgetting may have been increased because mathematical concepts were not made meaningful to students when they were presented. Many high school mathematics teachers do not possess adequate understanding of adolescent learning and behavior or sufficient preparation in subject matter and methods of teaching to be able to teach mathematics so that it is meaningful to pupils. Another possible reason for rather consistently poor performance on the Davis Test is that some of the items deal with situations not covered in the traditional high school mathematics courses except possibly in ninth grade general mathematics.

An additional means of interpreting the test results was obtained by considering the opinions of a group of twenty-six selected mathematics teachers and administrators as to which items on the Davis Test cover knowledge which is essential for the college student who will take a variety of general education courses and a major in a field not requiring specialized training in mathematics. The average number of test items considered essential by the judges was sixty-two. When that figure was considered as a minimum satisfactory score, it was found that only twenty-one or 1.16 per cent of the 1811 college freshmen made a score equal to or greater than the minimum. This last result is all the more revealing when considered in relationship to the fact that the judges agreed in their judgments to the extent that sixty of the eighty test items were marked essential by eighteen, approximately 70 per cent, or more of the judges, while only six items were considered nonessential by one-half or more of the judges.

It is possible that the minimum satisfactory score of sixty-two was somewhat higher than a similarly determined score based on the judgments of a random sample of administrators and mathematics teachers or on opinions of a stratified random sample of teachers from various subject matter fields would have been. It does not follow, however, that such a lower score would have been a better estimate of the minimum satisfactory score on the Davis Test for an entering college freshman. The group of mathematics teachers and administrators used as judges were selected because they were well prepared and experienced persons who were willing to use the necessary time and effort to make careful judgments. Because of their training and positions they were especially well qualified to make judgments which were to be used indirectly in considering the problem of the need for and nature of a college-level course in mathematics for general education which has as one of its chief purposes the improvement of functional competence in mathematics.

In view of the phases of the study summarized above, it is apparent that only a very few of the 1811 entering college freshmen tested had satisfactory understanding of and an ability to use the essentials for functional competence in mathematics which were recommended as a part of the general education of all citizens by the Commission on Post-War Plans of the National Council of Teachers of Mathematics. This situation indicates that there was a need in the six state colleges in Oklahoma in the fall of 1955 for a general mathematics course which included work designed to improve functional competence.

Although the item analysis phase of the study was undertaken in an effort to determine which ones of the mathematical concepts involved in the essentials for functional competence were least well understood and used by the subjects, it also revealed the widespread lack of functional competence in mathematics among the college freshmen tested. Only twenty-three of the eighty items were answered correctly by more than 50 per cent of the subjects, and only four questions received correct responses from more than 75 per cent of the group. The largest per cent of the freshmen answering any item correctly was 84.7 and the smallest per cent was 1.9.

When the eighty test items were grouped according to the basic mathematical concept tested, as shown in Table

8, the mean percentage of the freshmen giving correct responses to the items in each group varied from 73.7 to 4.2. However, in only four groups did the mean percentage of students answering correctly exceed 50, and in only one of these four groups was the mean greater than 60. It should also be noted that if the percentage of the freshmen giving correct responses to each of the items in Groups I, III, IV, and VII, where the mean percentage was greater than fifty, is examined the lack of functional competence in these areas is more evident than it is from consideration of the mean alone. Thus the subjects tested apparently lacked functional competence in each of the areas tested by a group of items, but the deficiency was greater in some phases than in others. It follows then that a college-level course in mathematics for general education which has as one of its chief purposes the improvement of functional competence might well include work on any of the seventeen topics tested, but that greater emphasis is needed in some areas than in others.

In connection with the conclusions stated in the last paragraph, it is of interest to note that the mean percentage of the judges marking the items in each of the seventeen groups essential ranged from 62.5 to 98.1, except for one group which contained only one item.

Upon examination of the thirteen groups of items listed in Table 8 for which the mean percentage of the freshmen giving the correct response was less than fifty, it was possible to draw some conclusions concerning the areas in which there was the greatest lack of functional competence on the part of the subjects tested. Among these thirteen groups of items were three groups (XV, XVI, XVII) which contained only one item each. Because of this very limited testing of the concept involved in each case, no consideration was given to these three groups in the following discussion of areas in which there was the greatest deficiency.

For the ten remaining groups of items the average per cent of the freshmen giving the correct response ranged from 10.9 to 45.9, but the percentage was greater than forty for only one group. The titles of these ten groups were arranged in order according to the average per cent of the subjects giving the correct response with the group having the lowest per cent first, and the result was the following list of the ten topics on which the 1811 freshmen showed the least functional competence.

1. Drawing conclusions.
2. Estimating answers.
3. Measurement.
4. Use of approximate numbers.
5. Basic geometric concepts.
6. Reading and interpreting tables.
7. Use of formulas.
8. Consumer problems involving per cents but also requiring some other knowledge.
9. Basic algebraic simplification.
10. Ratio and proportion.

Since the topics in the above list are rather general, a brief discussion of each one is included here. The two test items[1] dealing with drawing conclusions gave verbal statements of quantitative facts from which conclusions were to be drawn. The questions which required that answers be estimated involved multiplication and division of relatively large numbers and decimal fractions. The ideas concerning measurement which were tested included the meaning of measurement, units of measure, and measuring a line segment. The six test items on the use of approximate numbers dealt with rounding off approximate numbers, tolerance, error of measurement, and computation with approximate numbers. Basic geometric concepts tested included properties of similar triangles, the Pythagorean theorem, meaning of the size of an angle, properties of the equilateral triangle, definition of a regular polygon, area of a triangle, and area of a circle. Test questions on reading and interpreting tables made use of tables dealing with withholding tax, compound interest, roots and powers, and trigonometric functions. Some of the incorrect answers given for these questions may have resulted not from lack of ability to read a table but from lack of knowledge of terms used and ideas expressed in the tables. This may have been especially true of the table dealing with trigonometric functions.

The topic "use of formulas" mentioned in the above list included substituting values into a given formula,

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[1]The exact statement of all test items can be found in the appendix where a copy of the test is included.

writing a formula from a verbal statement, and knowledge of the formula relating time, rate and distance. The consumer problems involving per cents but also requiring some other knowledge dealt with depreciation, taxation, interest, and installment buying. The basic algebraic simplifications included addition, multiplication and division of algebraic monomials involving exponents. The items on ratio and proportion were concerned with the use of ratio and proportion in scale drawings, distances on a map, and division of a quantity in a given ratio.

Conclusions

The specific conclusions drawn from the study may be summarized as follows:

1. Only a very few of the 1811 entering college freshmen tested at the six state colleges in Oklahoma in the fall of 1955 had a satisfactory understanding of and an ability to use the essentials for functional competence in mathematics which were recommended as a part of the general education of all citizens by the Commission on Post-War Plans of the National Council of Teachers of Mathematics.

2. There was a definite need in the six state colleges in Oklahoma in the fall of 1955 for a general mathematics course which included work designed to improve functional competence.

3. The group of entering freshmen tested lacked

functional competence in all areas covered by the test, but they showed greater deficiency in some phases than in others. The ten topics on which greatest lack of competence was shown were (1) drawing conclusions, (2) estimating answers, (3) measurement, (4) use of approximate numbers, (5) basic geometric concepts, (6) reading and interpreting tables, (7) use of formulas, (8) consumer problems involving per cents but also requiring some other knowledge, (9) basic algebraic simplification, and (10) ratio and proportion.

4. A course in mathematics for general education which has as one of its chief purposes the improvement of functional competence might well include work on any of the mathematical concepts covered by the Davis Test, but emphasis should be placed upon the ten topics on which greatest lack of competence was shown.

CHAPTER IV

RECOMMENDATIONS AND FURTHER IMPLICATIONS

In this chapter recommendations will be made on the basis of the conclusions listed at the close of Chapter III. These recommendations will include some concerning a course in mathematics for general education at the six state colleges in Oklahoma and others concerning additional research needed in the area of this study. Also, some further implications of this investigation will be discussed.

Recommendations Concerning a Course in Mathematics for General Education

Providing the course. One of the assumptions made in this study was that it is desirable for a college to provide work in mathematics for general education which is designed to meet the needs of the students in view of limitations of their previous experiences with mathematics. On the basis of this assumption and the conclusion drawn in Chapter III that there was need in the six state colleges in Oklahoma in the fall of 1955 for a general mathematics course which included work designed to improve functional competence, it is recommended that the faculties of the six institutions give careful consideration to the problem of meeting this need. The curricula should be examined to determine whether there are courses included which give freshmen an opportunity to meet their need, as indicated by this study, for improving their functional competence in mathematics. Reference is made here to courses which have as one of their chief purposes the improvement of functional competence in mathematics and not to those which provide some incidental opportunity for this improvement. If such courses are not available in the present curricula, new courses should be designed.

The provision of the type of course mentioned above will do little to improve the college students' functional competence in mathematics unless the course is made a required part of the general education program of all students who need such improvement. Hence, it is recommended that each of the faculties of the six state colleges in Oklahoma give consideration to including in the requirements in the area of general education a mathematics course which provides definite opportunities for improvement of functional competence. It would be desirable to administer the Davis Test of Functional Competence in Mathematics to all entering freshmen to determine those who could profit from such a course. Had this been done in the fall of 1955 a high percentage of the entering freshmen would have demonstrated need for the course.

Developing the course. No effort will be made here to discuss all of the content which might profitably be presented in a college-level course in mathematics for general education which includes work designed to improve functional competence. Some suggestions as to content and organization will be given, but no attempt will be made to present a specific outline for the course. This can be done only after the length of the course, background and needs of the particular students in the class, and available teaching materials are known.

Certainly it would be desirable to determine from testing, conferences, and use of student records as much as possible about the functional competence in mathematics of the students in a given class before making all of the specific plans for the course for that group. However, much of the planning should be done in advance and adapted to the needs of each class.

It is recommended that the course be organized and presented in such a manner as to emphasize the development of understanding of mathematical concepts rather than the improvement of mathematical skills and the memorization of facts. There is some danger that a course of this type may be considered as remedial work which can best be conducted by much drill on topics and processes previously met by the student and again presented from the same viewpoint. In the opinion of the writer, it is doubtful whether such procedures will do much to improve functional competence in mathematics. It is possible to present relatively elementary mathematical concepts from an adult viewpoint in such a way as to include ideas which are new and challenging to the college student.

