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A Comparative Study of Two Methods of Teaching Arithmetic

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DEDICATION

To my husband, William,
whose patience and encouragement
made this effort possible.

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CHAPTER I

A STATEMENT OF THE PROBLEM INVESTIGATED

The administration of the West Valley School District of Yakima County is critically studying the curriculum for their entire school system. Their desire is to coordinate the program into the most modern and efficient curriculum possible for the district. This is being accomplished under the direct supervision of the assistant-superintendent, Dr. Robert Woodroof, with the help of numerous committees.

In considering the arithmetic program, several things were taken under advisement:

1. What, in the eyes of the present day authorities, comprises a good arithmetic program?
2. Was the present arithmetic program meeting this criterion?
3. If not, what program would most adequately meet these requirements for the West Valley District?

Those concerned with the arithmetic curriculum study checked through the available material on arithmetic textbooks. The Scott, Foresman series of arithmetic seemed to have the most radical changes toward the goals for a modern arithmetic program as set forth by authorities in arithmetic.

I. THE PROBLEM

It was the purpose of this study to (1) compare the achievement gained by youngsters being taught by two different methods of arithmetic; (2) find, for the benefit of the district, whether the children receive a better concept of numbers and processes through the Scott, Foresman method; and (3) determine whether the Scott, Foresman method makes the teaching of problem solving more efficient.

Before a district decides to invest a large amount of money in new textbooks, reorient its teachers to a new method of teaching, and instill a new philosophy, it should know whether the end result will warrant the change. Up until this time there has been no practical study made regarding the merit of the Scott, Foresman method. For this reason, it was decided to try this modern concept of teaching arithmetic in two of the four third grades located in separate schools during this past year. The result of the research will be reported in this thesis.

II. DEFINITIONS OF TERMS USED

Concepts in arithmetic. These are the ideas of inter-relationships of things studied in arithmetic, also those things in relation to life outside the arithmetic class. These ideas enable one to recognize whether a certain process will bring the correct answer.

<u>New philosophy in the teaching of arithmetic</u>. The philosophy is that if children learn arithmetic in such a way that they have good concepts of our number system, they will be able to solve problems easier than if they are just told what steps to take and then drilled without understanding the reasons.

<u>Processes in arithmetic</u>. Processes refer to the action done as part of solving problems.

<u>Telescope teaching of arithmetic</u>. This is relating new experiences to old ones and thus affecting a gradual step-by-step development of the processes.

<u>The traditional method of teaching</u>. In this method the teacher or textbook does the "telling" and the children memorize the facts. Little emphasis is placed on first-hand experiences or concepts. This is in contrast to the "modern" method of teaching, where the emphasis is placed on the experiences and concepts children receive from their own investigations.

CHAPTER II

REVIEW OF THE LITERATURE

When a school is considering changing textbooks, it is very advantageous to try the new text a year before the decision is made. This is what was done in the West Valley School District. The new text, _Seeing Through Arithmetic_, published by Scott, Foresman and Company, was tried in two of four third grades.

Before a reliable decision can be made, however, it is necessary that the administration making the decision know what the authorities in the arithmetic field believe is required to make a good arithmetic program. It is to this end that this chapter is directed.

I. THE ARITHMETIC PROGRAM

Brueckner and Grossnickle believe, in regard to the modern arithmetic program in the elementary school, that the two major objectives should be first to develop in the learner the ability to perform the various number skills, with an understanding of why he is using these specific processes. Secondly, the learner should be provided with a rich variety of experiences. These experiences should be of the type to prepare the pupil to apply quantitative procedures effectively in social situations in life outside the school (4:2).

In order to make clear the meaning of the objectives that relate to the mathematical and the social phases of arithmetic, Brueckner and Grossnickle give the following statement of outcomes to be expected (4:3):

1. Outcomes related to the mathematical phase of arithmetic.

    a. An understanding of the structure of the decimal number system and an appreciation of its simplicity and efficiency as compared with other number systems.

    b. The ability to perform computations connected with social situations with reasonable speed and accuracy, both mentally and with mechanical computing devices.

    c. The ability to make dependable estimates and approximations.

    d. Resourcefulness and ingenuity in perceiving and dealing with quantitative aspects of situations.

    e. Understanding of the technical vocabulary used to express quantitative ideas and relations.

    f. Ability to represent designs and special relations by drawings.

    g. Ability to use and to devise formulas, rules of procedure, and methods of bringing out relations.

    h. The ability to arrange numerical data systematically and to interpret information presented in graphic or tabular form.

2. Outcomes related to the social phase of arithmetic.

    a. Understanding of the process of measurement and skill in the use of instruments of precision.

b. Knowledge about the development and social significance of such institutions as money, taxation, banking, standard time, and measurement.

c. Knowledge of the kinds and sources of information essential for the intelligent buying and selling and for general economic competence.

d. Understanding of the quantitative vocabulary encountered in reading, in business affairs, and in social relations.

e. Appreciation of the contributions number has made to the development of social cooperation and to science.

f. Ability and disposition to secure and utilize reliable information in dealing with emerging personal and community problems.

g. Ability to rationalize and analyze experience by utilization of quantitative procedures.

Brueckner and Grossnickle also state that the understanding arithmetic teacher will recognize the further possible contributions good instruction in arithmetic can make to the social objectives of all education. They feel that many of the experiences that are rich in application of number can also be designed as experiences in democratic living (4:4).

Instead of naming the objectives of the arithmetic program, Morton discusses the fundamental criteria for determining the arithmetic program. He says there are three headings under which these criteria can be organized (26:21):

1. The <u>logical criterion</u>, which has reference to the structure and organization of arithmetic as a science.

2. The <u>social criterion</u>, which indicates a concern with the usefulness of arithmetic in life's affairs.

3. The <u>psychological criterion</u>, which is concerned with how children learn.

Dr. Morton contends that none of the three criteria can operate by itself. Each criterion depends on the other two. Dr. Morton feels that the teacher must base new topics in arithmetic upon situations which normally occur. It is also important that the teacher guarantees that the arithmetic the pupils experience be closely tied into activities interesting to the pupils. In this way the teacher is taking full account of the operation of the social criterion.

Dr. Morton would, however, expect the resourceful teacher to respect and take into proper account the organization of arithmetic as a science. In doing this the teacher should choose, from the many varied situations where arithmetic is used, those which will allow a program to be built in accordance with the logical criterion as well as the social criterion. These two criteria cannot be separated to the point where attention can be given to the logical criterion one day and to the social criterion the next day. It is most important that attention be given simultaneously to both of these criteria every day.

This authority feels that the "emphasis accorded to the psychological criterion will indicate its relative importance." He feels that through utilization of the psychological criterion better teaching of arithmetic will come. If arithmetic teaching is to be improved, the subject must be made meaningful to the pupils. This process takes in more than just explaining the rational of the number system and the processes with numbers. It is also the relating of new experiences to old experiences, the gradual step-by-step development of the processes. Furthermore, it allows pupils to make discoveries for themselves. When these things are done the futility of mechanical tricks and devices will be seen and acknowledged for what they are. It will be realized that it is better to telescope reteaching rather than to try to drill and test and then drill some more. These methods along with other important matters lead to the all-important objective of aiding in the learning of a practical arithmetic.

Dr. Morton feels that while the teacher will be working most consciously with the implications of the psychological criterion, all three of these fundamental criteria must be used together. Never is there a time when the teacher can afford to neglect the logical and social criteria. This is not an easy task but neither is it an impossible one (26:60-61).

McSwain, Ulrich, and Cooke have cooperated in a textbook series in which they state that arithmetical meanings are the basis of success and learning and using arithmetic. They feel that practice and review strengthen the understandings, and make functional the solution of problems encountered in the home and in the community. They give as the goals and objectives for accomplishing these meanings in arithmetic the following definitions (23:4-5):

1. To help pupils understand the meanings which are inherent in the structure, organization, and operation of our decimal system, and in the terms related to the system. . . .

2. To help each pupil create and build psychological patterns of reading, observing, thinking, and reasoning that will result in the development within his mind of a functional and meaningful number system which will be his own. . . .

3. To help pupils learn to use with understanding each of the four fundamental processes in arithmetic and the mathematical terms related to each. . . .

4. To help pupils discover the meaning of and the relation between whole numbers, common fractions, and decimal fractions, as well as the meanings of terms used with each. . . .

5. To help pupils develop the ability to solve problems, particularly those which involve the consideration of arithmetical factors and the application of arithmetical processes, by:

    a. Recognizing and analyzing problem situations in terms of the relationships between known and unknown factors involved.

    b. Determining, in terms of procedures necessary to find the answer, the meaning of the question posed by a problem situation.

    c. Taking the steps necessary to find the answer.

    d. Verifying the accuracy of the solution by tests of reasonableness as well as by arithmetical proof. . . .

6. To help pupils, under the teacher's guidance, to recognize the importance of, and take steps to develop, such learning attitudes as:

    a. An appreciation of the importance of establishing self-teaching procedures.

    b. An awareness of the value of determining one's own needs and learning difficulties and of taking steps to meet them.

    c. A realization of the worth of maintaining skill and accuracy in using arithmetic by means of review, relearning when necessary, and practice.

    d. An understanding of the usefulness of developing, understanding, and learning to use the fundamental generalizations or basic rules of arithmetic.

    e. A recognition of the necessity for accuracy and precision in exact arithmetical calculations, and an appreciation of the value of estimates and approximations in everyday experiences. . . .

7. To provide experiences for pupils which will lead them to discover and understand the functioning of basic arithmetical principles in the home and community, in the area of consumer economics, and in the American system of business, industry, and agriculture. . . .

Hartung, Van Engen, Knowles, and Gibb, authors of the Scott, Foresman series of arithmetic, state that the arithmetic program cannot be limited. It must cover the whole range of teaching arithmetic to children. There must be a provision for learning new and deeper understandings of arithmetic, and at the same time it must provide adequate practice to help these understandings develop. In addition to this, the program must be vast enough to be interesting and challenging to all groups: the fast learners, the average, and the remedial. The arithmetic program must be "suitable for use, with minor adaptations, in many different school systems" (14:5).

Another consideration is the building of a program on definitely recognized principles of learning. The principles emphasized by modern psychologists should be used as guides for developing insight and understanding by pupils. But such traditional principles as the association theory should be used to develop the skills in arithmetic.

When presenting the arithmetic program, the use of the manipulative and pictorial materials should be emphasized for the development of understanding. Another important factor is the use of equations as early as possible. These will help in analyzing problem situations and in communicating the thinking about them. It is necessary to carry the use of equations systematically through the six grades, strengthening them constantly and consistently.

Finally, according to Hartung, *et al.*, the arithmetic program must fit the criteria set forth for the general curriculum today. There must be maximum continuity in the pupil's learning. The program must be so organized that the child's learning is systematically broadening and deepening. He must be awakened to see the inter-relationships within the study of arithmetic, the relationships between arithmetic and other branches of knowledge, and the relationships of arithmetic to life outside school. These considerations make the difference between a program and a mere series of learning activities (14:5-6).

II. THE ARITHMETIC PROGRAM ON THE THIRD GRADE LEVEL

While it is true that the material reported in Part I is applicable to the third grade, other things are involved when considering the program for this level, such as the children's background experience, interests, and ability to learn certain things better than others.

