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A Study of Certain Factors Involved in the Mathematical Competence of High School Pupils

Madeleine Hixon Randle

Mathematical Competence of High School Pupils — Randle

A STUDY OF CERTAIN FACTORS INVOLVED IN THE MATHEMATICAL COMPETENCE OF HIGH SCHOOL PUPILS

By

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CHAPTER I

INTRODUCTION

When a larger percentage of high school age population began attending school after 1900, the mathematics courses began receiving a great deal of criticism because so many pupils were failing. Various schemes and plans of meeting the needs of the new high school population were tried. New courses were offered, sometimes the old ones were "watered-down" and revised until the whole secondary school mathematics curriculum was in a state of flux. Despite the efforts of leaders in the teaching of mathematics, very little agreement was attained concerning the appropriate content of the mathematics curriculum during the first forty years of the nineteenth century. Mathematics courses were designed for the college preparatory pupil and there seemed to be little concern with functional mathematics for the general public.

World War II changed all this. Suddenly there was a great need for millions of technically trained workers. Industries and the armed forces found the greatest deficiency in trying to train men and women was their ignorance in mathematics. This stirred interest in mathematics throughout the nation. Various committees were

appointed and met to discuss the situation and attempt to do something constructive about it. One of these committees, appointed by the National Council of Mathematics Teachers, published several preliminary reports.

In 1947 the Post War Commission of the National Council of Mathematics Teachers published a list of twenty-nine items that were purported to be the minimum requirements for functional competence in mathematics for high school graduates. Shortly thereafter, Davis[1] developed the Davis Test of Functional Competence in Mathematics. This test was devised to test the twenty-nine items listed by the Post-War Commission.

I. THE PROBLEM

Statement of the problem. The purpose of this study is three-fold:

(1) to discover the degree to which high school pupils, the majority of whom are in their terminal year of high school mathematics, are functionally competent in the subject as determined by their achievement on the

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[1] David J. Davis, Davis Test of Functional Competence in Mathematics, Manual of Directions (New York: The World Book Company, 1951), p. 1

Davis Test of Functional Competence in Mathematics.

(2) to ascertain to what degree pupils manifesting mathematical competency are dependent on such factors as intelligence, mathematical aptitude, and ability in arithmetic as measured by results obtained on certain tests purporting to measure those factors.

(3) to discover the relationship between the degree of competency in mathematics as measured by the Davis test and the marks made by the pupils in high school mathematics courses.

Delimitation of the problem. This study will be delimited to:

(1) competence in mathematics as measured by the Davis test.

(2) a sampling of pupils in Grades 10-12, in certain mathematics courses, in a certain high school.

Importance of the problem. Today the technical world in which people find themselves demands a much greater knowledge of mathematics and science than ever before. Young

people need to be prepared to live in a technological society. One subject that offers much to aid the layman in understanding the world is mathematics.

Educators need to know how much mathematics the students are learning in school today and what factors influence their learning. If there is found to be a definite relationship between mathematical competence and certain other characteristics, then this study should be helpful in enabling teachers to plan better for teaching mathematics.

II. DEFINITIONS OF TERMS USED

Practical Mathematics. "Practical mathematics" is used in this report to refer to a course in general mathematics. It is a course designed primarily to give the pupil an over-all picture of high school mathematics and to increase his proficiency in those phases of arithmetic he will need most in everyday life.

III. ORGANIZATION OF THE REMAINDER OF THE STUDY

Chapter II. Review of Related Literature. This chapter is devoted to a brief history and background of the teaching of mathematics in the United States high schools and the situations that led Davis to develop his

test. Also included are studies related to more or less specific aspects of the present investigation.

Chapter III. Method of Conducting the Study. This chapter describes the tests used, why they were chosen, and how and to whom they were administered.

Chapter IV. Analysis of the Data. Chapter IV presents certain relationships between the tests and shows the significance of the results.

Chapter V. The last chapter summarizes the results, draws conclusions from them, and makes certain appropriate recommendations.

CHAPTER II

HISTORY OF MATHEMATICS TEACHING AND RELATED STUDIES

Somewhere in the dark past man felt the need to answer the question of "How many?" From this question, perhaps felt rather than actually voiced, developed the number systems that grew out of man's endeavor to count. It is interesting to note that with very few exceptions man developed number systems on the base of ten. There may have been a rather obvious reason, since one still finds high school pupils using their fingers in calculating. Even those number systems that had bases other than ten, such as twenty or sixty, used some number divisible by ten. However, some primitive people never learned to count beyond two. Higher numbers were grouped under such words as "bunch."

It was a great step forward when man reached a stage at which he could begin to ask "How much?" and conceive what it meant. This necessitated the beginning of abstract thinking, since in order to determine "how much or how far," objects must be compared to some base of reference. This holds true whether people are dealing

in weights, lengths, monetary values, size, or other measurements. Many early measures used conveniently handy reference points of mensuration. Early weights still common today that illustrate this point are the grain, the stone, the foot, and the hand.

Early civilizations seem to have developed a rather high form of empirical mathematics by the time they left any written records. Until recently very little was known about mathematics in ancient Babylonia, but discoveries since 1920 have added much to man's knowledge about the high state of development there.[2] The Babylonians had an efficient number system. They were quite adept at working algebra, even to extracting roots but never made use of them. They also had developed very efficient methods of lending money and charging interest. Some of their methods would make finance loans today seem almost amateurish. All this was flourishing some 2000 years B. C. or earlier.

The Egyptians are usually given credit for having started geometry. Certainly they were forced to develop rather early in their civilization a fairly accurate method of surveying land in order to redistribute the

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[2] E. T. Bell, The Development of Mathematics (New York: McGraw-Hill Book Company, 1945), p. 7

farms after every inundation of the Nile. These methods incorporated into actual practice many of the theoretical ideas that are studied in geometry today. For example, they knew that a 3-4-5 unit side triangle was a good way of getting a right angle. They were also fairly good astronomers, and had developed a very efficient calendar. A papyrus by Ahmes[3] translated in recent times shows that the Egyptians had some knowledge of algebraic manipulations.

The early Greeks seem to have obtained their mathematics from the East. The Greeks had a natural affinity for philosophy. As a result of this they easily became more interested in the false science of numerology that could be used to explain the working of the universe than in the more precise algebra of the Babylonians. The Greeks did incorporate geometry into their philosophy because it is a method of thinking that they could appreciate.

Pythagoras and Thales developed the idea of the need of deductive proof in mathematics. Thales demanded that mathematical statements must be proved based on certain assumptions and definitions and thus made mathematics an

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[3] E. T. Bell, Men of Mathematics (New York: Simon and Schuster, 1945), p. 10

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exact science. When the great university was founded at Alexandria, Euclid, one of the leading mathematicians of his time, was brought there to teach. Here he wrote his famous book, The Elements, which was actually a compilation of the knowledge in plane and solid geometry, algebra, and the science of numbers that had been developed to that time. He set down synthetic proof very much as it is still taught in schools today. Many of his proofs are recognized as unsound and the average tenth grade geometry pupil can give a better proof of many theorems than Euclid did. His book has probably had as much impact on modern school mathematics as any other single work.

The greatest mathematician of Greece was Archimedes. He not only did work in numbers and geometry, but founded the whole science of hydrostatics. He anticipated the developments of Descartes and Newton.

After the death of Archimedes, mathematics suffered a great decline in the western world. The Romans were never mathematicians. They did keep the little arithmetic that was necessary to carry on trade, building, and their method of warfare, but chose to concentrate their efforts on law rather than science. After the fall of the Roman

Empire, mathematics as a science all but disappeared from the western world.

The early Moslem conquerors destroyed the books in the University of Alexandria on the theory that the Koran contained all that was necessary for a man to learn or to know. However, after the Moslems had secured their great holdings, they began to assimilate some of the culture of their conquered. They began to translate all the early mathematical works they could find. They also turned to the Hindus in India and from them obtained more recent concepts in algebra. Western culture is indebted to the Moslems for four things: (1) from them were received the characters used in writing numbers; (2) they conceived the idea of zero and passed it on to the present day civilization; (3) they not only gave numbers value, but made that value dependent on position; and (4) they preserved and passed on the learnings in mathematics of earlier civilizations.

The Crusaders may have failed in their avowed purposes, but they were instrumental in reviving learning in Western Europe. From the books obtained by them, the schools of Europe began to learn of the progress made in mathematics by previous civilizations. However, from 1200 to 1600, very little actual development took place.

Earlier works were copied and commented upon, but not much original research was done. With the advent of the seventeenth century, mathematics began to show possibilities of becoming the queen of sciences. Descartes developed his analytical or co-ordinate geometry. Newton and Liebnitz followed by inventing the Calculus almost simultaneously to aid them in the research they were doing. Other mathematicians apparently stimulated by all this development, began contributing much to the field. Gauss, who lived and did his work in the nineteenth century, contributed much to the fundamental knowledge in the fields of algebra and arithmetic.

In colonial America no mathematics was required to enter the colleges. The only mathematics offered was arithmetic and geometry in the last year of college. Algebra seems to have been introduced into the college curriculum at the beginning of the eighteenth century. However there seemed to be no distinct separation of subjects for some time.

Arithmetic, algebra and geometry gradually moved down in the college curriculum and finally by the beginning of the nineteenth century became entrance requirements.

When algebra and geometry first became secondary school subjects, they were taught in the junior and senior years, but were gradually moved downward until algebra was a ninth grade subject, geometry a tenth, and arithmetic was delegated to the elementary school. After algebra and geometry became college entrance requirements, the colleges prescribed the contents of the courses and sometimes even the textbooks. These were usually ones that had been written by college professors for college students.[4]

In 1893 the Committee of Ten recommended that algebra, geometry, and arithmetic be taught in a series of correlated courses rather than as separate compartmentalized subjects. This is noteworthy as the first general effort to improve the quality and nature of the mathematics curriculum in the United States. The suggestions made by the Committee were given some trial, but the traditional sequence remained the most popular.[5]

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[4] Clarence McCormick, The Teaching of General Mathematics in the Secondary Schools of the United States (Teachers College Contributions to Education, No. 386. New York: Teachers College, Columbia University, 1929), p. 12

[5] Ibid., p. 14

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The twentieth century brought many new problems to the schools. Originally the only pupils who attended secondary schools were those preparing for college. These were a rather select group representing less than 5 per cent of the population. However, as states passed compulsory attendance laws, more and more pupils began attending the secondary schools. There was not only a great influx of pupils, but a change in the make-up of the high school population. Instead of having only superior students, the high school began to contain a cross section of the population in general. This meant that eventually as many as 25 per cent of the high school pupils could be classed as slow learners.

Mathematics and Latin became the most controversial subjects in the high school curriculum since they were responsible for more failures than any of the other subjects. Latin was dropped from the curriculum, or became an elective. Mathematics remained in the curriculum, but even today there is still debate as to its proper place in the curriculum, what courses should be offered, how they should be taught, and how much mathematics should be required of pupils. According to E. L. Thorndike, it takes an I Q

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of about 110 to master algebra adequately.[6] Small wonder then that many demanded that mathematics be abolished as a high school graduation requirement.

Most secondary schools continued to offer algebra and geometry. Some tried to meet the needs of the slower pupils by means of watered-down courses or some form of arithmetic on a secondary level.

During World War I a committee was appointed to make a study of the movement for reform in the teaching of mathematics. Their report was published in 1923[7] and seemed to give some impetus to curricula changes.