From the item analysis phase of this study, it appears that the course might well include work on each of the seventeen topics listed in Table 8 but that there is greatest need for consideration of the following topics: (1) drawing conclusions, (2) estimating answers, (3) measurement, (4) use of approximate numbers, (5) basic geometric concepts, (6) reading and interpreting tables, (7) use of formulas, (8) consumer problems involving per cents but also requiring some other knowledge, (9) basic algebraic simplification, and (10) ratio and proportion.

The statement that the above mentioned topics should be included is not meant to imply that each of these topics should be taken up as a separate unit of the course and taught without showing its relationship to other parts of the work. It is recommended that these and other topics to be considered be organized about broad mathematical concepts as a means of unifying and making meaningful the various specific topics. For example, the idea of functional dependence can be used as a unifying concept through which to teach the following ones of the ten topics listed above: reading and interpreting tables, use of formulas, ratio and proportion, and some aspects of drawing conclusions and basic geometric concepts. Another topic from Table 8 which can also be studied best in connection with functional dependence is reading and interpreting graphs. A second broad mathematical concept which might be used as a means of unifying several smaller topics is measurement. Here it is possible to consider not only the meaning of measurement and the use of units of measure, but also use of approximate numbers, estimating answers, use of formulas, and some basic geometric ideas. Other possible broad concepts for use as a means of unifying the various aspects of a course of the type under consideration will occur at once to those interested in developing such material.

The college student whose functional competence in mathematics is weak is inclined to look upon the various specific details of mathematics as entirely independent facts to be remembered. The attention of such a student is likely to be directed completely toward remembering the specific facts rather than to understand the underlying concepts which unify the details. In fact, he is often wholly unaware of the existence of such underlying concepts. In order for any branch of mathematics to be useful to anyone it must be understood as a group of broad basic concepts around which the various details can be arranged in a logical manner. This kind of organization of the ideas in any mathematics course is not likely to be apparent to most students at relatively elementary levels unless emphasis is placed upon the unifying concepts in the teaching process. This is especially likely to be true of the student who has reached college without developing functional competence in basic mathematics. Hence, not only should a course in mathematics for general education which is designed to improve functional competence be organized about broad mathematical concepts, such as the above mentioned example of functional competence, but it should be presented in such a way as to assist the student in developing a clear understanding of such concepts and in seeing that the mathematical details which he already knows and the new ones which he learns are simply aspects of such fundamental ideas. Such a presentation of the course will require careful planning and skillful teaching in terms of the needs of the students in a given class. In fact, successful teaching of the type of course described here will tax the abilities of a well-prepared mathematics teacher and will probably require the employment of some methods of teaching not commonly used in college classrooms as well as extensive use of some of the usual methods. For example, the use of visual materials and other teaching aids will be required very frequently in building up the abstract mathematical concepts, for the college student who still lacks functional competence in mathematics is likely to be one who finds it difficult to understand abstract ideas without first seeing them in concrete form. For the same reason, it will be necessary to draw as many illustrations and problems from the student's own experience as possible in order that the concepts will take on meaning for him.

It should be assumed that the role of the teacher in a general education mathematics course at the college level is indeed significant. He must be willing and eager to accept the challenge which instruction at this level provides for the specialist in terms of meeting the needs of those for whom the course is planned.

One of the factors underlying lack of functional competence in mathematics is that many college students have no real understanding of the fundamental processes of arithmetic. What such a student knows is likely to be some sort of a set of rules which are meaningless and hence quite useless to him. Therefore, it will be necessary in the type of general mathematics course described here to help the student develop an understanding of the basic processes. This cannot be done by giving him extensive drill on the processes on the basis of his previous knowledge of how to carry out such procedures. The aim is not mere skill but understanding. Efforts must be made to make the fundamental processes of addition, subtraction, multiplication, and division with whole numbers, common fractions and decimal fractions meaningful to the student. Many college students have no idea that any relationship exists between addition and multiplication or between multiplication and division while others have no clear concept as to what these relationships are. Until such understandings are developed the student will be unable to use these processes in the solution of his everyday mathematical problems regardless of how meaningful the problems themselves may be to him.

In addition to knowing the meaning of each of the fundamental processes the student needs to develop an understanding of why the algorithms as commonly carried out give correct results. Here the role of place value in the number system is fundamental. Many students cannot correctly perform the fundamental processes with whole numbers and decimal fractions because they do not understand the role of place value in the structure of the number system. Hence, the type of general mathematics course designed to improve functional competence might well begin with a study of the number system. It was mentioned above that some relatively elementary ideas in mathematics can be presented from an adult viewpoint in a college-level general mathematics course. The study of the number system gives an excellent opportunity for such a presentation. Studying the historical development of the number system and learning to use numbers written by the employment of place value but with a base other than ten are ways of introducing useful material which is new to most college students. The advantage of using the number systems with a base other than ten is that the student cannot then depend upon methods which he has previously memorized but does not understand. He must think through the processes for himself.

The study of the number system illustrates a way of achieving with relatively elementary material another aim of a general education course. It is generally believed that a course in mathematics for general education should help the student to develop an appreciation of the role of mathematics in the development of modern civilization. An excellent means toward achieving this objective is offered by the study of the history and structure of the number system. It is difficult to see how anyone who had successfully completed such study could fail to appreciate the number system as one of the truly great inventions of mankind. In a similar manner other relatively elementary material can be used to assist in accomplishing the objective of helping students develop an appreciation and understanding of mathematics.

Recommendations Concerning Needed Research

Various aspects of this study have indicated need for additional research. The following are suggested as needed studies.

1. An investigation of life situations to determine whether the essentials for functional competence in mathematics listed by the Commission on Post-War Plans of

the National Council of Teachers of Mathematics are indeed the mathematical abilities needed by all citizens.

2. A study to determine what score a person should make on the Davis Test in order to indicate that he has satisfactory functional competence in mathematics.

3. The development of other instruments for measuring functional competence in mathematics.

4. Studies to determine the most appropriate content, organization, and methods for use in a college-level course in mathematics for general education designed to improve functional competence.

5. Studies based on the administration of the *Davis Test of Functional Competence in Mathematics* at other colleges and universities in Oklahoma and elsewhere.

6. Investigations of the causes of lack of functional competence in mathematics on the part of high school graduates.

Further Implications

Although this investigation was concerned entirely with a college curriculum problem, certain aspects of the study have some implications in relation to problems at the high school level, especially in connection with needed studies dealing with the high school mathematics program. The data from the present investigation indicate a widespread lack of functional competence in mathematics on the part of 1811 high school graduates who did go on to college. This suggests that it would be of value to study the functional competence in mathematics of high school graduates who did not go to college. Perhaps even more valuable would be studies of the functional competence of all students who are in their last semester of high school work in selected high schools.

Since high school graduates who go on to college are usually considered a select group, the data presented in this study seem to indicate a need for examination of the high school mathematics program to determine whether it is adequate as a means of developing functional competence. If the present high school program is inadequate, then study is needed on methods of improving it. In this connection possible topics for study are: (1) the question of whether all high school students should take general mathematics courses, (2) the need for revision of the traditional high school mathematics courses, (3) the problem of how much mathematics work high school students should be required to take, (4) the determination of the proper grade placement of high school mathematics courses, and (5) the improvement of teaching and learning methods in mathematics.

In connection with the first of the topics listed above it is of interest to note that several of the questions on the Davis Test which were frequently missed by the college freshmen dealt with ideas which are not covered in any high school mathematics work except possibly in ninth grade general mathematics or in other courses such as consumer mathematics which are intended to provide general education in the mathematics area. One such question concerning installment buying was the item most frequently missed by the college freshmen. These facts indicate need for study of possible revisions of the high school mathematics curriculum. It is possible that more students should take general mathematics courses and that additional and improved work of this type should be offered. Another approach to improvement is the possible revision of the traditional mathematics courses in order to make them more functional. Many aspects of the traditional high school courses in algebra and geometry should contribute much to the development of the kind of functional competence in mathematics tested by the Davis Test, but the subject matter and learning methods used in these courses do not always produce a mastery of mathematical concepts which is useful to the student. It should perhaps be noted at this point that there is need for study of possible revisions of the traditional high school mathematics curriculum in order to provide better opportunities for the student who plans to study more advanced mathematics as well as to improve the general education aspects of the program, but that problem will not be discussed here.

The question of how much mathematics the high school student should be required to take in order to meet his general education needs in the mathematics area is another which needs study. Perhaps the assumption that one year of high school mathematics is enough for this purpose is not correct. If that is the case, then efforts must be made to determine what is a more accurate estimate of the amount of time the high school student should spend on the mathematics area of general education. The close relationship between this problem and the development of improved general mathematics courses is obvious.

The determination of proper grade placement of high school mathematics courses cannot be completely separated from the questions discussed above. The suggestion has frequently been made that some provision for mathematics for general education should be made in the senior year of high school either in addition to or in place of earlier courses of this type. It seems reasonable that this procedure would improve the functional competence in mathematics of high school graduates, but studies are needed to determine the extent of such improvement. Such studies as well as investigations of the most advantageous grade placement for other high school mathematics courses could point to needed changes which might very well improve the mathematics background of entering college freshmen, and other high school graduates.

Studies in the area of the improvement of teaching and learning methods in mathematics are also needed. It is important that methods which make mathematical concepts meaningful to students be developed and used, for students will be unable to retain and use ideas which are not meaningful to them. Study in the field of teaching and learning methods at the high school level can best be done by well prepared high school teachers in the form of on-the-job research.

A final implication of the present investigation is the need for cooperative study by teachers of mathematics and administrators in college and in high school on the problem of developing functional competence in mathematics. Efforts should be made to determine the causes for the widespread lack of functional competence in mathematics on the part of college freshmen which was indicated by this study, and consideration should be given to developing improved programs of mathematics for general education in both high school and college.

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APPENDIX

COPY OF LETTER SENT TO JUDGES

Dear Mr.________:

As a part of the research for my doctoral dissertation under the direction of Dr. Glenn R. Snider, Associate Professor of Education, University of Oklahoma, I am attempting to evaluate the functional competence in mathematics of entering freshmen in selected Oklahoma colleges. The evaluation will be limited to consideration of functional competence in the mathematics which is needed by all college students regardless of major field. No attempt will be made to evaluate competence in the wider range of mathematical concepts needed by the person who will major in mathematics, engineering, physical science or other fields requiring relatively extensive training in mathematics. The evaluation will be based upon the results of the *Davis Test of Functional Competence in Mathematics* which was designed to test the twenty-nine mathematical abilities listed as essential for all citizens by the Commission on Post-War Plans of the National Council of Teachers of Mathematics.

