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The construction and validation of a test of functional competence in arithmetic at fourth grade level

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Thesis

THE CONSTRUCTION AND VALIDATION OF A TEST OF
FUNCTIONAL COMPETENCE IN ARITHMETIC AT
FOURTH GRADE LEVEL

Submitted by

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(A.B., Boston College, 1949)

In Partial Fulfillment of Requirements for
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CHAPTER I

THE PROBLEM

Purpose of study.— It is the purpose of this study to provide an instrument to measure ability to use arithmetic functionally. Functional arithmetic in this study will be considered synonymous with social arithmetic. It refers to the way a child uses arithmetic in normal situations in everyday life.

A variety of elements distinct from ability to compute accurately enter into ability to use number effectively and economically in everyday situations. Such elements are involved as the following:

1. Possession of a fund of worthwhile number information
2. Utilization of the number aspect of a situation to interpret that situation, make judgments about it, or perceive relationships within it
3. Ability to use techniques such as estimation rather than precise computation.

The test dealt with here is intended to measure ability to make arithmetic function effectively in everyday situations involving these and other similar elements.

-1-
A second aspect of arithmetic.-- Arithmetic thus functionally considered should be distinguished from arithmetic as a mathematically meaningful science of number. Arithmetic as a science of number may be thought to exist in and of itself, and to be independent of usage in everyday life. It should be noted that mathematically meaningful arithmetic can often be the key to effective functional arithmetic.

Justification.-- Arithmetic teaching was once concerned largely with computational routines and abstract problem solving. Modern thought continues to recognize the importance of proficiency in these areas of arithmetic. However, it also recognizes the importance of other, once neglected, areas. Such areas as the mathematical meanings of number or the functional meanings of number receive increased emphasis in the modern curriculum. The importance of teaching effectively in these two areas has received almost universal acceptance.

However, there has not been a corresponding increase in the number or quality of instruments for measurement in these areas. Standardized tests remain largely concerned with computational routines and abstract problem solving. A genuine measurement need exists in these areas. Procedures such as interviews, discussions, direct observation, and projects, are satisfactory non-test techniques for meeting
this need. There is also need, however, for easily administered group tests to supplement these techniques. It is the purpose of this study to compose, administer, and validate one such instrument, with emphasis on the social or functional aspect.

**Scope.**—A test was composed to measure a child's ability to use arithmetic in functional situations. It was administered in the first week of June, 1955, in five grade four classrooms in the city of Boston. In all, 122 children took the test. Of these, 78 were boys and 44 girls. The preponderance of boys is accounted for by the fact that two of the classes were in a school that had no girls. These two classes were in the same school, while each of the other classes was in a different school. A one-hour time limit was set on the test.
CHAPTER II
REVIEW OF LITERATURE

An extensive literature exists relating to social or functional arithmetic. It will be considered here under four headings, as follows:

1. Uses of arithmetic in daily life
2. Social arithmetic as theory
3. Social arithmetic in the school
4. Techniques for evaluation of social arithmetic.

1. Uses of Arithmetic in Daily Life

Number knowledge of preschool children. — A sizeable group of experimental studies deals with the knowledge of arithmetic possessed by children who are either of preschool age, or who, being of school age, have not yet begun formal study of arithmetic. Such studies make clear that arithmetic enters into the lives of these children in a functional way.

Buckingham and MacLatchy inventoried the arithmetic knowledge of children entering grade one. Six tests were administered to 1,356 children. These tests covered rote

counting, counting of concrete objects, selecting a given number of objects from a group of objects, naming the number in a given group of objects, verbal problems involving ten simple addition combinations, and problems for simple addition combinations involving concrete objects. In all of the areas covered by the tests, the children exhibited considerable understanding of numbers. This indicates that arithmetic forms a part of the experience of even very young children.

Mott tested 44 children of ages four and five. Ten different tests were used, similar to those mentioned in the previous study. The tests involved counting, manipulation of cubes, verbal problems, reading and writing numbers, and the like. The following conclusions of Mott help to clarify the arithmetic status of children in this age group:

1. Among children entering grade one, 90 per cent can count by rote to ten, 82 per cent to fifteen, 50 per cent to twenty, and 22 per cent to one hundred.

2. They can readily master the number names, and reproduce them in any sequence.

3. More or less clear concepts for the numbers from one to ten have been developed by 92 per cent of

the children.

4. The first five ordinals are recognized by 72 per cent of the children and reproduced by 64 per cent, while the first ten ordinals are recognized by 66 per cent and reproduced by 20 per cent.

5. The children add and subtract in work and at play with concrete objects.

6. In 86 per cent of the cases a number in a group is found by a one-by-one process. The more mature process of counting by twos, threes, and the like comes with experience.

3/ In a follow-up study, Mott and Martin found that these children carried over into grade one after three months away from school the number knowledge exhibited in kindergarten, with the exception of rote counting to one hundred. Since they probably did not need to count this high in their daily experiences, the ability atrophied.

Stotlar found that 19 preschool children show an awareness and understanding of number which can be traced to their real uses of number in daily life. 4/ Tests used by Stotlar covered rote counting, counting objects, repeating numbers,

3/ Sina Mott and Mary Elizabeth Martin, "Do First Graders Retain Number Concepts Learned in Kindergarten?" The Mathematics Teacher (February, 1947), 40:75-78.

and writing numbers.

A similar finding was reported by Woody in a study involving 2,700 children from kindergarten to grade two who had had no formal instruction in arithmetic. Tests used by Woody dealt with counting, reading numbers, telling time, fractions, money, measurement, addition and subtraction, and problems. The children as a whole showed possession of a substantial body of knowledge in these areas, even before being introduced to them in the classroom. Some correlation was noted between a child's grade placement and his score on the tests. It was likewise noted that boys did slightly better on all tests than girls. An important sidelight in the interpretation of the results, however, is the fact that many of the responses, although correct, were given in a hesitating and uncertain manner.

Arithmetic used by children of school age. Other writers have surveyed the actual situations in which children of school age report a need for arithmetic. They have further considered the kinds and amounts of processes needed for effective action in those situations.

In a survey by Ellsworth, 390 intermediate grade


children reported specific instances when they used arithmetic in their daily lives. In all, 53,163 cases were accounted for. Of these, telling time, using money, counting, and reading numbers made up almost 70 per cent of the usage. These were followed, in order of descending usage, by:

writing numbers, Roman numbers, adding of whole numbers, measuring length, measuring weight, subtracting of whole numbers, multiplication of whole numbers, division of whole numbers, adding fractions, measuring areas, improper and proper fractions, division of fractions, subtraction of fractions, and multiplication of fractions. The most used item here, writing numbers, constituted only 8.378 per cent of the total usage.

Moseley found that the arithmetic most used by 91 sixth grade children as recorded in their diaries had to do with making purchases, getting change, counting, adding, and subtracting. Division and fractions were little used by these children.

It was Polkinghorne's finding, however, that 266 primary grade children who had had no instruction in fractions, had acquired many fraction concepts from their


daily experiences. The best known concept was unit fractions, the least known, equivalent fractions.