This report distinguished three classes of aims that the teaching of mathematics should serve:

A. Practical aims

1. The immediate and undisputed utility of the fundamental processes of arithmetic

(a) An increase in the pupil's understanding of the fundamental operations and power to apply them.

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6 Mary A. Potter, "Mathematics for the Lower Fifty Per Cent," Mathematics in the Secondary Schools Today (Washington, D. C.: The National Association of Secondary School Principals, 1954), pp. 98-99

7 A Report by the National Committee on Mathematical Requirements, The Reorganization of Mathematics in Secondary Education (New York: The Mathematical Association of America, Inc., 1923), pp. 23-25

(b) Ability to compute from approximate data

(c) Self reliance in handling and checking numerical work

2. An understanding of the language of algebra

3. An ability to use and understand the fundamental laws of algebra

4. Ability to understand and interpret correctly graphic representations

5. Familiarity with geometric forms

B. Disciplinary aims

1. The acquisition of those ideas or concepts in terms of which the quantitative thinking of the world is done

2. The ability to think clearly in terms of such ideas and concepts

(a) Analysis of a complex situation into simpler parts

(b) The recognition of logical relations between interdependent factors

(c) Generalization

3. The acquisition of mental habits and attitudes which will make the above training effective in the life of the individual

4. The idea of relationship or dependence

C. Cultural aims

1. Appreciation of beauty in the geometrical forms of nature, art, and industry

2. Ideals of perfection as to logical structure, precision of statement, and of thought, logical reasoning, discrimination between the true and the false

3. Appreciation of the power of mathematics

The Committee recognized the junior high school movement by planning courses of study for Grades seven, eight, and nine.

> The course for these three years should be planned as unit with the purpose of giving each pupil the most valuable mathematical training he is capable of receiving in those years, with little reference to courses which he may or may not take in succeeding years.[8]

They also worked out courses of study for the three upper grades. In fact the Committee offered four different possibilities in arrangement of materials in each of the two groups. In each of the sequences there was an attempt made to present the material in a psychological sequence rather than in the logical sequence handed down from the universities.

In spite of the work done by this Committee and the recommendations made by it, mathematics sank further in esteem during the 1920's and 1930's. Many schools no longer required it for graduation. In some schools, special

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[8] Ibid., p. 14

courses in shop mathematics or business mathematics or general mathematics were offered. However, the textbooks were poor and the results on the whole were inadequate. The traditional schools retained algebra and geometry.

In 1940 the Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics[9] published their report. It listed approximately fifty aims and objectives of a mathematical curriculum.

These aims were listed under seven headings which were divided into many sub-topics. These seven were:

1. Number and computation
2. Geometric form and space perception
3. Graphic representation
4. Elementary analysis
5. Logical or "straight" thinking
6. Relational thinking
7. Symbolic representation and thinking

In this report the Joint Commission offered a double track program, starting with the seventh grade. This was

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supposed to help take care of the individual differences between the slow learners and the bright learners.

They still recommended correlated courses from Grades seven to twelve. Instead of offering compartmentalized mathematics each year, they suggested an offering of arithmetic, algebra, geometry, and trigonometry that was practical and understandable for each of the six years.

With the advent of the second World War, there was a great need for technicians skilled in the use of basic mathematics. It was found that the schools had turned out a generation of Americans deficient in this field. Even the army found its recruits too lacking in mathematics to be good soldiers without further schooling.

Educators became alarmed and began to realize that there was need for a better mathematics program. Young people also began to ask for additional mathematics as they found more was needed in the technical world of the 1940's.

Again a commission was appointed to make suggestions. After several preliminary reports, the Commission on Post War Plans published their findings in 1947.[10]

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10 "The Guidance Report of the Commission on Post War Plans," The Mathematics Teacher, 40:315-37, October, 1947.

This report was in the form of a guidance pamphlet and listed what the Commission considered the minimum requirements for functional competence in mathematics in the world today.

The twenty-nine requirements are as follows:

1. Computation. Can you add, subtract, multiply, and divide effectively with whole numbers, common fractions and decimals?

2. Per cents. Can you use per cents 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 off 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 measurement. Do you know the meaning of measurement, of a standard unit of 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, 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. Constructions. 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 into 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 vectors and can you find the resultant of two forces?

18. Metric system. Do you know how to use 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 relationship between yard and foot, inch and centimeter?

20. Algebraic symbolism. Can you use letters to represent numbers? Do you understand the symbolism of algebra--do you know the meaning of exponent and co-efficient?

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, triangles the ratio of corresponding sides are equal? Can you manage a proportion?

26. Trigonometry. Do you know the meaning of tangent, sine, consine? 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 the adequate protection against the numerous hazards of life, the wise management of money, and buying with a given income so as to get food values as regards both quantity and quality?

29. Proceeding from hypothesis to conclusion. Can you analyze a statement in a newspaper and determine whether the suggested conclusions really follow from the given facts or assumptions?

The main difference between these aims and the earlier ones is that these seem much more practical in meeting the needs of daily life while placing due emphasis on the theoretical aspects of mathematics. They have come to be the most authorative statement of the objectives of mathematics at the secondary level.

David J. Davis used this list of minimum requirements in developing the Davis Test of Functional Competence in Mathematics. This test is the basis of this study and has been used in several other studies involving secondary school pupils.

Betty Ruth Mosley[11] used the Davis Test of Functional Competence in her master's thesis at the University of New Mexico. This study was conducted during

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[11] Betty Ruth Mosley, "A Study of the Methods and Conditions of Mathematical Teaching in New Mexico High Schools" (unpublished Master's thesis, The University of New Mexico, 1953), pp. 5-6

the school year 1951-1953 in which she sent a questionnaire to 105 public schools in the state. The questionnaire covered the methods used in teaching, reviewing, and testing mathematics in the school; the size, length of class periods, and number of classes per teacher; the experience and education of each teacher. She also administered the Davis Test of Functional Competence in Mathematics to the seniors in five high schools in the state. She selected these schools so as to be representative in both size and geographical location of the schools of the state. School A had an enrollment of more than five hundred pupils; School B had between two hundred and five hundred pupils; School C and School D both had less than two hundred pupils; School E had approximately two hundred pupils.

The conclusions that she drew from her study were:

1. New Mexico schools are far below the national level of functional competence in mathematics.

2. The composite picture of high school mathematics in the state gives evidence of the low status of this subject.

3. With respect to the administrative factors, the number of mathematics courses offered in most high schools is insufficient, and the teaching load too heavy in some schools. The larger schools have better mathematical programs.

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2. The composite picture of high school mathematics in the state gives evidence of the low status of this subject.

3. With respect to the administrative factors, the number of mathematics courses offered in most high schools is insufficient, and the teaching load too heavy in some schools. The larger schools have better mathematical programs.

4. With respect to the teaching practices, many inferior methods are being used especially in regard to drill, review, life applications, differentiated assignments, presentation of subject matter, and individual guidance.

5. With respect to the teaching factors, a significant number of teachers are inadequately prepared in the field of mathematics. A majority of the teachers meet the recommendations in the field of education and teaching experience.[12]

As a result of her study, Mosley recommended that (1) the mathematics curriculum should be expanded, especially in the smaller schools; (2) the teaching load be reduced; (3) certain teaching procedures such as drill, review, and preparation for the assignment be improved; (4) differentiated assignments and life applications of mathematical problems be used more frequently; (5) the lecture and recitation method be replaced by projects, laboratory, and socialized discussion; (6) the mathematics standards should be raised in all schools; (7) pupils with mathematical ability be encouraged to continue in this field; (8) a large number of mathematics teachers should have more training in mathematics; and (9) one of the principal aims of mathematics teachers be to teach the students to be more functionally competent in mathematics.

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[12] Ibid., pp. 94-95

For his doctor's dissertation at Fresno State College, Alkire[13] made a study of the relationship between functional competence in mathematics as measured by the Davis test and certain factors present in the pupil, the school and the teacher. He chose his sample of schools to represent as closely as possible a cross section of South Dakota secondary schools with reference to size, geographical location, and economic standards of the community. The sample consisted of twenty, four-year schools and one 6-6 type to represent that class of secondary school enrolling less than one hundred; seven four-year and one 6-3-3 type were chosen to represent that class of secondary school enrolling between one hundred and five hundred; and one 6-3-3 type was chosen to represent that class of secondary school enrolling five hundred or more.

He obtained data concerning sex, mathematical background, and educational plans of the pupil by having a schedule filled in by the seniors. The principals or superintendents answered a questionnaire concerning the

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13 G. Don Alkire, Summary of his Doctor's dissertation (Fresno State College, 1953), "Functional Competence in Mathematics," Journal of Experimental Education, 22:227-36, March, 1954

length of employment, experience in teaching mathematics, and academic qualifications of the teachers. The principals or superintendents also filled in a schedule giving the mathematics courses offered, the units of credit for each course, and the rank of each pupil in his graduating class. The Davis Test of Functional Competence in Mathematics and the Terman-McNemar Test of Mental Ability were administered to each of the seniors.

As a result of his study, Alkire was able to make the following generalizations:

On the average a pupil was significantly more functionally competent in mathematics if:

1. The pupil were a boy.

2. The pupil had taken his elementary arithmetic training in rural schools rather than in urban schools.

3. The pupils had planned to attend college rather than to terminate his academic training at the end of the twelfth grade.

4. The pupil had taken more than two years of mathematics in high school rather than two or less years of mathematics.

5. The pupil's grade-point average in mathematics placed him in the upper one-fourth of the distribution of pupils on the basis of grade-point average in mathematics rather than in the lower one-fourth.

6. The pupil's academic record in high school ranked him in the upper one-fourth of his graduating class rather than in the lower one-fourth.

7. The pupil were in a school enrolling more than 500 pupils rather than in one enrolling either less than 100 or between 100 and 500.

8. The pupil were in a school, the assessed valuation of whose school district placed the school in the upper one-fourth of the distribution of schools on the basis of assessed valuation of school district rather than in the lower one-fourth.

9. The pupil were in a school, the average T score (a number which took into account both the number of years of teaching experience and the number of semester hours of mathematics preparation in higher institutions), of whose mathematics teachers placed the school in the upper one-fourth of the distribution of schools on the basis of average T score rather than in the lower one-fourth.

Alkire also found that the mean I Q of the seniors was 103 with a standard deviation of 13. (Norm 105:13) The mean score on the Davis test was 114.02 with a standard deviation of 15 (Norm 116:16). The coefficient of correlation between intelligence and functional competence in mathematics was .61.

Alkire recommended that the results of research be made more readily available to those who could use it so that boys and girls can be more adequately trained in mathematics. This would be not only for pupils desiring to become mathematicians, but for all future

citizens. He also recommended that grants be made by governmental and private agencies to encourage further experimental research necessary to establish mathematics instruction upon a scientific basis and assure its continuous improvement.

Schunert[14] made a study of the status of mathematics instruction in Minnesota's public secondary schools and investigated the relationship of mathematical achievement to certain factors resident in the teaching, in the teacher, in the pupil, and in the school. The study included an investigation of the status of instruction in general mathematics, elementary algebra, and plane geometry, and an investigation of the association of selected factors with mathematical achievement in algebra and plane geometry. Primarily the purpose of the study was to investigate the relation of mathematical achievement with (1) the preparation and experience of the teacher; (2) the sex, social background, and educational plans of the student; (3) the class size and the size and organization of the school; and (4) with twelve selected factors resident in the methods and materials of instruction. This

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14 Jim Schunert, Summary of his Doctor's dissertation (The University of Minnesota, 1950), "The Association of Mathematical Achievement with Certain Factors Resident in the Teacher, in the Teaching, in the Pupil, and in the School." The Journal of Experimental Education, 19:219-38. March, 1951.