In my research it seems desirable to have the opinions of a small group of teachers and administrators as to whether each item on the Davis Test is essential as a part of the knowledge of the college student regardless of major field. I should like to ask you to be one of the judges. Will you please fill in the attached form according to the directions on it and return it to me as soon as possible? I shall appreciate very much your cooperation in this matter.

Sincerely yours,

REPLY FORM

Directions to judges:

You will find attached a copy of the Davis Test of Functional Competence in Mathematics and a manual of directions for the test. Please indicate which items on the test you believe are essential as a part of the knowledge of the college student taking work in a variety of general education fields and in a major field not requiring extensive training in mathematics.

Below are listed the numbers of the eighty test items and after each one the letters E and N. If you believe the concept tested by an item is essential as a part of the knowledge of an entering college freshman in meeting his needs as a citizen and as a college student as described in the preceding paragraph, circle the E. If you believe the item is nonessential for the college student, circle the N. Please note that you are not asked to indicate whether you think the average entering college freshman will be able to answer the item correctly. Instead you are asked to indicate whether you think the concept tested by the item is essential to the freshman in meeting his needs as a college student and as a citizen.

Item Number	Rating		Item Number	Rating		Item Number	Rating	
1	E	N	28	E	N	55	E	N
2	E	N	29	E	N	56	E	N
3	E	N	30	E	N	57	E	N
4	E	N	31	E	N	58	E	N
5	E	N	32	E	N	59	E	N
6	E	N	33	E	N	60	E	N
7	E	N	34	E	N	61	E	N
8	E	N	35	E	N	62	E	N
9	E	N	36	E	N	63	E	N
10	E	N	37	E	N	64	E	N
11	E	N	38	E	N	65	E	N
12	E	N	39	E	N	66	E	N
13	E	N	40	E	N	67	E	N
14	E	N	41	E	N	68	E	N
15	E	N	42	E	N	69	E	N
16	E	N	43	E	N	70	E	N
17	E	N	44	E	N	71	E	N
18	E	N	45	E	N	72	E	N
19	E	N	46	E	N	73	E	N
20	E	N	47	E	N	74	E	N
21	E	N	48	E	N	75	E	N
22	E	N	49	E	N	76	E	N
23	E	N	50	E	N	77	E	N
24	E	N	51	E	N	78	E	N
25	E	N	52	E	N	79	E	N
26	E	N	53	E	N	80	E	N
27	E	N	54	E	N			

EVALUATION AND ADJUSTMENT SERIES

GENERAL EDITOR: WALTER N. DUROST, SCHOOL OF EDUCATION, BOSTON UNIVERSITY

DAVIS TEST OF FUNCTIONAL COMPETENCE IN MATHEMATICS

BY DAVID J. DAVIS

EASTERN ILLINOIS STATE COLLEGE

FORM AM

DIRECTIONS:

Do not open this booklet until you are told to do so.

This is a test of your competence in mathematics. For each question there are five possible answers. You are to work each question and determine which answer is correct. You are *not* expected to be able to answer all the questions. Do not worry if you find a question on something you have not covered in class. You may answer a question even when you are not perfectly sure that your answer is correct, but you should avoid wild guessing. Do not spend too much time on any one question.

Study the sample questions below, and notice how the answers are to be marked on the separate answer sheet.

Sample A. The sum of 10 and 10 is

a. 0
b. 15
c. 17
d. 20
e. 100

For Sample A the answer, of course, is "20," which is answer d. Now look at your answer sheet. At the top of the page in the left-hand column is a box marked SAMPLES. In the five answer spaces after Sample A, a heavy mark has been made filling the space (the pair of dotted lines) marked d.

Sample B. If an airplane travels 1105 miles in 5 hours, what is the average number of miles it travels in one hour?

f. 201 miles
g. 205 miles
h. 221 miles
i. 225 miles
j. none of the above

The correct answer for Sample B is "221 miles," which is answer h; so you would answer Sample B by making a heavy black mark that fills the space under the letter h. Do this now. If the correct answer had not been given, you would have chosen answer j, "none of the above."

Read each question carefully and decide which one of the answers is best. Notice what letter your choice is. Then, on the separate answer sheet, make a heavy black mark in the space under that letter. In marking your answers, always be sure the question number in the test booklet is the same as the question number on the answer sheet. Erase completely any answer you wish to change, and be careful not to make stray marks of any kind on your answer sheet or on your test booklet. When you finish a page, go on to the next page unless you are told to stop. Work as rapidly and as accurately as you can.

This test is divided into two parts. You will do Part I during the first testing period and Part II during the second testing period. You will have 40 minutes working time for each part. It is not necessary for you to stop between Sections A and B in each part.

When you are told to do so, open your booklet to page 2 and begin.

Issued 1951 by World Book Company, Yonkers-on-Hudson, New York, and Chicago, Illinois

PRINTED IN U.S.A. DFCM: AM-2

Part I — Section A

1. Mr. Buchanan has an income of \$250 per month. In his budget he allows 25% of his income for rent. If Mr. Buchanan stays within his budget, what is the most he can pay per month for rent?
   a. \$37.50
   b. \$50.00
   c. \$60.50
   d. \$62.50
   e. none of the above

2. If a real estate agent's commission is 5% of the selling price, what does he receive for selling a house for \$15,000?
   f. \$75.00
   g. \$300.00
   h. \$333.00
   i. \$750.00
   j. none of the above

3. Mr. Jones takes out an ordinary life insurance policy for \$10,000. If the annual premium rate is \$22.85 per \$1000 of insurance, Mr. Jones's annual premium is
   a. \$2285.00
   b. \$229.00
   c. \$228.50
   d. \$22.90
   e. none of the above

4. How much would you have to pay for a suit listed at \$55, if the sales tax is 3%?
   f. \$71.50
   g. \$56.65
   h. \$55.17
   i. \$53.35
   j. none of the above

5. Mr. Johnson's car averages 18 miles per gallon of gasoline. If gasoline costs 26 cents per gallon, how much will the gasoline cost Mr. Johnson for a trip of 549 miles?
   a. \$5.49
   b. \$9.10
   c. \$10.14
   d. \$14.27
   e. none of the above

6. Which of the following statements in regard to taxation is true?
   f. Coöperative sharing of the cost of governmental services is a basic idea in taxation.
   g. The sales tax is determined according to a person's ability to pay.
   h. As a general price level rises, the amount of taxes paid per person tends to decrease.
   i. As the services and functions of the government increase and expand, the amount of taxes paid per person tends to decrease.
   j. People in our country are not taxed for public services and conveniences provided by the government, unless they actually use them.

7. The original value of a house is \$20,000. If this house depreciates $2\frac{1}{2}$% of the original value each year, the value of the house at the end of 8 years will be
   a. \$4000
   b. \$16,000
   c. \$19,600
   d. \$24,000
   e. none of the above

8. If the total assessed valuation of the property in the city of Campbell is \$50,000,000, what tax rate is necessary to raise \$2,000,000 in property taxes?
   f. 25%
   g. 4%
   h. 2.5%
   i. 0.4%
   j. none of the above

9. On September 1, Tom Kelley's bank balance was \$160.40. Deposits made and checks written during the month were as follows:

DATE	DEPOSITS	CHECKS
Sept. 3		\$40.50
Sept. 18	\$150.65	26.35
Sept. 25	65.46	
Sept. 30		38.27

   Tom's bank balance on October 1 was
   a. \$110.99
   b. \$271.39
   c. \$321.23
   d. \$481.63
   e. none of the above

10. Mr. Martin plans to rent a house which he bought for \$8000. He figures his yearly expenses on the house as follows: taxes, \$120; insurance, upkeep, and depreciation, \$220; and loss of interest on money invested in the house, \$200. How much yearly rent must Mr. Martin charge in order to meet these yearly expenses and still receive a 5% yearly return on his \$8000 investment?
   f. \$400
   g. \$580
   h. \$940
   i. \$980
   j. none of the above

11. A purchase of \$6.12 is paid with a ten-dollar bill. The accepted order for the clerk to make and to return the change is
   a. two dimes, 3 nickels, three 1-dollar bills, 3 pennies, 1 half-dollar.
   b. three 1-dollar bills, 1 nickel, 1 quarter, 8 pennies, 1 half-dollar.
   c. three pennies, 1 quarter, 1 half-dollar, 2 nickels, three 1-dollar bills.
   d. three pennies, 1 dime, 1 quarter, 1 half-dollar, three 1-dollar bills.
   e. one half-dollar, 2 nickels, three 1-dollar bills, 1 quarter, 3 pennies.

Go on to the next page.

12. A recipe for 4 servings calls for $3\frac{1}{3}$ cups of skim milk and $\frac{1}{2}$ cup of farina. If there are 16 tablespoons to a cup, how many tablespoons of farina are needed for 1 serving?

f. 1
g. 2
h. 4
i. 8
j. none of the above

13. If a pair of shoes marked \$10.50 is offered at 30% discount, the selling price, without sales tax, is

a. \$3.15
b. \$6.35
c. \$7.15
d. \$7.35
e. none of the above

14. Mr. Jackson wishes to insure his house against loss by fire for \$4000. An insurance company's representative tells him that the cost of a 3-year policy is $2\frac{1}{2}$ times the cost of a 1-year policy. If the rate on a 1-year policy is 42 cents per \$100 of fire insurance, how much would Mr. Jackson save by buying one 3-year policy rather than three 1-year policies?

f. \$8.40
g. \$4.20
h. \$1.05
i. \$0.84
j. none of the above

15. Which of the following statements in regard to insurance is true?

a. A fundamental idea in insurance is coöperative sharing of losses.
b. The use made of a building does not affect the cost of fire insurance on the building.
c. The older the person, the lower the rate that is paid for each \$1000 of life insurance taken out.
d. People living in large cities pay lower premium rates for automobile-liability insurance than do people living in small towns.
e. The rates on an ordinary life insurance policy are higher than the rates on either a 20-payment life or on a 20-year endowment policy.