Analysis by Wahlstrom of 1,687 spontaneous problems experienced by third grade children revealed the following:

1. Use of addition and subtraction almost to the exclusion of multiplication and division
2. Need for many kinds of addition and subtraction procedures, but in multiplication, of only the basic facts in isolation
3. Relative simplicity of all computations
4. Majority of problems of one step only
5. The importance of money transactions, but in small denominations only
6. The position of buying as the most widely used activity involving arithmetic.

Warren and Burton report the following as the most common business practices calling for use of arithmetic by 1050 fifth and sixth grade children: spending money, doing errands, counting change, earning money, mailing letters, addressing mail, buying stamps, visiting the post office, voting, using the telephone directory, using the telephone.


paying fares, and using the library.

Willey reviewed the arithmetical processes needed by children from kindergarten to grade six in solving 2,484 spontaneous daily problems. From kindergarten to grade two the majority of problems had to do with counting and reading numbers, while the most used computational routines were addition and subtraction. However, addition and subtraction were used more often by children in grades three and four than at any other level, and division and multiplication to a somewhat lesser extent. Common fractions, multiplication, and division were used more in grades five and six than at the lower grade levels. Mensuration received about equal emphasis in all the grades, while decimal fractions were needed chiefly above grade two.

Although these studies differ among themselves in details as to the placement of topics in social arithmetic, they do make clear that arithmetic is a factor in the lives of children.

Surveys of adult usage.—Wilson surveyed the amounts and kinds of arithmetic needed by 4,068 adults. Relatively simple cases of multiplication, addition, subtraction, division, fractions, and keeping of accounts, constituted 90 per cent of adult usage. Accordingly, Wilson concluded

that the arithmetic taught in the schools should be greatly simplified. What remains should be taught on a motivated, systematic, and meaningful basis, for 100 per cent mastery.

Betz also advocates a scientifically complete study of the uses of arithmetic in the modern world as a basis for the curriculum in arithmetic. He warns however of the inability of "life-situations" and curriculum workshops to provide really adequate surveys.

Criticism of surveys.-- Brownell is strongly critical of such attempts to survey arithmetic usage by children and adults. The fault lies, he feels, in the reliance on uses made by persons who have been taught arithmetic "... in the vacuum of the arithmetic class period" and who have never mastered the essential ideas and processes of arithmetic. This being the case, the uses actually discovered are


not reliable bases on which to determine the potential uses of an arithmetic properly acquired. The main value of such studies in Brownell's view is to demonstrate that needs in arithmetic follow rather than precede the learning of arithmetic concepts and skills.

Riggs is also critical of basing the curriculum on only those aspects of arithmetic shown by statistics to be useful to the average person. He maintains that much of arithmetic is of value to children per se and not because of the social uses to which it may be put. The primary emphasis in teaching should be on arithmetic as a body of number truths which have a rationale all their own.

According to Buckingham, surveys of usage place too narrow a restriction on the curriculum. In his view, "... a fuller treatment of topics is actually necessary in order that the parts of the topics which are most frequently used may be successfully learned." He contends further that frequency of usage surveys represent faulty technique because of the impossibility of securing all or even the major portion of usage in daily living. Topics revealed by surveys as


low in frequency, such as case three percentage, should not thereby be eliminated from the schools. The need for ability to handle them correctly is as urgent when it does arise as is ability to handle topics of higher frequency. Frequency of usage percentages might further be interpreted as a mandate to concentrate teaching attention on low frequency topics because of the probability that the high frequency ones will be taught by life. 

In the view of Grossnickle, the use of the criterion of adult usage, while eliminating much superfluous matter, has tended to ignore mathematical meanings and emphasize meaningless drill.

2. Social Arithmetic as Theory

Buckingham conceives of arithmetic as a subject of broad social implications, above and beyond ability to compute accurately. So considered, it involves a wide area of information, facts, judgments, generalizations, types, relationships, and attitudes, which touch the life of the individual at many points.


Buswell sees the true social utility of arithmetic, not in computational fluency, but in the relation of arithmetic to the higher rational processes and the development of a high type of quantitative thinking.

Weaver writes that the distinction between mathematically meaningful arithmetic and socially meaningful arithmetic is generally recognized. He cites however the confusion in terminology where different authors use different terms to refer to ideas that are essentially the same.

This confusion in terminology can be noted in the writings of many theorists. Thus, Brownell refers to the meaning of and the meaning for arithmetic. These correspond to the mathematical and the social phases respectively. In Buckingham's terminology, these are referred to simply as meaning and significance, with still a third element, insight, being closely united with them. Johnson in like manner


distinguishes between the structural (mathematical) meaning and the functional (social) meaning. He also perceives a third or operational meaning relating to the computational routine itself. Morton uses the terms logical criterion, social criterion, and psychological criterion. These refer to arithmetic as a science of number, as a factor in everyday life, and as a subject to be learned. According to Sueltz, the functional aspect of arithmetic is to be distinguished from the computational, and includes concepts, information, principles, relationships, understandings, and judgments.

Brueckner regards the mathematical and social phases as equally necessary for an effective arithmetic program. The scope of social arithmetic extends to such themes as

25/ J. T. Johnson, "What Do We Mean by Meaning in Arithmetic?" The Mathematics Teacher (December, 1948) 41:362-367.


the evolution of our institutions and ways of dealing with
the quantitative aspects thereof, the cooperation between
peoples made possible by number, and number as an aid to
economic literacy.

In the view of the Commission on Post-War Plans, the
social aim of arithmetic is the fundamental reason for
teaching arithmetic. However, to effectively attain this
end, the mathematical aim must be considered as well.

3. Social Arithmetic in the School

Activity programs. -- A number of educators have advocated
the development of functional competence through the
incidental teaching of arithmetic in a series of activity
units.

Harding and Bryant report a study in which one fourth
grade class was taught arithmetic by traditional textbook-
drill methods while a second fourth grade class was taught
through participation in a series of activities. Arithmetic
processes were learned as need for them arose in the activities.
At the conclusion of the experiment, both classes took the

29/ Commission on Post-War Plans, "The Second Report of
the Commission on Post-War Plans," The Mathematics Teacher
(May, 1945), 38:195-221.

30/ Lowry W. Harding and Inez P. Bryant, "An Experimental
Comparison of Drill and Direct Experience in Arithmetic
Learning in a Fourth Grade," Journal of Educational Research
(January, 1944), 37:321-337.
arithmetic subtests of the Stanford Achievement Test. It was found that the group taught by the activity method did as well as the more traditionally taught group in computations and better than the more traditionally taught group in problem solving. Moreover, the activities proved workable in the classroom, and resulted in the acquisition by the children of socially desirable habits.

Harap and Mapes report two studies in which children showed satisfactory gains in arithmetic after participating in an activity program. In the first study, 37 fifth grade children learned denominate numbers and multiplication and division of fractions through such activities as planning a candy sale or party. In the second study, 39 sixth grade children taught decimals by the activity method attained a mastery of 96 per cent while a group conventionally taught achieved a mastery of only 67 per cent.

Harap and Barrett report similar progress in arithme-
tic fundamentals in a third grade class taught by the activity method.