According to Brueckner and Grossnickle, "All learning is a process of growth." Probably arithmetic proves this to be true more than any other subject matter. Especially is this so, "where it is carefully guided and directed so that it insures an understanding and mastery of efficient procedures as well as ability to use quantitative methods in the intelligent management of daily affairs" (4:10).

These writers say that arithmetic naturally falls into five stages. The third stage, the one of interest in this paper, because it includes grades three and four, is where the children progress at a rapid pace in the fundamental attitudes and habits of arithmetic. They master the simpler processes with whole numbers. They expand their knowledge and understanding of social arithmetic and develop the ability to use simple quantitative methods in their own affairs; in fact, by the time they reach the end of this stage, they should be masters in using addition and subtraction and easier multiplication and division facts. They should also be able to handle any simple computation involving whole numbers as well as having a good working understanding of the simple fractions (4:110-111).

Morton, who feels that too many schools outline a definite program for the third grade without regard for what the children have accomplished in the two previous grades, suggests that the children should have a wide experience with number situations of the concrete type before they are introduced to the abstract. He also believes that mental age, although important, is not as crucial as a rich and extensive background experience, which allows the new to be understood through its relationship to the old. These experiences should decide the proper grade placement of arithmetic topics.

Dr. Morton also calls attention to the tendency to withhold until the fourth grade much material which used to be taught in the third grade. This is especially true of certain type multiplication and division problems. Morton, not stating whether this is good or not, indicates that some textbook authors admit that this trend might be wrong. The publishers of these authors issue a dual set of textbooks, one with the old traditional content, grade by grade, and the other offering the modern program.

Dr. Morton names eight topics which should be covered in the third grade: (1) the reading and writing of numbers; (2) addition; (3) subtraction; (4) multiplication; (5) division; (6) measurement; (7) fractions; and (8) problems and activities.

Dr. Morton states that the children should be able to read and write numbers through 10,000. As to Roman notation, he would have the children able to read and write to XXX.

As a rule, children learn part of the addition facts in the second grade. Dr. Morton states that by the end of the third grade they should know all of them, and they should know all the subtraction facts as well. The children should be able to add single columns of six or seven addends, and to carry in addition. They should be able to subtract with four-digit minuends and subtrahends, and to borrow. All the zero facts should be learned in addition and subtraction.

Dr. Morton would introduce multiplication and division in the third grade. He recommends carrying the combinations through the 5's and any other combinations having products less than some assigned number such as forty. The problems could be two or three-digit multiplicans with one-digit multipliers, but carrying would be optional. Zeros could occur in the multiplicand.

Morton states that the children should learn the vocabulary identified with each process they are learning. They should also learn to check their problems.

Morton would add the "mile" and the "ounce" to the units of measure the children have learned in the second grade. He would also have the children know how many cents and dimes there are in a dollar.

"The children should be able to use any unit between one-half and one-ninth which would be used in combination with measuring," Morton states. But most of the work should be with common fractions of one-half, one-fourth, one-third, and one-eighth, one-fifth and one-sixth. A few additional fractions such as three-fourths and two-thirds could also be used.

Dr. Morton says that there should be problems and activities using all the procedures as far as they are learned. Teachers should supplement those in the book by additional problems drawn from local situations (25:390,395).

In discussing the arithmetic program as it is related to the third grade, Hartung, Van Engen, Knowles, and Gibb indicate that the most important thing is that pupils make a substantial headway toward systematic mathematical methods of problem solving. They feel that, because a better balance between the development of problem-solving abilities and computational skill is needed, there should be careful study of fundamental methods of attacking mathematical problems. It is their contention that in the past the approach to problem solving was too often superficial and unsystematic. In addition to the problem-solving abilities, the children should learn all the addition and subtraction basic facts well enough so that they can be recalled immediately. The third learning they stress is a substantial start on the multiplication and division basic facts. The children should study the products and dividends up to and including thirty-six. The scope of the base-ten numeration system should be extended to 9999. The children should be given a wider knowledge of measurement, money, and fractions. Their fifth stipulation is that the addition and subtraction processes should be learned meaningfully and carried through successfully with numbers in the hundreds. These authors end by saying:

> This is a substantial program, but is well within the capabilities of most pupils if modern instructional methods and materials are used. It should be taken for granted that instruction must always be as meaningful as possible (14:40).

Hartung, _et al_., consider it of utmost importance that third grade children have an opportunity to develop the skill of computing mentally. They close their discussion of third grade content by saying that more instruction along that line would be given.

They caution, however, that because individuals work problems differently, only general principles such as the base-ten numeration system and those involved in regrouping should be stressed. The pupil can take these principles and develop his own techniques and short cuts for mental calculation.

They state that in doing arithmetic the pupil should be encouraged to do as much work as possible mentally. Some will be able to do this more than others. Speed should not be a requisite since it will come with practice for most pupils. Each child should be able to use his own methods.

One of the most important things to remember is that the pupils should be encouraged to be resourceful in finding ways to work problems mentally. Most of them enjoy having the opportunity to show their ingenuity in figuring out methods. The teacher should never discourage this inventiveness, and will probably be surprised at seeing the many ways pupils find to shorten tedious figuring (14:65-66).

III. METHODS OF TEACHING ARITHMETIC AND EVALUATING AND IMPROVING INSTRUCTIONAL PRACTICES

It is not feasible at this point to outline a program of instruction for every computational skill, but certain principles in the teaching of arithmetic cover all the skills. These principles, of the utmost importance, will be covered in this section as thoroughly as time permits

Herbert Spitzer states that "change in the teaching of arithmetic is not a new phenomenon. . . . there has never been an extended period when methods of teaching were not changing." For the past twenty-five to thirty years the greatest emphasis has been on helping children understand what they are learning (32:1).

Dr. Morton refers to this trend when, in referring to his earlier book, he says that through investigations and experience his point of view has been modified in several respects (17:III). In his later book he puts more emphasis upon numbers as a series of meaningful experiences, having changed his psychology to an emphasis on relationships and recognizing that new discoveries can be made by the pupils themselves. While it is felt that activities are not sufficient alone to provide a desirable education in numbers, more activities are used. Accordingly, Dr. Morton has put less emphasis upon the early mastery of number facts as such in the first and second grades. He put more emphasis on experiences which lead gradually to an appreciation of these facts as well as a deferred learning of them which leads to a better understanding (25:III, IV).

Clark and Eads feel that the activities of teaching and learning are not widely separated. Formerly the teacher imparted the knowledge and tested the children to see how well they could parrot the answers back. Any independence of thinking was discouraged. Children were required to learn and do things as the teacher or text book instructed; no other way was allowed. Rules were learned in the same way. This method was probably used more in the study of arithmetic than in any other subject.

Today the teacher is more a guide. She opens opportunities for children to investigate and experiment. They are encouraged to use their own ingenuity to think things through. They are active in planning, evaluation, and self-discipline and in this way develop independence and individuality in thinking and performance. Through this modern guiding method of teaching the teacher stimulates pupil growth. In this role the teacher is not less important. She is more important, in that she organizes her classroom and plans how to set up conditions for this independent learning. In regard to arithmetic, the learning progresses from the concrete to the more abstract and difficult aspects (8:2-3).

A further explanation of the two theories of teaching arithmetic was presented by Brueckner in his book on improving the arithmetic program. He names these two theories the Meaning Theory and the Drill Theory. In order to more clearly show the distinction between the two, Brueckner has prepared the following chart:

CONTRASTING PRINCIPLES UNDERLYING TWO THEORIES OF TEACHING ARITHMETIC (3:68-69)

Meaning Theory	Drill Theory
1. Learning takes place through experiences that are intrinsically and genuinely purposeful.	1. Extrinsic devices and effective means for motivating learning.
2. Learning should be meaningful and insightful.	2. Learning is essentially a mechanistic, neurological process.
3. The discovery of facts, meanings, and generalizations by the learner through inductive procedures leads to understanding and insight.	3. Authoritative prescription by the teacher through deductive procedures of facts, methods, and ideas to be learned leads to the establishment of correct connections.
4. Content should be presented so that the perception of relations is made possible.	4. Learning consists of forming specific bonds or connections that are presented as unrelated elements.
5. A wide variety of learning experiences including practice should be provided to extend meanings and to assure needed practice.	5. A process of repetitive drill assures learning mastery.
6. Learning is a growth process leading gradually to responses of an increasingly mature level.	6. Performance at the adult level is expected and required at all stages of learning.

Spitzer advocates a method called the "Developmental Method," and compares it with the "Explanatory Method" of teaching by first calling attention to the fact that there is some explaining in the "Developmental Method" and some development in the "Explanatory Method." He also calls attention to the fact that superior teaching procedures are not in any way related to the description either method implies. He cites seven ways in which the "Explanatory" and "Developmental" methods differ:

1. In the developmental method, multiplication facts for 2's, 3's, 4's, and 5's are all used in initial teaching, whereas in the explanatory method only the 3's and the basic facts with 3 as a multiplier are used.

2. In the developmental method, word problems are used as an introduction. These problem activities provide the basis for the pupil's identification of the learning problem and the setting for discovery of the important arithmetic facts and relationships. In the explanatory method, problems are used initially to provide the setting for explaining to the pupil the fact or relationships under consideration.

3. In the developmental procedure pupil participation is stressed, whereas in the explanatory method "telling" and "showing" are emphasized.

4. In the developmental method, the frequently used "show that your answer is correct" assignment fosters pupil initiative and self-reliance, and provides a basis for evaluation and discussion which is lacking in the explanatory method. The direction of pupil thought through use of carefully chosen completion statements and the requirement of working exercises, as shown in a book which advocates the explanatory method, lead the pupil to rely on the instructional materials presented.

5. In the developmental method, the multiplication number question (e.g., "How many are three 4's?") plays a major role in instruction. This multiplication question is not identified in the explanatory procedure.

6. In the developmental method, directing pupils to solve problems and show that answers are correct allows the use of different procedures and rates of working on the key exercises. In the explanatory method, all pupils consider the key exercises simultaneously, usually by

listening to the presented explanations. This simultaneous consideration of key exercises results in a lock-step type of teaching.

7. In the developmental method, a need for knowing facts based on pupil experience becomes the foundation for study for mastery of multiplication facts. In the explanatory method, the study for mastery of multiplication facts is begun by directing pupils to "Practice until you can say every answer"(32:8).

Hartung, Van Engen, Knowles, and Gibb acknowledge these modern methods of teaching when they state that instead of separating their adding processes into a dozen or more "skills," they present carrying when they first present two-figure numbers in addition. Their third grade textbook starts with word problems and pictures to help children in the interpretation of the processes. The section entitled, "Exploring Problems," shows the pupil how to write simple equations and leads them to an analysis of the situation (14:8).

Number base and role of zero. One of the things which makes our number system unique is the fact that place value is used. Until children understand the functions of zero and the logic of "base ten," they do not know arithmetic. Dr. Morton agrees with the importance of the idea:

> An understanding of numbers is necessary before pupils can learn to put groups together to find sums. It is just as important a prerequisite to addition in the abstract. It would be folly to attempt to teach a pupil to add 68 and 84 if he did not already understand that 68 means 6 tens and 8 ones and that

> 84 means 8 tens and 4 ones. He must have a basis for understanding that the sum of 8 ones and 4 ones must be separated into 1 ten and 2 ones if he is to see what he should write in ones' place in the sum and why he should combine the 1 ten with the 6 tens and the 8 tens. An acquaintance with numbers and an understanding of the decimal nature of the number system must precede the learning of 'carrying' in addition or 'borrowing' in subtraction.
>
> Even though no carrying were involved, the adding of two two-figure numbers would be nothing more than a mechanical process if the meaning of the two numbers were not understood (25:116-117).