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[14] Jim Schunert, Summary of his Doctor's Dissertation (The University of Minnesota, 1950). "The Association of Mathematical Achievement with Certain Factors Resident in the Teacher, in the Teaching, in the Pupil, and in the School." The Journal of Experimental Education, 19:219-38, March, 1951.

study was conducted during the school year of 1947-48 as a doctoral dissertation at the University of Minnesota.

Schunert made three objective measures of pupil characteristics. Mathematical achievement was measured at the beginning and end of the school year by identical examinations constructed by him. The Otis Quick Scoring Mental Ability Test was also given. In addition, a questionnaire concerning the age, sex, educational plans, and social background of the pupils, as well as a ninety-item schedule descriptive of the teacher's experience, training, and instructional practices was used.

The following were among the findings of Schunert:

1. Boys exceeded girls in geometry.

2. Algebra classes in schools enrolling between one hundred and five hundred pupils exceed others.

3. Geometry classes in four-year schools exceeded the achievement of classes in schools of three-year and six-year organizations.

4. Algebra classes enrolling from twenty to thirty pupils exceeded the achievement of smaller classes.

5. Teachers of more than eight years experience are more successful in teaching algebra.

He recommended that results of educational research be available and subsidies be granted to encourage further research into mathematical instruction.

On the whole most investigators seem to find that the average high school pupil is not competent in mathematics. At present it would appear that those students who are taking college preparatory courses are, in the main, the ones that exhibit competency. This leaves a great majority of the high school students sadly lacking in mathematical knowledge and ability.

CHAPTER III

METHOD OF CONDUCTING THE STUDY

Since this is a study of some of the factors involved in the functional competence of high school pupils in mathematics, all sources of data were chosen to contribute information to this problem.

Pupils in mathematics classes at Highland High School in Albuquerque, New Mexico, were chosen for the subjects of this study. These four classes consisted of two in plane geometry and two in practical mathematics. The classes were chosen because they were approximately the same size and because half the pupils were enrolled in geometry and half in practical mathematics. Seventy-six pupils were tenth graders, twenty-four were eleventh graders and thirteen were twelfth graders. The majority of these pupils indicated that they planned to take no further mathematics after completing the courses then underway.

These four groups of pupils were given a battery of four tests. The first of these was the Davis Test of Functional Competence in Mathematics. This is based on the essentials for functional competence in the twenty-

nine items set up by the Commission on Post War Plans of the National Council of Mathematics Teachers. There are two comparable forms of the test, AM and BM. Each is comprised of eighty items carefully selected on the basis of curricular validity and satisfaction of statistical requirements. A copy of the form AM may be found in the Appendix, page 81.

The test requires two forty-minute periods to administer. This time fitted adequately into two consecutive class periods. The answers were recorded on separate answer sheets.

The two parts of the test are divided into two sections each. 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)[15]

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[15] David J. Davis, Davis Test of Functional Competence in Mathematics, Manual of Directions (New York: The World Book Company, 1951), p. 1

As listed in the Manual of Directions, among the objectives measured by the test are the following:[16]

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?

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[16] *Ibid.*, p. 1

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?

The procedures followed in selecting the content of the test to measure important outcomes consisted of (1) determining in the soundest manner possible the objectives to be measured; (2) determining the proper emphasis 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.[17]

The items that were finally put into the test were constructed after a thorough analysis of instructional materials and writings by leading mathematical educators. Most elements measured by the test may be justified in terms of the frequency with which they are included in mathematics textbooks and also on the basis of expert judgment as to what is important.

Forms AM and BM are comparable in both content and difficulty of the tests. The two tests were designed

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[17] Ibid., p. 2

with the same amount of material devoted to the same items and with the same average difficulty, distributed in a balanced manner.

The validity and reliability of the text was established by intensive standardization.

The second test to be administered to the subjects was the Schorling-Clark-Potter Hundred Answer Arithmetic Test. This test was chosen because it appeared to be the most adequate test available on basic arithmetic computation. The test, originally published in 1928, was revised and a new edition published in 1944.

There are two forms of the test, Form V and Form W. Each form consists of one hundred items arranged in five sections. The time required on the test is forty minutes.

The five sections and their timing are:

1. Addition--ten items
   (6 minutes)

2. Subtraction--ten items
   (6 minutes)

3. Multiplication--fifteen items
   (7 minutes)

4. Division--fifteen items
   (7 minutes)

5. Fractions, Decimals, and Per cents-- fifty items
   (14 minutes)[18]

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[18] Raleigh Schorling, John R. Clark, and Mary A. Potter, Hundred Problem Arithmetic Test, Manual of Directions (New York: The World Book Company, 1944), p. 1

This test not only measures skills with whole numbers, but it also involves the various steps by which skills are built up in the less frequently measured subjects in common fractions, decimals, percentage, and denominate numbers.

The revision of the test was made by checking the original test against two criteria: (1) inclusion in courses of study and (2) the composite judgment of twenty-nine writers of arithmetic texts or courses of study.

Within each section of the test the items are arranged from the easiest to the most difficult.

Extensive tests on the validity and reliability were made in 1939. In 1942 the test was standardized by obtaining norms with well controlled groups. A copy may be found in the Appendix, page 89.

The third test administered was "Arithmetic Reasoning," one of the Multiple Aptitude Tests of the California Test Bureau. The test consists of thirty-five items and the actual working time is thirty minutes.

The thirty-five items in this test are concerned with the pupil's ability to understand and solve arithmetic reasoning problems as well as his knowledge of arithmetic symbols. Each item consists of a written

statement followed by four possible choices. The answers are recorded on a separate answer sheet. The person taking the test must comprehend the problem, apply the correct principle, and employ some arithmetic fundamentals to obtain the correct answers. Several items involve a unique numbering system and the pupil's ability to understand and apply new mathematical concepts. The reliability and validity of the test were carefully determined and found to be satisfactory. A copy may be found in the Appendix, page 93.

The final test given was the Kuhlmann-Anderson Intelligence Test H. This test consisted of ten sub-tests that required from two to three minutes each to administer. The answers were recorded on the test booklet. The purpose of this test is to measure the mental development of the pupils and their capacities for learning.

The essential validity of the Kuhlmann-Anderson Test is its capacity to discriminate between small increments of mental development.

> In the initial development of the Kuhlmann-Anderson Tests, evidence of increasingly successful performance at successive higher levels of chronological age was used as the criterion of what the tests proposed to measure. The median chronological age among successive large, unselected age-groups at which certain number of trials of a test was passed was designated as the tentative mental age for that number of

statement followed by four possible choices. The answers are recorded on a separate answer sheet. The person taking the test must comprehend the problem, apply the correct principle, and employ some arithmetic fundamentals to obtain the correct answers. Several items involve a unique numbering system and the pupil's ability to understand and apply new mathematical concepts. The reliability and validity of the test were carefully determined and found to be satisfactory. A copy may be found in the appendix, page 93.

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> trials . . . when ten of such tests are administered to a child, as they are in each battery booklets and the ten tests scores are combined by obtaining the median of the mental ages indicated--result is a valid and reliable measure of mental development.[19]

Even though this is a timed test, experiments have shown that given more time, subjects make essentially the same score on the tests since the items are arranged in order of difficulty. The correlations between the timed and untimed scores indicate that speed of performance is only a relatively small part of what the tests measure.

The school records were consulted for obtaining a record of each pupil's previous mathematics marks. The previous semester's record book was the source of the current marks made in mathematics.

Finally, each pupil was asked to list his first three occupational choices. These were compared with his scores on the various tests to see if the pupil was realistic in his choice of life work.

Because of dropouts, illness, athletic activities, and various other causes, the total number of pupils

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[19] F. Kuhlmann and Rose G. Anderson, Kuhlmann-Anderson Intelligence Tests, Master Manual (Princeton, New Jersey: Personnel Press, Inc., 1942), pp. 9-10

who took all tests was 113, as compared with almost 130 enrolled in the four classes. It must, therefore, be assumed that this group who did not complete all tests did not materially affect the final results, but those who did complete were representative of the group as a whole.

CHAPTER IV

ANALYSIS OF THE DATA

It was first desired to compare the scores made on the four tests with the norms provided for the tests. This would compare the performance of the pupils used in this study with the performance that should be expected of an average group. The mean for the complete group of 113 pupils on the Davis Test of Functional Competence was 114.49 with a standard deviation of 12.85. This was obtained by converting the raw scores to standard scores, since 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. This would indicate that the pupils at Highland High School were just above the average and were slightly more homogeneous when compared with the norms of the test. The scores ranged from 83 to 135. It was difficult to compute an over-all mean percentile rank for the Highland High pupils since the test percentiles are based on groupings according to grade level and the mean for this study was based on heterogeneous grades. A mean score of 114.49 for mid-year sophomores indicates a percentile rank of 63.5;

CHAPTER IV

ANALYSIS OF THE DATA

It was first desired to compare the scores made on the four tests with the norms provided for the tests. This would compare the performance of the pupils used in this study with the performance that might be expected of an average group. The mean for the complete group of 115 pupils on the Davis Test of Functional Competence was 114.49 with a standard deviation of 12.85. This was obtained by converting the raw scores to standard scores, since the raw scores on the Davis Test of Functional Competence in Mathematics are converted to standard scores having a mean of 113 and a standard deviation of 13.5. This would indicate that the pupils at Highland High School were just above the average and were slightly more homogeneous when compared with the norms of the test. The scores ranged from 83 to 155. It was difficult to compute an over-all mean percentile rank for the Highland High pupils since the test percentiles are based on groupings according to grade level and the mean for this study was based on heterogeneous grades. A mean score of 114.49 for mid-year sophomores indicates a percentile rank of 53.8;

for juniors 52.5; for seniors 43.5. Since the classes were predominantly sophomores, the 63.5 percentile rank was chosen to indicate the performance of the pupils as compared to the test norms. The highest score on the test was 139, which placed the boy at the 98 percentile. The lowest scores of 83 were made by two boys, which placed them at the 2 percentile.

It is interesting to compare these results with the results obtained by Mosley[20] in her study. In testing only seniors in five New Mexico schools she obtained the following results:

School	Mean	Percentile
A	117	45
B	98	9
C	97.36	8
D	101.07	13
E	98.46	9

Since Highland High School belongs in the same classification as School A, namely, over five hundred pupils, it would seem that the results obtained were not so high as Mosley's until one remembers that the average

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20 Mosley, op. cit., pp. 82-83

pupil in this study is not a senior, but a sophomore. The reader will also note the higher scores obtained in this study compared with those bbtained by Mosley for smaller schools. This tends to confirm her conclusion that the larger schools seem more functionally competent in mathematics. Alkire[21] also found that pupils who were functionally competent in mathematics on the Davis test were more likely to be enrolled in schools of more than five hundred.

Alkire[22] obtained a mean of 114.02 with a standard deviation of 15 when he gave the Davis Test of Functional Competence in Mathematics to a cross section of South Dakota seniors. The pupils at Highland High School made slightly higher scores in spite of the fact that they were mainly in a lower grade level. The achievements of the pupils in this study on the tests included in the total battery as compared to the respective norms for those tests, are presented in Table I.