According to a study by Wilson, a group of children in grades one and two were taught addition and subtraction by a program of socially significant activities. Tests at the beginning of grade three indicated 100 per cent mastery of addition by 82 per cent of the children, 100 per cent mastery of subtraction by 74 per cent of the children, and a high degree of mastery by the rest of the children.

Criticism of activity programs. Hanna surveyed the opportunities for the use of arithmetic at grade three and at grade six level in a program based on problem situation activities. Many opportunities were found, both computational and non-computational in nature. However, in his view, such uses alone are not sufficient to develop arithmetic skills. They should more properly be regarded as readiness experiences preceding meaningful practice or drill. It was also noted that the activities surveyed tended to be hit-or-miss, with the danger that important outcomes of


35/ Paul R. Hanna, "Opportunities for the Use of Arithmetic in an Activity Program," The Teaching of Arithmetic, Tenth Yearbook of the National Council of Teachers of Mathematics, 1935, Teachers College, Columbia University, New York City, pp. 85-120.
instruction will be neglected. Such activities can be valuable in the building of a meaningful background but are not sufficient of themselves to develop functional competence. They must be supplemented by systematic practice. \[36/\]

In the opinion of Wheat, social arithmetic, i.e. arithmetic taught by the activity method with incidental attention to the number aspect of the situations, errs by expecting too mature a response from the child. It is necessary for the child in such a system to abstract the mathematical meaning from the social situation where his primary interest lies. Attempts to bolster the mathematical aspect by occasional attention to arithmetic constitute a denial of real value to mathematical meanings. It is in effect a rejection of the concept of arithmetic as a unity of related ideas in favor of an aggregation of unrelated and disposable parts.

Buswell is critical of incidental arithmetic because "... the essential content of arithmetic is in its number relationships which are not mastered through casual number experiences." \[38/\] It may be further doubted whether the


are incapable of measuring understanding as demonstrated in adaptation and application at the point of use. Other techniques must be substituted, such as discussion, observation, conferences, reports from parents, case histories over relatively long periods of time, and inventories of concepts and skills.

Spitzer takes the opposite view by advocating objective tests as well as subjective techniques in such non-computational areas as social arithmetic. Objective tests, however, need to be improved along such lines as the following:

1. Inclusion of situations for oral or mental arithmetic, with approximate answers sufficient in many cases

2. Use of language forms different from the language of instruction

3. Measurement of one aspect of a whole as the key to the whole.

Sueltz has written extensively on the evaluation of functional arithmetic. He favors testing for concepts, judgments, perception of relationships, social and economic information, processes and manipulations, problems

and basic thought patterns, reflections and judgments. Evaluation can take many forms, such as pencil and paper tests, observations of daily work, interviews, discussion, and the like. Measurement instruments can make profitable use of objective materials or of pictorial materials, verbally described. In tests involving such materials, interviews showed that there was almost no pure guessing.

5. Recapitulation

It is evident from the studies reviewed that increasing attention is being focussed on the social aspect of arithmetic. Educators are attempting to define the arithmetic needs which children experience in their daily lives and will continue to experience throughout life. They are attempting to develop programs of classroom instruction which will meet these needs both on an immediate and on a long-range basis. Finally, they are attempting to develop evaluation techniques and devices which will be in keeping with the expanded objectives of the modern arithmetic program.


CHAPTER III

PROCEDURE

1. General Objectives

It was the purpose of the study to construct and validate a test capable of measuring sensitivity to number in social situations at fourth grade level. Study of the literature relating to social arithmetic revealed widespread acceptance of the need for considering certain of the broader aspects of arithmetic in devising any such instrument. These broader aspects may be considered to be the general objectives of the test. They are as follows:

1. Possession of arithmetic information
2. Ability to use graphic material
3. Mastery of processes
4. Understanding and interpretation of principles
5. Knowledge of arithmetic vocabulary
6. Possession of economic information
7. Understanding of arithmetic concepts
8. Formulation of arithmetic judgments.

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2. Specific Objectives

Since the test is one of functional ability in arithmetic, the specific objectives have to do with situations in which need for arithmetic occurs, rather than with computations or with a course of study as such. Primary interest is on situations rather than subject matter. For this reason, few exact computations are involved, and those are of a relatively simple nature. The course of study was consulted primarily as a check against overly difficult computations. The source of the specific objectives can be traced to the various studies which investigate the daily arithmetic needs of children. The more or less general situations found there are interpreted in the test in terms of more concrete everyday situations. The number of such situations is conceivably limitless. However, an attempt was made to select a representative cross section which would yield a reliable index of overall functional competence in number.

The situations constituting the specific objectives of the test, arranged in the order in which they occur, are as follows:

1. Using clocks (Items 1-3)
2. Using dates of birth interpretatively (Items 4-6)
3. Taking books from the library (Item 7)
4. Using various time measures (Items 8-10)
5. Understanding and using the calendar (Items 11-15)
6. Judging the reasonableness of cost (Item 16)
7. Converting change into dollars (Items 17-18)
8. Determining a common purchase unit (Item 19)
9. Understanding of relative values of commodities (Item 20)
10. Possessing a fraction vocabulary (Item 21)
11. Understanding concept of relative size of fractions (Item 22)
12. Verbalizing a telephone number (Item 23)
13. Functional understanding of number sequence (Item 24)
14. Possessing concepts of the approximate populations of the nation and community (Items 25-26)
15. Interpreting mileage on a speedometer (Item 27)
16. Performing blackboard computations (Item 28)
17. Identifying common geometric shapes (Items 29-31)
18. Determining street addresses (Item 32)
19. Keeping various scores (Items 33-35)
20. Keeping a budget (Items 36-38)
21. Making a purchase (Item 39)
22. Buying theater tickets (Items 40-41)
23. Using thermometers (Items 42-44)
24. Using a train schedule (Items 45-50)
25. Interpreting and estimating measures of distance (Items 51-52)
26. Interpreting scales (Items 53-54).

3. Analysis of the Test

Construction.-- A test of fifty-four items was composed, covering each of the situations listed under special objectives. The vocabulary and reading difficulty of the items were kept as simple as possible. Pictures were included in several instances where it was felt that they would help to clarify a situation.

Interpretation of results.-- There are no subtests as such in the test, although in a number of cases, two or more items apply to one situation and are grouped together. An individual's score on the test corresponds to the total number of correct answers. A single score has little meaning in itself and should be interpreted in terms of the group distribution. This total score is the overall measure of functional competence in arithmetic when properly interpreted.

Corrections.-- Three errors in the text of the tests were detected only after all the tests were duplicated and had to be corrected by pen. In item 18, the (a) (b) (c) (d) alternatives in the answer space were omitted. In the drawings of the scale for items 53 and 54, some of the figures did not reproduce clearly and had to be inserted in ink. Finally, there was no correct answer provided for item 54 as it appeared originally. The (b) alternative
had to be corrected to read 32 ounces.

4. Description of Items

**Items 1-3.** The first item calls for ability to identify a clock depicting 10:45. Items 2 and 3 call for this ability to use a clock face, plus knowledge of the approximate time for supper and for daily dismissal of school.