The authors of the Scott, Foresman series find that by utilizing knowledge of the base ten facts, they can introduce "carrying" in addition problems at the very beginning of formal addition. In their book called _Charting the Course for Arithmetic_, they devote a great deal of space to the value of this knowledge. They believe that little understanding of arithmetic in any form is possible until pupils know the basic principles of the base-ten numeration system. They contend that pupils in the third grade should learn to see how a large group of objects can be organized through grouping by tens. After they become familiar with the grouping of objects, they can learn how written records of such groups can be made. After attention has been directed to objects grouped in tens and ones, the use of place value in writing the numeral that represents the total number of objects should be taught. Finally, attention can be given to the decade numbers and their names and symbols. The objective of grouping objects is to be sure that the pupils learn to visualize and understand the relationships within the numeration system as a whole (14:47-49).

First hand experiences. Much is being said in regard to the place of firsthand experiences in developing meaning and understanding in arithmetic. When children are allowed to have the experiences of "discovering" or "re-discovering" number facts, they understand the facts better. Because they understand the facts better, they remember them longer and have a better appreciation of arithmetic, confidently enjoying their successes.

In comparing learning to compute to learning to read, Hickerson says it was only recently recognized that a child is not really reading unless he gains meaning from the words he sees (12:17). He compares counting by rote to the alphabet-phonetic method of teaching reading. Having children learn to count by rote is similar to having them recite the alphabet. When children are required to memorize the addition and subtraction facts and the multiplication and division tables, they are again learning by rote. It is possible to add to the above learnings the processes for adding, subtracting, multiplying, and dividing, and still have the children working by rote. They still would not know why they were using the processes they were told to use.

Hickerson says that when an example such as 7032-4096 is broken down to steps such as 6 from 12 is 6, 9 from 12 is 3, and so on, it is the same as pronouncing words syllable by syllable or reading word by word. Just as the child who has pronounced his way through sentence after sentence cannot always tell the teacher what he has read, so the child, after he "divides-multiplies-subtracts-brings down," cannot always tell the meaning of the arithmetical expression," or know whether the answer arrived at makes sense (16:17).

Hickerson wrote that when we are teaching children to read with meaning and understanding, we provide them with firsthand experiences which are interesting, varied, and challenging. We try to give the children better concepts, images, and ideas of people, things, situations, and processes, by teaching symbols as words and having the words call forth these concepts, ideas, and images. His feeling is that we should do the same when teaching them to compute. Children can be provided frequent, interesting, and challenging experiences in situations involving amounts, sizes, shapes, distances, costs, and quantitative relationships. At this time appropriate vocabulary and terminology is learned. This enables images, ideas, and concepts of quantity, space, and relationships to be developed. Only by calling to mind images, concepts, and ideas can mathematics become meaningful. When mathematics is meaningful it is easily learned (16:18).

The school, state Brueckner and Grossnickle, should follow the role of a guide in the learning activities of the child. It should enable him to acquire a clear understanding of the structure of the number system. It should help him obtain such an insight in performing computations that he can apply it intelligently to the affairs of daily life. The school should put the emphasis on development of organization of meanings, and at the same time provide a wide variety of lifelike learning situations in which there are many opportunities to consider and apply quantitative procedures.

These authors also feel that children should be given the chance to discover quantitative elements and procedures rather than to have them always presented by the teacher. By arranging learning experiences in which discovery is the means to the solution of some problem or the carrying out of some purpose or project, a self-active attitude of exploration and discovery can be developed (5:108-109).

Spencer and Brydegaard, in a discussion in this matter of developing understandings through first-hand experiences, compare it with the "tell-and-do" system. They also say that the "tell-and-do" system retards mathematical learning. The knowing of meanings gives independence and competency in performance. When children are told what to learn and are required to memorize certain things, they usually become dependent on the "teller." The children do not really know what they are doing or why they are doing it. Just as with any authoritarian and undemocratic instruction, the "tell-and-do" system is ineffectual because the learner has little or no personal conviction that what he is learning is worthwhile or that it even makes sense. It violates the basic principle of respect for the individual; therefore, it is undemocratic. With the "tell-and-do" system the pupil is required to conform to, rather than to adjust with, his society. A major criticism of mathematics, as it has been taught, is that it is too often the "tell-and-do" variety. The teacher is representing society with all the answers. Students are required to memorize and repeat the statements or to compute the number by means of devices they need not comprehend. Neither performance demands much use of the "higher mental processes" (31:32).

Importance of developing concepts in arithmetic. When using the traditional methods for teaching arithmetic, great emphasis was put on learning by rote and drill exercises. Now it is realized that unless children have a good concept of what they are trying to do and why they are doing it in a certain way, they will not be able to accomplish the desired results. Lucy Lynde Rosenquist brings this out when she mentions that society has imposed a highly complex number system on its members. It is so complex that even the brightest of children cannot reason its basic ideas out for themselves. But when they once get the basic ideas they can apply them in their own activities and thereby clarify and extend their understanding of the quantitative relationships expressed by the number system. When these relationships are understood, skill in intelligently using the number system can be developed (30:113).

When one has meanings they can be transferred to a wide variety of situations. This is one of the reasons Madden, Beatty, and Gager say we need to understand mathematics. While a meaning can be transferred, a skill which has been learned without understanding has specific and limited application only. They go on to say that while it might seem otherwise, it is really time saving to teach meanings in mathematics because an insight into relationships assures transfer from one situation to another. It leads to new insights. Genuine understanding is less likely to be forgotten. This means that less time will be consumed (24:3).

Buswell, Brownell, and Sauble used the comparison Hickerson used. They compared arithmetic concepts with knowing the meaning of words in reading. It is their contention that we commonly confuse words and ideas, thinking that if we know words we also know the ideas they symbolize. They take the word <u>goletis</u> (gō-lē′tĭs) and ask the reader to pronounce it. Then they say, "You can pronounce it, but do you have the idea?" They say we must at all costs avoid this kind of "goletis business" in teaching arithmetic. They call attention to the fact that repetitive practice such as saying goletis five times taught the word all right, but neither that nor writing it fifty times would teach the meaning. Repetitive practice simply makes us more proficient in doing what we have been doing. Varied practice is what is needed to advance meaning. When working on a thing to be learned one must do so in different ways and in different settings.

Buswell, et al., go on to say that merely because a child has repeated several times that there are three feet in a yard does not guarantee that he has a true conception either of a foot or of a yard. Also, continued repetition of counting, adding abstract numbers, or saying the table of linear measures will not increase the meanings. What is needed is varied, rather than repetitive, practice (7:9).

Stern believes her method of teaching is best and explains why in the following statements:

> Structural Arithmetic puts the number system on the child's table where he can discover arithmetic for himself. Since our materials are true representations of the numbers, the concrete experience leads directly to the formation of exact mathematical concepts. In experimenting with the materials, the child develops insight into the structure of the number system and the meaning and behavior of numbers. From the first step he learns that there is no unrelated fact in numbers, and that the understanding of one

basic principle gives him the key to the solution of a great many connected number facts.

> This is in contrast to the approach of the drill method, in which the child merely memorizes, often without knowing why, and usually without knowing how the teacher or the textbook derived a certain operation or came to favor a special answer. Such teaching may produce pupils who mechanically supply the correct responses; but another method is required if they are to be made to think (33:287).

Brownell and Carper state that the "understanding" theorists say that the multiplication combinations call for meaningful learning. They say that a parrot can be taught to say, "Five 2's are 10," but that no parrot has been found that can use this "knowledge" in an intelligent way. They say that the five words, "know," "understand," "discover," "recognize," and "meanings" are the key words to reveal how much meaningful learning, in the case of the multiplication combination, transcends rote learning and how far memorizing falls short of meeting the needs of the situation. It takes longer to develop a firm basis of understanding, because to do this means an abundance of varied experiences. But it is better to wait for this understanding than to expect children to give the products glibly with no evidence of sound learning. For them, the teaching of the combinations consists of varied experiences and guiding, as rapidly as consistent, to the adopting of more effective and mature ways of thinking of the combinations (2:153).

Spencer and Brydegaard stress the need for clearly understanding the reason for having zero in our number system. They contend that the child should have the privilege of discovering ideas of zero as a point of origin in such a manner that he develops understanding in its function in measurement. They feel that the concept of zero as meaning "not any" develops in the child's awareness at an early stage. They give the example of a child seeing two tricycles but another child taking both of them and so there are "not any" tricycles available for him. All the child has to do is change this idea to another situation.

It is necessary for the child to have a good concept of zero in order to compute by forming generalizations concerning zero such as, a number minus itself is zero. These concepts are learned by the child. Forming these generalizations takes the place of long hours of drill. Very frequently drill does not change the child's computational efficiency anyway, because his concepts have not changed. Spencer and Brydegaard say, "The time and effort involved in mastering number facts and skills can be reduced to a minimum if the child is led to formulate generalizations that are founded upon ideas of relationship" (31:91-92).

Hickerson gives an explanation which might be the answer to why more children have not been given opportunities to form more arithmetical concepts. He states that some teachers believe children would be confused if they were taught that there is more than one way of getting an answer. These teachers feel that the children have trouble enough learning the one way. He also feels that an over-emphasis upon accuracy and perfection in computation causes many children (and teachers) to hold on to one sure method.

Hickerson states that children from the kindergarten up should be encouraged to explore and experiment with numbers. Never should those children who are potential mathematical thinkers be hindered from learning what creative mathematical thinking is. It is necessary that they have the opportunity to experience the joys of arithmetical discovery (16:138).

<u>Problem solving</u>. In discussing the solving of word problems, Mr. Reed says it is necessary to help pupils develop the ability to think creatively. He gives six essential principles a teacher should follow to develop creative thinking in arithmetic (29:45):

1. Problems become the mainspring to creative thinking.

2. The skillful teacher will guide the child in clarifying the issues of the problem.

3. The formulating of hypotheses for the solution of the problem is where most of the creative thinking occurs.

4. Knowing when to help and not to help a child when he is formulating hypotheses to a problem is of great importance.

5. Equally important to creative thinking are the questions the teacher asks the children.

6. The key to creative thinking is the teacher herself and her attitude toward arithmetic.

As every teacher knows, many children know how to compute ordinary problems in the form of equations but find it very difficult, if not impossible, to compute "story" problems. Hickerson feels that the textbooks have advanced in giving the children problems within the range of the activities of many children. But, he warns, the teacher must be sure the child can read the particular word-problem she wants him to read. A child may be ready to read one problem with meaning but not another.

Hickerson says that being ready to read a particular word-problem will depend a great deal upon the first-hand experiences the child has had in a situation such as the one described in the problem. The oral language development of the child, the understanding the child has of the arithmetical vocabulary and symbols, and his ability to visualize the concrete situation described by the words and symbols are all important to his ability to read problems.

After the child has accomplished the complex procedure of translating printed symbols into images, ideas, and concepts, there are three more tasks to be performed.