From the table one will note that the mean on the Schorling-Clark-Potter Hundred-Problem Arithmetic Test is slightly higher than the test norm. However, some

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21 Alkire, op. cit., p. 235

22 Alkire, op. cit., p. 236

TABLE I

SCORES MADE BY THE PUPILS IN THIS STUDY COMPARED TO THE NORMS ON THE TESTS

	This study		Test norms	
Test	Mean	Standard deviation	Mean	Standard deviation
Davis Test of Functional Competence in Mathematics	114.49	12.85	112	13.5
Schorling-Clark-Potter Hundred-Problem Arithmetic Test	67.21	17.44	65.7	20.4
Arithmetic Reasoning Test	53	5.83	50	---
Kuhlmann-Anderson Test	104.03	14.88	104.9	13.7

explanation is needed. Form V and Form W of the Schorling-Clark-Potter Hundred-Problem Arithmetic Test have different means. The mean for Form V is 67.3 and for Form W is 64.2. Since half the pupils in this study received one form and half the other, an average of the two means was used to compare with the means obtained for the pupils in this study. The 67.21 score made by Highland High School pupils indicates average performance. To be more specific, a mean of 67.21 places the pupils in this study at the 53 percentile.

The highest score made on the Schorling-Clark-Potter test was 97, made by a boy and girl. This score placed them at the 99 percentile. The low score of fourteen was made by a boy, placing him at the zero percentile. It is interesting to note that he is currently taking geometry for the second time.

Some difficulty was encountered in computing the mean for the Arithmetic Reasoning Test. Since several pupils make negative raw scores the mean was computed only on the number right and found to be 53, as shown in Table I. The pupils ranged in percentile rank from 99 to zero, indicating a wide range of ability in arithmetic reasoning. There were five pupils who placed at the 99 percentile rank on this test. Of these five, four were boys, but the

girl tied for high score. A boy and a girl tied for low score, which placed them at the 8 percentile. The average achievement of the pupils in this study was slightly above the mean for the test norms.

The pupils in this study achieved almost the identical test mean I Q for tenth graders on the Kuhlmann-Anderson Test as shown in Table I. High school pupils tend to have higher I Q's because there is some natural selection taking place and some slower pupils have already dropped out. The mean I Q of 104.03 is almost identical to that of 104.9 for all tenth graders. Alkire[23] found a mean I Q of 103.8 with a standard deviation of 13 for the seniors in his study. In view of this, 104 is higher when one remembers the majority of pupils in this study are sophomores.

The pupils enrolled in geometry and those enrolled in practical mathematics classes are compared in Table II. The geometry classes with a mean of 119.62 did considerably better than the practical mathematics classes with a mean of 108.89. The mean for the geometry classes on the Davis test placed them at the 74 percentile. The mean for the practical mathematics classes placed them at the 47

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[23] Alkire, loc. cit.

TABLE II

MEAN SCORES MADE ON THE DAVIS TEST OF FUNCTIONAL COMPETENCE IN MATHEMATICS BY PUPILS ENROLLED IN GEOMETRY AND PRACTICAL MATHEMATICS CLASSES

Group	Number of pupils	Mean	Standard deviation	Critical ratio
Total	113	114.49	12.85	
Geometry classes	59	119.62	11.45	7.26
Practical mathematics classes	54	108.89	11.80	

percentile. Even though the practical mathematics classes were much lower in achievement than the geometry classes, the former nevertheless exceeded the seniors in percentile rank in all of the schools in Mosley's study.[24]

The critical ratio of the mean scores of the two classes was computed to be 7.26, which indicates that a true difference exists in their mathematical competence, since a critical ratio of more than 4.0 indicates a true statistically significant difference when probable error formulas are used in calculation. Such a difference is thus not due in any way to the element of chance in the sampling.

When the pupils were compared for achievement on the Schorling-Clark-Potter Hundred-Problem Arithmetic Test by enrollment in geometry and practical mathematics classes, an interesting result was obtained. The difference between the two mean scores was only .67 out of a possible one hundred points, as shown in Table III. This was the only test on which the geometry pupils did not make definitely superior scores. This may possibly be explained in part by the fact that, for most of the geometry students,

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[24] Mosley, op. cit., pp. 82-83

TABLE III

MEAN SCORES MADE ON THE SCHORLING-CLARK-POTTER HUNDRED-PROBLEM ARITHMETIC TEST BY PUPILS ENROLLED IN GEOMETRY AND PRACTICAL MATHEMATICS CLASSES

Group	Number of pupils	Mean	Standard deviation	Critical ratio
Total	113	67.21	17.44	
Geometry classes	59	67.71	16.14	not significant
Practical Mathematics classes	54	67.04	14.70	

it had been at least two years since they had had any formal work in arithmetic. The practical mathematics pupils, however, had had considerable review and practice in arithmetic fundamentals in the semester just prior to taking the test. This would also seem to indicate that the geometry pupils have a better background in the fundamental arithmetic processes, since they were able to make comparable scores without prior practice. The critical ratio was not computed, since simple observation indicates it is not significant. Both classes placed at the 53 percentile.

When the pupils are again compared between geometry and practical mathematics classes as to their performance on the Arithmetic Reasoning Test, a significant difference is found in the mean scores of the two groups, as shown in Table IV. The geometry classes' mean of 20.21 when converted to a T score of 57 indicates a mean at the 76 percentile. The mean of the practical mathematics classes, when converted to a T score of 50, places those pupils at the 50 percentile. The critical ratio was found to be 6.56 which indicated that there was a true difference in the arithmetical reasoning ability of the two groups and that the difference was not just due to the element of chance in the sampling.

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TABLE IV

MEAN SCORES MADE ON THE ARITHMETIC REASONING TEST BY PUPILS ENROLLED IN GEOMETRY AND PRACTICAL MATHEMATICS CLASSES

Group	Number of pupils	T. Score	Mean	Standard deviation	Critical ratio
Total	113	53	18.08	5.83	
Geometry classes	59	57	20.21	5.47	6.56
Practical Mathematics classes	54	50	15.74	5.28	

According to the Master Manual for the Kuhlmann-Anderson Tests, a retarded group of tenth grade pupils has a mean I Q of 95.9, an average group 100.8, and a superior group an IQ of 111.1.[25] Thus it will be seen that the geometry classes in this study compare favorably with superior or accelerated pupils, while the practical mathematics pupils fall between the retarded and average groups, as shown in Table V. This would seem to indicate that geometry has a tendency to attract pupils of superior ability. In addition, all of the geometry pupils plan on entering colleges, while a large number of practical mathematics pupils only plan to complete high school or quit as soon as they reach seventeen. The critical ratio for the two groups was found to be 7.13, thus indicating that the difference in the mean scores made by the two groups represents a real or significant difference in intellectual ability.

The results of computing the coefficients of correlations between the scores made on the Davis test and marks received in mathematics courses are shown in Table VI. It will be noted that the highest correlation is

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[25] Master Manual, Kuhlmann-Anderson Tests, op. cit., p. 16

TABLE V

MEAN I Q'S ON THE KUHLMANN-ANDERSON TESTS
BY PUPILS ENROLLED IN GEOMETRY AND
PRACTICAL MATHEMATICS CLASSES

Group	Number of pupils	Mean I Q	Standard deviation	Critical ratio
Total	113	104.03	14.88	
Geometry classes	59	109.92	13,94	7.13
Practical Mathematics classes	54	97.59	13.22	

TABLE VI

COEFFICIENTS OF CORRELATION BETWEEN DAVIS TEST SCORE AND MARKS RECEIVED BY THE PUPILS IN MATHEMATICS COURSES

Course	Number of pupils	Coefficient of correlation	Probable error
Practical Mathematics	60	.53	.06
Algebra	107	.60	.04
Geometry	68	.52	.06
Average of all mathematics marks	113	.61	.04

between the point ratio of all the mathematics marks and the scores made on the Davis Test of Functional Competence in Mathematics. This would indicate that in a large group of pupils there is a strong tendency for those who do well in mathematics courses to be more functionally competent in mathematics as measured by the Davis test. This tends to confirm Alkire's[26] finding that the pupil who is in the upper one-fourth grade point average for his class is much more likely to be functionally competent in mathematics.

It was also desired to find the relationship between functional competence in mathematics as measured by the Davis test and such other test measured factors as intelligence, arithmetic computational ability, and arithmetic reasoning ability. The results are shown in Table VII, in which are presented the complete set of intercorrelations. All correlations were positive and around .5 to .6 with two exceptions. The correlation between the Kuhlmann-Anderson Test and the Schorling-Clark-Potter Hundred-Problem Arithmetic Test was only .371, indicating that intelligence is not highly related to working computational arithmetic problems.

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[26] Alkire, op. cit., p. 235

TABLE VII

CORRELATION ON THE FOUR TESTS

	Kuhlmann-Anderson Test	Schorling-Clark-Potter Test	Arithmetic Reasoning Test
Davis Test	.53	.57	.71
Kuhlmann-Anderson Test	---	.37	.53
Schorling-Clark-Potter Test	---	---	.51

A correlation of .43 between the scores on the Schorling-Clark-Potter Hundred-Problem Arithmetic Test and those on the Terman-McNemar Test of Mental Ability was found when the tests were administered to 278 pupils in Grade ten.[27] Thus these two coefficients of .37 and .43 seem to be approximately the same magnitude and indicate about the same degree of relationship. A coefficient of .66 between the scores made on the Schorling-Clark-Potter test and those on the Foust-Schorling Test of Functional Thinking was found for 222 pupils in Grade 10.[28] One may compare this with the coefficient of correlation of .572 between the scores made on the Schorling-Clark-Potter test and those made on the Davis test. The fact that the first two mentioned tests have an author in common might account for the somewhat higher coefficient.

The second exception was the coefficient of .713 between the scores made on the Davis Test of Functional Competence in Mathematics and those on the Arithmetic Reasoning Test. It would thus seem to be indicated that in order to be really functionally competent in mathematics as measured by the Davis test one must have the ability to

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27 Schorling-Clark-Potter, op. cit., p. 2

28 Ibid., p. 2

do mathematical type reasoning. This would appear to be more of a necessary factor than the general ability components which make up the usual intelligence test.

Since the 113 pupils used in this study were a heterogeneous group, it was desired to classify them into certain groups and study their achievement on the various tests in this study. The first classified group consisted of seven pupils who had had only practical mathematics in high school. The remaining 106 pupils were divided into two groups: (1) those who had had algebra and were taking practical mathematics; (2) those who had had algebra and were taking geometry. In the second group were also included those who had taken practical mathematics or first-year algebra, but, in addition, either geometry or second-year algebra. The means, standard deviations, and critical ratio for the scores made on the Davis Test of Functional Competence in Mathematics were computed for these groups and the results are shown in Table VIII. The seven pupils who had had only practical mathematics made the lowest score. This score of 103.20 is considerably below the test norm mean of 112. These pupils are taking the very minimum amount of mathematics required to graduate from high school. The group

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TABLE VIII

MEANS, STANDARD DEVIATION, AND CRITICAL RATIO FOR SCORES MADE ON THE DAVIS TEST BY PUPILS WITH VARYING AMOUNTS OF MATHEMATICS

Group	Number of pupils	Mean	Standard deviation	Critical ratio
(1) Practical Mathematics	7	103.21	10.90	
(2) Algebra and Practical Mathematics only	38	108.16	11.20	
(3) Algebra and Geometry and other mathematics	68	122.06	12.06	8.85*

* between groups (2) and (3)

taking only practical mathematics and algebra is taking the minimum amount of mathematics required for college entrance at many universities. Some pupils were not taking practical mathematics as their second course in mathematics as a college entrance requirement, but merely because they were required to have so many minors and majors for graduation and mathematics seemed to be a good minor. These several non-intrinsic causes for taking the course are possibly reflected in the mean of 108.16, still below the test norm mean. The last group, those who either had had or were taking geometry, or second-year algebra, did considerably better as indicated by the mean of 122.16. It would appear that these pupils not only have more interest and units in mathematics, but are more functionally competent as measured by the Davis test. This is borne out by Alkire[29] who found that characteristically the pupil who is functionally competent in mathematics is the one who has had more than two years of mathematics in high school. Mosley[30] also found that there was an improvement of the mean score on the Davis test for each additional year of mathematics taken. The Davis test of competency seems

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[29] Alkire, loc. cit.