**Items 4-6.** The first two items require application of the generalization that a person born in an earlier year is older than one born in a later year. Item 6 requires the judgment that the data furnished is insufficient for the question asked.

**Item 7.** This item calls for recognition of the fact that a day three weeks from a given day will fall on that same day itself.

**Items 8-10.** The first item requires knowledge of the opening and closing time for school each day, plus ability to convert the interval between the two times to hours. Item 9 is similar, but deals with whole months. Item 10 is primarily a test of number information.

**Items 11-12.** These items require the knowledge that February 30 is an impossible date while February 29 is not.

**Items 13-15.** In these items, a knowledge of the exact date of three holidays is necessary, plus ability to use a calendar corresponding to a year which is asked
for in more or less special terms.

**Item 16.** Here, the child must read a number of sums of money and decide which one is reasonable under the circumstances.

**Items 17-18.** In these items, it is necessary to convert change to dollars and cents and then decide which one set of similar figures expresses that amount correctly.

**Item 19.** This item tests for information regarding the purchase unit of a common household commodity.

**Item 20.** Here is required a general idea of the relative value of four expensive commodities.

**Items 21-22.** Item 21 is a test of ability to verbalize a fraction correctly, while item 22 is concerned with interpretation of the relative sizes of fractions.

**Item 23.** This item deals with the commonly accepted way of saying a telephone number. Strictly speaking, none of the alternative answers can be called incorrect. The emphasis here, however, is on the usual way of doing things.

**Item 24.** This item requires ability to count in series, when at one point in the series, regrouping from smaller to larger groups is necessary.

**Items 25-26.** These items test for concepts of the size of the populations of the nation and of the community, plus ability to characterize them in the most satisfactory numerical terms.
Item 27.-- This item calls for knowledge of the use of a familiar device which is also often used in teaching, plus ability to count in the ten thousands.

Item 28.-- This item requires ability to perform fourth grade calculations without error.

Items 29-31.-- It is necessary here to identify three geometric figures in common use.

Item 32.-- In this item the child must know that the street numbers of two adjacent houses differ by two. He must also be able to go from tens to hundreds in counting.

Items 33-35.-- These items require knowledge of ways of keeping score in popular games, plus ability in addition. It should be noted in connection with item 35 that the course of study for grade four limits column addition to four addends. The inclusion of a larger number of addends here seems justified, however, since (1) the situation, or like situations, are conceivably common in children's experiences, and (2) the computations involved are not difficult.

Items 36-38.-- Here it is necessary to read a simple budget. Item 36 calls further for ability in addition, item 37 for an interpretation of overall spending habits, and item 38 for the understanding that the week of no savings is the week in which the entire allowance was spent.
Item 39.-- In this item the child must determine the amount of money at hand and the cost of various combinations of articles in accordance with the prices listed.

Items 40-41.-- Here it is necessary to (1) read the list of prices at the theater, (2) determine the time of day, either from the clock or by inference, and (3) decide upon the admission prices both for individuals and for groups.

Items 42-44.-- These items test ability to interpret the temperatures on the thermometers in such terms as hot, just right, and cold.

Items 45-50.-- Each of these items calls for ability to read a simple train schedule. Item 45 relates the schedule to a given time of day as represented by the clock. In item 46 it is necessary to (1) determine the time lapse between that time indicated by the clock and that indicated for departure by the schedule, and (2) formulate a judgment as to the sufficiency of that time for a particular activity. Item 49 requires ability to determine the time lapse between 12:30 P. M. and 3:18 P. M., plus the recognition of 48 minutes as approximately three quarters of an hour.

Items 51-52.-- Item 51 requires the understanding that the smaller the size of the measure, the larger the number of those measures in a given unit. Item 52 requires ability to estimate a short measured length.
Items 53-54.-- These items require originality of performance in perceiving that one quarter, one half, and three quarters of a pound can conveniently be considered as four, eight, and twelve ounces respectively. The given weight on the scale in item 53, and the maximum weight asked for in item 54, can then be converted readily.

5. Administration of the Test

The test was administered in June of 1955 in five grade four classrooms in the city of Boston. These classes are hereafter referred to as classes A, B, C, D, and E. Each teacher administered the test to his own class, while the present writer corrected and analyzed the results. Each teacher had at his disposal a sheet of directions for administering the test, plus sufficient copies for his class. In all, 122 children took the test. No attempt was made to give the test to the several children absent on the day of the test since it was felt that the data already procured was adequate and a few additional cases would not have strongly influenced any of the trends noted in the analysis which follows in the next chapter.
CHAPTER IV
ANALYSIS OF DATA

1. Introduction

In this chapter, data pertinent to this study will be analyzed under three headings, as follows:

1. Data descriptive of the group
2. Data relevant to item analysis
3. Data relevant to correlation study.

Under data descriptive of the group will be considered (1) the chronological ages, (2) the intelligence quotients, (3) the reading grades, and (4) the functional competence in arithmetic (F. C. A.) test scores for individual classes and for the total group.

Under data relevant to item analysis, (1) the difficulty and (2) the discriminative power of each item will be examined.

Finally, in the correlation study, the F. C. A. test results will be correlated with the results derived from the use of measures in three other areas.
2. Data Descriptive of the Group

**Chronological ages.**—Table 1 summarizes data relevant to the chronological ages for each class and for the total group of 122 children taking part in this study. The youngest child who took the test had a chronological age of nine years, two months. The oldest child had a chronological age of twelve years, nine months. All of the children were in the fourth grade. The mean age for the total group was ten years, three months, with a standard deviation of 8.9 months. The modal age group is found in the interval from nine years, eight months, to nine years, ten months. The highest mean chronological age is found in class E. This class also showed the greatest degree of heterogeneity in terms of the sizes of the standard deviations, while class D showed the least variability in this respect.

**Intelligence quotients.**—The distribution of the intelligence quotients for each class and for the total group appears in Table 2. The data is derived from the Kuhlmann-Anderson group intelligence tests which were administered in October of 1954. The range of intelligence quotients for the total group is from a low of 68 to a high of 126. The mean intelligence quotient for the total group is 90.0, with a standard deviation of 11.1. The modal interval is from 86 to 88. The group as a whole is thus of low average intelligence as measured by this test.
Class E again showed the greatest amount of variability. Class C was most homogeneous in intelligence, followed by class A. Data on two children in class E was lacking.

Reading grades.—Table 3 lists the distribution of reading grades for each class and for the total group. The data is based on the word meaning and paragraph meaning subtests of the Durrell-Sullivan Reading Achievement Test. This test was administered in October of 1954. It is to be expected that each child's actual reading grade in June of 1955 when the F. C. A. tests were administered was higher than recorded in Table 3. However, it is likely that the majority of children held the same relative position within the group in June that they held the previous October. For this reason, the reading grade data is summarized here and appears later in the correlation study.

