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Multi-Sensory Materials in the Teaching of Third and Fourth Grade Arithmetic

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MULTI-SENSORY MATERIALS IN THE TEACHING OF THIRD AND FOURTH GRADE ARITHMETIC

by

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This research paper is dedicated to the memory of Dr. Reginald Shaw, whose inspiration made the study possible.

CHAPTER I

INTRODUCTION

The purposes of this research were to broaden the scope of the writer's knowledge in (1) the use of multi-sensory materials in teaching, (2) the philosophy of visual education, and (3) the newest theories of teaching arithmetic in the intermediate grades.

Today, in the instruction of arithmetic, meanings have become increasingly important in the thinking of many teachers. Unless meanings, the outcomes in arithmetical instruction, are comprehended the outcomes are never reached. Teachers must know what their purposes of instruction are and unless they understand the nature of the child to whom the subject is taught, teaching can never be effective.[1]

Learning is defined as a process of adaptation. Through the process of learning, men acquire new ways of behaving or performing in order that they can make better adjustment to the demands of life.[2]

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[1] Stokes, C. Newton, Teaching the Meanings of Arithmetic, New York: Appleton-Century-Crofts, Inc., 1951, 3-4.

[2] National Society for the Study of Education, Learning and Instruction, Forty-ninth yearbook, Part I, Chicago: National Society for the Study of Education, 1950, 8.

In the past, it was assumed that learning was synonymous with memorizing. It was thought that instruction was a matter of defining the content to be learned, followed by a checking-up to see that the "lesson" had been learned. This resulted in assign-study-recite procedures or the familiar assignment-recitation type of instruction. In the old traditional type of school factual information became the learning product.[1]

Today, teachers are concerned with improving the quality of instruction so that children will develop skills, attitudes, and appreciations that will enable them to become well-adjusted citizens of the community.

A successful teacher must understand how a child learns and must realize that learning proceeds from the concrete to the abstract. A very small child has to experience direct contact with concrete objects by seeing, handling, or manipulating them. After having had many, rich, personal experiences, the pupil can build concepts about his environment. It is the teacher's role to supply the concrete school experiences which will enable the child to make comparisons and generalizations that will build concepts.

> The process of building concepts operates quite naturally from the time a child begins to draw

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[1] Ibid., 16, 25.

> certain conclusions from experience and applies these conclusions to a new situation. It continues, thereafter, as he makes new generalizations from new experiences and from experiences in which new and old are combined. The overall activity of building concepts, therefore, is a realistic definition of education because classifying of experiences proceed in school and out of school. Whenever the child learns something new and is able to use this new something, he is building or refining a concept.[1]

All of us do our best learning and remember longest when motivation is strong, when learning purpose is clear, and when the use of the learning is thoughtful and meaningful.[2] Facts are more likely to be forgotten, while principles are better retained. When material is seen in all its interrelatedness with other material and when it is learned and used as a part of an organized body of material, it is best remembered.[3]

A child must have a reason for learning and it must be significant to him. If a particular activity or experience seems unimportant to the child it cannot greatly benefit him. For without thought will come no generalization of the

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[1] Dale, Edgar, Audio-Visual Methods in Teaching, New York: The Dryden Press, 1946, 26.

[2] Ibid., 24.

[3] National Society for the Study of Education, Learning and Instruction, Forty-ninth yearbook, Part I, Chicago: National Society for the Study of Education, 1950, 33.

idea in relation to his past experiences and no concept will have been gained. The child must have a "Why" for learning and the value of the experience to his daily living has to be made clear to him in his own thinking. Teachers may explain why a particular activity will be of great value to the child, but the teacher cannot build the child's concepts for him. The motivation must come from within the child himself in order to be truly beneficial. Learning is real when it becomes a part of our daily life.

A child must understand the goals or outcomes to be achieved. The teacher, with the cooperation of the pupils, must set up these goals and be certain that they are understood by the child before any activity is begun. The teacher can capitalize on sub-goals along the way so that all pupils may achieve a measure of success. Goals, attainable by only a few, should be avoided.

Goal-setting is something a child should learn. If taught in childhood to plan in small things, the child will be better able to plan as an adult. The teacher should give the pupils many opportunities to practice setting up goals in approved ways and achieving them by socially approved techniques.