1. The child must know what to do with the numbers: add, subtract, multiply, and/or divide.

2. If he cannot perform the computation mentally, he must know how to write the numbers in positions relative to each other that are convenient for calculation.

3. He must know how to perform the computation or computations to obtain the correct answer to the question asked in the problem (17:8-9).

Hickerson suggests that the above description might seem to be an overly complicated analysis of the word-problem solving act. He then calls attention to the fact that many children are confused by written problems. It is suggested that perhaps the confusion is the result of lack of readiness in one or more of the above elements. Furthermore, he feels that the wise teacher will be sure that her children obtain the necessary first hand experiences, in addition to acquiring the necessary learnings, so that they can solve word-problems with a degree of understanding (17:8-9).

Conclusion. In concluding this chapter it might be wise to consider the philosophy of arithmetic instruction given by Howard F. Fehr. He says that a child will not be able to learn arithmetic unless it has meaning to him. This meaning comes from thinking about things, from concrete experience, and from problem situations. However, these meanings and experiences must be organized into some sequential structure. The facts must be so automatic through practice that they are easy to recall. This background must come before drill. Testing is done to help with learning and to motivate the learner. The teacher helps the child to evaluate his own progress and guides him onward. The goal of the arithmetic teacher is to develop within the child an ability to solve problems in quantitative situations. She can do this best by providing experience in the problem-solving approach to learning arithmetic operations and by giving practice in real problem situations (11:31-32).

William A. Brownell calls attention to the search through the years for a functional curriculum. Since 1900 there has been an evolutionary process where each modification has emerged from a given status and has led to the next modification. It is now generally agreed that arithmetic must have both a mathematical aim and a social aim. Children must be able to perceive sense in the arithmetic they learn if it is to mean anything in quantitative situations for them. For this reason, instruction must have meaning and be well organized around the ideas and relationships inherent in arithmetic as mathematics. But arithmetic must also be built into the structure of their everyday living. This gives them experiences in using the arithmetic they learn while they are learning it. It is impossible to emphasize either one of the two aims to the exclusion of the other. One aim is as important as the other in obtaining a functional curriculum in arithmetic. We cannot choose between them. Both aims are attainable. In fact, that is what is being accomplished in good arithmetic instruction today (1:5).

CHAPTER III

METHOD OF INVESTIGATION AND RESULTS

I. PROCEDURES

It was decided to use two schools in the experiment based on the use of the Scott, Foresman series of arithmetic in the elementary schools of West Valley District. These schools will be known as schools One and Two. The study was made on the third grade level because this would be the grade level where the new series would be first introduced. Each school had a control group and an experimental group.

During the month of October each of the four third grade groups was given three tests: (1) The *Lorge-Thorndike Intelligence Tests*; (2) Sections A-I, and A-II of the *Iowa Tests of Basic Skills*, covering arithmetic concepts, and arithmetic problem solving; and (3) the *Scott, Foresman Seeing Through Arithmetic Tests*.

During April the same tests were given with the exception of the *Lorge-Thorndike Intelligence Tests*. These tests were given a month before school was out. This meant that the tests were given before all the material was covered. This was necessary to get the results of the study to the school board so they could make a decision regarding adoption of new arithmetic textbooks.

The tests were administered by the coordinators of the two schools in their own buildings. The teachers did not do any of their own testing or correcting of tests.

During the school year the teachers of the experimental groups used the Scott, Foresman textbooks and teacher's manual. The teachers of the control groups used the material they had used in previous years.

II. RESULTS

By referring to Table I it will be seen that according to the Lorge-Thorndike Intelligence Tests, the means for Experimental Room Two and Control Room Two are very nearly the same. Control Room One has a lower mean than the rest. The mean for the group of 103 children is 100.15, well within what is considered average intelligence.

Because the study was concerned with arithmetic, only the arithmetic section of the Iowa Tests of Basic Skills was given. This part consisted of (a) a test of concepts and (b) problem solving. The results of these tests are shown on Tables II and III.

To test the null hypothesis, namely, that the group means for each method are the same, a statistical technique entitled analysis of covariance was employed. This technique is described on pages 317-339 in Lindquist's Design and Analysis of Experiment in Psychology and Education (14:172-189).

TABLE I

DISTRIBUTION OF SCORES ACCORDING TO THE LORGE-THORNDIKE INTELLIGENCE TESTS, SHOWN BY ROOMS

Room	High Score	Low Score	Range	Mean	Number In Room
Experimental Room One	118	72	46	98.6	27
Control Room One	109	78	31	92.7	22
Experimental Room Two	127	83	44	104.4	28
Control Room Two	131	83	48	104.9	26
Total	131	72	59	100.15	103

TABLE II

DIFFERENCES BY ROOM
BETWEEN FALL AND SPRING TESTS,
IOWA TESTS OF BASIC SKILLS

Room	October Test	April Test	Difference	Months Advanced	Mean
Experimental Room One	1202	2271	1069	534.5	19.79
Control Room One	984	1610	626	313.0	14.23
Experimental Room Two	1837	2588	751	375.5	13.41
Control Room Two	1794	2498	704	352.0	14.31

TABLE III

DIFFERENCES BETWEEN
THE EXPERIMENTAL AND CONTROL ROOMS
IN THE FALL AND SPRING TESTS,
IOWA TESTS OF BASIC SKILLS

Room	October Test	April Test	Difference	Months Advanced	Mean
The Two Experimental Rooms	3039	4859	1820	910.0	16.60
The Two Control Rooms	2778	4108	1330	665.0	14.27

Simply stated, this technique makes it possible to statistically control a variable which under the circumstance is impractical to control in any other fashion. The uncontrolled variable in this study was the mean intelligence of the youngsters involved in the experiment.

Table IV presents the summary of analysis of the data from the Iowa Tests of Basic Skills. The appropriate test of the null hypothesis under this design is a F-test involving the ratio of the adjusted mean square for methods and within-methods. This ratio for 1 and 101 degrees of freedom is 1.14. Comparing this to the .05 for 1 and 120 degrees of freedom, which is 3.92, leads to a retention of the hypothesis.

While there is not a significant difference between the means of the control and experimental groups, the mean for the experimental groups is higher than that of the control groups.

The Iowa Tests of Basic Skills are, as a rule, accepted as a good test in arithmetic. However, the Scott, Foresman Company say that the tests do not cover all aspects of pupils' competence in arithmetic, as taught by their method. To accomplish this they have compiled a test in six parts. The six parts cover "Problem Solving, Selecting Answers"; "Computation"; "Problem Solving, Selecting Equations"; "Problem Solving, Solving Equations"; "Information"; and "Concepts." By using this test along

SUMMARY TABLE IV

	df	SS_A	SP_{AI}	SS_I	SS_Y	df	ms_y
Methods	1	185.64	15.50	123.67	146.88	1	146.98
Within methods	101	7,612.12	3,440.40	14,428.06	12,873.12	100	128.73
Total	102	7,797.76	3,455.90	14,551.73	13,020.10	101	

$_{.05}F_{1,120}=3.92$

$F=\frac{146.98}{128.73}=1.14$

with the Iowa Tests of Basic Skills, it was felt that a more accurate picture could be obtained in the comparison of the groups. Tables V and VI show the results for this Scott, Foresman test. By adding the means of the two experimental rooms and dividing by two, thus obtaining an average, and then doing the same with the means of the control groups, it will be seen that the experimental rooms ranked higher in this test also, the difference being 4.055.

Appendixes J, K, L, and M show the results for the individual children taking the Scott, Foresman test. The scores reported are raw. They report the number of items correctly done. The scores shown on the Iowa Tests of Basic Skills, appendixes F, G, H, and I, are of the grade equivalent type.

TABLE V

DIFFERENCES BY ROOM
BETWEEN FALL AND SPRING TESTS,
SCOTT, FORESMAN TEST GRADES

Room	October Test	April Test	Difference	Mean
Experimental Room One	856	1548	692	25.63
Control Room One	640	1027	387	17.59
Experimental Room Two	811	1857	1046	37.35
Control Room Two	796	1554	758	29.15

TABLE VI

DIFFERENCES BETWEEN
THE EXPERIMENTAL AND CONTROL ROOMS
IN THE SPRING AND FALL TESTS,
SCOTT, FORESMAN TESTS

Room	October Test	April Test	Difference	Mean
The Two Experimental Rooms	1667	3395	1738	31.48
The Two Control Rooms	1436	2581	1145	23.37

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

The primary purpose of this study was to compare the achievement of children being taught by the Scott, Foresman method of arithmetic with those being taught by more traditional methods. Beyond the comparison of achievement, the writer wished to find for the arithmetic committee whether the children received better concepts of numbers and processes through the Scott, Foresman method. She also wanted to know whether the Scott, Foresman method made the teaching of problem solving more efficient.

If the answers to these three questions were in the affirmative, the arithmetic committee would recommend that the school board adopt the Scott, Foresman method of teaching arithmetic. This adoption would be for grades three through eight in the entire district.

The committee had decided to try Scott, Foresman because this series seemed to have a more radical change of methods for the teaching of arithmetic than any other series considered. The third grade was used because the new method would be started there if it was selected.

Research has shown that the two major objectives of modern arithmetic should be to (1) develop in the learner the ability to perform the various number skills, with the understanding of why he is using these specific processes, and to (2) provide the learner with a rich variety of experiences. These experiences should be of the type to prepare the pupil to apply quantitative procedures effectively in social situations in a democratic life outside the school.

Arithmetic must be made meaningful to the students. This is best done by relating the new experiences to the old. This makes a gradual step-by-step development of the processes. Beyond this method of step-by-step development is the necessity of allowing pupils to make discoveries for themselves. The wide use of varied manipulative and pictorial materials is necessary in a program of making arithmetic meaningful.

In the third grade children master most of the simpler processes with numbers. By the time they reach the end of this grade they should be masters in using addition and subtraction and easier multiplication and division facts. They should also be able to handle any simple computation involving whole numbers. They should have a good understanding of the simple fractions.

In order to accomplish this the children must have had a rich and extensive background experience. These experiences have to be with number situations of the concrete type before children can be introduced to the abstract. If they have not had these experiences in previous grades, the teacher will have to furnish them before the children will be able to understand and learn further procedures in problem solving.

It is important that children be encouraged to experiment and find new ways to work problems both mentally and with a pencil. They should be allowed to share their ingenuity in figuring out methods with others in the class. The teacher acts as a guide in opening opportunities for children to investigate. In this way the teacher stimulates pupil growth.

Probably the most important understanding children must have in arithmetic is the base-ten principle. First, they should learn to see how a large group of objects can be organized through grouping by tens. After they become familiar with grouping objects, they learn to record this grouping in writing. From this they naturally grasp the idea of place value. The objective of grouping objects is to be sure that the pupils learn to visualize and understand the relationships within the numeration system as a whole.

Children must be given first-hand experience enough to enable them to have a good concept of why certain procedures are necessary. The vocabulary of the story problems must be on their level. When this is done children will both learn and enjoy arithmetic.

Research proves the fallacy of the teacher being the "teller" and the children only doing what they are told. It also condemns requiring children to memorize things they know no reason for. This is an authoritarian way of treating children; we are trying to teach them to live in a democracy. It cripples the children to the extent that they become so dependent upon the "tellers" for directions and approval that their learning is retarded.