[30] Mosley, op. cit., p. 94

definitely to measure certain mathematical knowledge taught in later high school courses.

The critical ratio between the last two groups was found to be 8.85, indicating that there is a statistically significant difference between them. In other words, the superior scores made by the group taking more than the minimum requirements in mathematics is a true difference in achievement on the Davis test, and is not a difference due to the element of chance in the sampling.

The 113 scores were divided into quartile according to the scores made on the Davis Test of Functional Competence in Mathematics. This resulted in twenty eight pupils in each group. The upper and lower quartiles were compared not only as to the mean scores made on the Davis test, but also on the mean score computed on the other three tests. The results of the scores of the upper quartile and the lower quartile are shown in Table IX.

On examining the table one immediately notices that the group that made superior scores on the Davis test seem to have made consistently higher scores on the other test. In other words, the mean score for the upper quartile on the Davis Test of Functional Competence is considerably above the mean norm and a great deal above the mean of the lower quartile. The critical ratio of 29.1 indicates a

TABLE IX

MEANS OF THE UPPER AND LOWER QUARTILES ON THE DAVIS TEST OF FUNCTIONAL COMPETENCE IN MATHEMATICS

	Upper quartile		Lower quartile		
Test	Mean	Standard deviation	Mean	Standard deviation	Critical ratio
Davis Test of Functional Competence in Mathematics	129.62	5.4	97.57	6.75	29.1
Schorling-Clark-Potter Hundred-Problem Arithmetic Test	82.14	2.02	57.29	3.88	44.5
Arithmetic Reasoning Test	63	4.79	46.00	2.21	14.4
Kuhlmann-Anderson Test	112.82	3.32	95.04	4.02	26.7

large true difference between the two groups.

When one examines the mean scores made by the two groups on the Schorling-Clark-Potter test, one observes that the mean for the upper quartile is above the mean norm for the test, while the mean for the lower quartile is about as far below the mean norm. In comparing the mean scores of the upper quartile to the mean scores of the lower quartile, a critical ratio of 44.5 was obtained. This indicates that the large difference that exists between the two groups is a statistically true difference and not just due to the element of chance in the sampling.

There is a large variation between the mean scores on the Arithmetic Reasoning Test made by the upper quartile of the Davis test and the mean scores on the Arithmetic Reasoning Test made by the lower quartile on the Davis test. The critical ratio of 14.4 indicates that the upper quartile definitely have better arithmetical reasoning abilities than the lower quartile.

When the mean scores of the two groups on the Kuhlmann-Anderson Test were compared a critical ratio of 26.7 was obtained. This indicated that the pupils who did well on the Davis test definitely have superior mental capacities compared to those who did poorly on the Davis test.

In other words it was found that the upper quartile on the Davis test was a superior group as indicated by their high performance on the tests. The large critical ratios between the groups on all four tests further substantiated the true differences between the two groups.

In order to see if there was any significant difference between the scores made by boys and girls on the Davis test especially and on the other three tests as well, the pupils were classified according to sex and the means, standard deviations, and critical ratios were computed. The results are shown in Table X. The boys made a higher mean score by 4.04 points on the Davis Test of Functional Competence in Mathematics, but the critical ratio of 2.52 indicates that the difference is not statistically significant and may be due only to the sampling used in this study. As a result, it would seem that competency in mathematics as measured by the Davis test is not conditioned by sex. This is contrary to the finding of some other investigators. Alkire[31] found that if a pupil were functionally competent in mathematics the chances were that he would be a boy. Schunert[32] found that boys exceeded girls in geometry. Mosley[33] found

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[31] Alkire, op. cit., p. 235

[32] Schunert, op. cit., p. 235

[33] Mosley, op. cit., p 89

TABLE X

MEANS, STANDARD DEVIATIONS, AND CRITICAL RATIOS FOR SCORES MADE BY BOYS AND GIRLS ON THE FOUR TESTS

Test	Boys		Girls		Critical ratio
	Mean	Standard deviation	Mean	Standard deviation	
Davis Test	116.44	13.86	112.4	11.4	2.52
Schorling-Clark-Potter Test	67.91	17.3	66.44	17.5	*
Arithmetic Reasoning Test	18.34	3.81	16.18	5.12	3.71
Kuhlmann-Anderson Test	101.01	15.5	104.96	13.36	2.15

* Not computed, since it is insignificant by inspection.

that boys in five schools she tested made 2.9 points higher than the girls. This is a relative small amount of difference, however, and in view of the fact that she did not compute the critical ratio, one is inclined to question whether she is drawing a valid conclusion in stating that the boys proved to be more functionally competent than the girls.

The boys also made a better mean score than the girls on the Schorling-Clark-Potter Hundred-Problem Arithmetic Test. The difference, however, was so small that the critical ratio was not computed, since inspection alone indicates it would not be significant.

The Kuhlmann-Anderson Test was the only test in which the girls made a superior score to the boys. Again, the difference was so slight that it could be due to the element of chance of the sampling rather than to any true difference in the two sexes. These three tests tend to confirm the finding on the Davis test, namely, no apparent differences in mathematics competency between boys and girls are evident.

A final phase of this study was to see if the pupils were realistic in choosing a career in light of their mathematical and intellectual abilities. The pupils were

TABLE XI

CERTAIN OCCUPATIONAL CHOICES OF THE BOYS AND GIRLS INCLUDED IN THIS STUDY

Boys	Number	Number above norm	Girls	Number
Engineer*	23	16	Housewife	22
Navy*	8	4	Secretary	21
Pilot*	5	3	Teacher	10
Coach	5		Model	8
Ranching	5		Hostess	8
Garage	5		Nurse	6
Architect*	5	3	Artist	6
Air Force*	5	3	Religious	6
Doctor*	3	2	Interior decorator	3
Dentist*	3	3	Technician	3
Chemist*	2	1	Beautician	2
Dancer	2		Interpreter	2
Photographer	2		Child care	2
Railroad	2		Music	2
Forest service	2		Designer	1
Machinist*	2	0	Civil service	1
Pharmacist	2	2	Attorney*	1
Accountant*	2	1	Doctor*	1
Clergyman	2		Therapist	1

* Occupations requiring more than average amount of math

asked to list their first two occupational choices. Their choices were tabulated and the results of some of the occupations chosen are shown in Table XI. The boys listed a total of forty-four occupations. All the various types of engineering were grouped under one general heading. The girls showed much less imagination for they listed only 30 occupational choices with many of them wanting to be either secretaries or housewives.

While the girls showed less imagination, it would seem that they faced reality better than the boys and chose mostly occupations easily open to them. As is to be expected, predominantly the boys wanted to enter the professions, with engineering the first choice and flying, either commercially or militarily, coming second. Even though engineering is the top heavy choice, a majority of the boys who chose it could probably succeed in it. Those occupations which require more than the average amount of mathematics are starred on the table. Then the number of pupils who made a score on the Davis test of 112, the test mean norm, or above were counted. All the girls who chose starred occupations fell into this group. All the boys did not. In fact seven of the choices for engineer or pilot appear for boys in the lower quartile on the Davis test.

The majority of these seven have I Q's well below 100.

It is conceivable that many of the boys who made scores close to 112 would have great difficulty in engineering and the other occupations requiring much mathematics. In light of the occupational choices as compared to their functional competence in mathematics, it becomes obvious that many of the pupils are in need of better occupational counseling so that they can make wiser choices for careers.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

This study dealt with factors related to the mathematical competence of a sampling of 113 boys and girls at Highland High School in Albuquerque, New Mexico. Chapter IV presented an analysis of the data obtained primarily from four tests administered to the pupils. The following findings are considered significant to the study:

1. The mean on the Davis Test of Functional Competence in Mathematics placed the pupils at the 62 percentile, well above the national test norms.
2. The mean on the Schorling-Clark-Potter Hundred-Problem Arithmetic test, a test of computational ability, placed the pupils at the 53 percentile.
3. The mean on the Arithmetic Reasoning Test placed the pupils at the 62 percentile for that ability.

4. The mean on the Kuhlmann-Anderson Test showed the pupils approximately equal to the test norms for tenth grade intelligence level. The great majority of pupils in this study were in Grade 10.
5. The pupils in geometry classes had a mean on the Davis test that placed them at the 74 percentile. Pupils who had had algebra and were taking geometry, or were or had taken practical mathematics as well as having previously had geometry and/or second year algebra, made a mean score on the Davis test that placed them at the 81 percentile.
6. The pupils in practical mathematics classes had a mean on the Davis test that placed them at the 47 percentile. Pupils who had less than one year of high school mathematics made a mean score on the Davis test that placed them at the 32 percentile. Pupils who had had algebra and were taking practical mathematics, made a mean score on the Davis test that placed them at the 47 percentile.

7. The pupils in the geometry classes and practical mathematics classes made almost identical scores on the Schorling-Clark-Potter test, placing them at the 53 percentile.
8. The mean made by pupils in the geometry classes placed them at the 76 percentile on the Arithmetic Reasoning Test.
9. The mean made by the pupils in the practical mathematics classes placed them at the 50 percentile on the Arithmetic Reasoning Test.
10. The mean on the Kuhlmann-Anderson Test showed the pupils in the geometry classes were very close to being a superior group.
11. The mean on the Kuhlmann-Anderson Test showed the pupils in the practical mathematics classes were between retarded and average groups.
12. The coefficient of correlation between marks received in practical mathematics and the Davis test scores was .53.
13. The coefficient of correlation between marks received in algebra and the Davis test scores was .60.
14. The coefficient of correlation between marks received in geometry and the Davis test scores was .52.

15. The coefficient of correlation between the average of all mathematics marks received and the scores on the Davis test was .61.

16. The coefficient of correlation between Davis test scores and the Kuhlmann-Anderson Test scores was .53.

17. The coefficient of correlation between the scores on the Davis test and the scores on the Schorling-Clark-Potter Test was .57.

18. The coefficient of correlation between the scores on the Davis test and those on the Arithmetic Reasoning Test was .71. This was the highest degree of relationship found.

19. The coefficient of correlation between the scores on the Kuhlmann-Anderson Test and those on the Schorling-Clark-Potter Test was .37.

20. The coefficient of correlation between the scores on the Kuhlmann-Anderson Test and those on the Arithmetic Reasoning Test was .53.

21. The coefficient of correlation between the scores on the Schorling-Clark-Potter Hundred-Pròblem Arithmetic Test and those on the Arithmetic Reasoning Test was .51.