Children forget when what they are asked to learn does not seem important to them, when they do not see clearly what it is that they are supposed to be learning, and when

they do not make use of what they have been asked to learn in daily living.[1] Thus a newly learned skill should be practiced and applied in meeting new situations if it is to be significant. New and important insights are gained when learning comes from rich sense-experiences which have a quality of newness, freshness, creativeness, adventure, and emotion about them.[2]

Instruction in the past has tended to become formal, verbalistic, and irresponsive to the needs of life.[3] Verbalism results when there is no association between verbal subjects and life outside the school. Words have no meaning to a pupil unless they have some direct bearing on his own personal experience or environment. It is the result of teaching in which no real understanding or concept is built up. It can be avoided by the use of direct concrete experiences and the use of multi-sensory materials in instruction.

The term multi-sensory materials, refers to visual, auditory, and manipulatory materials that can be used to en-

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1 Dale, Edgar, Audio-Visual Methods In Teaching, New York: The Dryden Press, 1946, 12.

2 Ibid., 23.

3 Horn, Ernest, Methods of Instruction in the Social Studies, New York: Charles Scribner's Sons, 1937, 413.

rich learning experiences. They appeal to the child's sense of feeling, hearing, and seeing. For example, tape recordings and records appeal to the auditory sense; motion pictures, filmstrips, and slides to the visual; and the abacus, number frame, and counting disks to the sense of touch. Manipulatory materials are valuable in teaching arithmetic because they can be moved, arranged, and rearranged. Some materials, of course, may be classified under more than one grouping since the appeal to a combination of senses. Movies and sound filmstrips appeal, both, to the auditory and visual.

The primary purpose of multi-sensory materials to instruction is to assist the pupil in making clear, accurate, and meaningful concepts.[1] Although these materials are all slightly different and varying techniques are required in their use, they should all meet the above requirement. Techniques used in building meanings with movies would have to be slightly different from the techniques used in building meaning through the use of flat pictures, a model, or a tape recording.

For successful use, the materials must be available when required, be of high quality and contribute directly to the course of study.[2] They must not become an end in themselves

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[1] Horn, Ernest, Methods of Instruction in the Social Studies, New York: Charles Scribner's Sons, 1937, 382.

[2] Ibid., 383.

but must serve a purpose or not be used at all. Some teachers miss the true purpose of multi-sensory materials when they use them indiscriminately. Children may see a movie, not because it will help in building an understanding of the course of study at the time, but because the movie happens to be available in the building on that particular day. Films may be ordered and used without their integration in the course of study; when this happens they are merely used as a means of entertainment.

Multi-sensory materials are valuable in introducing a new unit of study by arousing interest in the subject and stimulating thinking and research on the part of the pupil. They help to supplement the varying backgrounds of the children in the classroom and bring them together on a more equal footing. They direct the pupil's attention to the more important phases of the question and emphasize what is to be learned. They provide the authenticity that is lost in the study of the text or in the listening to lectures.

The teacher may use multi-sensory materials as a culmination to check on the exactness of the concepts to be learned. This, then, can provide a basis for further reteaching or reclarifying of the understandings to be obtained.

Multi-sensory materials cannot take the place of the

teacher in the classroom. They help to clarify or enrich the child's understanding but should never be used in themselves to do the teaching and building of concepts that is necessary in real learning. They may be used to compensate for lack of knowledge or teaching skill on the part of a poorly trained teacher, but their full benefit is obtained only in the hands of competent teachers. Their selection and introduction, the preparation of the pupils for the work at hand, the discussion and guidance of culminating activities that follows takes a great deal of teaching skill.[1] A wise teacher knows that multi-sensory materials will enrich and clarify understandings but she is responsible for building concepts. They are used as a means to better teaching.

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[1] Horn, Ernest, op. cit., 386.

CHAPTER II

THE MODERN PHILOSOPHY OF TEACHING ARITHMETIC

The older conception of teaching and of learning as a sort of filling-station process with knowledge passing from a larger to a smaller tank has been replaced by ideas emphasizing the dynamics of interpersonal and group action during learning.[1] Schools are now attempting to stimulate learning through meaningful, problem-solving activities because such activities are valuable in the daily living of both children and adults.

Today, in the instruction of arithmetic, meanings have become increasingly important in the thinking of many teachers.[2] Unless meanings are stressed in the first and second grades, the child becomes lost in his number work in the intermediate grades. The pupil verbalizes or memorizes the work at hand, but cannot apply or use number in daily living. The child is merely parroting the answers required by the teacher and they have no meaning for him. Without many rich

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[1] National Society for the Study of Education, Learning and Instruction, Forty-ninth yearbook, Part I, Chicago: National Society for the Study of Education, 1950, 65.