As of October, 1954, the highest reading grade for the total group was 5.8, and the lowest, 2.0. The mean reading grade was 3.4, with a standard deviation of 0.8. The modal interval was 2.6 to 2.8. Class C was again the most homogeneous, while classes A and D showed the greatest variability in reading grades. Data on 22 children was not available.
F. C. A. test scores.-- The distribution of total scores for each class and for the entire group on the F. C. A. tests appears in Table 4. The highest score on this test was 41 and the lowest was 3. The modal interval was from 23 to 25. The mean score for the total group was 21.1, with a standard deviation of 6.9. The mean score may be interpreted as an indication that the average child answered 21.1 items, or 39.1 per cent of the total 54 items of the test, correctly. If a criterion of 50 per cent difficulty for the average child be set up, it follows that the test was roughly 10 per cent too difficult for this particular group. Class E showed the greatest variability in test scores and class B the least.
Table 1. Frequency Distribution of Chronological Ages for Each Class and for the Total Group

<table>
<thead>
<tr>
<th>Age</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
<th>Class D</th>
<th>Class E</th>
<th>Total Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-8 to 12-10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12-5 to 12-7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12-2 to 12-4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11-11 to 12-1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>11-8 to 11-10</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>11-5 to 11-7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>11-2 to 11-4</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>10-11 to 11-1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>10-8 to 10-10</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>10-5 to 10-7</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>10-2 to 10-4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>9-11 to 10-1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>9-8 to 9-10</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>9-5 to 9-7</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>9-2 to 9-4</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>27</td>
<td>29</td>
<td>122</td>
</tr>
</tbody>
</table>

Mean........... | 10-3 | 10-3 | 10-2 | 10-2 | 10-5 | 10-3 |
S. D........... | 8.9 mos. | 9.4 mos. | 9.4 mos. | 7.6 mos. | 9.3 mos. | 8.9 mos. |
Table 2. Frequency Distribution of Intelligence Quotients for Each Class and for the Total Group

<table>
<thead>
<tr>
<th>I. Q.</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
<th>Class D</th>
<th>Class E</th>
<th>Total Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 to 128</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>122 to 124</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>119 to 121</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>116 to 118</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>113 to 115</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>110 to 112</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>107 to 109</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>104 to 106</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>101 to 103</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>98 to 100</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>95 to 97</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>92 to 94</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>89 to 91</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>86 to 88</td>
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<td>1</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>83 to 85</td>
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<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>80 to 82</td>
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<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>77 to 79</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>74 to 76</td>
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<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>5</td>
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<td>71 to 73</td>
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<td>1</td>
<td>0</td>
<td>2</td>
<td>5</td>
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<td>68 to 70</td>
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<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>27</td>
<td>27</td>
<td>120</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>88.9</td>
<td>91.0</td>
<td>90.8</td>
<td>93.1</td>
<td>85.3</td>
<td>90.0</td>
</tr>
<tr>
<td><strong>S. D.</strong></td>
<td>8.9</td>
<td>12.1</td>
<td>8.8</td>
<td>10.6</td>
<td>13.4</td>
<td>11.1</td>
</tr>
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</table>
Table 3. Frequency Distribution of Reading Grades for Each Class and for the Total Group

<table>
<thead>
<tr>
<th>Reading Grade</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
<th>Class D</th>
<th>Class E</th>
<th>Total Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.6 to 5.8...</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
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<td>5.3 to 5.5...</td>
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<td>5.0 to 5.2...</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4.7 to 4.9...</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4.4 to 4.6...</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>4.1 to 4.3...</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3.8 to 4.0...</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>11</td>
</tr>
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<td>3.5 to 3.7...</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
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<td>3.2 to 3.4...</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>2.9 to 3.1...</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>2.6 to 2.8...</td>
<td>4</td>
<td>5</td>
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<td>18</td>
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<td>2</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>2.0 to 2.2...</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Total..........</td>
<td>18</td>
<td>20</td>
<td>9</td>
<td>27</td>
<td>26</td>
<td>100</td>
</tr>
<tr>
<td>Mean..........</td>
<td>3.3</td>
<td>3.5</td>
<td>3.3</td>
<td>3.4</td>
<td>3.3</td>
<td>3.4</td>
</tr>
<tr>
<td>S. D..........</td>
<td>0.9</td>
<td>0.8</td>
<td>0.4</td>
<td>0.9</td>
<td>0.8</td>
<td>0.8</td>
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</table>
Table 4. Frequency Distribution of Scores in Functional Competence in Arithmetic (F. C. A.) Tests for Each Class and for the Total Group

<table>
<thead>
<tr>
<th>F. C. A. Scores</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
<th>Class D</th>
<th>Class E</th>
<th>Total Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>41 to 43...</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>38 to 40...</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>35 to 37...</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<td>32 to 34...</td>
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<td>6</td>
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<td>29 to 31...</td>
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<td>26 to 28...</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>23 to 25...</td>
<td>4</td>
<td>3</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>20 to 22...</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>17 to 19...</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>14 to 16...</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>22</td>
</tr>
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3. Data Relevant to Item Analysis

**Difficulty of items.**—Table 5 lists the number of children in each class and in the total group who passed each item. Examination of the table shows that item 1 was answered correctly by the total group more often than any other item. Conversely, item 22 was answered correctly by the total group the least number of times. The items as they appear in the table and as they appear in the test are not arranged in the order of difficulty.

Table 6 converts the data of Table 5 to percentages. It will be seen that item 1, the easiest item in the test in terms of the number of correct answers, was passed by 84.5 per cent of the total group. Item 22, the most difficult item, was passed by only 4.9 per cent of the total group.

Conversion of numbers of correct responses to per cents of correct responses permits direct comparison of the difficulty of each item from class to class. The relative difficulty of many of the items will then be seen to vary from class to class. Thus, item 7 was answered correctly by 62.9 per cent of class D, but by only 20.4 per cent of class E. However, items 22 and 53 proved difficult for all groups.

A rather general tapering off in per cents of correct responses toward the end of the test can also be noted in
Table 6. However, the easy and the more difficult items are scattered fairly evenly throughout the test.

In Table 7, the items of the test are arranged in order of difficulty from hardest items to easiest. The degree of difficulty, both for individual classes and for the total group, is determined by the per cent of correct responses for each item.

The largest difference in per cent of correct responses between any two adjacent items in Table 7 is that found between items 2 and 23. Item 2 was answered by 82.0 per cent of the total group and item 23 by 71.3 per cent, for a difference of 10.7 per cent. Otherwise, a gradual but steady rise in difficulty can be noted from the easiest item to the hardest.

Forty items were answered correctly by less than 50 per cent of the total group. Fourteen items were answered correctly by more than 50 per cent of the total group. If a criterion of 50 per cent difficulty of the entire test for the average child be adopted, a number of items would have to be made easier.

For purposes of this investigation, the total range of per cents in Table 7 can be conveniently subdivided into five equal sub-ranges, running from 1 per cent to 100 per cent, as follows:
1. From 1 per cent to 20 per cent
2. From 21 per cent to 40 per cent
3. From 41 per cent to 60 per cent
4. From 61 per cent to 80 per cent
5. From 81 per cent to 100 per cent.