16. Which of the following investments is probably LEAST safe?

f. 4% mortgage bonds of the Interstate Railroad Company
g. common stock of the Interstate Railroad Company
h. 6% preferred stock of the Interstate Railroad Company
i. 3% bonds of the State of New York
j. $2\frac{1}{2}$% bonds of the United States Treasury

17. Which of the following statements in regard to banking procedure is true?

a. When you pay a bill by check, the "filled-out" stub of that check is your receipt proving the bill has been paid.
b. When you endorse a check, you write your name on the bottom right-hand corner of the check.
c. People open savings accounts at banks because of the convenience offered for paying bills by check.
d. If the monthly statement sent by the bank shows that you still have \$640 in your checking account, but your check stubs show only \$600 remaining, then either you or the bank must have made an error in figuring.
e. A canceled check is one that has been paid by a bank and when returned to you should be kept as a receipt.

18. Mr. Sparrow bought forty \$100 G Bonds of the United States Government. Each bond bears simple interest at 2.5% per annum, the interest being paid semiannually. How much interest does Mr. Sparrow receive every six months from his forty bonds?

f. \$500
g. \$100
h. \$50
i. \$10
j. none of the above

19. Which of the following statements in regard to installment buying is true?

a. The installment price is less than the cash price.
b. The difference between the cash and the installment price is the profit for the seller.
c. The annual rate of interest charged in installment buying is usually about 6%.
d. When you buy on the installment plan, you are actually borrowing the use of money.
e. The down payment in installment buying is usually about 50% of the cash price.

20. Which of the following statements in regard to the budgeting of income is true?

f. It is safer to underestimate than to overestimate your necessary expenses.
g. If your income varies from month to month, it is safer to underestimate than to overestimate your monthly income.
h. If you receive \$200 each month, you will have \$50 each week to budget.
i. People in the lower-income groups should plan to take their yearly fuel, insurance, and emergency expenses from one month's income.
j. A budget will increase your monthly income.

Go on to the next page.

21. Mrs. Healy buys 4 pounds of butter each month. If butter sells for 70 cents and margarine for 26 cents a pound, how much would Mrs. Healy save in a year by buying margarine rather than butter? (Do not consider any tax.)
    - a. $17.60
    - b. $21.12
    - c. $21.60
    - d. $25.92
    - e. none of the above

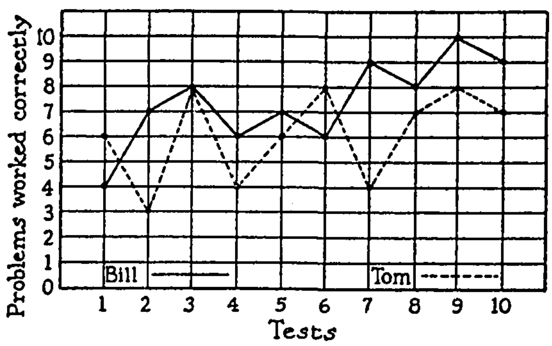
22. The assessed valuation of Mr. Cooper's property is $9500. If the tax rate is 40 mills per dollar, Mr. Cooper's property tax is
    - f. $0.38
    - g. $3.80
    - h. $38.00
    - i. $237.50
    - j. none of the above

23. What is the cost, without tax, of burning five 60-watt lamps for 4 hours each night for 30 nights, if the cost of electricity is 3 cents per kilowatt-hour?
    - a. $10.80
    - b. $3.60
    - c. $1.08
    - d. $0.36
    - e. none of the above

24. A typewriter can be bought for $60 cash or, on the installment plan, for a $10 down payment and $5 each month for 12 months. If you bought this typewriter on the installment plan, the yearly rate of interest you would pay is most nearly
    - f. 2%
    - g. 6%
    - h. 10%
    - i. 15%
    - j. 40%

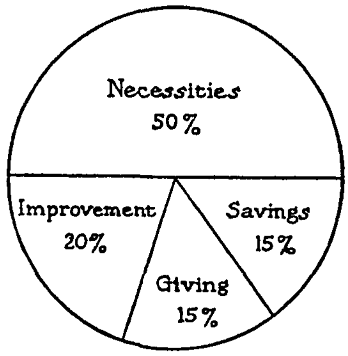
Part I — Section B

TESTS IN ARITHMETIC



25. According to the graph above, on which test was there the greatest difference in the number of problems worked correctly by Tom and Bill?
    - a. 2nd
    - b. 3rd
    - c. 7th
    - d. 10th
    - e. none of the above

TOM'S WEEKLY BUDGET



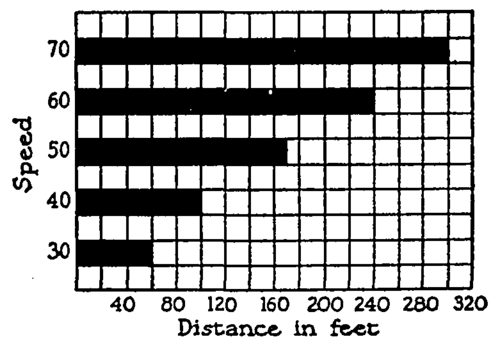
26. After the withholding tax, Tom's weekly wages amount to $42. According to the graph above, how much more money does Tom allow for "Necessities" than for "Savings"?
    - f. $10.50 g. $13.50 h. $14.70
    - i. $15.70 j. none of the above

TAX WITHHELD FROM MONTHLY WAGES

MONTHLY WAGE		NUMBER OF EXEMPTIONS			
AT LEAST	BUT LESS THAN	1	2	3	4
		TAX WITHHELD MONTHLY			
$240	$248	$28.20	$19.90	$11.60	$3.30
248	256	29.30	21.00	12.70	4.40
256	264	30.50	22.20	13.90	5.60
264	272	31.70	23.40	15.10	6.80
272	280	32.90	24.60	16.30	8.00

27. According to the table above, if a married man earns $264 per month and has a wife and 1 child, both entirely dependent upon him, how much is withheld from his monthly wage for income taxes? (NOTE. The taxpayer himself also is an exemption.)
    - a. $23.40 b. $22.20 c. $15.10
    - d. $13.90 e. none of the above

DISTANCES NEEDED TO STOP A CAR AT CERTAIN SPEEDS



28. According to the graph above, how many more feet are needed to stop a car traveling at 70 than at 50 miles per hour?
    - f. 135 g. 130 h. 125
    - i. 120 j. none of the above

AMOUNT OF $1 — INTEREST COMPOUNDED ANNUALLY

YEARS	1%	2%
1	1.010000	1.020000
.	.	.
.	.	.
5	1.051010	1.104081
6	1.061520	1.126162
7	1.072135	1.148686
8	1.082857	1.171659
9	1.093685	1.195093
10	1.104622	1.218994
11	1.115668	1.243374
12	1.126825	1.268242
13	1.138093	1.293607
14	1.149474	1.319479

Question 29 is based on the table above.

29. When Tom was 10 years old, his father put $1000 in a bank to help provide for Tom's future education. If this bank pays 2% interest compounded annually, what is the total amount in the bank, 8 years later, when Tom is ready for college? (Determine your answer to the nearest cent.)
  a. $1218.99
  b. $1171.66
  c. $1104.62
  d. $1082.86
  e. none of the above

ROOTS AND POWERS

NO.	SQUARES	CUBES	SQUARE ROOTS	CUBE ROOTS
51	2601	132,651	7.141	3.708
52	2704	140,608	7.211	3.733
53	2809	148,877	7.280	3.756
54	2916	157,464	7.348	3.780

Questions 30 through 32 are based on the table above.

30. The square root of 5200 is
  f. 7.211 g. 27.04 h. 37.33
  i. 72.11 j. 721.1

31. The cube root of 54 is
  a. 0.3780 b. 3.756 c. 3.780
  d. 157,464 e. none of the above

32. The square root of 53.5 is
  f. 7.284 g. 7.294 h. 7.314
  i. 7.325 j. 7.341

SINES, COSINES, AND TANGENTS

ANGLE	SIN	COS	TAN
45°	.7071	.7071	1.0000
10′	.7092	.7050	1.0058
20′	.7112	.7030	1.0117
30′	.7133	.7009	1.0716
40′	.7153	.6988	1.0235
50′	.7173	.6967	1.0295

Question 33 is based on the table above.

33. Tan 45° 46′ is equal to
  a. 1.0271 b. 1.0266 c. 1.0261
  d. 1.0241 e. none of the above

STOP! Do not go on to the next page. Go back and check your answers.

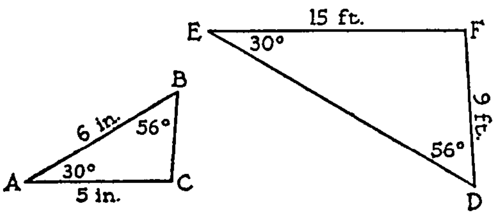
Part II — Section A

34. In the equation $3r + 6 = 12$, the value of r is
a. 1 b. 2 c. 3
d. 4 e. none of the above

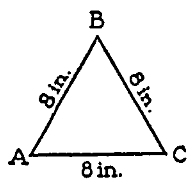
35. How far would you travel in 3 hours and 20 minutes at a speed of 45 miles per hour?
f. 144 miles g. 150 miles h. 157.5 miles
i. 160 miles j. none of the above

36. In the equation $2y + 12 = -5$, the value of y is
a. $3\frac{1}{2}$ b. $-3\frac{1}{2}$ c. -6
d. $-8\frac{1}{2}$ e. none of the above

37. In the formula $I = prt$, if $p = \$1600$, $r = .03\frac{1}{2}$, and $t = \frac{1}{2}$, then I equals
f. \$560 g. \$56 h. \$28
i. \$2.80 j. none of the above



38. Examine the two similar triangles in the figure above. In triangle ABC, the length of side BC is
a. 2 in. b. 3 in. c. 4 in.
d. $4\frac{1}{2}$ in. e. none of the above



39. The size of each angle of triangle ABC in the figure above is
f. 30° g. 40° h. 45°
i. 50° j. none of the above

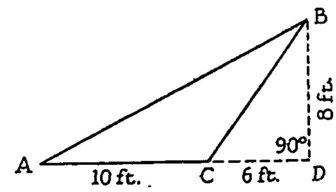
40. In any regular polygon
a. each angle is a right angle.
b. no two sides are equal.
c. there are 4 equal sides and 4 equal angles.
d. the angles are of equal size and the sides of equal length.
e. two and only two sides are parallel.