Children will not be able to learn arithmetic unless it has meaning to them. They get this meaning from first-hand experience. But these meanings must be organized into some sequential structure. The facts must become automatic through practice. This background must come before drill. When arithmetic is taught in this manner, children will have a practical knowledge they can apply in any situation where it is needed.

The writer set up this study to see if the methods used in the textbooks would accomplish what modern research requires. If the requirements were met the results of the study should show that the children in the experimental rooms advanced further than those in the control groups. The procedure followed in this study was to (1) find the intelligence quotients of the groups being used, (2) find the advance made in arithmetic by each of these groups, and (3) study the difference in advance made by the experimental and control groups.

II. CONCLUSIONS

As a result of this study, it is concluded that there is no apparent advantage for the Scott, Foresman method of teaching over the traditional approach, since there was no statistically significant difference between the two groups of children being taught by the two methods.

III. RECOMMENDATIONS

It is recommended by the writer, to anyone planning research of this kind, that the experiment be carried on for two years rather than one. All the tests should be given by one person. Another factor which should be considered is to have groups whose intelligence quotients were nearly the same. In order to have a better check on what was being taught in the control rooms a record should be made of the material taught by those teachers. Because it is possible that some teachers might spend more time teaching arithmetic than others, a record should be kept of the amount of time spent on the study of arithmetic in each group.

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APPENDIXES

APPENDIX A:

SCOTT, FORESMAN SEEING THROUGH ARITHMETIC PROGRAM THIRD GRADE DESCRIBED

Scott, Foresman say that their arithmetic is presented in such a way that the children get better concepts of the number system and processes. They say that it is easier to teach and to comprehend because it has been simplified. The following are some of the ways it has been simplified.

1. The arithmetic is simplified through better organization of the work. As a rule the process of addition is separated into many different "skills." Here addition of two-figure numbers is introduced with an example that involves carrying. Thus the children know immediately why they must start adding on the right column. The same general principle is true in subtraction with borrowing. Before carrying and borrowing are introduced as such, the children have a great deal of experience in regrouping ones into tens, tens into hundreds, and hundreds into thousands. And they learn how to regroup thousands into hundreds, hundreds into tens, and tens into ones. This experience helps them to understand how to carry and borrow later on. In both addition and subtraction the principle of introducing all the basic facts, before processes are attempted, is practiced. The multiplication and division facts through thirty-six are introduced

in the third grade, but the computational processes are deferred to the time when all the facts are known. That is in the fourth grade. A new visual method of presentation and provision of a good understanding of the number system is used to open the door to insight.

2. The arithmetic is simplified through help in analyzing the problem situation. First, the children are helped to recognize what is happening in the problem situation and then to state it in an equation. Then the children learn to go through the appropriate process with the number symbols.

3. The arithmetic is simplified through use of effective methods. The number system is thoroughly taught by the use of many pictures. These pictures help the children see the relation, rather than to learn the names of the "places," in written numerals. The basic facts are introduced pictorially. All the ways of stating or writing them are taught instead of having the children say, "2 threes = 6," or "2 times 3 = 6." This is done because it is desired that the children understand them wherever or however they see them outside the classroom. The "four-step teaching method" is made use of by using a series of pictures to help the children see in detail what to do. Under the heading Think, another example is worked out by use of pictures. Questions about important details are asked. Under the heading Try, some worked out

problems are given, but the children are expected to work these out for themselves. They then compare this work with the completed examples in the book. Finally the section Do finishes the "four-steps" of learning new processes. The children are expected to work the problems in this section by themselves.

Pictures are used freely and use is made of color not only to add general attractiveness, but to call attention to special points. The vocabulary is well within the reading ability of all the children in the third grade.

APPENDIX B:

DISTRIBUTION OF SCORES ACCORDING TO THE LORGE - THORNDIKE INTELLIGENCE TESTS, EXPERIMENTAL ROOM ONE

Coded Student	Sex	I. Q. Total	Rank
A	F	118	1
B	F	108	3
C	F	108	3
D	M	108	3
E	M	107	5.5
F	M	107	5.5
G	M	106	7.5
H	M	106	7.5
I	F	105	9.5
J	M	105	9.5
K	M	103	12
L	F	103	12
M	F	103	12
N	F	101	14.5
O	M	101	14.5
P	M	99	16.5
Q	M	99	16.5
R	M	97	18
S	M	95	19
T	F	94	20
U	M	93	21
V	M	87	22
W	M	86	23
X	F	85	24.5
Y	M	85	24.5
Z	F	80	26
XZ	F	72	27
Mean		98.6	

APPENDIX C:

DISTRIBUTION OF SCORES ACCORDING TO THE LORGE - THORNDIKE INTELLIGENCE TESTS, CONTROL ROOM ONE

Coded Student	Sex	I. Q. Total	Rank
a	F	109	1
b	M	107	2
c	M	104	3.5
d	M	104	3.5
e	M	103	5.5
f	F	103	5.5
g	F	102	7
h	M	99	8
i	M	97	9.5
j	M	97	9.5
k	F	95	11
l	F	92	12
m	F	89	13
n	F	87	14
o	M	85	15
p	M	83	16.5
q	F	83	16.5
r	M	82	18
s	M	81	19
t	M	80	20
u	F	79	21
v	M	78	22
Mean		92.7	

APPENDIX D:

DISTRIBUTION OF SCORES ACCORDING TO THE LORGE - THORNDIKE INTELLIGENCE TESTS EXPERIMENTAL ROOM TWO

Coded Student	Sex	I. Q. Total	Rank
1A	F	127	1
1B	F	124	2
1C	M	120	3
1D	F	118	4
1E	F	116	5
1F	M	114	6
1G	F	112	7
1H	M	111	8.5
1I	M	111	8.5
1J	F	109	10.5
1K	M	109	10.5
1L	M	107	12.5
1M	M	107	12.5
1N	M	106	14
1O	M	102	15.5
1P	F	102	15.5
1Q	F	99	17.5
1R	F	99	17.5
1S	F	98	19.5
1T	F	98	19.5
1U	M	97	21.5
1V	F	97	21.5
1W	M	96	23
1X	M	95	24
1Y	M	93	25
1Z	M	87	26
1XY	F	85	27
1XZ	F	83	28
Mean		104.4	

APPENDIX E:

DISTRIBUTION OF SCORES ACCORDING TO THE LORGE - THORNDIKE INTELLIGENCE TESTS CONTROL ROOM TWO

Coded Student	Sex	I. Q. Total	Rank
1a	M	131	1
1b	F	125	2
1c	F	121	3.5
1d	M	121	3.5
1e	F	120	5
1f	M	118	6
1g	M	113	7
1h	M	107	8
1i	M	106	9
1j	M	105	10
1k	M	104	13
1l	M	104	13
1m	M	104	13
1n	F	104	13
1o	F	104	13
1p	F	103	17
1q	F	103	17
1r	F	103	17
1s	M	99	19
1t	F	95	20.5
1u	F	95	20.5
1v	F	91	22.5
1w	M	91	22.5
1x	F	90	24
1y	F	88	25
1z	F	83	26
Mean		104.9	

APPENDIX F:

DIFFERENCES BETWEEN FALL AND SPRING TESTS
IOWA TESTS OF BASIC SKILLS
EXPERIMENTAL ROOM ONE

Coded Student	October Test		April Test		Differences		Months Advanced
Test no.	1	2	1	2	1	2	1&2 aver.
A	1-7	2-2	5-5	3-9	3-8	1-7	27.5
B	1-9	2-3	4-8	5-2	2-9	2-9	29.0
C	2-4	2-5	4-5	4-3	2-1	1-8	19.5
D	2-0	2-7	5-9	5-4	3-9	2-7	33.0
E	2-2	2-5	3-5	2-6	1-3	0-1	7.0
F	1-7	2-5	3-3	3-4	1-6	0-9	12.5
G	1-7	2-5	5-8	5-2	4-1	2-7	34.0
H	1-7	2-5	5-5	5-1	3-8	2-6	32.0
I	2-0	2-7	5-0	4-1	3-0	1-4	22.0
J	2-2	2-2	4-3	4-9	2-1	2-7	24.0
K	1-5	2-0	4-3	4-6	2-8	2-6	27.0
L	1-7	2-7	5-0	5-0	3-3	2-3	28.0
M	2-0	2-5	5-8	5-1	3-8	2-6	32.0
N	1-7	1-7	4-3	4-9	2-6	3-2	29.0
O	2-0	2-2	5-5	4-4	3-5	2-2	28.5
P	2-0	4-0	3-3	2-5	1-3	1-0	-1.5
Q	2-0	2-0	5-7	5-0	3-7	3-0	33.5
R	2-0	3-0	4-6	3-5	2-6	0-5	15.5
S	1-9	3-2	4-0	3-8	2-1	0-6	13.5
T	1-9	2-5	5-5	5-4	3-6	2-9	32.5
U	2-4	2-5	4-6	3-8	2-2	1-3	17.5
V	1-9	2-0	2-0	2-0	0-1	0-0	.5
W	2-2	2-9	3-0	3-4	0-8	0-5	6.5
X	2-2	2-5	2-8	3-0	0-6	0-5	5.5
Y	1-9	3-0	2-8	2-2	0-9	-8	.5
Z	2-4	2-0	4-3	3-1	1-9	1-1	15.0
XZ	1-2	2-5	2-6	3-1	1-4	0-6	10.0
Total	524	678	1182	1089	658	411	534.5
Mean							19.79

APPENDIX G:

DIFFERENCES BETWEEN FALL AND SPRING TESTS
IOWA TESTS OF BASIC SKILLS
CONTROL ROOM ONE

Coded Student	October Test		April Test		Differences		Months Advanced
Test No.	1	2	1	2	1	2	1&2 aver.
a	1-9	2-5	4-6	4-4	2-7	1-9	23.0
b	2-0	2-3	5-8	5-1	3-8	2-8	33.0
c	1-7	2-3	5-7	3-9	4-0	1-6	28.0
d	1-4	2-2	1-8	4-3	0-4	2-1	12.5
e	2-4	2-7	5-7	5-2	3-3	2-5	29.0
f	1-9	2-7	4-6	4-0	2-7	1-3	20.0
g	1-9	2-7	2-4	2-8	0-5	0-1	3.0
h	1-9	2-3	5-6	3-4	3-7	1-1	24.0
i	2-4	2-5	4-1	4-1	1-7	1-6	16.5
j	2-4	2-2	2-4	2-8	0-0	0-6	3.0
k	2-4	2-2	2-2	3-1	-2	0-9	3.5
l	1-9	3-3	2-8	3-5	0-9	0-2	5.5
m	1-7	3-2	3-0	2-6	1-3	-6	3.5
n	1-4	2-9	3-7	3-8	2-3	0-9	16.0
o	1-9	2-0	3-8	3-5	1-9	1-5	17.0
p	1-5	2-2	2-8	3-1	1-3	0-9	11.0
q	2-8	2-5	4-8	4-7	2-0	2-2	21.0
r	1-4	2-7	2-6	2-8	1-2	0-1	6.5
s	1-5	2-0	2-6	3-1	1-1	1-1	11.0
t	2-4	2-5	4-6	4-6	2-2	2-1	21.5
u	1-9	2-5	2-0	2-6	0-1	0-1	1.0
v	2-4	2-9	2-6	3-4	0-2	0-5	3.5
Total	431	553	802	808	371	255	313.0
Mean							14.23