Examination of data for the total group in Table 7 will then show that 7 items, or 12.9 per cent of the total of 54 items in the test, were answered correctly from 1 to 20 per cent of the time. Likewise, 25 items, or 46.3 per cent of the test, were answered correctly from 21 to 40 per cent of the time. A total of 15 items, or 27.8 per cent of the test, were answered correctly from 41 to 60 per cent of the time. A total of 5 items, or 9.2 per cent of the test, were answered correctly from 61 to 80 per cent of the time. Finally, 2 items, or 3.7 per cent of the test, were answered correctly from 81 to 100 per cent of the time. From this, it follows that the largest per cent of correct answers occurred only 21 to 40 per cent of the time. This again is an indication of a slight deviation of the test results from a criterion of 50 per cent difficulty for the average child. Under such a criterion, the largest number and percentage of correct answers would be found in the range from 41 to 60 per cent.
From Table 7, it appears that no single item is too easy, while items 22 and 53 are possibly too difficult individually for this group. However, the items as a whole probably need to be made slightly easier for use with this particular group.

**Discriminative power of items.**-- In Table 8, the number and per cent of correct answers made on each item by the 21 per cent of the total group scoring highest on the F. C. A. test are compared with similar data for the 21 per cent scoring lowest. The high group and the low group each include 26 children. The rather arbitrary figure of 21 per cent was selected because it accommodated more readily with the ungrouped frequency distribution of test scores than would the use of the upper and lower quartiles. Use of upper and lower quartiles would have involved inclusion in this portion of the study of four scores of 16 at the upper limit of the lower quartile and exclusion of two other scores of 16. The problem then arose as to which four scores to include and which two to exclude. This difficulty was avoided by reducing the quartiles to 21 per cent. This meant a loss of only four children in each group, which it was felt would not affect the findings in any marked fashion.
From Table 8, it appears that the great majority of items discriminate well between the high group and the low group. Particularly worthy of note on this account are items 2, 5, 7, 8, 11, 16, 17, 31, 40, 41, and 43. Items 25, 26, 49, 53, and 54 are less satisfactory and should be improved to make them more discriminative. Item 22 was answered correctly more often by the low group than by the high group.
Table 5. Number of Correct Responses Per Item for Each Class and for the Total Group

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Table 7. Arrangement of Items According to Difficulty as Determined by the Number and Per Cent of the Total Group Passing Each Item

| Item | Total Group | | Item | Total Group |
|------|-------------| | --- | --- |
|     | Number | Correct | Per Cent | Number | Correct | Per Cent |
| 22   | 6 | 4.9 | | 37 | 45 | 36.9 |
| 53   | 11 | 9.0 | | 18 | 48 | 39.4 |
| 25   | 17 | 13.9 | | 19 | 48 | 39.4 |
| 49   | 17 | 13.9 | | 36 | 48 | 39.4 |
| 54   | 17 | 13.9 | | 44 | 48 | 39.4 |
| 26   | 20 | 16.4 | | 7 | 50 | 41.0 |
| 51   | 23 | 18.9 | | 33 | 51 | 41.8 |
| 48   | 26 | 21.3 | | 52 | 52 | 42.6 |
| 47   | 27 | 22.1 | | 11 | 55 | 45.1 |
| 15   | 28 | 23.0 | | 9 | 58 | 47.6 |
| 45   | 28 | 23.0 | | 20 | 58 | 47.6 |
| 12   | 30 | 24.6 | | 28 | 59 | 48.4 |
| 38   | 30 | 24.6 | | 35 | 59 | 48.4 |
| 29   | 31 | 25.4 | | 5 | 62 | 50.8 |
| 39   | 31 | 25.4 | | 17 | 62 | 50.8 |
| 32   | 32 | 26.2 | | 16 | 63 | 51.7 |
| 40   | 32 | 26.2 | | 30 | 67 | 54.9 |
| 41   | 32 | 26.2 | | 13 | 69 | 56.8 |
| 50   | 35 | 28.7 | | 31 | 71 | 58.2 |
| 10   | 36 | 29.5 | | 43 | 71 | 58.2 |
| 46   | 36 | 29.5 | | 4 | 77 | 63.1 |
| 14   | 37 | 30.3 | | 8 | 82 | 67.2 |
| 21   | 38 | 31.2 | | 5 | 83 | 68.1 |
| 34   | 38 | 31.2 | | 42 | 86 | 70.5 |
| 24   | 42 | 34.4 | | 23 | 87 | 71.5 |
| 27   | 42 | 34.4 | | 2 | 100 | 82.0 |
| 6    | 45 | 36.9 | | 1 | 103 | 84.5 |
### Table 8. Number and Per Cent of Correct Responses Per Item by the 21 Per Cent of the Total Group Making the Highest Scores and by the 21 Per Cent of the Total Group Making the Lowest Scores

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Table 8. (concluded)

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4. Data Relevant to Correlation Study

The results of the F. C. A. tests were correlated with the chronological ages, intelligence quotients, and reading grades of the group. Otis Correlation Charts were used.

The Pearson product-moment coefficient of correlation between the F. C. A. test and the intelligence quotients of the total group was .562 with a probable error of .042. This indicates a moderate tendency for brighter children to score higher on the test than less bright children. This is not sufficiently high, however, to cast doubt on the validity of the test. Some correlation was to be expected since the test purposely emphasized the elements of novelty, interpretation, and originality of performance.

The coefficient of correlation between the F. C. A. test and the reading grades of the total group was .567 with a probable error of .045. This again indicates a moderate tendency for good readers to perform more effectively than poor readers in a test that must of necessity make use of written material. The important reading skill of interpreting graphic material probably affects a child's total score to some extent also. This may be taken as an indication that here, as in many functional situations in real life where arithmetic is needed, ability to utilize a number of reading skills can often be the key to effective action.
The coefficient of correlation between the F. C. A. test and the chronological ages of the group was a negative .119 with a probable error of .006. This indicates a very slight tendency for younger children to score higher on this test than older children.

Because of circumstances beyond the control of the present writer, no data from standardized arithmetic achievement tests was available for use in this study.
CHAPTER V
CONCLUSIONS AND LIMITATIONS

1. Conclusions

The major conclusions to be drawn from this study are as follows:

1. No single test item was too easy for the total group.
2. No single test item was too difficult for the total group.
3. The test as a whole tended to be about 10 per cent too difficult for the average child.
4. The test items were not arranged according to difficulty, although the first two items proved coincidentally to be the two easiest items in the test.
5. The great majority of test items discriminated between the group scoring highest on the test and the group scoring lowest.
6. Children need more experiences in interpreting graphic material.
7. The reading difficulty of the test items was not a major factor in the F. C. A. test results, but
there was a tendency for good readers to score higher than poor readers.

8. The intelligence quotients of the total group were not major factors in the F. C. A. test results, but again, a moderate tendency was noted for high I. Q. children to score higher on the test than low I. Q. children.

9. The chronological ages of the children had very little effect on their total scores.

10. A tendency for per cent of correct responses to taper off toward the end of the test was noted. This suggests that possibly the test was too long to be administered at one sitting. Administration of the test in two half-hour sittings would probably bring the test into greater conformity with the criterion of 50 per cent difficulty for the average child.
2. Limitations

The findings of this study are to be interpreted in the light of the following limitations:

1. The size of the sample tested was comparatively small.

2. The sample was drawn from a single community, and was representative of only one socioeconomic level of the population.