[2] Stokes, C. Newton, Teaching the Meanings of Arithmetic, New York: Appleton-Century-Crofts, Inc., 1951, 3.

experiences in counting, manipulating materials, and working with number, the child cannot build concepts that will help him in his later work.

No one ever faces a situation which is completely identical with any previous one. But learning becomes significant only when it is generalized. Whether our learning products are knowledge, skills, social attitude, appreciations, or techniques of solving problems we want them generalized so that they have utility in as many as possible of the unpredictable exigencies of life.[1]

Meanings can be taught by providing rich experiences related to the local environment through the media of excursions, field trips, pictures, exhibits, charts, slides, demonstrations, and participation in community enterprises.

The aim of the school should be to provide activities in which the child will get a clear understanding of the number system, develop skill in computation, and be able to apply his knowledge to his daily living. The activities should be varied and life-like so that concepts built up in school about number can be directly applied to problems in number outside of school.

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[1] National Society for the Study of Education, Learning and Instruction, Forty-ninth yearbook, Part I, Chicago: National Society for the Study of Education, 1950, 20.

> Resourceful teachers and other students of curriculum . . .hold that it should always be possible to organize a program for learning which will not do violence to the innate structure of arithmetic, and at the same time harmonize with social situations and take full account of the ways in which children can best learn.[1]

In order to plan and organize her work, the teacher must know the child--his nature intellectually, socially, emotionally, and his level of maturation.[2] The teacher must know where the children are and make that the starting point in any instruction so that there will be normal and systematic growth on the part of all the students.

Good teachers, for years, have been putting meaning into number. But there are still teachers who do not understand how a child learns and how number meanings should be properly taught. As discussed in the previous chapter, in any learning situation, the child must understand the "Why", the "What", and the "How". There must be the proper motivation to learning, an understanding of what is to be achieved, and opportunities for applying the learning to daily living.

Goals should be set up under the guidance of the teach-

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[1] Conference on Arithmetic, Arithmetic 1949, Supplementary Educational Monography, Published in Conjunction with School Review and the Elementary School Journal, No. 70, Chicago: The University of Chicago Press, 1949, 1.

[2] Stokes, C. Newton, Teaching the Meanings of Arithmetic, New York: Appleton-Century-Crofts, Inc., 1951, 183.

er. The pupils should be aware of the possibility of success in achievement, the possibility of failure, the obligations of completion of the activity, and the values of accomplishing it. The activity in order to be meaningful, must be a part of their activities in school or be related to life in the community. The pupils must see a need for accomplishment. Then, lastly, they must be given many opportunities to use the newly learned skill. Without use, there is no real meaning to activity.

There must be a variety of interesting activities in the arithmetic program so that the varying backgrounds of all the children are equalized as much as possible. The teacher must take into consideration the abilities and maturity of the pupils so that success is assured. A feeling of success and accomplishment will assure continued interest in the work at hand and motivation for future activities.

Reading and talking about number, alone, will not develop meaningful concepts. Verbalism will probably be the result. Words have meaning to the child if they are related to his experience. If not, the teacher must provide for individual differences and build up a readiness for new understandings. Her instruction must be adjusted to the pupil's development. Interest, enthusiasm, and purpose sometimes indicate total readiness or ability for learning but at other times readiness comes from the enthusiasm of others

or from the desire to do what others enjoy.

Instead of plunging a class, with no preparation or preliminary exploration, into the study of a new topic, the teacher must build up a readiness for number through contact with concrete number ideas, uses, and processes. Later it can be dealt with systematically and abstractly.[1] The teacher should determine whether or not the pupils have developed the skills and understandings necessary for the basic concepts of the new project. One good test for determining readiness is to have the pupil set up procedures for solving the new problems. If he cannot do this easily and successfully, he needs more work and study on the previous unit and is not ready for the more advanced work.

During the unit of study, the teacher should be sure that the child understands her procedures of solving a problem. But, even more so, should she be sure that the child can discover them for himself and arrive at the correct solution to the problem. Real meanings will evolve out of a period of discovery and exploration.

The competent teacher helps the child invent ways of using what he has already learned in solving new problems. Instead of merely telling the child what the steps in a new

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[1] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 106.

process are going to be; she helps the child discover them for himself in such a way that success is assured. If there might be a chance of failure, she points these out. With practice, the child builds up in his own mind a system for attacking new problems.