APPENDIX H:

DIFFERENCES BETWEEN FALL AND SPRING TESTS
IOWA TESTS OF BASIC SKILLS
EXPERIMENTAL ROOM TWO

Coded Student	October Test		April Tests		Differences		Months Advanced
Test No.	1	2	1	2	1	2	1&2 aver.
1A	3-3	3-5	4-6	5-0	1-3	1-5	14.0
1B	5-5	4-3	5-8	5-4	0-3	1-1	7.0
1C	4-0	3-8	5-8	5-1	1-8	1-3	15.5
1D	3-8	4-0	5-5	5-2	1-7	1-2	14.5
1E	3-8	3-8	5-2	5-2	1-4	1-4	14.0
1F	5-5	5-1	4-8	5-1	-7	0-0	-3.5
1G	2-2	2-8	4-3	5-0	2-1	2-2	21.5
1H	3-8	3-6	4-6	5-2	0-8	1-6	12.0
1I	4-3	4-3	5-5	5-2	1-2	0-9	10.5
1J	3-0	3-5	4-8	5-2	1-8	1-7	17.5
1K	3-5	3-0	4-5	4-7	1-0	1-7	13.5
1L	2-8	2-4	4-0	3-9	1-2	1-5	13.5
1M	3-0	2-8	4-3	5-0	1-3	2-2	17.5
1N	1-6	3-0	5-2	4-6	3-6	1-6	26.0
1O	3-7	3-0	4-5	5-1	0-8	2-1	14.5
1P	2-8	3-1	4-5	4-1	1-7	1-0	13.5
1Q	4-1	4-0	5-0	5-1	0-9	1-1	10.0
1R	3-0	2-6	3-8	5-2	0-8	2-6	17.0
1S	3-2	3-4	3-8	4-9	0-6	1-5	10.5
1T	3-0	3-0	5-2	4-4	2-2	1-4	18.0
1U	2-8	3-1	4-8	4-3	2-0	1-2	16.0
1V	1-6	2-2	4-1	3-1	2-5	0-9	17.0
1W	3-2	3-5	3-8	5-2	0-6	1-7	11.5
1X	3-6	3-3	4-6	4-1	1-0	0-8	9.0
1Y	2-6	3-3	4-3	4-0	1-7	0-7	12.0
1Z	1-8	3-0	3-6	3-8	1-8	0-8	13.0
1XY	3-7	3-1	4-5	4-7	0-8	1-6	12.0
1XZ	2-0	2-0	3-2	2-4	1-2	0-4	8.0
Total	912	925	1286	1302	374	377	375.5
Mean							13.41

APPENDIX I:

DIFFERENCES BETWEEN FALL AND SPRING TESTS
IOWA TESTS OF BASIC SKILLS
CONTROL ROOM TWO

Coded Student	October Test		April Test		Difference		Months Advanced
Test No.	1	2	1	2	1	2	1&2 aver.
1a	4-8	4-9	5-9	5-0	1-1	0-1	6.0
1b	3-2	3-1	5-2	4-7	2-0	1-6	18.0
1c	3-8	3-1	5-2	4-6	1-4	1-5	14.5
1d	3-5	3-0	5-2	5-2	1-7	2-2	19.5
1e	4-1	3-0	5-7	5-2	1-6	2-2	19.0
1f	4-8	4-7	5-9	4-7	1-1	0-0	5.5
1g	4-6	4-4	5-8	4-9	1-2	0-5	8.5
1h	3-7	3-0	5-5	4-9	1-8	1-9	18.5
1i	2-4	2-8	4-8	5-1	2-4	2-3	23.5
1j	1-8	2-4	5-0	3-8	3-2	1-4	23.0
1k	2-0	2-2	4-6	4-9	2-6	2-7	26.5
1l	3-7	3-3	4-6	4-9	0-9	1-6	12.5
1m	2-0	2-4	3-3	3-5	1-3	1-1	12.0
1n	4-6	3-9	5-5	5-1	0-9	1-2	10.5
1o	4-8	4-0	5-8	5-4	1-0	1-4	12.0
1p	4-3	3-9	5-2	5-0	0-9	1-1	10.0
1q	2-6	3-5	5-0	4-6	2-4	1-1	17.5
1r	4-6	3-9	5-5	5-2	0-9	1-3	11.0
1s	2-6	2-6	3-2	4-1	0-6	1-5	10.5
1t	4-3	3-8	5-5	4-7	1-2	0-9	10.5
1u	4-0	3-3	4-6	4-6	0-6	1-3	9.5
1v	4-3	4-4	5-2	4-1	0-9	-3	3.0
1w	2-8	2-4	4-1	2-8	1-3	0-4	8.5
1x	2-6	2-8	4-6	4-1	2-0	1-3	16.5
1y	3-3	2-8	5-3	4-1	2-0	1-3	16.5
1z	3-2	3-4	4-0	4-4	0-8	1-0	9.0
Total	924	870	1302	1196	378	326	352.0
Mean							14.31

APPENDIX J:

SCOTT, FORESMAN TEST GRADES
EXPERIMENTAL ROOM ONE

Coded Student	Fall Test							Spring Test						
	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
A	4	5	4	11	4	10	38	15	15	10	15	9	13	77
B	9	10	5	9	5	6	44	15	15	13	15	12	11	81
C	6	6	8	3	2	3	28	6	15	8	14	8	6	57
D	7	10	9	13	8	9	56	13	14	11	15	10	13	76
E	2	4	2	4	0	4	16	4	7	7	13	8	0	39
F	2	4	6	7	1	4	24	8	8	8	13	7	4	48
G	12	2	6	15	7	17	59	15	15	8	14	14	12	78
H	5	1	3	6	5	1	21	14	10	10	13	11	9	67
I	3	5	6	4	3	6	27	4	15	8	14	10	4	55
J	0	1	4	2	4	1	12	16	15	8	15	8	8	70
K	1	4	4	7	2	4	25	12	15	7	15	8	11	68
L	5	3	6	7	3	6	30	12	13	10	15	9	7	66
M	11	7	7	9	10	8	52	15	15	8	15	13	7	73
N	4	4	1	4	4	3	20	14	9	8	12	6	11	60
O	6	7	5	8	9	9	44	13	15	13	13	11	13	78
P	5	8	4	10	3	5	35	6	8	4	9	9	6	42
Q	2	5	4	4	5	4	24	12	14	12	13	11	12	74
R	5	4	4	5	4	9	31	10	13	8	10	8	7	56
S	6	6	7	5	5	9	38	4	9	8	12	6	7	46
T	8	10	6	11	8	7	49	15	14	12	15	10	12	78
U	8	4	5	6	4	6	33	11	13	8	14	9	8	63
V	9	4	7	6	1	2	29	5	4	2	9	4	1	25
W	3	4	3	3	6	5	24	2	7	1	9	6	7	32
X	2	7	1	6	4	5	25	2	14	7	7	6	10	46
Y	3	4	0	1	2	4	14	2	6	7	6	4	4	29
Z	4	3	5	1	6	6	25	7	11	10	8	7	3	46
ZQ	5	9	9	6	1	3	33	2	5	1	5	2	3	18
Total							856							1548

APPENDIX K:

SCOTT, FORESMAN TEST GRADES
CONTROL ROOM ONE

Coded Student	Fall Test							Spring Test						
	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
a	7	9	4	10	6	7	43	13	13	7	11	9	7	60
b	8	15	12	9	9	12	65	14	15	8	13	14	11	75
c	1	6	5	4	2	6	24	14	13	7	10	14	9	67
d	2	3	4	3	3	2	17	11	10	7	10	6	9	53
e	7	8	8	10	7	6	46	10	12	10	15	12	10	69
f	7	4	4	3	4	4	26	6	11	2	10	8	2	39
g	1	1	1	5	5	5	18	2	8	3	4	5	5	27
h	9	10	8	7	5	8	47	15	15	13	13	14	9	79
i	4	5	2	3	2	6	22	7	9	7	8	8	5	44
j	3	4	7	4	1	3	22	8	8	10	10	10	6	52
k	5	5	4	3	2	2	21	2	9	5	6	4	5	31
l	1	5	4	2	5	5	22	1	8	5	7	6	5	32
m	1	3	5	8	4	4	25	2	11	6	9	7	7	42
n	2	8	1	8	4	6	29	8	11	6	10	10	5	50
o	8	6	2	2	7	7	32	11	11	4	9	12	7	54
p	3	3	3	4	5	5	23	5	3	6	6	8	3	31
q	7	4	3	2	3	4	23	11	10	7	13	9	4	54
r	10	6	6	7	7	8	44	6	6	4	4	7	5	32
s	4	4	2	6	6	4	26	4	4	9	11	10	7	45
t	3	4	4	4	4	8	27	4	11	7	14	7	6	49
u	2	7	4	5	6	3	27	2	3	5	3	7	4	24
v	3	3	0	2	2	1	11	3	4	4	3	2	2	18
Total							640							1027

APPENDIX L:

SCOTT, FORESMAN TEST GRADES
EXPERIMENTAL ROOM TWO

Coded Student	Fall Test 1	2	3	4	5	6	Total	Spring Test 1	2	3	4	5	6	Total
1A	3	6	4	6	5	4	28	13	13	9	14	14	9	72
1B	8	5	6	9	2	7	37	15	15	12	15	13	14	84
1C	10	10	5	13	6	4	48	12	15	11	15	11	12	76
1D	11	3	8	5	7	7	41	15	15	9	15	11	6	71
1E	8	5	5	5	3	6	32	13	15	19	13	8	11	79
1F	9	9	7	15	2	11	53	15	14	11	15	14	15	84
1G	6	1	6	6	1	7	27	13	14	10	13	10	7	67
1H	9	6	5	11	4	7	42	15	13	11	14	13	11	77
1I	8	8	6	11	5	6	44	15	15	12	14	11	13	80
1J	4	10	4	10	4	1	33	12	15	9	15	12	9	72
1K	4	4	5	1	2	5	21	14	15	8	14	11	10	72
1L	4	5	2	2	3	7	23	7	14	8	11	4	7	51
1M	2	7	3	3	2	2	19	8	14	8	10	8	9	57
1N	7	9	5	9	1	4	35	15	14	9	12	11	12	73
1O	6	3	7	5	3	3	27	15	14	11	13	9	9	71
1P	3	4	3	5	2	4	21	8	9	10	12	7	9	55
1Q	8	6	4	6	2	7	33	13	13	14	13	10	10	73
1R	5	5	3	1	1	7	22	12	15	10	13	9	9	68
1S	4	6	2	8	1	2	23	13	12	10	15	10	9	69
1T	6	5	3	11	3	4	32	12	11	11	12	7	9	62
1U	5	6	0	0	0	0	11	12	12	8	14	9	9	64
1V	4	2	1	1	3	5	16	3	6	6	8	10	8	41
1W	2	4	5	3	4	4	22	13	12	8	11	8	10	62
1X	5	5	3	0	3	6	22	8	14	9	13	7	5	56
1Y	5	5	3	5	2	3	23	8	13	6	11	8	6	52
1Z	2	2	4	3	4	4	19	9	14	9	13	7	5	57
1XY	7	5	5	3	3	4	27	13	15	13	14	9	7	71
1XZ	6	4	6	4	4	6	30	7	6	6	11	7	4	41
Total							811							1857