3. The sample was, as a group, of low average intelligence.

4. The number of boys exceeded the number of girls by almost two to one.

5. The scores made by boys were not compared with the scores made by girls.

6. Results of the F. C. A. test were not correlated with results from a standardized arithmetic achievement test.

7. No norms were determined for the F. C. A. test.

8. The situations involved in the test items may not have represented a true cross section of the daily arithmetic needs of children.

9. The emphasis on the various situations in the test was not distributed in accordance with their importance in the life of the child.
10. The test was not diagnostic.

11. A total of 54 items of the type used in this test was probably too large for children of fourth grade level to answer in one uninterrupted sitting.

3. Suggestions for Further Study

1. The test should be revised. It should be made easier, with the items arranged according to difficulty wherever practicable.

2. A new test along similar lines could be constructed and compared experimentally with this test.

3. A new test could be constructed which would give exhaustive coverage to one type of situation only, such as use of measures of time. Such a test would differ from the F. C. A. test which samples widely in a number of types of situations in arriving at a general measure of functional competence in arithmetic.

4. The value of the pictorial approach featured in a number of items should be studied experimentally.

5. The effect of the novelty of the test items should be studied experimentally.
6. Local percentile norms should be developed.

7. Analysis of test results could be followed up by individual interviews with children to determine the thought processes underlying particular responses.

8. The relation of computational arithmetic to social arithmetic should be experimentally defined.

9. The daily arithmetic needs of children involving attitudes, judgments, computations, and the like, should be more precisely determined.

10. The test should be administered at different grade levels to determine where it can best be used.


27. Mott, Sina, and Mary Elizabeth Martin, "Do First Graders Retain Number Concepts Learned in Kindergarten?" The Mathematics Teacher (February, 1947), 40:75-78.


APPENDIX
DIRECTIONS

1. Giving the test.

Make sure that each child has a pencil with a sharp point. Have a supply of sharpened pencils on hand.

Write the two sample questions from the first test page on the blackboard before passing out the test booklets.

When the booklets have been passed out, have each child write his name and the date in the appropriate place on the first page.

Then, read the first sample question to the class. Show that four possible answers are given, only one of which is the right answer. Let the class decide that (c) is the right answer in this case. Then, show that there is an answer space, listing (a), (b), (c), (d), at the right hand edge of the paper. Fill in the (c) alternative on the blackboard sample and also on a demonstration test booklet held up for the class to see. Then, have each child black in the (c) alternative on his copy. Stress that the choice be indicated by a heavy black mark, thus: (a) (b) (c) (d).

Then, follow the same procedure for the second sample question, the most acceptable answer in this case being (d).

Then, say that there are a number of other questions in the booklet that are done in just the same way as the two samples just completed. Say that each question should be done carefully, any pictures or charts being carefully noted. Say that if any question is too hard, it should be omitted for the present, and taken up again at the end of the test if there is time.

Then, have the class open to the next page and go on with the rest of the test. Allow each child as much time as he needs, up to one hour. Collect each child's paper as he finishes, and all the unfinished tests after one hour.
3. Scoring the test

The teacher will not need to score the test. This will be done by the writer. It would be appreciated, however, if the teacher would copy from the child's standardized test record card the rest of the information called for on the first page of the test, viz:

Date of birth
Kuhlmann-Anderson I. Q. or Mental Age (preferably I. Q.)
Durrell-Sullivan Reading Grade or Reading Age (preferably Reading Grade).

The corrected tests will be returned to the teacher desiring them in the fall.
(1) Which example above is not right?
(a) 1  (b) 2  (c) 3  (d) 4

(a) (b) (c) (d)

(2) Which picture shows the best way to send away 25¢ in the mail?
(a) 1  (b) 2
(c) 3  (d) 4

(a) (b) (c) (d)
(1) Which clock shows 10:45?
   (a) 1  (b) 2  (c) 3  (d) 4

(2) Which clock shows the best time for supper?
   (a) 1  (b) 2  (c) 3  (d) 4

(3) Which clock shows the time school is over each day?
   (a) 1  (b) 2  (c) 3  (d) 4

(4) Fred was born in 1938. Which is right to say—
   (a) he is older than you are?
   (b) he is younger than you are?
   (c) he is the same age that you are?
   (d) there is no way of telling which he is? (a) (b) (c) (d)

(5) Helen was born in 1949. Which is right to say—
   (a) she is the same age that you are?
   (b) she is older than you are?
   (c) she is younger than you are?
   (d) there is no way of telling which she is? (a) (b) (c) (d)
(6) Jim was born on April 4. Which is right to say—
(a) he is older than you are?
(b) he is younger than you are?
(c) there is no way of telling which he is?
(d) he is the same age that you are?  (a) (b) (c) (d)

(7) You can keep a library book for three weeks. Then do you have to bring back a book you take out on Wednesday?
(a) Monday  (b) Wednesday  (c) Friday  (d) Saturday  (a) (b) (c) (d)

(8) About how long do you go to school every day?
(a) 5 1/2 hours  (b) 4 hours
(c) 8 hours  (d) 3 1/2 hours  (a) (b) (c) (d)

(9) How many whole months is school closed during the summer?
(a) 2  (b) 4
(c) 1  (d) 5  (a) (b) (c) (d)

(10) Which century do we live in?
(a) 21, A.D.  (b) 20, A.D.
(c) 21, B.C.  (d) 20, B.C.  (a) (b) (c) (d)

(11) Which date is not on this year’s calendar?
(a) April 30  (b) December 31
(c) March 31  (d) February 30  (a) (b) (c) (d)

(12) Which date could never be on a calendar?
(a) April 31  (b) January 31
(c) February 29  (d) May 31  (a) (b) (c) (d)
13. Look at the calendars. What day is Christmas this year?

(a) Saturday  (b) Monday  
(c) Sunday    (d) Thursday

14. Look at the calendars. What day was Columbus Day last year?

(a) Wednesday (b) Tuesday  
(c) Monday     (d) Sunday

15. The May calendars are not finished. If they were finished, 
what day would have been Memorial Day two years ago?

(a) Friday   (b) Monday  
(c) Thursday (d) Saturday
(16) How much would Tom’s mother pay for one
dozen of eggs?
(a) $65  (b) $0.65
(c) $0.65  (d) $6.50
(a) (b) (c) (d)

(17) Alice has 603 pennies in her bank. How
much is that?
(a) $60.30  (b) $0.603
(c) $603  (d) $6.03
(a) (b) (c) (d)

(18) David has this in his bank: 3 half-dollars,
4 quarters, 6 dimes, 3 nickels, and 8 pennies.
How much is that?
(a) $3.33  (b) $3.29
(c) $3.77  (d) $3.27
(a) (b) (c) (d)

(19) How do you buy coal?
(a) By the gallon  (b) By the pound
(c) By the ton  (d) By the liter
(a) (b) (c) (d)