22. The pupils in the upper quartile on the Davis test made a mean score on that test that placed them in the 92 percentile.
23. The pupils in the lower quartile on the Davis test made a mean score on that test that placed them at the 17 percentile.
24. The pupils in the upper quartile on the Davis test made a mean score on the Schorling-Clark-Potter test that placed them at the 82.5 percentile.
25. The pupils in the lower quartile on the Davis test made a mean score on the Schorling-Clark-Potter test that placed them at the 32 percentile.
26. The pupils in the upper quartile on the Davis test made a mean score on the Arithmetic Reasoning Test that placed them at the 90 percentile.
27. The pupils in the lower quartile on the Davis test made a mean score on the Arithmetic Reasoning Test that placed them at the 34 percentile.
28. The pupils in the upper quartile on the Davis test made a mean score on the Kuhlmann-Anderson Test that placed them in an accelerated grouping.
29. The pupils in the lower quartile on the Davis test made a mean score on the Kuhlmann-Anderson Test which placed them in a retarded grouping.

30. The critical ratio between the mean scores made by the upper and lower quartiles on the Davis test was 29.1, indicating true difference in the functional competence in mathematics of the two groups.

31. The critical ratio between the mean scores made on the Schorling-Clark-Potter Hundred-Problem Arithmetic Test by the upper and lower quartiles on the Davis test was 44.5, indicating again that there was a decided true difference in the arithmetic computational ability of the two groups.

32. The critical ratio between the mean scores made on the Arithmetic Reasoning Test by the upper and lower quartiles on the Davis test was 14.4, indicating a true difference in the arithmetic reasoning ability of the two groups.

33. The critical ratio between the upper and lower quartiles on the Davis test for the scores they made on the Kuhlmann-Anderson Test, was 26.7, indicating a very real difference in the intellectual ability of the two groups.

34. The boys made a slightly higher mean score than did the girls on the Davis test, the

Schorling-Clark-Potter test, and the Arithmetic Reasoning Test. The girls exceeded the boys a little on the Kuhlmann-Anderson Test. However, the critical ratios between the boys and girls on all the tests indicated there was no true difference in the two groups.

35. The pupil's I Q and mathematical ability seem to have little relation to the fields picked for occupational choices.

II. CONCLUSIONS

The conclusions derived from this study are:

1. Functional competence of high school pupils in mathematics as measured by the Davis Test of Functional Competence in Mathematics is proportionate to the amount of mathematics courses taken in school. Pupils who elect more mathematics courses and do a better quality of work in them are more functionally competent.
2. More paramount than the amount of mathematics taken by the pupil, however, is the factor of mental ability in determining mathematical competency. Not only do those pupils electing

more mathematics courses exhibit greater mathematics competence, but such pupils also possess greater mental aptitude as measured by various other tests.

3. In order to be functionally competent in mathematics, a pupil must not only elect more mathematics courses and exhibit adequate computational ability, but most important of all, he must possess a superior ability to do mathematical reasoning.
4. Pupils superior in mathematical competency as measured by the Davis test are also superior in performance on other tests measuring such factors as computational ability, arithmetic reasoning ability, and intelligence.
5. High school boys display a certain degree of phantasy and lack of realism in their occupational choices, since many with inadequate mathematical competency chose occupations demanding considerable mathematical facility.
6. No significant differences in mathematical competency are found when the pupils' performances are compared by sex. Slight differences measured

by the tests in favor of the boys were found to not be statistically significant.

III. RECOMMENDATIONS

As a result of this study the following recommendations are made with the desire to improve the mathematics curriculum of the high schools in order to improve the mathematical competence of the pupils. They are:

1. Mathematics teachers should study the check list published by the Post War Commission organized by the National Council of Mathematics Teachers and attempt to give the pupils as much as possible of the material listed there.
2. Attempts should be made by writers of high school mathematics textbooks to include the twenty-nine points listed by the Commission in their texts.
3. At least two years of mathematics should be required for high school graduation since those pupils having only one year showed extreme lack of competence in mathematics.

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APPENDIX

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 hous depreciates $2\frac{1}{2}$% of the original value each year, th 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 th city of Campbell is $50,000,000, what tax rate i 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 wa $160.40. Deposits made and checks written durin 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 fo $8000. He figures his yearly expenses on the hous as follows: taxes, $120; insurance, upkeep, and de preciation, $220; and loss of interest on money in vested in the house, $200. How much yearly ren must Mr. Martin charge in order to meet these yearl expenses and still receive a 5% yearly return on hi $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 bil The accepted order for the clerk to make and to retur the change is
   a. two dimes, 3 nickels, three 1-dollar bills, 3 pen nies, 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

2. 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

3. 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

4. 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

5. 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.

6. 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 semi-annually. 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?

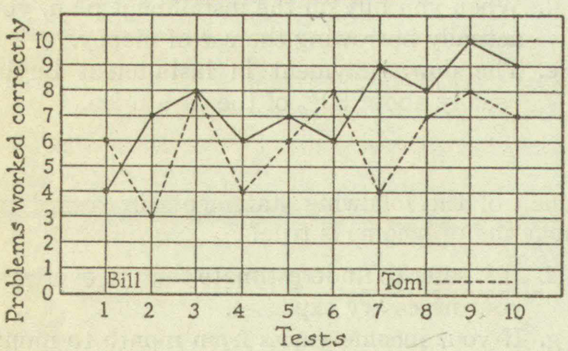
a. $10.80
b. $3.60
c. $1.08
d. $0.36
e. none of the above

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

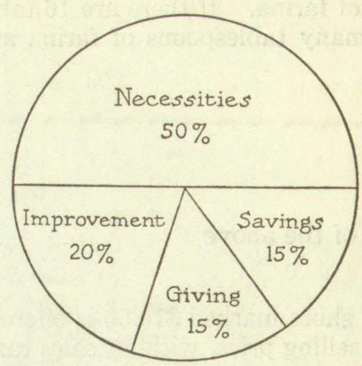
TESTS IN ARITHMETIC



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 wage 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

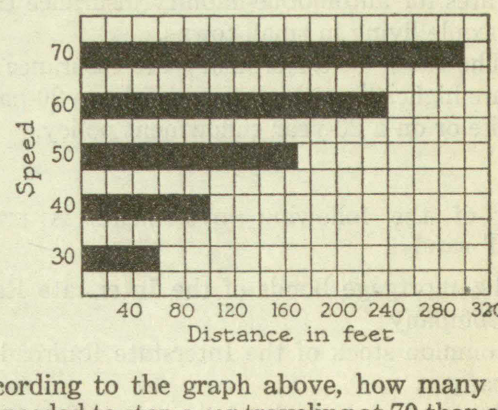
TAX WITHHELD FROM MONTHLY WAGES

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 earn $264 per month and has a wife and 1 child, both en tirely dependent upon him, how much is withhel 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 fee are needed to stop a car traveling at 70 than at 50 mile per hour?

f. 135 g. 130 h. 125
i. 120 j. none of the above

Go on to the next page

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.

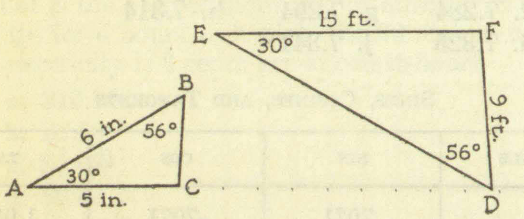
Part II — Section A

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

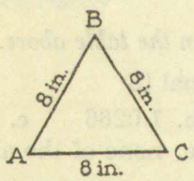
35. How far would you travel in 3 hours and 20 minutes at a speed of 45 miles per hour?
    f. 144 miles g. 150 miles h. 157.5 miles
    i. 160 miles j. none of the above

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

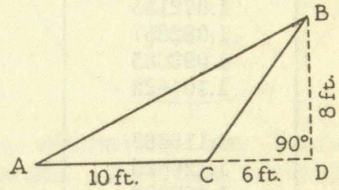
40. In any regular polygon
    a. each angle is a right angle.
    b. no two sides are equal.
    c. there are 4 equal sides and 4 equal angles.
    d. the angles are of equal size and the sides of equal length.
    e. two and only two sides are parallel.

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.

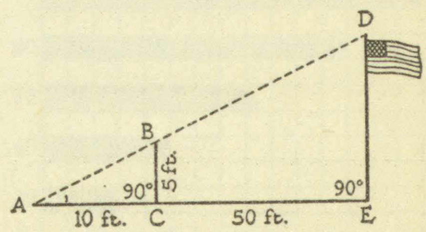
46. In the formula $S = \frac{(h - 2d)}{m}$, if $m = 2$, $h = -6$, and $d = 4$, then S is equal to
    a. -7 b. -1 c. $+1$
    d. $+7$ e. none of the above

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.

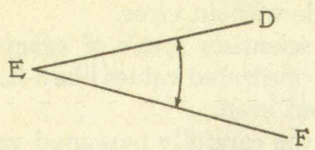


51. Bill used a 5-foot stick, BC, to determine the height of the flagpole DE. By sighting from point A, Bill found the top of the stick in line with the top of the pole. Use the information in the figure above to find the height of the flagpole. This height is
    f. 10 ft. g. 20 ft. h. 25 ft.
    i. 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

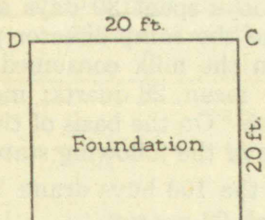
f. the lengths of line segments *DE* and *EF*.
g. the distance from *D* to *F*.
h. the area enclosed by line segments *DE* and *EF* and a straight-line segment drawn from *D* to *F*.
i. the amount of rotation of line segment *EF* around point *E* necessary to reach the position of line segment *ED*.
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

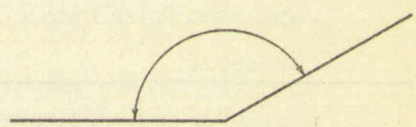
f. 688,500 g. 689,000 h. 690,000
i. 700,000 j. none of the above

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. $2\frac{2}{16}$ in. b. $2\frac{3}{16}$ in. c. $2\frac{4}{16}$ in.
d. $2\frac{5}{16}$ in. e. none of the above

Go on to the next page.

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

450 ft.

A ———————————————— B

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.

HUNDRED-PROBLEM ARITHMETIC TEST

WHOLE NUMBERS—COMMON FRACTIONS—DECIMAL FRACTIONS—PER CENTS

By RALEIGH SCHORLING
Head of Department of Mathematics, the University High School,
and Professor of Education, University of Michigan
JOHN R. CLARK
The Lincoln School, Teachers College, Columbia University
and MARY A. POTTER
Supervisor of Mathematics, Public Schools, Racine, Wisconsin

V

TOTAL NUMBER RIGHT	
%-ILE RANK	

TEST: FORM V

Name.......................................Date.................................Grade........

Age......years and......months. Teacher..

School..................................City..........................State..............................

DIRECTIONS

Do not turn this page until you are told to do so. Read the following directions.

This test contains several groups of arithmetic examples. When you finish one group, go right on to the next. If you come to an example that you cannot do, skip it and try it again later if you have time. Begin at the top of each column and work down the page.

You are not expected to finish every example, but work steadily and do the best you can.

You may do your figuring on the test paper or on the blank paper that has been given you. But you must be sure to **write the answer to each example in the box near the example.**

Do not turn the page until I say the word *Begin.*

PARTS	NUMBER CORRECT	+	NUMBER WRONG	+	NUMBER OMITTED	=	TOTAL NUMBER
I. Addition..........................		+		+		=	10
II. Subtraction........................		+		+		=	10
III. Multiplication......................		+		+		=	15
IV. Division..........................		+		+		=	15
V. Fractions, Decimals, and Per Cents....		+		+		=	50
VI. Total..............................		+		+		=	100

[This test is a revision of the *Schorling-Clark-Potter Arithmetic Test*, Form A (1928).]