41. The value of $r^3 + 2r^3$ is equal to
f. $3r^3$ g. $3r^6$ h. $3r^9$
i. $2r^6$ j. $2r^9$

42. At a point 100 feet away, and level with the base of a tree, the angle of elevation of the top of the tree is 32°. The height of the tree is — (Given: $\sin 32° = .53$, $\cos 32° = .85$, $\tan 32° = .62$)
a. 45 ft. b. 53 ft. c. 62 ft.
d. 85 ft. e. none of the above

43. The value of $2x^2 \cdot x^3$ is equal to
f. $4x^6$ g. $4x^5$ h. $3x^6$
i. $2x^6$ j. $2x^5$

44. In the equation $\frac{3m}{4} - 6 = 15$, the value of m is
a. 28 b. 12 c. 9
d. -8 e. none of the above



45. The area of triangle ABC in the figure above is
f. 40 sq. ft. g. 48 sq. ft. h. 64 sq. ft.
i. 80 sq. ft. j. 128 sq. ft.

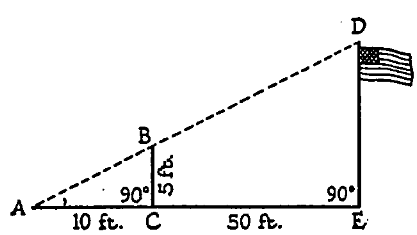
46. In the formula $S = \frac{(h - 2d)}{m}$, if $m = 2$, $h = -6$, and $d = 4$, then S is equal to
a. -7 b. -1 c. $+1$
d. $+7$ e. none of the above

47. The value of $2 \cdot 3^3$ is equal to
f. 12 g. 18 h. 27
i. 54 j. 216

48. In the formula $A = p(1 + rt)$, if $p = \$1000$, $r = 0.02$, and $t = 1\frac{1}{2}$, then A equals
a. \$1003 b. \$1030 c. \$1033
d. \$1300 e. none of the above

49. The value of $\frac{2x^6}{x^2}$ is equal to
f. $2x^4$ g. $2x^3$ h. $(2x)^3$
i. $64x^3$ j. 2^3

50. If two sides of a triangle are 10 inches and 12 inches in length, the third side can NOT have a length of
a. 2 in. b. 3 in. c. 10 in.
d. 12 in. e. 20 in.

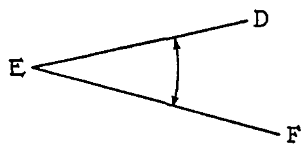


51. Bill used a 5-foot stick, BC, to determine the height of the flagpole DE. By sighting from point A, Bill found the top of the stick in line with the top of the pole. Use the information in the figure above to find the height of the flagpole. This height is
f. 10 ft. g. 20 ft. h. 25 ft.
i. 30 ft. j. none of the above

Go on to the next page.

52. The area of a circle with a diameter of 6.00 feet is most nearly

a. 12.6 sq. ft. b. 18.8 sq. ft. c. 28.3 sq. ft.
d. 37.7 sq. ft. e. 113.0 sq. ft.



53. The size of angle DEF in the figure above depends upon

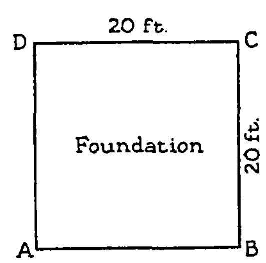
f. the lengths of line segments DE and EF.
g. the distance from D to F.
h. the area enclosed by line segments DE and EF and a straight-line segment drawn from D to F.
i. the amount of rotation of line segment EF around point E necessary to reach the position of line segment ED.
j. none of the above.

54. In the formula $r = \frac{d}{t}$, if the value of d is multiplied by 4 and the value of t is divided by 2, then the value of r is

a. multiplied by 2.
b. divided by 2.
c. multiplied by 8.
d. multiplied by 4.
e. none of the above.

55. How would you express the cost in dollars (d) of any number (n) of gallons of gasoline at c cents a gallon?

f. $d = 100\,cn$ g. $d = \frac{cn}{100}$ h. $d = \frac{c}{n}$
i. $d = \frac{c}{100} + n$ j. none of the above



56. Two carpenters are checking to make sure the foundation $ABCD$ in the figure above is square. They measure the diagonal distances AC and BD. If the foundation is a square, each diagonal distance will be

a. $\sqrt{40}$ ft. b. $\sqrt{400}$ ft. c. 25 ft.
d. 30 ft. e. $\sqrt{800}$ ft.

57. How would you express the fact that the cost in cents (C) of sending a package of n lb. by parcel post is 10¢ for the first pound and 2¢ for each additional pound?

f. $C = 10 + 2n$ g. $C = 10n + 2$
h. $C = 10 + 2n - 1$ i. $C = 10 + 2(n + 1)$
j. none of the above

Part II — Section B

58. When you multiply the *approximate numbers* 4.3 ft. and 6.9 ft., your answer should be expressed as

a. 29 sq. ft. b. 29.6 sq. ft. c. 29.67 sq. ft.
d. 29.7 sq. ft. e. 30 sq. ft.

59. The number 688,546 expressed correctly to the nearest thousand is

f. 688,500 g. 689,000 h. 690,000
i. 700,000 j. none of the above

60. The number *two hundred and forty-seven thousandths* when written in figures is

a. 247,000 b. 20,047 c. 0.247
d. 0.0247 e. none of the above

61. If the length of a metal plate for a machine is 12 feet long, what will be its length on a blueprint which uses the scale $\frac{1}{8}$ inch = 1 foot?

f. $1\frac{1}{8}$ in. g. $1\frac{1}{4}$ in. h. $1\frac{1}{2}$ in.
i. $1\frac{3}{4}$ in. j. none of the above

62. A reasonable estimate of the size of the angle in the figure above is — (Do not use a protractor.)

a. 30° b. 60° c. 120°
d. 150° e. 200°

63. How many square inches are there in 10 square feet?

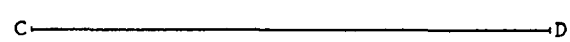
f. 120 g. 1200 h. 1440
i. 1728 j. none of the above

64. The ratio of 2 pints to 3 quarts is

a. $\frac{1}{6}$ b. $\frac{1}{3}$ c. $\frac{2}{3}$
d. $\frac{3}{2}$ e. none of the above

65. If $2\frac{1}{2}$ inches on a map represents 150 miles, what distance does $3\frac{3}{4}$ inches on the map represent?

f. 280 miles g. 250 miles h. 244 miles
i. 225 miles j. none of the above



66. The length of line segment CD in the figure above, to the nearest $\frac{1}{16}$ inch, is — (Use ruler.)

a. $2\frac{12}{16}$ in. b. $2\frac{13}{16}$ in. c. $2\frac{14}{16}$ in.
d. $2\frac{15}{16}$ in. e. none of the above

67. If \$120 is divided between Ralph and Jack in the ratio of 1 to 3, Ralph will receive

f. \$30 g. \$33.33 h. \$40
i. \$45 j. none of the above

68. If $6\frac{5}{16}$ inches is a measurement correct to the nearest $\frac{1}{16}$ inch, the largest possible error is

a. $\pm\frac{1}{4}$ in. b. $\pm\frac{1}{8}$ in. c. $\pm\frac{1}{16}$ in.
d. $\pm\frac{1}{32}$ in. e. none of the above

69. The number 0.00996 expressed correctly to the nearest ten-thousandth is

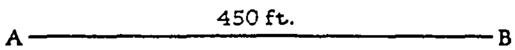
f. 0.0010 g. 0.0090 h. 0.0101
i. 0.0110 j. none of the above

70. A reasonable estimate of the value of $\frac{19,975}{498,590}$ is — (Determine your estimate without use of pencil.)

a. 0.4 b. 0.04 c. 0.004
d. 0.0004 e. 0.00004

71. If 1 inch = 25.4 millimeters, how many centimeters are there in 1 inch?

f. 254 g. 12.7 h. 2.54
i. 0.254 j. none of the above



72. If line segment AB in the figure above represents 450 feet, the scale used as 1 inch equals — (Use ruler.)

a. 215 ft. b. 200 ft. c. 190 ft.
d. 180 ft. e. 175 ft.

73. The basic length of a bolt to be made is $2\frac{1}{4}$ inches. If a tolerance of $\pm\frac{1}{32}$ inch is allowed, which of the lengths of finished bolts below is acceptable?

f. $2\frac{1}{8}$ in. g. $2\frac{3}{16}$ in. h. $2\frac{6}{32}$ in.
i. $2\frac{17}{64}$ in. j. $2\frac{19}{64}$ in.

74. Before adding the *approximate numbers* 25.5 inches, 6.49 inches, 7.049 inches, and 2.0473 inches, round off to the LEAST precise number. The sum is

a. 41.1 in. b. 41.09 in. c. 41.0863 in.
d. 41.086 in. e. 41.0 in.

75. A reasonable estimate of the value of $\frac{0.0504 \times 402}{0.403}$ is — (Determine your estimate without use of pencil.)

f. 0.005 g. 0.05 h. 0.5
i. 5 j. 50

76. How many cubic feet are there in 27 cubic yards?

a. 3 b. 9 c. 243
d. 729 e. none of the above

77. Which one of the following statements is true?

f. No measurement can be made without error.
g. Some measurements, only, can be made without error.
h. If standard units are used, any measurement can be made without error.
i. When scientists speak of exact numbers, they refer to measured values like 3 ft. or 20 in., which come out even.
j. When the carefully measured values of b and h are substituted in the formula $A = \frac{1}{2}bh$, the value of A is exact.

78. A school superintendent in a certain city, basing his information on present enrollment figures and school records for previous years, issued the following statements:

(1) There are 1200 pupils in our high school today.
(2) Sixty per cent of these pupils will graduate from high school.
(3) Twenty per cent of those who graduate from high school will go to college.
(4) One out of three who go to college will graduate.

If the information above is true and is the only information you have, which one of the following statements is a logical conclusion to make?

a. Two hundred forty of these pupils will go to college.
b. A majority of people in this city do not believe in higher education.
c. Four hundred of these pupils will graduate from college.
d. Less than sixty per cent of these pupils may graduate from high school.
e. One hundred forty-four of these pupils will go to college.