(20) Which usually costs most brand new?
(a) Car  (b) House
(c) Motorcycle  (d) T.V. set
(a) (b) (c) (d)

(21) How would you say this number: 3½ inches?
(a) Three- one-fourth inches
(b) Three- fourths inches
(c) One and three-quarters inches
(d) Three and one-quarter inches
(a) (b) (c) (d)
(22) Which number is the largest?
(a) $\frac{3}{6}$  (b) $\frac{3}{4}$
(c) $\frac{3}{16}$  (d) $\frac{1}{2}$

(23) How would you say this telephone number?
(a) Greenwood, Three, Forty-seven, Sixty-nine
(b) Greenwood, Three, Four-thousand, Seven-hundred, Sixty-nine
(c) Greenwood, Thirty-four-thousand, Seven-hundred, Sixty-nine
(d) Greenwood, Three, Four, Seven, Six, Nine

(24) Which set of numbers is wrong?
(a) 398, 399, 400, 401, 402
(b) 6007, 6008, 6009, 7000, 7001, 7002
(c) 49,998, 49,999, 50,000, 50,001
(d) 298,999, 299,000, 299,001

(25) Which word tells best how many people altogether live in the United States?
(a) millions  (b) hundreds of thousands
(c) thousands  (d) billions
(26) Which word tells best how many people altogether live in Boston?

(a) millions  (b) hundreds of thousands
(c) thousands  (d) billions

(a) (b) (c) (d)

(27) This is a part of the speedometer of Larry's father's car. How will it look the next time it changes?

(a)  (b)  (c)  (d)

(a)  (b)  (c)  (d)

(28) The children were working at the blackboard.

Whose work has a mistake?

(a) Alfred's  (b) Jane's
(c) Martha's  (d) Donald's

(a) (b) (c) (d)
(29) Which drawing shows a rectangle?
   (a) 1    (b) 2
   (c) 3    (d) 4

(30) Which drawing shows a right angle?
   (a) 1    (b) 2
   (c) 3    (d) 4

(31) Which drawing shows a triangle?
   (a) 1    (b) 2
   (c) 3    (d) 4

(32) Michael lives at 99 Maple St. His best friend, David, lives next door. What is David's address?
   (a) 101 Maple St.    (b) 100 Maple St.
   (c) 98 Maple St.    (d) 105 Maple St.

(33) What was the score of this football game?
   (a) Eagles 61 - Cubs 54
   (b) Cubs 56 - Eagles 55
   (c) Cubs 58 - Eagles 55
   (d) Eagles 57 - Cubs 57
(34) What score do the tallies show?
(a) Rams 15 -- Lions 15
(b) Lions 15 -- Rams 14
(c) Rams 15 -- Lions 14
(d) Lions 15 -- Rams 10

(a) (b) (c) (d)

(35) In the dart game, who scored the most points?
(a) Tom
(b) Sue
(c) Dick
(d) Ruth

(a) (b) (c) (d)

Frank gets $1.50 every week for himself. This is how he spent it for 4 different weeks:

<table>
<thead>
<tr>
<th>MAY 2-8</th>
<th>MAY 9-15</th>
<th>May 16-22</th>
<th>May 23-29</th>
</tr>
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<tbody>
<tr>
<td>Shows   $0.35</td>
<td>Shows $0.70</td>
<td>Shows $0.70</td>
<td>Shows $0.90</td>
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<td>Candy   $25</td>
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<td>Other   $30</td>
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<td>Save    $50</td>
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<td>Save    $35</td>
<td>Save    $20</td>
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(36) How much did he spend on candy these 4 weeks?
(a) $1.05
(b) $0.90
(c) $0.95
(d) $1.00

(a) (b) (c) (d)
(37) What does he usually spend the least on each week?
(a) Church   (b) Candy
(c) Shows     (d) Savings

(38) Which week did he spend all his money?
(a) May 2-8   (b) May 9-15
(c) May 16-22 (d) May 23-29

<table>
<thead>
<tr>
<th>Prices of Toys</th>
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<tbody>
<tr>
<td>Tin Soldiers</td>
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<td>10¢ each</td>
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<td>3 for 25¢</td>
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<td>Tops</td>
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<td>20¢ each</td>
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<td>Airplane Kits</td>
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<td>25¢ each</td>
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(39) Ted has 1 quarter, 4 dimes, and 1 nickel. Which set of toys can he buy with his money at the toy counter?
(a) 1 soldier, 1 top, 2 airplane kits
(b) 4 soldiers, 2 tops
(c) 3 soldiers, 1 top, 1 airplane kit
(d) 6 soldiers, 1 airplane kit

(40) How much would it cost for you and two other children to go to the Strand Theater when the clock is like this? (Turn the page)
(41) How much would it cost for your father, your mother, and you to go to the Strand Theater after supper?
(a) $1.50
(b) $2.00
(c) $2.25
(d) $1.75

(42) Which thermometer shows a day you might want to go swimming at the beach?
(a) 1
(b) 2
(c) 3
(d) 4

(43) Which thermometer shows a day you might want to go ice-skating?
(a) 1
(b) 2
(c) 3
(d) 4

(44) Which thermometer shows the best temperature for the inside of your house?
(a) 1
(b) 2
(c) 3
(d) 4
(45) Look at the clock in the train station. If it is morning, when is the next train to Franklin?

(a) 4:50 P.M.  (b) 2:45 P.M.
(c) 12:30 P.M.  (d) 9:30 A.M.  (a) (b) (c) (d)

(46) Will a man have time for lunch at the restaurant before taking that train?

(a) Yes  (b) No
(c) No way of telling  (a) (b) (c)

(47) What time will he be at Edwardton?

(a) 11:05 A.M.  (b) 6:28 P.M.
(c) 2:25 P.M.  (d) 4:22 P.M.  (a) (b) (c) (d)

(48) What time will he be at Franklin?

(a) 11:57 A.M.  (b) 2:50 P.M.
(c) 7:20 P.M.  (d) None of these  (a) (b) (c) (d)
49) About how long will the trip take?
(a) 5 hours  (b) 2 $\frac{1}{4}$ hours
(c) 1 $\frac{1}{2}$ hours  (d) 55 minutes  (a) (b) (c) (d)

50) How many trains go to Franklin from Smithtown each day?
(a) 4  (b) 3
(c) 2  (d) 1  (a) (b) (c) (d)

51) Are there more feet in a mile or more yards?
(a) Feet  (b) Yards
(c) Same  (d) Depends on the mile  (a) (b) (c) (d)

52) About how long is this line: ____________________________ ?
(a) 10 inches  (b) 1 inch
(c) 7 inches  (d) $\frac{1}{2}$ inch  (a) (b) (c) (d)

53) How much does the box on the scale weigh?
(a) 4 pounds  (b) 12 ounces
(c) 4 $\frac{1}{2}$ pounds  (d) $\frac{1}{2}$ pound  (a) (b) (c) (d)

54) What is the most you can weigh on this scale?
(a) 12 ounces  (b) 32 ounces
(c) 12 pounds  (d) 76 pounds  (a) (b) (c) (d)
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