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 HPAT:V-19

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a

I. ADDITION

Add:

1. 8, 7, 3, 6, 9, 5, 8 (1)

2. 463, 877, 539, 198 (2)

3. \$386.85, 96.66, 6.57, .98, 100.00, 5.94, 60.00 (3)

4. $\frac{7}{10}$, $\frac{3}{5}$ (4)

5. $\frac{7}{8} + \frac{3}{16} =$ (5)

6. $17\frac{5}{6}$, $5\frac{1}{3}$ (6)

7. $\frac{3}{5} + \frac{1}{2} + \frac{7}{10} =$ (7)

8. $9\frac{3}{4}$, $27\frac{7}{8}$, $8\frac{9}{16}$ (8)

9. .07 + 5.23 + 8.29 + 1.40 = (9)

10. \$2.25 + \$14.70 = (10)

When you finish this part, go right on with the next.

II. SUBTRACTION

Subtract:

11. 1124, 742 (11)

12. 880.75, 785.78 (12)

13. $\frac{11}{12} - \frac{1}{6} =$ (13)

14. $8\frac{3}{8}$, $5\frac{3}{4}$ (14)

15. $2\frac{3}{4} - \frac{2}{3} =$ (15)

16. \$5.04 − 18¢ = (16)

17. 9.752 − 6.007 = (17)

18. \$32 − \$6.58 = (18)

19. 9.25 − 2.20 = (19)

20. 9006, 4039 (20)

When you finish this part, go right on with the next.

III. MULTIPLICATION

Multiply:

Do your work here.
95
82

21. 95, 82 (21)

Write your answer in the box.

Do your work here.
609
40

22. 609, 40 (22)

Write your answer in the box.

Do your work here.
769
708

23. 769, 708 (23)

Write your answer in the box.

24. $\frac{3}{4} \times 60 =$ (24)

25. $\frac{5}{4} \times \frac{3}{2} =$ (25)

26. $\frac{5}{8} \times \frac{12}{10} =$ (26)

27. $45 \times \frac{2}{5} =$ (27)

28. $20\frac{3}{5} \times 12 =$ (28)

29. $1\frac{1}{2} \times 2\frac{1}{4} \times \frac{3}{4} =$ (29)

Do your work here.
4.928
3.2

30. 4.928, 3.2 (30)

Write your answer in the box.

(*Part III is continued on the next page.*)

III. MULTIPLICATION

(*Continued*)

The answers in the following examples have not been "pointed off." Put the decimal point in each answer where it belongs.

31. $20 \times .20 =$ [4 0 0] (31)

32. $1.6 \times 0.3 =$ [4 8] (32)

33. $0.5 \times 5 =$ [2 5] (33)

34. $0.2\,4\,5 \times 2 =$ [4 9 0] (34)

35. Does 1.2×0.5 equal 6.0 or .60 or .060 or 60? [ ] (35)

When you finish this part, go right on with the next.

IV. DIVISION

Divide:

36. $36 \div 3 =$ [ ] (36)

37. $636 \div 6 =$ [ ] (37)

38. $948 \div 9 =$ [ ] (38)

39. $.0\,0\,4\overline{).0\,2\,8\,4}$ [ ] (39)

40. $.3\,4\overline{)1\,0\,5.4}$ [ ] (40)

The answers in the following examples have not been "pointed off." Place the decimal point in each answer where it belongs, adding zeros when necessary.

41. $.1\,2\,3\overline{)5\,6\,0.8\,8}$ [4 5 6] (41)

42. $1.2\,3\overline{).5\,6\,0\,8\,8}$ [4 5 6] (42)

43. $1\,2.3\overline{)5\,6.0\,8\,8}$ [4 5 6] (43)

44. Does $4786 \div 10$ equal 4.786 or 47.86 or 478.6 or 4786? [ ] (44)

45. $2\frac{1}{2} \div 4\frac{1}{2} =$ [ ] (45)

46. $3\frac{3}{4} \div \frac{3}{4} =$ [ ] (46)

47. $\frac{3}{8} \div 4 =$ [ ] (47)

48. $4\frac{1}{2} \div 8 =$ [ ] (48)

49. $2\,1\overline{)8\,8\,2}$ [ ] (49)

50. $8\,3\overline{)1\,1\,3\,7\,1}$ [ ] (50)

When you finish this part, go right on with the next.

V. FRACTIONS, DECIMALS, AND PER CENTS

Write each of the following as per cent:

SAMPLE $\frac{1}{5} =$	(Your answer should read $\frac{1}{5} = 20\%$.)

51. $\frac{3}{100} =$ [%] (51)

52. $\frac{3}{5} =$ [%] (52)

53. $\frac{5}{8} =$ [%] (53)

54. $.75 =$ [%] (54)

55. $.075 =$ [%] (55)

56. $\frac{4}{5} =$ [%] (56)

57. $\frac{1}{3} =$ [%] (57)

58. $\frac{3}{8} =$ [%] (58)

59. $.2 =$ [%] (59)

60. $0.875 =$ [%] (60)

Write each of the following as a decimal fraction:

61. $\frac{3}{10} =$ [ ] (61)

62. $\frac{1}{4} =$ [ ] (62)

63. $\frac{2}{5} =$ [ ] (63)

64. $60\% =$ [ ] (64)

65. $7\frac{1}{2}\% =$ [ ] (65)

66. $\frac{7}{100} =$ [ ] (66)

67. $\frac{3}{5} =$ [ ] (67)

68. $\frac{1}{8} =$ [ ] (68)

(*Part V is continued on the next page.*)

PART V. (*Continued*)

Write each of the following as a decimal fraction:

69. $12\frac{1}{2}\%$ = ☐ (69)

70. $37\frac{1}{2}\%$ = ☐ (70)

Write each of the following as a common fraction:

71. 20% = ☐ (71)

72. 9% = ☐ (72)

73. 25% = ☐ (73)

74. $12\frac{1}{2}\%$ = ☐ (74)

75. $33\frac{1}{3}\%$ = ☐ (75)

Complete the following:

76. 25% of 120 = ☐ (76)

77. 2.3% of 40 = ☐ (77)

78. 120% of 20 = ☐ (78)

79. $\frac{2}{3}\%$ of 3000 = ☐ (79)

80. ☐ % of 24 = 8.

81. ☐ % of 60 = 6.

82. ☐ % of 20 = 25.

83. 4 = ☐ % of 20.

84. 9 = ☐ % of 18.

85. 8 = ☐ % of 80.

Write these decimals as per cents:

86. .355 = ☐ % (86)

87. .123 = ☐ % (87)

88. .1825 = ☐ % (88)

Rewrite the following decimals, arranging them in the order of their size, the largest first and the smallest last:

89. .93 .15 .94 ☐ (89)

90. .40 2.5 .875 ☐ (90)

Write these as decimal fractions; carry the answer to three places and round off to two places:

91. $\frac{7}{16}$ = ☐ (91)

92. $\frac{5}{16}$ = ☐ (92)

93. Mary bought an $8 dress at a 15% discount. What did she pay for the dress? ☐ (93)

94. What is the interest for a year on $175 at 6%? ☐ (94)

95. Mr. Brown found that $22\frac{1}{2}\%$ of his peaches were not good enough to sell. Out of 80 bushels he could sell ___?___ bushels. ☐ (95)

96. Carl earned $32 during his summer vacation. He spent $14\frac{1}{2}\%$ of this money for schoolbooks. How much did his books cost? ☐ (96)

97. What do you pay for goods marked $13.50 with a discount of 2%? ☐ (97)

98. What per cent of your investment do you make if you invest $125 and gain $5? ☐ % (98)

99. What is the interest for a year on $300 at $4\frac{1}{2}\%$? ☐ (99)

100. There are 2150 pupils in one junior high school of this city. The principal of this school expects an increase of 6% in the number of pupils next semester. How many pupils does he plan to have next semester? ☐ (100)

When you finish this part, go back and make sure that your work is correct.

5. Arithmetic Reasoning

Multiple Aptitude Tests

EVISED BY DAVID SEGEL AND EVELYN RASKIN

o not write or mark on this booklet unless told to do so by the examiner.

ame.. Occupation or Grade........................ Sex M-F
Last First Middle

chool or rganization.................................City.. Date of Test..........................
Month Day Year

xaminer..(..........) Examinee's Age.......... Date of Birth..........................
Month Day Year

INSTRUCTIONS TO EXAMINEES:

This is a test of arithmetic reasoning. No one is expected to do the whole test correctly, but you should do as many of the problems as you can. Work as fast as you can without making mistakes.

Each problem is followed by four answers, only one of which is correct. Identify the ONE of the four answers which is correct and then mark the answer you have chosen as you are told.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

ample: H. If three candy bars can be bought for 10¢, how many candy bars can be bought for 20¢?

a 3 1/3
b 9
c 6
d 6 2/3

Correct Test Booklet Mark	Correct Answer Sheet Mark
c H	H a b c d (c marked)

SCORE

%-ILE RANK

PERCENTILE SCALE (Mark examinee's %-ile rank here)

1 2 5 10 20 30 40 50 60 70 80 90 95 98 99

M F

CHECK SEX AND LEVEL OF NORMS USED

Grade 7 8 9 10 11 12

College 13

Others

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RANCH OFFICES: NEW CUMBERLAND, PA.; MADISON, WIS.; DALLAS, TEXAS.
8 7 6 5 4 3 2 1

261. If \$3000 is 60% of a man's annual salary, what is his salary?

a \$3600
b \$4800
c \$5000
d \$6000 ______261

262. If A spends 85% of her salary each year and saves the rest, what per cent does she save?

e 5%
f 10%
g 15%
h You cannot find out from what is given. ______262

263. City A and City B are 500 miles apart. How far apart will these 2 cities be on a map drawn to the scale of 1 in. = 50 miles?

a 5 in.
b 10 in.
c 15 in.
d 100 in. ______263

264. A boxcar is 40 feet long. If a freight train made up of 20 boxcars is 1000 feet long, how many boxcars are there in a freight train 5000 feet long?

e 100
f 120
g 125
h 200 ______264

265. If 20 fish weigh 10 pounds, the average weight of each fish is

a 1/4 lb.
b 4 1/2 lbs.
c 2 lbs.
d 1/2 lb. ______265

266. In a given city how much time passes between 5:15 A.M. and 2:45 P.M. the same day?

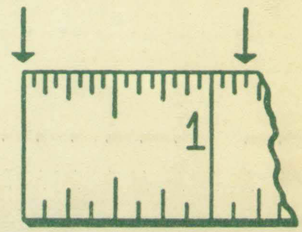
e 8 hr. 0 min.
f 8 hr. 30 min.
g 9 hr. 30 min.
h 9 hr. 50 min. ______266

267. A factory employing 200 men increased the number of its employees by 15%. How many people were then working in the factory?

a 215
b 230
c 250
d 255 ______26

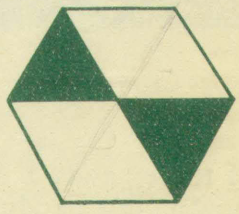
268. There are 19 girls in an arithmetic class. If girls make up .5 of all the students in the class, how many students are there in the class?

e 38
f 10
g 40
h 95 ______26



269. How many inches are there between the arrows on the above figure?

a 1 1/8 in.
b 1 3/8 in.
c 1 3/16 in.
d 1 3/4 in. ______26



270. What per cent of the above figure is shaded?

e 20%
f 33 1/3%
g 40%
h 66 2/3% ______27

GO RIGHT ON TO THE NEXT PAGE

71. A student finds that out of every hour of study in the library, he spends 15 minutes getting his reference books. What per cent of the time does he spend in actual study?

a 45%
b 66%
c 75%
d 85%

______271

72. What rate of simple interest will yield $72 on $360 in 4 years?

e 1%
f 2%
g 3%
h 5%

______272

73. A dress which was first marked $30 was reduced to sell at 40% off. What was the reduced sales price?

a $12
b $15
c $18
d $26

______273

74. With 40 games still to be played, a big league baseball team had won 50 and lost 60. How many of these additional games was it necessary to win in order to complete the season winning 60% of all games played?

e none of them
f 20
g 30
h all of them

______274

75. Mr. X's salary was raised from $200 to $220 per month. By what per cent was his $200 salary raised?

a 10%
b 5%
c 20%
d 30%

______275

276. The general equation for finding the volume of a cylinder is $V = \pi r^2 h$, where r = radius and h = the height of the cylinder. What is the volume of a cylinder having a radius of 2 inches and a height of 4 inches?

e 8 π sq. in.
f 16 π cu. in.
g 32 π cu. in.
h 32 π sq. in.