Brueckner and Grossnickle list three steps essential to the teaching of a particular unit of work:[1]

1. A readiness program intended to develop the basic concepts and abilities underlying the new work.

2. The administration of a readiness test to discover deficiencies likely to interfere with success in learning the new work.

3. A well-graded sequence of lessons consisting of a step by step development of the process beginning with the simplest types of examples and extending to the more complex type.

In order to establish learning, practice is essential. It must not be confused with mere drill which is the repeating, again and again, of only one particular task. Stokes says:[2]

> Drill, as usually construed, does not guarantee immediate recall in terms of understanding. It

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[1] Brueckner, Leo J., and Grossnickle, Foster, E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 117.

[2] Stokes, C. Newton, Teaching the Meanings of Arithmetic, New York: Appleton-Century-Crofts, Inc., 1951, 183.

> initiates repetition for the purpose of completing and fixing the learning for future use. This encourages immature procedures of mechanical performance which may really impede progress and growth. We have expressed the idea that drill, as such, makes little if any contribution to growth in quantitative thinking. If this is not the case . . .why the preponderance of evidence in the nature of incomplete learning . . .?

Practice alone does not produce learning, but we do not learn without practice. Teachers should manage the amount, kind, and distribution of practice so that it becomes meaningful. There is a place for drill in arithmetic, but it should follow and not precede the development of understandings. In meaningful practice a child uses a number process in a variety of situations and in different contexts. The pupil becomes successful in achieving his purposes. If systematically organized materials are used the pupil will develop speed, ease, control, and precision of work.[1] Efficiency is a matter of reducing the time and energy necessary to be expended in order to bring forth the appropriate response when we face a situation.[2]

Practice should be meaningful to the learner, related

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[1] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 117.

[2] National Society for the Study of Education, Learning and Instruction, Forty-ninth yearbook, Part I, Chicago: National Society for the Study of Education, 1950, 19.

to other processes learned, and lead to new discoveries of relationships. This practice should help the pupil see the progress he is making and help locate difficulties and weak spots. If it is well organized and well written the pupil can proceed at his own rate of speed. When the particular process is learned, the child should spend extra time on other valuable activities that will help him in making concepts for use in the social side of arithmetic. The child can then further develop his interests, attitudes, appreciations, understandings, purposes, and social insight. Growth will also come in his ability to cooperate and assume responsibilities in leadership.[1]

Twelve principles of learning in arithmetic set up by Brueckner and Grossnickle are:[2]

1. There should be readiness for learning. Readiness includes not only a favorable attitude toward the activity to be pursued but also the capacity, maturity, and previous experience necessary to successful performance.

2. Learning should be goal centered. The learning activity should be purposeful. The more remote goals as well as the immediate task at hand should be clearly understood. The motivation should be adequate to maintain activity. The means-end relationships should be

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[1] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 117.

[2] Ibid., 114-5.

clear. The contribution of interest is fundamental.

3. Learning is reacting; there can be no learning without purpose and activity. There are many simultaneous learnings in any learning experience. Education is a growth process involving experiences adapted to the age, needs, health, interests, and ability of each individual.

4. There should be intent to learn. The learner is more likely to recall aspects of objects, activities, and situations to which he has attended directly and actively, and about which he has made discoveries.

5. The learning experience should be meaningful and significant. To be meaningful the essential relationships involved must be understood. The organization of pupil experience and the use of what is learned in social activity facilitates retention.

6. During the learning process responses are modified by their after effects. Responses are selected and eliminated, organized and stablized, in terms of their relevance to the learner's goals. Insight leads to satisfaction.

7. Spaced or distributed learning is superior to massed or concentrated learning. Frequent and strategically placed reviews aid recall and retention.

8. The wholeness of learning should be emphasized. Effective learning does not arise from the memorization of isolated facts or the mastery of parts divorced from wholes, but from the understanding of essential part-whole relationships and their organization. The ability to detect differences as well as likenesses is the important aspect of effective learning.

9. Knowledge of progress is essential to effective learning. Since a fundamental condition

of learning is intelligent trial and correction, knowledge of progress in learning becomes an essential condition of learning.

10. Transfer of learning between situations is roughly proportional to the degree to which the situations are similar in structure or meaning. Learning is facilitated by increasing the number of connections where each new association adds new meaning to the material.