79. One hundred boys spent 30 days at camp. At the end of this time the camp director published the following facts on the milk consumed per boy for the entire 30 days: mean, 28 quarts; median, 29 quarts; mode, 30 quarts. On the basis of the above information, which one of the following statements is true?

f. More of the 100 boys drank 30 quarts of milk than drank 28 quarts.
g. The 100 boys drank a total of 2900 quarts of milk.
h. More information is needed to determine the total number of quarts of milk drunk by the 100 boys.
i. The median tells how many quarts of milk each boy drank.
j. A majority of the 100 boys each drank only 28 quarts of milk.

80. On six tests, Mary receives the following marks: 30, 74, 76, 78, 82, and 86. The median of these marks is

a. 71 b. 75 c. 77
d. 78 e. 80

Go back and check your answers on Part II.

EVALUATION AND ADJUSTMENT SERIES

GENERAL EDITOR: WALTER N. DUROST, SCHOOL OF EDUCATION, BOSTON UNIVERSITY

DAVIS TEST OF FUNCTIONAL COMPETENCE IN MATHEMATICS

BY DAVID J. DAVIS

EASTERN ILLINOIS STATE COLLEGE

MANUAL OF DIRECTIONS

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NATURE AND CONTENT

The *Davis Test of Functional Competence in Mathematics* has been constructed to measure mathematical competence, as defined below, in Grades 9 through 12. There are two comparable forms, AM and BM, each comprising 80 test items carefully selected on the basis of curricular validity and satisfaction of statistical requirements.

The time required for administration of the test is two class periods. Test booklets are non-expendable, all student responses being recorded on separate answer sheets. The answer sheets may be scored easily either by hand or by machine.

The test is based on the essentials for functional competence in mathematics as outlined by the Commission on Post-War Plans of the National Council of Teachers of Mathematics. The different sections of the test measure specifically the following areas:

Part I.	Section A.	Consumer Problems (Questions 1–24)
	Section B.	Graphs and Tables (Questions 25–33)
Part II.	Section A.	Symbolism, Equations, etc. (Questions 34–57)
	Section B.	Ratio, Tolerance, etc. (Questions 58–80)

The *Davis Test of Functional Competence in Mathematics* is one of the tests in the *Evaluation and Adjustment Series* of high school tests.

The achievement tests in this series cover a variety of subjects in the fields of mathematics, science, social studies, and the language arts. Each test in the series contributes toward a complete, integrated evaluation program for secondary schools. These tests are designed specifically to evaluate the outcomes of instruction in the various subjects as they are being taught in the typical schools of our country.

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Among the objectives measured are the following:

1. Can the student operate effectively with whole numbers, common fractions, decimals, and per cents?
2. Can he solve simple verbal problems in arithmetic, algebra, geometry, and trigonometry?
3. Can he estimate an answer before he does the actual computation?
4. Does he know the arithmetic useful in personal affairs, home, and community?
5. Is he mathematically conditioned for satisfactory adjustment to a first job in business?
6. Does he have a basis for dealing intelligently with the main problems of the consumer?
7. Can he use letters to represent numbers; i.e., does he understand the symbolism of algebra?
8. Can he solve simple equations?
9. Is he skillful in the use of tables?
10. Does he know how to use rounded numbers?
11. Does he have a clear understanding of ratio?
12. Can he analyze given facts or assumptions and draw valid conclusions from those assumptions?
13. Does he understand the meaning of similar triangles, and does he know how to use the fact that in similar triangles the ratios of corresponding sides are equal?
14. Does he know the meaning of a measurement, of a standard unit, of the largest possible error, of tolerance, and of the phrase "a measurement is an approximation"?
15. Can he use a ruler?
16. Can he use the 3–4–5 relationship in a right triangle?

DEVELOPMENT OF THE TEST

The *Davis Test of Functional Competence in Mathematics,* like the other tests in the *Evaluation and Adjustment Series,* was constructed and validated according to rigid standards.

The procedures followed in selecting the content of this test to measure important outcomes consisted of (1) determining in the soundest manner possible the objectives to be measured; (2) determining the proper emphases and weights to be assigned to the various objectives; (3) deciding upon suitable methods of measuring these objectives; and (4) developing test items calculated to furnish the desired measurements.

The items were constructed only after a thorough analysis of varied instructional materials and authoritative pronouncements in the mathematics field. Most elements measured may be justified both in terms of frequency of inclusion in commonly used textbooks and on the basis of expert judgment as to importance.

In determining the objectives and content of this test the following sources were utilized:

1. "The First Report of the Commission on Post-War Plans." *The Mathematics Teacher,* 37: 226–232; 1944.
2. "The Second Report of the Commission on Post-War Plans." *The Mathematics Teacher,* 38: 195–221; 1945.
3. "Guidance Report of the Commission on Post-War Plans." *The Mathematics Teacher,* 40: 315–339; 1947.
4. The Commission on Secondary School Curriculum of the Progressive Education Association. *Mathematics in General Education.* New York: D. Appleton-Century Company, Inc., 1940. Pages xiv + 423.
5. The Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics. *The Place of Mathematics in Secondary Education.* Fifteenth Yearbook of the National Council of Teachers of Mathematics. New York: Bureau of Publications, Teachers College, Columbia University, 1940. Pages xvi + 253.
6. The National Committee on Mathematical Requirements. *The Reorganization of Mathematics in Secondary Education.* Boston: Houghton Mifflin Company, 1923. Pages x + 652.
7. National Committee Report. "Essential Mathematics for Minimum Army Needs," *The Mathematics Teacher,* XXXVI (October, 1943), 243–82.
8. National Committee Report. "Pre-Induction Courses in Mathematics," *The Mathematics Teacher,* XXXVI (March, 1943), 114–24.
9. Representative textbooks, tests, and curricula.

Initial tryout. After the curriculum research outlined in the preceding paragraphs had been completed, two experimental forms of the *Davis Test of Functional Competence in Mathematics* were developed. Each preliminary form of the test comprised 90 items. These experimental forms were administered near the close of school in 1949 to approximately 4500 students in Grades 9, 10, 11, and 12 from 13 high schools in 5 states. Their mean IQ's, according to results on the *Terman-McNemar Test of Mental Ability* given at the same time as the experimental forms, were 105 for Grade 9, 104 for Grade 10, 107 for Grade 11, and 109 for grade 12.

Construction of final forms. The results of the preliminary tryout were analyzed during the summer of 1949. Difficulty and validity indices [1] were computed for each item in the test. The mean validity index of the test items in Form AM is .39 for Grade 9, and .46 for Grade 12; and in Form BM, .39 for Grade 9, and .47 for Grade 12. Difficulty values for each item are given in Table 1. On the basis of these difficulty and validity data, items were selected in such fashion as to yield two final forms of the test precisely balanced in difficulty, of suitable range of difficulty, and composed of items known to be of significant discriminating power.

In selecting material for the final forms of the test, consideration was given not only to the statistical evidences of suitable difficulty and validity, but also to the construction of a test which, from a content standpoint, would correspond to the original outline or blueprint and which would, therefore, represent a balanced coverage of objectives.

[1] Difficulty values for each item were computed by averaging the per cent passing each item in the upper and lower 27 per cent of the item-analysis population. Validity indices are approximations of the item-total score correlation obtained from the upper-lower 27 per cent groups by means of the Flanagan table.

All teachers who administered the preliminary forms in this initial experimentation were asked to criticize these forms, particularly with respect to coverage of topics, clarity of questions, difficulty of the materials, adequacy of directions, etc. Thus, in effect, the test was subjected to the critical review of many classroom teachers prior to publication; these criticisms have been taken into account in developing the final forms of the test.

RELIABILITY AND EQUIVALENCE OF FORMS

For a proper evaluation of a test it is necessary to have relevant information pertaining to the stability, or consistency, of the test scores, and to the degree of comparability among the forms. Such information for the *Davis Test of Functional Competence in Mathematics* is given below.

Reliability. Table 2 gives corrected split-half reliability coefficients for the *Davis Test of Functional Competence in Mathematics.* Inasmuch as this test is essentially a power test, these reliability coefficients may be regarded as good estimates of the reliability of the instrument itself. The median of eight interform correlations was .85. (N's = 71 to 120.)

TABLE 1. ITEM-DIFFICULTY VALUES

Item No.	Form AM		Form BM		Item No.	Form AM		Form BM	
	9	12	9	12		9	12	9	12
1	77	90	62	69	41	35	49	30	44
2	71	79	62	69	42	28	33	18	46
3	66	81	61	69	43	45	46	37	48
4	65	73	56	69	44	35	47	26	45
5	63	75	42	53	45	26	38	34	40
6	44	62	50	52	46	31	40	44	42
7	47	67	48	63	47	32	43	31	42
8	44	54	49	58	48	28	46	28	39
9	44	51	47	57	49	29	39	23	41
10	36	57	42	60	50	18	36	28	39
11	34	59	36	55	51	17	35	19	33
12	39	53	37	50	52	16	32	24	39
13	43	51	39	54	53	16	31	19	30
14	35	45	34	57	54	26	30	18	30
15	28	44	32	41	55	20	21	16	27
16	35	41	34	44	56	11	28	11	16
17	31	39	31	45	57	10	18	11	24
18	25	38	30	45	58	56	65	51	62
19	22	35	23	36	59	53	70	40	55
20	24	38	28	33	60	39	45	48	61
21	27	42	23	35	61	42	41	38	50
22	18	20	18	23	62	36	43	38	53
23	17	24	12	11	63	36	45	30	45
24	2	4	8	4	64	26	34	32	42
25	49	65	44	61	65	28	26	22	30
26	38	43	31	48	66	30	25	34	29
27	31	58	34	43	67	28	32	26	38
28	30	47	26	30	68	25	34	26	29
29	8	7	8	12	69	24	29	22	30
30	41	54	14	34	70	20	27	15	34
31	10	12	12	15	71	25	34	19	25
32	17	30	11	17	72	22	15	19	25
33	11	19	19	31	73	15	26	21	22
34	65	70	62	66	74	17	18	15	18
35	55	67	55	59	75	16	16	16	24
36	51	59	45	60	76	13	15	15	21
37	51	55	44	59	77	19	20	11	19
38	34	54	48	52	78	12	14	13	20
39	32	46	22	49	79	11	6	15	14
40	23	45	42	48	80	6	2	10	8
					Mean Diff.	31	40	30	40

TABLE 2. CORRECTED SPLIT-HALF RELIABILITY DATA

r	N	Grade	Community
.81	176	9	Kennewick, Washington
.81	158	9	Wickford and Harrisville, R. I.
.86	116	10	Kennewick, Washington
.86	130	10	Wickford and Harrisville, R. I.
.91	106	11	Kennewick and Granger, Wash.
.87	112	11	Charleston, S. C., and Scottdale, Pa.
.90	106	12	Wickford and Harrisville, R. I., and Scottdale, Pa.
.90	200	12	Union City, New Jersey, and Kennewick, Washington

It is somewhat difficult even for the statistically trained user of tests to interpret the practical significance of a reliability coefficient in terms of the fluctuation in the test results of an individual student that may be expected from one testing to another. For this reason it is often more meaningful to use the *standard error of measurement,*[1] which is an estimate of the amount by which an individual's obtained score is likely to vary from his "true" score. The standard error of measurement is more meaningful, also, because it is less a function of the variability of the group on which it is based and is more comparable from test to test than is the reliability coefficient. The standard error of measurement on the *Davis Test of Functional Competence in Mathematics* is 5.9 standard score points for Grade 9 and 4.9 for Grade 12. At Grade 12 this means that there are two chances in three that an individual's score on the test does not differ by more than 4.9 points from his hypothetical "true" score.