APPENDIX M:

SCOTT, FORESMAN TEST GRADES CONTROL ROOM TWO

Coded Student	Fall Test							Spring Test						
	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
1a	5	10	7	9	7	8	46	9	9	9	12	6	11	56
1b	3	5	5	7	2	5	27	14	14	9	10	11	12	70
1c	8	6	6	7	4	4	35	14	12	9	11	7	9	62
1d	3	3	2	7	2	5	22	14	11	8	10	10	7	60
1e	9	4	6	4	6	5	34	13	14	10	13	11	12	73
1f	10	4	6	7	8	9	44	11	15	10	13	12	12	73
1g	10	5	4	11	5	7	42	14	12	9	13	12	12	72
1h	1	5	6	4	6	3	25	10	14	8	15	13	12	72
1i	3	3	5	5	3	3	22	10	15	10	14	9	6	64
1j	4	2	5	4	5	4	24	7	9	7	12	7	8	50
1k	5	3	4	2	4	5	23	10	13	7	10	6	11	57
1l	8	3	3	1	6	5	26	10	14	8	12	8	12	64
1m	1	5	5	1	4	5	21	6	7	5	6	3	7	34
1n	6	7	4	10	5	10	42	14	12	10	10	10	13	69
1o	7	8	2	7	5	3	32	14	15	8	11	11	12	71
1p	7	3	6	7	6	2	31	13	15	10	10	10	8	66
1q	7	5	2	4	4	3	25	11	14	9	12	9	6	61
1r	12	10	9	11	8	7	57	12	14	10	15	15	13	79
1s	2	3	2	4	7	5	23	7	14	4	8	6	6	45
1t	5	5	7	8	8	7	40	13	13	11	10	9	11	67
1u	4	5	7	5	3	5	29	5	11	10	13	10	6	55
1v	7	5	3	1	5	5	26	6	12	6	13	10	6	53
1w	4	3	3	4	5	7	26	3	10	5	8	2	2	30
1x	3	3	5	2	4	3	20	4	13	7	10	7	5	46
1y	6	4	2	6	7	6	31	7	15	8	12	9	9	60
1z	3	5	4	2	4	5	23	11	12	6	7	5	4	45
Total							796							1554

Maurice L. Hartung
Henry Van Engen
E. Glenadine Gibb
Lois Knowles

STAT 3

Seeing through arithmetic test

Scott, Foresman and Company *Chicago, Atlanta, Dallas, Palo Alto, Fair Lawn, N.J.*

Part		Number correct
Problem solving: Selecting answers	1	
Computation	2	
Problem solving: Selecting equations	3	
Problem solving: Solving equations	4	
Information	5	
Concepts	6	
Total		

Pupil

Teacher

Grade

Date

Part 1 *Problem solving: selecting answers*

Sample Betty has 32 shells. Ann has 25 shells. Ann has how many fewer shells than Betty?

- ☐ 57
- ☐ 17
- ☒ 7
- ☐ Answer is not given.

Sample Jack had 19 marbles. He lost 7 of them. Jack has how many marbles left?

- ☐ 26
- ☐ 17
- ☐ 7
- ☐ Answer is not given.

A Jim's father had 17 apple trees on his farm. This year he planted 14 more apple trees. How many apple trees does he have now?

- ☐ 3
- ☐ 21
- ☐ 31
- ☐ Answer is not given.

B Tom got $2.00 for his birthday. He spent $.83 for a book. How much of the $2.00 was left?

- ☐ $1.17
- ☐ $.17
- ☐ $2.83
- ☐ Answer is not given.

C Ann's mother made 18 sandwiches for a picnic. Carol's mother made 26 sandwiches. Together, they made how many sandwiches for the picnic?

- ☐ 8
- ☐ 34
- ☐ 44
- ☐ Answer is not given.

D Nancy had 43 jacks. She gave away 15 of them. How many jacks did she have left?

- ☐ 58
- ☐ 18
- ☐ 28
- ☐ Answer is not given.

E Ann's mother needs 48 cookies for a party. She has made 23 cookies. How many more cookies does she need to make?

- ☐ 25
- ☐ 61
- ☐ 71
- ☐ Answer is not given.

F Carol's mother made 53 chocolate cookies and 37 peanut butter cookies. She made how many fewer peanut butter cookies than chocolate cookies?

- ☐ 14
- ☐ 90
- ☐ 16
- ☐ 24
- ☐ Answer is not given.

Go on to the next page.

G June bought 3 bags of peanuts. Each bag cost 6¢. How much in all did June pay for the peanuts?

☐ 3¢
☐ 24¢
☐ 18¢
☐ 2¢
☐ Answer is not given.

H Jack has 15 toy cowboys. He has 21 toy horses. He has how many more toy horses than toy cowboys?

☐ 16
☐ 6
☐ 36
☐ Answer is not given.

I May bought 6 packages of candles. There were 5 candles in each package. How many candles did she buy?

☐ 11
☐ 24
☐ 36
☐ 30
☐ Answer is not given.

J Tom bought 25 new pictures of airplanes. Then he had 92 airplane pictures. How many airplane pictures did Tom have before he bought the new ones?

☐ 57
☐ 67
☐ 117
☐ 73
☐ Answer is not given.

K 24 boys are playing ball. There are 4 teams, with the same number of boys on each team. How many are on each team?

☐ 20
☐ 8
☐ 28
☐ 6
☐ Answer is not given.

L One day Mary saw that 16 red flowers in the garden had opened. The next day, 26 red flowers were open. How many more red flowers had opened?

☐ 10
☐ 32
☐ 42
☐ Answer is not given.

M Tom put the 32 library chairs, at the tables. He put 4 chairs at each table. How many tables were there?

☐ 24
☐ 8
☐ 36
☐ 6
☐ Answer is not given.

N Bill put $1.25 he had earned in his bank. Then he had $5.10 in his bank. How much money did he have in his bank before he put in the $1.25?

☐ $6.35
☐ $3.85
☐ $7.60
☐ Answer is not given.

O Nancy needs 20 cups of milk for a party. There are 4 cups in each quart of milk. How many quarts of milk does she need?

☐ 20
☐ 16
☐ 24
☐ 4
☐ Answer is not given.

☐ *Number correct Part 1*

Part 2 *Computation*

Sample 268 − 260 = ▒

☐ 108
☐ 18
☐ 528
☐ 8
☐ Answer is not given.

A 6 + 9 + 4 + 7 = ▒

☐ 27
☐ 26
☐ 25
☐ 36
☐ Answer is not given.

B 37 − 20 = ▒

☐ 7
☐ 16
☐ 27
☐ 57
☐ Answer is not given.

C 949 − 16 = ▒

☐ 933
☐ 965
☐ 833
☐ 923
☐ Answer is not given.

D 312 + 321 = ▒

☐ 623
☐ 0
☐ 624
☐ 633
☐ Answer is not given.

E 325 + 110 = ▒

☐ 215
☐ 535
☐ 345
☐ 435
☐ Answer is not given.

F 721 + 127 = ▒

☐ 594
☐ 698
☐ 898
☐ 848
☐ Answer is not given.

G 6 + 320 = ▒

☐ 326
☐ 380
☐ 920
☐ 236
☐ Answer is not given.

H 123 − 72 = ▒

☐ 51
☐ 151
☐ 41
☐ 195
☐ Answer is not given.

I 31 + 84 + 78 = ▒

☐ 183
☐ 193
☐ 192
☐ 93
☐ Answer is not given.

J 284 + 145 = ▒

☐ 139
☐ 329
☐ 429
☐ 339
☐ Answer is not given.

K 427 − 388 = ▒

☐ 49
☐ 139
☐ 149
☐ 39
☐ Answer is not given.

L 458 − 19 = ▒

☐ 349
☐ 449
☐ 439
☐ 477
☐ Answer is not given.

M 399 + 213 = ▒

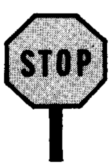
☐ 512
☐ 612
☐ 602
☐ 502
☐ Answer is not given.

N 425 − 175 = ▒

☐ 350
☐ 360
☐ 250
☐ 260
☐ Answer is not given.

O 100 − 8 = ▒

☐ 88
☐ 108
☐ 92
☐ 102
☐ Answer is not given.



☐ *Number correct Part 2*

Part 3 *Problem solving: selecting equations*

Sample Ann's mother needs 15 candles for a birthday cake. There are 5 candles in a box. How many boxes of candles does she need?

- ☐ 15 − 5 = ___
- ☐ 15 + 5 = ___
- ☐ 15 ÷ 5 = ___
- ☐ Equation is not given.

A One morning the grocer had 55 boxes of soap. He sold 37 boxes that day. How many boxes of soap did he have left that night?

- ☐ 55 − 37 = ___
- ☐ 37 + ___ = 55
- ☐ ___ + 37 = 55
- ☐ 55 + 37 = ___
- ☐ Equation is not given.

B Nancy's father has 38 white lambs and 7 black lambs on his farm. He has how many lambs in all?

- ☐ 38 − 7 = ___
- ☐ 38 + 7 = ___
- ☐ ___ + 7 = 38
- ☐ Equation is not given.

C Jim had saved $6.75. He spent $3.98 for a football. How much of his savings did Jim have left after he bought the football?

- ☐ $3.98 + ___ = $6.75
- ☐ $6.75 + $3.98 = ___
- ☐ $6.75 − $3.98 = ___
- ☐ Equation is not given.

D One Monday Dick's father sold 24 dozen eggs. On Saturday he sold 33 dozen eggs. He sold how many fewer dozen eggs on Monday than on Saturday?

- ☐ 24 + ___ = 33
- ☐ 33 − 24 = ___
- ☐ 33 − ___ = 24
- ☐ Equation is not given.

E Don bought a game that cost $2.19. Dick bought a game that cost $1.75. The game that Don bought cost how much more than the game that Dick bought?

- ☐ $1.75 + ___ = $2.19
- ☐ $2.19 − $1.75 = ___
- ☐ ___ + $1.75 = $2.19
- ☐ $2.19 + $1.75 = ___
- ☐ Equation is not given.

F June made bunches of flowers to sell. She used 30 flowers in all. She put 6 flowers in each bunch. How many bunches of 6 flowers did she make?

- ☐ 30 + 6 = ___
- ☐ 6 + ___ = 30
- ☐ 30 − 6 = ___
- ☐ Equation is not given.

G Bill paid 35¢ for 5 candy bars of the same kind. How much did he pay for each candy bar?

- ☐ 35¢ − 5 = ___
- ☐ 35¢ × 5 = ___
- ☐ 35¢ ÷ ___ = 5
- ☐ 35¢ ÷ 5 = ___
- ☐ Equation is not given.

H Tom bought 4 packages of balloons. There were 9 balloons in each package. How many balloons in all did Tom buy?

- ☐ 4 + 9 = ___
- ☐ 4 × 9 = ___
- ☐ 9 ÷ 4 = ___
- ☐ Equation is not given.

I Jim bought a bag of 25 new marbles. He now has 84 marbles in all. How many marbles did Jim have before he bought the new ones?

- ☐ 25 + 84 = ___
- ☐ 84 − 25 = ___
- ☐ ___ + 25 = 84
- ☐ 25 + ___ = 84
- ☐ Equation is not given.