11. Learning is essentially complete when the learner has grasped the essential relationships in the situation involved. Subsequent practice ordinarily will insure greater precision of response and a higher level of performance.

12. Overlearning strengthens retention. Overlearning should not be carried beyond reasonable limits with standards adjusted to the level of maturity of the learner.

If the foregoing twelve learning principles are to be achieved by the pupils then the teacher's main objectives should consist of the following:[1]

1. to develop in the learner the ability to perform the various number operations skillfully and with understanding, and

2. to provide a rich variety of experiences which will assure the ability of the pupil to apply quantitative procedures effectively in social situations in life outside the school.

It has become apparent that teachers in the past have put too much emphasis on the computational skills of arith-

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[1] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 1.

metic and have ignored the social phase.

> The numerous discussions and excerpts of meaningful learning in arithmetic which have been published, show clearly that this kind of teaching and learning takes considerable time. It is rather generally agreed that this time should be found by reducing the amount now devoted to practice or drill. The question arises: Just how much time can or should be taken from drill and used for developing understandings? Should the proportion be interchanged, so that 50% is given to developing concepts and understandings, only 20% be given to developing conclusions and understandings, and only 20% to practice or drill? Unfortunately, no one as yet knows the optimum distribution of class time under a modern program of meaningful learning. All we know is that a redistribution of time is desirable.[1]

Thus it is desirable in modern courses of study, to give both phases due consideration so that neither phase is emphasized unduly or not given the proper weight. Children certainly need to understand number and computational processes but they also need to have the opportunity to apply these to social situations that arise both in life at school and outside the school. There should be in the arithmetic curriculum, a basic core of subject matter plus a variety of rich learning experiences that the child can relate to his own social situations. The pupil should be able to make use of his knowledge and skills.

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[1] Conference on Arithmetic, Arithmetic 1949, Supplementary Education Monograph, Published in Conjunction with School Review and the Elementary School Journal, No. 70, Chicago: The University of Chicago Press, 1949, 1.

Units of instruction can be grouped under subject matter units or experience units. The well-planned curriculum should contain both types of units. In the first type--subject matter units--the activities of the pupil's are directed by the teacher and stress is on subject matter or skills. Experience units make use of the interests of the pupil. The activity evolves from the experiences of the children by themselves or attention is called to some need by the teacher. In this type of unit, the children plan the unit of study, set up goals, plan for achieving them, and evaluate the results. This type of unit provides a richer understanding of number, builds interests, attitudes, and appreciations. The children learn to cooperate in social situations.

Sometimes during an experience unit, time must be set aside to learn a new arithmetic process. There is a sequential nature to mathematics which must be observed. Certain topics must precede others, or the efforts of the child are impeded or doomed to failure. The teacher can revert back to the experience activity when the needed skill is mastered. At other times, a variety of activities should be provided to test the pupil's skill in relating processes already learned to new situations.

In a well-planned unit of study, with a varying number of activities, children obtain general information, make

comparisons and similarities, use number in counting, writing, reading, and in building relationships to previous work. If the unit contains both mathematical and social phases of arithmetic, it can give the pupils valuable information and experiences dealing not only with arithmetic, but with reading, language, art, and social studies.

In working out the social phases of a unit, the children need to know how to define the problem they are about to study, how to set up possible methods of solving the problem, make a choice of the best means of solution, and arrive at the correct conclusions, and prove these conclusions. The students must learn how to work with others in group activities. Their arithmetical vocabulary and knowledge of arithmetic processes must be used in such a way that they become meaningful to others as well as to themselves. Children also need to learn how to locate and organize information that is needed for the solution of their problems.

Brueckner and Grossnickle, in their study of modern courses of study in arithmetic have set up the following outcomes for the mathematical and social phases of arithmetic as follows:[1]

1. Mathematical Phase

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[1] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 2-3.

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 use and to devise formulas, rules of procedure, and methods of bringing out relations
g. Ability to represent designs and special relations to drawings
h. Ability to arrange numerical data systematically and to interpret information presented in graphic or tabular form

2. Social Phase

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 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.