It is necessary to keep constantly in mind the fact that the obtained score on this test, as on any test, is not an absolutely accurate measure of an individual's achievement, but that it involves certain measurement errors, the approximate magnitude of which is suggested by the standard error of measurement. It is especially important that this concept of measurement error be given consideration in connection with the interpretation of differences between scores of any two tests.

[1] S.E. Meas. = $\sigma_1\sqrt{1 - r_{11}}$ when σ_1 = S.D. of total score and r_{11} is corrected split-half reliability coefficient.

Equivalence of forms. Forms AM and BM are comparable in content in the sense that their respective items cover in approximately equal proportions the various aspects of the subject with which the test is concerned. In both forms there is approximately the same amount of emphasis devoted to any given aspect of the subject. The forms are, moreover, of equal difficulty. On the basis of item-difficulty values derived in the initial tryout of the materials, items were allocated to the final forms in such a manner as to result in two forms precisely balanced not only with respect to average difficulty, but also with respect to distribution of item difficulties. Furthermore, the items in the two forms were balanced with respect to validity indices.

As an additional check on the equivalence of forms, a study was undertaken involving the administration of both forms of the test in a rotation-type experiment. A randomly determined half of the group took Form AM first; the other half, Form BM first. Comparison of the distributions of scores of the two forms for the groups tested indicated that the two forms are almost directly comparable at all points along the scale, even in terms of raw score.

Thus, any differences found between results of administration of the two forms are accurate reflections of changes that have taken place from one administration to the other, within the limits of the reliability of the test, and are not consequences of any systematic differences between the forms.

GENERAL DIRECTIONS TO THE EXAMINER

This test may be given by the regular classroom teacher, without any extensive previous training. Students may be tested in the usual instructional groups or in larger groups if sufficient proctors are provided. Before attempting to administer this test the examiner should become thoroughly familiar with the directions governing its administration. The usual physical standards for good test administration — e.g., lighting, desk space, quiet, etc. — should be met.

Time schedule. This test is to be given in two periods. The actual working time which must be allotted to each period is 40 minutes. To the working time of the first testing period must be added approximately 10 minutes for the examiner to distribute and collect testing materials, for the students to fill in the identifying information on the answer sheet, and for the examiner to give the directions. Testing periods should be so arranged that the full working time is available.

Materials needed by each student. Each student taking the test will need a copy of the test booklet, a copy of the separate answer sheet, scratch paper, two soft-lead pencils, and an eraser. If the answer sheets are to be scored by machine, a special electrographic pencil must be furnished to each student.

SPECIFIC DIRECTIONS FOR ADMINISTERING

FIRST TESTING PERIOD

Be sure that each student has two soft-lead pencils, scratch paper, and an eraser, and that the desks are cleared of all other materials.

If the students are not familiar with the use of separate answer sheets, and particularly if the tests are to be scored on an International Business Machines Scoring Machine, the students should have special practice in marking their answers before they start on this test.[1] *The special practice answer sheets should be inspected to be certain that each student is making one glossy black response for each item. The blackened area should not extend either above or below the pair of dotted lines, but it may extend approximately* $\frac{1}{16}$ *inch to either side. Two up-and-down strokes over each other usually are adequate.*

Begin the specific instruction period for this test by saying: **"You will now be given your materials for the *Davis Test of Functional Competence in Mathematics.*"**

Give each student an answer sheet and say: **"Now fill in your name and the other information called for on the left-hand side of the answer sheet. Be sure to fill in all the information accurately. The date of testing is . . . . ."** (Give the date.) **"Be sure to record your birth date — the year, month, and day of your birth. Now look farther to the right. It says, 'FORM OF TEST AM, BM (CIRCLE ONE).' Now put a circle around . . .** (whichever form is used)."

Allow sufficient time for each student to fill in the required data. When all information has been filled in on the answer sheet, say: **"I am now going to distribute the test booklets. Do not open them. You are not to make any marks whatever on these test booklets."** (Pass out the test booklets.) Then say: **"Now study the directions on the cover page of the test booklet."**

If tests are to be scored by the International Business Machines Scoring Machine, the following additional directions should be read:

"Your papers are going to be scored by an electrical scoring machine. If your papers are to be scored fairly, it is essential that you remember the following rules: (1) Use only the special pencil. (2) Make heavy black marks as long as the pairs of lines on the answer sheet by moving your pencil up and down several times. (3) Do not make any stray marks. (4) Do not mark more than one answer for a question. (5) Erase carefully any answer you wish to change. Failure to follow these instructions is apt to reduce your score as read by the machine."

[1] IBM Form ITS 1100–S288, "General Directions to Pupils Using Special Answer Sheets for Machine-Scored Tests," can be obtained through the nearest IBM branch office; or the Division of Test Research and Service, World Book Company, will provide suggested practice materials, which may be adapted and mimeographed locally.

While the students are reading the directions, move about the room in order to make sure that everyone knows how to handle the answer sheet and has marked the samples correctly. When this has been done, say: **"Are there any questions about how you are to take the test? No questions will be answered after the examination starts."** (Allow time for questions.)

Then say: **"This test is in two parts. You will do only Part I at this time. You will have 40 minutes in which to complete it. Part I ends on page 5, so when you finish page 5, do not go on to page 6, but go back and check your answers. When you have finished checking your answers, put your answer sheet inside the test booklet so that your name on the answer sheet will show when the test booklet is closed, and leave it on your desk until you are given further instructions. Remember, do not make any marks on your test booklet. Now open your test booklet and fold it so that only page 2 is showing. Always keep the booklet folded so that you have only one page in front of you at a time. Start work now."** (Record time in hours and minutes on the blackboard.)

During the testing period, move quietly about the room, making sure that the students are marking the answer sheets properly.

At the end of 40 minutes, say: **"Stop! Close your booklets."**

Collect the test booklets, answer sheets, electrographic pencils (if furnished), and used scratch paper. Count booklets and answer sheets to make sure that all are returned.

Second Testing Period

Be sure that each student has two soft-lead pencils, scratch paper, a ruler, and an eraser, and that the desks are cleared of all other materials.

Then say: **"You are going to take Part II of the *Davis Test of Functional Competence in Mathematics.* Do not open your booklet or remove your answer sheet from it until I tell you to."**

Hand back the test booklets and answer sheets to the students by name. Be sure that each student gets his own booklet and that he does not open it until told to do so.

Then say: **"Remove your answer sheet from the test booklet. You will record your answers for Part II on the answer sheet in the same manner as you did for Part I. Are there any questions about how or where to mark the answers? No questions will be answered after the examination starts."** (Allow time for questions.)

Then say: **"Part II begins at the top of page 6 and ends on page 8. You will have 40 minutes to complete this part of the test. When you finish checking your answers, close your booklet, and leave it on your desk until you are given further instructions. Do not go back to Part I at any time and do not make any marks on your test booklet. Now open your test booklet to page 6, fold it so that only page 6 is showing, and start working on the problems in Part II."** (Record time in hours and minutes on the blackboard.)

During the testing period, move quietly about the room, making sure that the students are marking the answer sheets properly and that they do not go back to Part I of the test.

At the end of 40 minutes, say: **"Stop! Close your booklets."**

Collect the test booklets, answer sheets, electrographic pencils (if furnished), and used scratch paper. Count booklets and answer sheets to make sure that all are returned.

DIRECTIONS FOR SCORING

The score on this test is the number of right answers.

Hand scoring. Hand scoring is accomplished accurately and rapidly by means of a perforated stencil type of scoring key. To score an answer sheet by hand, proceed as follows:

1. Scan each answer sheet and, with a colored pencil, draw a line through any row of spaces in which more than one answer has been marked by the student. Count multiple-marked items as omitted. Do not count multiple-marked items as right even though the right answer is one of those marked.
2. Place the scoring key over the answer sheet so that the heavy black arrows in the center of the answer sheet show through the openings on the key and the arrows on the answer sheet and those on the key are point to point, thus: →←. Adjust the key, if necessary, with a slight rotary motion so that the answer spaces on the answer sheet show through the openings on the key.
3. To obtain the score on the test, count the number of marks appearing through the holes punched in the stencil. This is the number right, or *raw score,* for this test. Encircle the standard score corresponding to this raw score in the table at the left margin of the answer sheet, like this example for a student whose raw score on Form AM of a test is 21:

20	21	22	23
149	151	152	154

Machine scoring. It is assumed that all persons attempting to score this test by means of the International Test Scoring Machine will have familiarized themselves thoroughly with the scoring techniques described in the various International Business Machines publications, particularly as they concern the manipulation of the machine itself.

The same stencil which serves as the hand-scoring key may be used as the machine-scoring stencil.