J Nancy has 23 shells. Jim has 19 shells. Nancy has how many more shells than Jim?

- ☐ 19 + ___ = 23
- ☐ ___ + 19 = 23
- ☐ 23 + 19 = ___
- ☐ 23 − 19 = ___
- ☐ Equation is not given.

K A book that Jim wants to buy costs $1.45. He has $.90. How much more money does he need to buy the book?

- ☐ $.90 + ___ = $1.45
- ☐ $1.45 + $.90 = ___
- ☐ $1.45 − $.90 = ___
- ☐ Equation is not given.

Go on to the next page.

L There were 8 cages of bears at the zoo. There were 4 bears in each cage. How many bears were there at the zoo?

- ☐ 8 ÷ ▒ = 4
- ☐ 8 + 4 = ▒
- ☐ 8 × 4 = ▒
- ☐ Equation is not given.

M Betty had some dolls. Then she got 3 dolls for her birthday. Now she has 15 dolls. How many dolls did Betty have before her birthday?

- ☐ ▒ + 3 = 15
- ☐ 15 ÷ 3 = ▒
- ☐ 15 + 3 = ▒
- ☐ Equation is not given.

N Mary has 35¢ to spend for pencils. Each pencil costs 5¢. How many pencils can Mary buy?

- ☐ 35¢ ÷ ▒ = 5¢
- ☐ 35¢ − 5¢ = ▒
- ☐ 35¢ ÷ 5¢ = ▒
- ☐ Equation is not given.

O 28 children want to go to the museum. There are 7 cars to take them. The same number of children will go in each car. How many children will be in each car?

- ☐ 28 ÷ ▒ = 7
- ☐ 28 − ▒ = 7
- ☐ 28 ÷ 7 = ▒
- ☐ Equation is not given.

☐ *Number correct Part 3*

Part 4 *Problem solving: solving equations*

Sample 8 + 16 = ▒

- ☐ 8
- ☐ 16
- ☐ 24
- ☐ None of these

A 20 − 5 = ▒

- ☐ 25
- ☐ 15
- ☐ 4
- ☐ None of these

B 8 × 4 = ▒

- ☐ 2
- ☐ 12
- ☐ 32
- ☐ None of these

C 32 + 8 = ▒

- ☐ 24
- ☐ 4
- ☐ 38
- ☐ None of these

D 8 × 2 = ▒

- ☐ 6
- ☐ 10
- ☐ 16
- ☐ None of these

E ▒ + 13 = 26

- ☐ 13
- ☐ 26
- ☐ 39
- ☐ None of these

F 18 ÷ 6 = ▒

- ☐ 12
- ☐ 6
- ☐ 24
- ☐ 3
- ☐ None of these

G 44 − 11 = ▒

- ☐ 35
- ☐ 33
- ☐ 55
- ☐ 4
- ☐ None of these

H 21 ÷ 7 = ▒

- ☐ 28
- ☐ 14
- ☐ 7
- ☐ None of these

I 5 + ▒ = 25

- ☐ 20
- ☐ 5
- ☐ 30
- ☐ None of these

J ▒ + 6 = 36

- ☐ 42
- ☐ 30
- ☐ 6
- ☐ None of these

K 16 ÷ ▒ = 2

- ☐ 8
- ☐ 32
- ☐ 14
- ☐ 4
- ☐ None of these

Go on to the next page.

L 36 − 9 = ___

- ☐ 4
- ☐ 45
- ☐ 25
- ☐ 27
- ☐ None of these

M 8 + ___ = 24

- ☐ 32
- ☐ 16
- ☐ 3
- ☐ None of these

N 32 ÷ ___ = 8

- ☐ 8
- ☐ 24
- ☐ 40
- ☐ 4
- ☐ None of these

O ___ + 6 = 18

- ☐ 12
- ☐ 3
- ☐ 24
- ☐ None of these

STOP

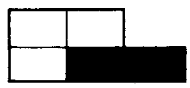
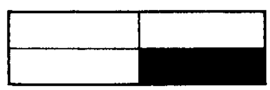
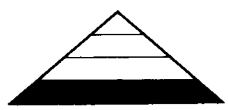
☐ *Number correct Part 4*

Part 5 *Information*

Sample Which is equal to 1 yard?

- ☐ 9 feet
- ☐ 30 inches
- ☐ 3 feet
- ☐ 12 inches
- ☐ None of these

A In which picture is one fourth black?

- ☐ 
- ☐ 
- ☐ 
- ☐ 
- ☐ None of these

B Which is the answer for 6 × 4?

- ☐ 10
- ☐ 2
- ☐ 24
- ☐ 23
- ☐ None of these

C Which number is the sum of 6 and 2?

- ☐ 4
- ☐ 8
- ☐ 3
- ☐ 12
- ☐ None of these

D Which is the answer for 3 × 9?

- ☐ 28
- ☐ 36
- ☐ 21
- ☐ 27
- ☐ None of these

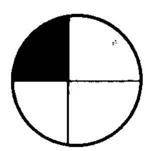
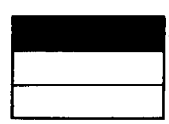
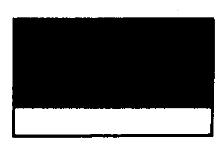
E Which is a correct way to write two dollars and six cents?

- ☐ $2.06
- ☐ $2.60
- ☐ $.26
- ☐ $2.6
- ☐ None of these

F Which is the answer for 7 times 4?

- ☐ 11
- ☐ 21
- ☐ 28
- ☐ None of these

G In which picture is one half black?

- ☐ 
- ☐ 
- ☐ 
- ☐ 
- ☐ None of these

Go on to the next page.

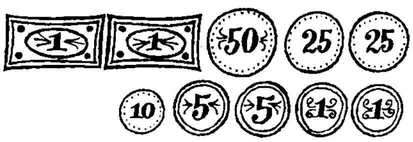
H Which is the answer for 35 ÷ 6?

- ☐ 6
- ☐ 4 and 1 remainder
- ☐ 7 and 2 remainder
- ☐ 5 and 5 remainder
- ☐ None of these

I Which is a correct way to write three thirty-five in the afternoon?

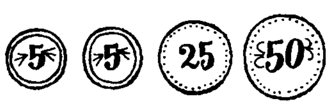
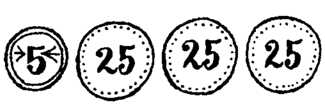
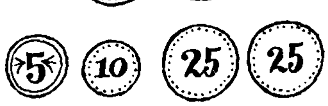
- ☐ 3:35 A. M.
- ☐ 335 P. M.
- ☐ 3:35 P. M.
- ☐ None of these

J How much money does the picture show?



- ☐ $2.97
- ☐ $3.17
- ☐ $32.20
- ☐ $3.22
- ☐ None of these

K Bill paid $1.15 for a book. He gave the clerk $2. Which picture shows the correct change?

- ☐ 
- ☐ 
- ☐ 
- ☐ None of these

L Which is equal to 1 gallon?

- ☐ 3 quarts
- ☐ 6 pints
- ☐ 2 quarts
- ☐ 8 pints
- ☐ None of these

M Nancy bought crayons that cost 37¢. She gave the clerk 50¢. Which group of coins shows the correct change?

- ☐ 
- ☐ 
- ☐ 
- ☐ None of these

N Which is equal to 6 pints?

- ☐ 3 gallons
- ☐ 2 quarts
- ☐ 3 quarts
- ☐ 12 quarts
- ☐ None of these

O Which is equal to 20 ounces?

- ☐ 1 pound 4 ounces
- ☐ 1 pound 8 ounces
- ☐ 1 pound
- ☐ 2 pounds
- ☐ None of these

☐ *Number correct Part 5*

Part 6 *Concepts*

Sample What number is missing below?

10 12 14 ▒ 18 20

- ☐ 13
- ☐ 16
- ☐ 15
- ☐ 17
- ☐ None of these

A Which circle is black?

- ☐ The fourth circle
- ☐ The third circle
- ☐ The fifth circle
- ☐ The second circle

B In which of the four numerals does 5 stand for the most things?

652 256 523 1925

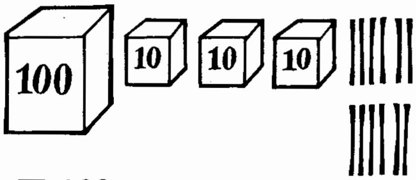
- ☐ In 652
- ☐ In 256
- ☐ In 523
- ☐ In 1925

C Jim is the nineteenth child to come into the schoolroom. Which numeral shows how many children in all came into the room before Jim?

- ☐ 19
- ☐ 18
- ☐ 10
- ☐ 8
- ☐ None of these

Go on to the next page.

D Which numeral shows how many sticks there are below?



- ☐ 132
- ☐ 1312
- ☐ 152
- ☐ 162
- ☐ None of these

E The same number is missing in 4 + ▒ and in each example below. Which example will have the same sum as 4 + ▒?

- ☐ 1 + ▒
- ☐ ▒ + 4
- ☐ ▒ + 3
- ☐ 2 + ▒
- ☐ None of these

F Imagine that you are to add a number that has two figures to another number that has two figures. Which says something true about the sum?

- ☐ It can be smaller than one of the numbers.
- ☐ It can be the same as one of the numbers.
- ☐ It will be larger than each of the numbers.
- ☐ None of these

G Which could you use to tell about the number 83?

- ☐ 8 tens 13 ones
- ☐ 7 tens 3 ones
- ☐ 7 tens 13 ones
- ☐ None of these

H The same number is missing in 4 × ▒ and in each example below. Which example will have the same answer as 4 × ▒?

- ☐ ▒ × 2
- ☐ 2 × ▒
- ☐ ▒ × 4
- ☐ None of these

I When zero is subtracted from a number, what is the answer?

- ☐ Zero
- ☐ A smaller number
- ☐ The same number
- ☐ A larger number
- ☐ None of these

J Which could you use to tell about the number 5048?

- ☐ 5 thousands 4 tens 8 ones
- ☐ 5 thousands 4 hundreds 8 ones
- ☐ 5 thousands 4 hundreds 8 tens
- ☐ None of these

K Imagine that you are to subtract a number that has two figures from another number that has two figures. Which says something true about the answer?

- ☐ It can be larger than each of the numbers.
- ☐ It will be smaller than one of the numbers.
- ☐ It will have only one figure.
- ☐ None of these

L The lists below show ways of writing 1011, 1001, 1010, and 1100. Which way shows them in order of size, with the smallest first?

- ☐ 1001, 1011, 1010, 1100
- ☐ 1001, 1010, 1100, 1011
- ☐ 1001, 1100, 1010, 1011
- ☐ 1001, 1010, 1011, 1100

M When zero is added to a number, what is the sum?

- ☐ A smaller number
- ☐ A larger number
- ☐ Zero
- ☐ The same number
- ☐ None of these

N Which could you use to tell about the number 704?

- ☐ 70 hundreds 4 ones
- ☐ 7 tens 4 ones
- ☐ 6 hundreds 9 tens 14 ones
- ☐ 7 hundreds 4 tens

O Mary bought 1 dozen cookies. Ann bought 1 pound of cookies. Which girl bought the larger number of cookies?

- ☐ You cannot tell.
- ☐ Ann
- ☐ Each girl bought the same number.
- ☐ Mary

☐ *Number correct Part 6*