Studies of child development revealed the limitations of traditional instructional procedures. Curriculum makers have eliminated much of the deadwood material that existed and have fashioned the modern curriculum around subject matter that functions in the lives of most people. New processes and procedures are being added as times change. In the past many topics were taught long before the pupils had the mental maturity to master them without strain and tension. The tendency today is to arrange the topics to be taught according to their relative difficulty rather than according to their logical sequence in relation to the whole arithmetic program. Curriculum makers have also tried to provide for individual differences. With improvements in teaching methods and instructional materials has come a need for revision of the curriculum. Since only essential skills are stressed, there is much more time provided for projects and activities that help the child apply number to his daily living. In the new courses of study can be found many experience units. Skills, attitudes, purposes, interests, appreciations, and understandings are thought to be very important outcomes of the modern arithmetic program. In the past, mental discipline, was thought to be an important aim of the arithmetic program. Today, curriculum makers feel that much more can be gained by engaging in activities that are socially significant.

The Use of Multi-Sensory Materials in Relation to Arithmetic

The teacher's problem is how to convey to students certain ideas, basic knowledge, and information in the shortest possible time and in accordance with the principles of learning. To accomplish this objective and to aid the learner in retaining the knowledge, teaching aids are practically indispensable. They will not replace the teacher, but they will make the teaching job easier and result in greater learning.[1]

> Very few, if any, of the commonly used teaching materials are instructional in themselves. If used with groups which have not received earlier preparation and guidance by the teacher most of the potential educative power will be lost. On the other hand, these same materials, properly used by trained teachers, make it possible to teach the student more in a given time, and teach more thoroughly, so he will remember the useful information much longer. The advantage gained by this procedure, easily measured, has been found to range from a small percentage to 40% or more, depending largely upon the favorable and unfavorable factors involved. The percentage gain, in carefully controlled classroom situations, has been great enough and consistent enough to cause all modern educators to look with favor upon the proper use of audio-visual materials in the instructional program.[2]

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[1] Weaver, G. G., and Bollinger, E. W., Visual Aids, New York: D. Van Nostrand Co., Inc., 1949, 2.

[2] Dent, Ellsworth C., The Audio-Visual Handbook, Chicago: Society for Visual Education, Inc., 1949, 4.

Recently a third aspect has been added to experience arithmetic. The social and the mathematical were discussed in the previous chapter and the first part of this chapter. The sensory-aids aspect has been added and Stokes[1] lists all three as follows:

a. The social aspect.
b. The sensory-aids aspect.
c. The mathematical aspect.

Multi-sensory aids help teachers by making class work more meaningful, interesting, enjoyable, and bridge the gap between the concrete and the abstract. Stokes[2] says that teachers in the elementary school should help pupils bridge this gap by using multi-sensory aids in the following sequence:

a. Animate things;
b. Concrete things (inanimate);
c. Semi-concrete things (pictures, sketches, drawings);
d. Abstractions.

Since different materials are needed at various stages of learning, it is important that the teacher know her students well enough to determine what kind will be most valuable to him at the beginning of a unit of study. Some students may need to begin every unit with the study of concrete

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[1] Stokes, C. Newton, Teaching the Meanings of Arithmetic, New York: Appleton-Century-Crofts, Inc., 1951, 62.

[2] Ibid., 31.

things, while others may be able to begin with semi-concrete things or even abstractions. It is the function of good instruction in arithmetic to have a pupil operate at the highest level of difficulty at which the work is meaningful to him. It is obvious that there are pupils who develop sufficient insight into the meaning of number that the use of visual and manipulatory material is not needed to introduce a new process.[1]

The teacher needs reliable readiness tests which will help her determine a pupil's understanding of number so that it will be known at what level the pupil should begin a new topic or process. If the teacher has no tests available, the best procedure is to start all the pupils with manipulatory materials at the beginning of a new topic. However, if she sees that these are no longer necessary, she should encourage the pupil to work with symbolic materials instead. If the child can give a meaningful verbal statement of the solution of the problem he is ready to work with the abstraction.[2] Some pupils, due to individual differences, will need to use manipulatory materials much longer than others.

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[1] National Society for the Study of Education, The Teaching of Arithmetic, Fiftieth yearbook, Part II, Chicago: National Society for the Study of Education, 1951, 172.

[2] Ibid., 172.

> The use of multi-sensory aids in the teaching of pupils with average intelligence or lower is unquestionably necessary. These pupils must learn facts, see these facts applied in practical situations, and then make corresponding applications in similar situations. This does not mean that pupils of superior ability do not need to use sensory aids. It does mean, however, that their use of sensory aids will be made in a different manner and for different purposes from those in the case of lower ability pupils.[1]

Teachers have been using multi-sensory materials in arithmetic for years but not much has been written about the subject until recent years. With revision in the arithmetic curriculum, they have become increasingly more important. In the past teachers had to devise many of the aids that were to be used. Even today, with the wealth of material offered in films, filmstrips, and manufactured manipulatory materials, teachers should use materials they themselves have devised.