To insure satisfactory accuracy in scoring, the following steps are suggested:

1. Be sure that the machine is properly adjusted according to IBM directions.
2. Scan each answer sheet carefully, completely erasing all double-marked items and stray marks, no matter how slight, which fall within the sensing spaces. Darken all faint marks with an electrographic pencil. If answer sheets are badly marked, it frequently is easier to score them by hand than to scan and clean them.
3. Punch field holes in the spaces indicated by black circles at the top and bottom of the key.

Note which form is encircled on the answer sheet and make sure that the proper machine-scoring key is used. Then, with the master switch on field A, the A formula switch in the RIGHTS position, and the B and C formula switches in any position but A, read the raw score (number right) on the RIGHTS circuit of the A field. Locate this raw score in the raw score-standard score table. The numbers which appear below the raw score are the corresponding standard scores for Forms AM and BM. Draw a circle around or otherwise mark the appropriate standard score.

The percentile rank corresponding to the student's standard score is obtained from Table 3. This percentile rank may be recorded in the box provided on the answer sheet, and on the Class Record.

INTERPRETATION OF RESULTS

Raw scores on most tests are in themselves of but limited significance. They do permit an objective ranking of students in accordance with achievement status, but for maximum significance of results it is necessary that there be some basis for comparison and interpretation of the scores. In the case of this test meaningful interpretation of scores is made possible by standard scores and percentile norms. The nature and uses of these two types of interpretative scores are described below.

Standard scores. Raw scores on the *Davis Test of Functional Competence in Mathematics,* as on all the tests in the *Evaluation and Adjustment Series,* are converted to a scale of normalized standard scores. These standard scores have the property of constituting a scale of more nearly equal units than do the raw scores and are, hence, better suited to the measurement of growth. They have the further great advantage of representing a uniform mode of interpretation for all tests in the series. The standard scores for all tests in the series are comparable in the sense of being derived according to a uniform method, relating them all to scores on the *Terman-McNemar Test of Mental Ability.* The raw scores on the *Davis Test of Functional Competence in Mathematics* are converted to standard scores having a mean of 112 and a standard deviation of 13.5, these values having been chosen because they represented the median and standard deviation, respectively, of the distribution of *Terman-McNemar* standard scores of the students in the Grade 10 mathematics test standardization population.

Percentile norms. Expression of scores in terms of percentile norms is the most common mode of interpretation of test results at the secondary level. Table 3 presents middle and end-of-year percentile norms by grade corresponding to standard scores on the *Davis Test of Functional Competence in Mathematics.* The percentile rank corresponding to a given standard score indicates the per cent of the national normative group which had scores equal to or less than a given standard score. The relative standing of a student in various tests in the *Evaluation and Adjustment Series* may be compared in terms of his percentile rank in the several tests; but such comparison suffers from the fact that the percentile scale is not a scale of equal units, and from the more serious limitation that the standardization populations for the various tests differ in ability level one from another.

Standardization. The *Davis Test of Functional Competence in Mathematics* is one of eleven tests in the *Evaluation and Adjustment Series* standardized in the spring of 1950 in a comprehensive national standardization program. This test was administered to 1464 Grade 9, 1179 Grade 10, 1136 Grade 11, and 1371 Grade 12 students in 31 schools representing 19 states throughout the country.

It is now generally recognized that it is practically impossible to demonstrate that any normative group is truly representative of a hypothetical national school population. At best the test author and publisher can only present data on certain characteristics of the normative group which are known to be related to achievement; this information permits the test user to compare his own students with the normative group with respect to these characteristics. Two such characteristics which may be defined easily are age and intelligence. The median chronological ages of the students on whom this test was standardized are: Grade 9, 15 yrs.–2 mos.; Grade 10, 16 yrs.; Grade 11, 17 yrs.; and Grade 12, 17 yrs.–11 mos. Their median IQ's on the *Terman-McNemar Test of Mental Ability* are 100, 102, 103, and 105, respectively. If a teacher or an administrator knows that his school deviates appreciably from the normative group in average ability or in age-for-grade, he should, of course, take account of such deviations when interpreting results for the school.

All tests in the standardization program were administered by the classroom teacher or the principal; all scoring was checked and the statistical work and analysis of results were done by the Division of Test Research and Service.

TABLE 3. MIDDLE AND END-OF-YEAR PERCENTILE NORMS FOR TOTAL SCHOOL POPULATION BY GRADE

Standard Score	Percentile Rank							
	Gr. 9		Gr. 10		Gr. 11		Gr. 12	
	Mid.	End	Mid.	End	Mid.	End	Mid.	End
156+								99+
156							99+	99
155						99+	99	99
154						99	99	99
153						99	98	98
152						99	98	98
151					99+	99	98	98
150					99	99	98	97
149					99	98	97	97
147				99+	98	98	97	96
146				99	98	98	97	96
145				99	98	97	96	95
144			99+	99	98	97	96	95
143			99	99	98	97	95	94
142			99	99	97	96	94	93
141		99+	99	99	97	95	93	92
140		99	98	98	96	95	93	91
139		99	98	98	96	94	92	90
138		99	98	97	95	93	91	89
137	99+	99	98	97	94	92	90	88
136	99	99	97	96	93	91	88	86
135	99	98	97	96	93	90	87	85
134	99	98	96	95	92	89	86	83
133	99	97	95	94	91	88	84	81
132	99	97	95	93	89	86	83	80
131	98	96	94	92	88	85	81	78
130	98	95	92	90	86	83	79	75
129	98	95	92	89	85	81	77	73
128	98	94	90	87	83	79	75	71
126	95	92	89	86	81	77	73	69
125	95	91	87	84	79	75	70	66
124	94	90	86	82	77	73	68	64
123	93	88	83	79	74	70	65	61
122	91	86	81	77	72	68	63	58
121	89	84	79	74	69	65	60	56
120	87	82	77	72	67	63	58	53
119	86	80	74	69	64	60	55	50
118	83	77	71	66	61	57	52	47
116	82	75	68	62	58	54	49	44
115	79	72	65	59	54	50	45	41
114	76	69	62	55	51	47	42	38
112	74	66	58	51	47	44	39	35
111	70	62	54	47	43	40	36	33
110	67	59	51	43	40	37	33	30
108	63	55	47	40	37	34	30	27
107	59	51	43	36	33	31	27	24
105	53	46	39	32	29	27	24	21
104	48	41	34	28	26	24	21	18
102	44	37	30	24	22	20	17	15
101	38	32	26	21	19	18	15	13
100	32	27	22	18	16	15	13	11
98	27	23	19	15	13	12	10	9
96	23	19	15	12	11	10	8	7
94	18	15	12	9	8	8	7	6
92	15	12	9	7	7	7	6	5
90	13	10	7	5	5	5	4	4
88	9	7	5	4	4	4	3	3
87	6	5	4	3	3	3	2	2
85	5	4	3	2	3	3	2	2
83	4	3	2	2	2	2	1	1
81	3	2	1	1	1	1	1	1
79	1	1	1	1	1	1	1	1

USING THE TEST RESULTS

Some of the uses which may be made of the results on the *Davis Test of Functional Competence in Mathematics* are described below.

Evaluating individual achievement. The primary function of this test is to provide a valid, objective measure of achievement in mathematics for the individual student. This measure of the student's accomplishment permits the teacher to determine how well the student has succeeded in mastering those objectives set forth by the Commission on Post-War Plans of the National Council of Teachers of Mathematics which are covered by the test. The percentile rank corresponding to the score tells the teacher how the student compares with the normative group of other students throughout the country.

The concept of "evaluating" a student's achievement implies more than a mere measurement of status. It suggests an appraisal of his performance, presumably in relation to his ability, and a judgment as to whether or not his achievement is in line with what may be expected from him in light of his ability. The standard scores for the *Davis Test of Functional Competence in Mathematics* are such as to permit ready comparison of achievement with mental maturity level, since the scores have been equated to standard scores derived from the *Terman-McNemar Test of Mental Ability.*[1] Thus, a direct comparison of the student's standard score on the test with his *Terman-McNemar* standard score will indicate the direction and extent of the difference between his ability and achievement in this field. There has also been prepared an expectancy table indicating the level of achievement on the *Davis Test of Functional Competence in Mathematics* associated with varying levels of ability for a random sample of students in the normative group.

Individual guidance. Every achievement test result which is obtained for a student during his school career has significance not only as a measure of what he has accomplished, but also as a predictor of what he is likely to do in the future, particularly in closely related fields. Thus, results on the test reasonably may be assumed to be prognostic of success in later work in the field of mathematics.

Evaluating group achievement. The *Davis Test of Functional Competence in Mathematics* may be administered at any time during the school year to determine the student's general level of functional competence in mathematics. The results of administration of this test will reveal the extent to which those mathematical skills and abilities considered necessary for effective living in a modern world have been acquired. Consequently, it is appropriate for use as an evaluation instrument in

[1] Similar comparisons may also be made with results from the *Otis Quick-Scoring Mental Ability Test: Gamma,* and the *Pintner General Ability Test: Advanced,* by means of tables of comparable scores on these three intelligence tests available upon application to World Book Company.

life and consumer mathematics courses. The test, however, is not designed as a diagnostic instrument; it does not furnish analytical measures of the individual student's mastery of various aspects of the subject. The interested teacher can make effective use of the results in the analysis of the achievement of a whole class, looking toward the improvement of instruction.

The first step in the study of performance of the class as a whole is, of course, the determination of the average standing of the class on the test which, like the results for an individual student, may be evaluated in relation to the ability level of the class. Beyond this simple appraisal of achievement as a whole, however, it will be profitable to make a question-by-question study of the results for the class. This may be done by determining the number of students who answered each question correctly, converting these values to per cents of the class passing each question (which are really local difficulty values), and then comparing these local difficulty values with the item-difficulty values reported in Table 1. The teacher can determine for each question whether the class is achieving as high a level of success as the students on whom the item-difficulty values are based. By grouping the questions according to topic, perhaps in accordance with the outline given on page 1 of this Manual, and summarizing the item values for each topic, the teacher can determine which topics, if any, seem to be mastered less well by the local group than by the typical students.

Information on the topics or areas in which students are relatively weak will prompt the teacher to give thought either to devoting greater time to the topics in question, or to revising the instructional program in some other appropriate way. It is possible, of course, that the teacher will conclude that the areas in which the students do not do well are not particularly important and that no change in the instructional program need be made. The important thing, in either case, is that the teacher's attention has been focused on objective evidence as to relative mastery of various topics.