______276

277. A square frame for a picture is to be made by cutting the inside from a square piece of wood having an area of 25 square inches. If one side of the picture is 2 inches in length, what is the distance between the edge of the picture and the outside of the frame?

a 1 ½ in.
b 2 ¼ in.
c 3 in.
d 21 in.

______277

278. How much linoleum should originally be ordered to allow for 25% waste if the finished room is 12 ft. x 10 ft?

e 90 sq. ft.
f 160 sq. ft.
g 145 sq. ft.
h 150 sq. ft.

______278

279. Box A measures 8 ft. by 8 ft. by 8 ft.; Box B measures 4 ft. by 4 ft. by 4 ft. How many times larger than Box B is Box A?

a ½
b 2
c 4
d 8

______279

GO RIGHT ON TO THE NEXT PAGE

280. One pound of a certain metal contains .25 copper. How many ounces of copper are there in 5 pounds of this metal?

- e 1.25 oz.
- f 20 oz.
- g 80 oz.
- h 125 oz.

______280

281. In which of the following is the pair of arithmetic processes fundamentally the same?

- a multiplication and division
- b division and subtraction
- c subtraction and multiplication
- d addition and division

______281

282. Mr. M. just received a raise of 10% in his salary. He now earns $165 per month. What was his monthly salary before this raise?

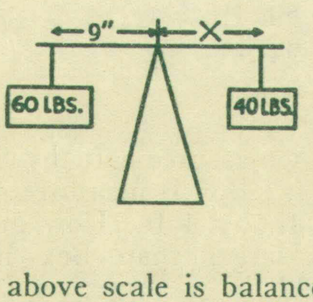
- e $149.50
- f $155
- g $150
- h $181

______282

283. If milk from a certain dairy contains 4% butterfat, about how many pounds of milk will be required to produce 20 pounds of butterfat?

- a 8 lbs.
- b 50 lbs.
- c 80 lbs.
- d 500 lbs.

______283



284. If the above scale is balanced as shown, how long is X?

- a 6 in.
- b 13 1/2 in.
- c 15 in.
- d 26 1/3 in.

______284

285. A man borrowed $400 from a bank for 60 days at 6% per annum. If he repayed the principal at the end of this period, how much interest did he pay? (1 banking year = 360 days)

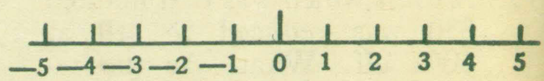
- e $2
- f $4
- g $12
- h $24

______28

286. A 10-foot length of lumber is cut into two pieces. The shorter piece is two-thirds as long as the longer one. What is the length of the shorter piece?

- e 2 ft.
- f 3 1/3 ft.
- g 4 ft.
- h 6 2/3 ft.

______28

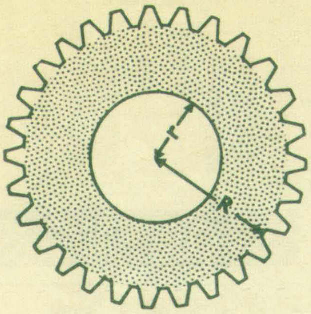


287. Which one of the statements below correctly describes addition in terms of movement on this scale?

- a Adding a positive whole number, N, to any whole number, L, whether positive or negative, is equivalent to moving number L, N spaces to the right.
- b Adding a negative whole number, Z, to a positive whole number, S, is equivalent to moving S, Z spaces to the right.
- c Adding a negative whole number, R, to a negative whole number, T, which has a smaller absolute value than R, is accomplished by moving the number T, R spaces to the right.
- d Adding a negative whole number, R, to a negative whole number, T, which has a larger absolute value than R, is accomplished by moving the number T, R spaces to the right.

______28

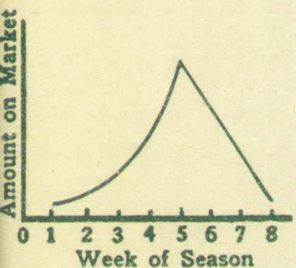
GO RIGHT ON TO THE NEXT PAGE



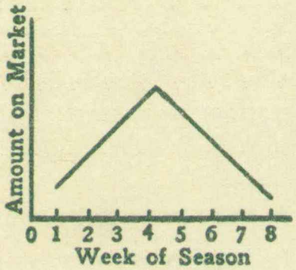
288. The general equation for the area of a circle is π times the square of the radius. What is the formula for the area of the shaded section of the above gear?

- e $A = \pi(R - r^2)$
- f $A = \pi(r^2 - R^2)$
- g $A = \pi(R^2 - r^2)$
- h It cannot be stated from the information given.

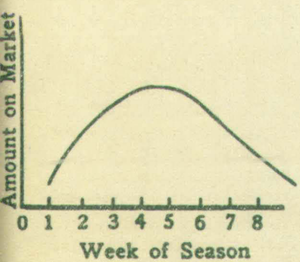
_____288



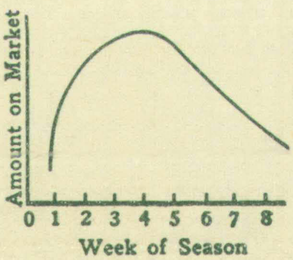
A



B



C



D

289. A certain fruit appears on the market in very small quantities one week; during each of the next four weeks the amount on the market is twice what it was the previous week; and after that the quantity is reduced sharply until the end of the season. Which one of the above graphs shows the general relationship between quantity on the market and the week of the season?

- a A
- b B
- c C
- d D

_____289

✓ Questions 290 through 295 are based on the following supposition:

Suppose we had a system of numbers in which the only numbers we had were 0, 1, 2, 3, and 4. This means that the numbers 5, 6, 7, 8, and 9 did not exist and therefore could never be used in this new system. If we had such a system, then the first 24 numbers counted in order would be:

1	2	3	4	10
11	12	13	14	20
21	22	23	24	30
31	32	33	34	40
41	42	43	44	50

290. What would be the next number after 44 in this system?

- e 45
- f 50
- g 99
- h 100

_____290

291. The number 50 in our regular system is equal to which one of the following numbers in this *new* system?

- a 25
- b 50
- c 100
- d 200

_____291

What is the answer to each of the following problems in this new system?

292. 14+1

- e 15
- f 20
- g 25
- h 30

_____292

GO RIGHT ON TO THE NEXT PAGE

293. 11−4

a 2
b 3
c 5
d 7

______293

294. 3×4

e 17
f 24
g 23
h 22

______294

295. 31÷4

a 4
b 3.875
c 7.75
d 10

STOP NOW WAIT FOR FURTHER INSTRUC

Test 5 Score
(rights − ⅓ wrongs)........

Extended Profile
Multiple Aptitude Tests

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Name.. Last .... First .... Middle

Grade or Occup.........................

Sex (Circle One) M - F

School or Org.. City..

Test Dates..

Examiner.. (...................) Age.............

Date of Birth.................................... Month Day Year

TEST	Possible Score	Scoring Formula	Raw Score	%-ile Rank	Stand. Score
1. Word Meaning	60	R - ⅓ W			
2. Paragraph Meaning	50	Rights			
3. Language Usage	120	Rights			
4. Routine Clerical Facility	180	Rights			
5. Arithmetic Reasoning	35	R - ⅓ W			
6. Arithmetic Computation	35	R - ⅓ W			
7. Applied Science & Mechanics	60	R - ⅓ W			
8. Spatial Relations — 2 Dimens.	25	R - ⅓ W			
9. Spatial Relations — 3 Dimens.	25	R - ⅓ W			

PERCENTILE SCALE

(Vertical marks below lines = %-ile points)

1 2 5 10 20 30 40 50 60 70 80 90 95 98 99

FACTOR	TEST STANDARD SCORES			Average Stand. Sc.	%-ile Equiv.
I. VERBAL COMPREHENSION	1	2	3		
II. PERCEPTUAL SPEED	3	4			
III. NUMERICAL REASONING	5	6			
IV. SPATIAL VISUALIZATION	7	8	9		

27 30 35 40 45 50 55 60 65 70 73

STANDARD SCORE SCALE

(Vertical marks above lines = standard scores)

Circle Norms Used: Sex, M F; Level, 7 8 9 10 11 12 13 College Other ....

See page 29 of the Manual for instructions.

STANDARD ERRORS OF THE DIFFERENCES BETWEEN STANDARD SCORES FOR THE NINE MULTIPLE APTITUDE TESTS*

MAT NO.	MULTIPLE APTITUDE TEST NUMBER 1	2	3	4	5	6	7	8	9
1		5.7	4.8	5.1	5.0	4.6	6.3	4.9	6.1
2	5.6		5.6	5.8	5.7	5.4	6.9	5.7	6.7
3	4.8	5.7		5.0	4.9	4.5	6.2	4.8	6.0
4	4.9	5.7	5.0		5.2	4.8	6.5	5.1	6.2
5	4.8	5.7	4.9	5.0		4.7	6.4	5.0	6.2
6	4.4	5.3	4.5	4.6	4.5		6.1	4.6	5.8
7	5.7	6.4	5.7	5.8	5.7	5.4		6.3	7.3
8	4.9	5.7	5.0	5.1	5.0	4.6	5.8		6.1
9	5.7	6.5	5.8	5.9	5.8	5.5	6.6	5.9	

FEMALES (above diagonal) — MALES (below diagonal)

STANDARD ERRORS OF THE DIFFERENCES BETWEEN MAT FACTOR STANDARD SCORES*

MAT FACTOR NO.	MAT FACTOR NUMBER I	II	III	IV
I		3.6	3.7	3.3
II	3.6		4.1	3.7
III	3.5	3.9		3.9
IV	3.5	3.9	3.7	

FEMALES (above diagonal) — MALES (below diagonal)

*The actual difference between the standard scores for two tests must be twice the standard error of the difference, or more, to be significant at or beyond the 5% level of confidence. The standard errors of measurement are provided in the Manual in Tables 2 and 3 on pages 7 and 8.

IMPORTANT!

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MAY 27 RECD
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MAY 21 1965
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MAY 19 RECD