We need multi-sensory aids. They can give a more lasting and vivid impression than mere words, printed or spoken. With their use, we can better develop understandings that would be impossible. A film on seed dispersal is very effective because it can show the movement that is hard to describe in words. Very small children touch everything they see. As children grow older they still want to learn ac-

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[1] Fehr, Howard F., "The Place of Multi-Sensory Aids in the Teacher Training Program" Mathematics Teacher Vol. 40 No. 5 212-3 (1947).

tively instead of passively.[1] Even in high school, students like to take things apart "to see what makes them tick."

> Put something concrete into the hands of a child, something that will enable him to enter actively into the learning situation and, auditory, visual, oral, tactual, and muscular sensations unite in a drive that has real power in forming new thought patterns.[2]

Since there are many different kinds of multi-sensory materials that can be used in the teaching of arithmetic, the teacher must know what the functions of each kind should be and use them accordingly. She must be able to set up an effective arithmetic program before she can use multi-sensory materials to the greatest advantage.

> The extent to which these valuable training materials are used and the degree of effectiveness with which they may be employed in any teaching situation will depend almost entirely upon the amount and quality of training the teacher has received. The greatest factor retarding the more extensive and more intelligent use of visual-sensory materials is the inadequate training of teachers to make proper use of the materials available.[3]

Dale[4] offers seven standards for evaluating audio-

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1 The National Council of Teachers of Mathematics, Multi-Sensory Aids in the Teaching of Mathematics, Eighteenth yearbook, New York: Bureau of Publications, Teachers College, Columbia University, 1945, 4.

2 Ibid., 4.

3 Dent, Ellsworth C., The Audio-Visual Handbook, Chicago: Society for Visual Education, Inc., 1949, 22.

4 Dale, Edgar, Audio-Visual Methods in Teaching, New York: The Dryden Press, 1946, 500-505.

visual teaching materials with a view to promoting good teaching:

1. Do teaching materials make those who use them more critical-minded?
2. Audio-visual materials should give us a true picture of the ideas which they present.
3. Does the material contribute meaningful content in the topic under study?
4. Is the material appropriate for the age, intelligence, and experience of the learners?
5. Is the material used worth the time, expense, and effort involved?
6. Is the physical quality of the audio-visual materials satisfactory?
7. Is there a Teacher's Guide available to provide help in effective use of audio-visual materials?

In constructing and designing visual aids, the teacher might use the criteria set up by Weaver and Bollinger:[1]

1. The aid should explain an abstract idea, show a relationship, or present a sequence of procedure that cannot be clarified without it.
2. It should be large enough to be clearly visible to everybody in the group. An aid is not an aid if part of the class cannot see it.
3. The lettering should be large and bold to avoid eyestrain from any point in the classroom. Avoid decoration and prevent distraction.
4. The amount of lettering should be limited to terminology within the comprehension of the learner.
5. The important parts should be accentuated by by the use of spots of bright color. This emphasis on the essential parts will enhance

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[1] Weaver, G. G., and Bollinger, E. W., Visual Aids, New York: D. Van Nostrand Co., Inc., 1949, 88-90.

the value of the aid.

6. It should be made to scale, whether reduced or enlarged. The various parts should be in proper proportion; otherwise the learner may be confused.
7. It should be constructed of good materials if it is to stand constant usage in the classroom.
8. It should show evidence of good workmanship and be carefully finished in good taste.
9. It should be mounted in such a way as to make it portable, which will permit its use in more than one location.
10. Charts, drawings, and photographs should be properly protected with paint, shellac, glass, cellophane, or other protective materials.

The classroom should be a laboratory where a pupil is able to discover principles or facts just as he does in a science laboratory.[1] But this does not mean that all of the work is laboratory work. After discovering one or more facts about a process, the child must use and apply it. Then the laboratory becomes a workshop where the pupil practices with materials until he masters the process. The classroom becomes a place where discoveries about arithmetic are made and not a place where the teacher tells the pupil what to do or to learn. The pupil learns by doing in a laboratory type of classroom.

However the laboratory period should not become an activity period, just for the sake of having an activity.

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[1] Grossnickle, Foster E., and Metzner, William, The Use of Visual Aids in the Teaching of Arithmetic, Brooklyn: Rambler Press, 1950, 5-6.

The teacher should guide, question and stimulate the pupil to make discoveries of principles by the effective use of multi-sensory materials.[1]

If the classroom is to become a laboratory, it must contain many books, learning aids, magazines and other reference materials. There has to be adequate blackboard space provided. As materials are brought in and accumulated, there is a need to add bulletin boards, bookcases, exhibit shelves, and filing cabinets. Many science rooms are beautifully equipped but rooms for teaching arithmetic are provided with just the bare essentials. In the past, it was thought that all the arithmetic teacher needed was just a piece of chalk and a text book. All the pupil needed for learning arithmetic was a piece of paper and a pencil. He was expected to work a large number of examples but was given no real insight into the meaning of number.[2]

Grossnickle and Metzner[3] point out four steps that teachers of arithmetic should follow if learning is to be the most effective. These steps are:

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[1] National Society for the Study of Education, Arithmetic in the Elementary School Curriculum, Fiftieth yearbook, Part II, Chicago: University of Chicago Press, 1951.

[2] Grossnickle, F. E., "Laboratory for Meaningful Arithmetic," Mathematics Teacher Vol. 41:116-9 (March, 1948).

[3] Grossnickle, Foster E., and Metzner, William, op. cit., 7.

1. Readiness for learning
2. Laboratory period of discovery
   a. exploratory
   b. developmental
      (1) class demonstration
      (2) pupil discovery for himself
3. Symbolic representation of a process
4. Performance at an adult level

If beginning work in number is interesting and meaningful the teacher does not have to rely on drill. The successful teacher makes use of the many varied interests of the children to build readiness. Here different kinds of multisensory materials such as posters, pictures, charts, or exhibits can help the teacher build up curiosity and interest in a new unit of study.

During the period of discovery, the pupils may work alone or in a group. In individual discovery, the pupil works individually and under teacher guidance attempts to find the answer to the problem. When discoveries have been made they should be placed on the blackboard and discussed by the child. In this way his generalization is verbalized. During group discovery all may work together in one group or be members of several small groups. Teachers should be careful to see that the pupils are really "discovering" and not imitating what some one else has done.[1]

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[1] National Society for the Study of Education, Arithmetic in the Elementary School Curriculum, Fiftieth yearbook, Part II, Chicago: National Society for the Study of Education, 1951, 158.

During the period of discovery each child should try to see a solution to the problem. He should try to create a novel way for solving a problem. In doing this, he will discover relationships among numbers. If a child has little understanding of number he cannot devise very many ways of finding a solution to the problem and is limited by his experience. The teacher should point out the conventional method for performing the process, too; but should be sure that the pupils understand each step in the sequence. The child should not be allowed to imitate the process if he has not first discovered the meaning.[1]

A class demonstration gives the pattern of activity to follow so that the pupil may discover for himself a particular fact or principle.[2] A film will present the topic effectively and serve as a guide to the teacher and the pupil. It can suggest the kinds of activities to use to present a new process.

It is very important that the pupil have at his disposal adequate manipulatory materials during the period of discovery. Demonstrations can be made by the teacher in the

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[1] Grossnickle, Foster E., and Metzner, William, The Use of Visual Aids in the Teaching of Arithmetic, Brooklyn: Rambler Press, 1950, 10-12.

[2] Ibid., 13.

front of the room on a large table, felt board, or blackboard but learning will become more effective if each child has his own materials. If the children make the material that they are going to use in the laboratory period it will be of more value than if it is something manufactured by someone else. During free periods during the day, the child can also work with the material if he has his own. In sharing materials it is not always possible for everyone to work individually as time is limited. Discoveries made by the child with his own materials are more meaningful to him than observation of someone else's discoveries.

After the discovery stage the pupil progresses to the symbolic stage of learning. First the child should make a verbal statement of what he has discovered and explain the steps necessary to the solution of the problem. If this has been done correctly, the numerical symbols for the process may be set down on paper. If the child is unable to do this, the teacher must give him additional guidance in the initial steps in learning.

The final step to learning, is to use the symbolic material found in workbooks and textbooks. As the child studies the steps in the solution to the problem, it will have meaning for him. If the teacher has not made use of concrete materials and a period of discovery, the child merely memorizes the printed material in the text, does not understand

its meaning, and cannot apply it to the work at hand.

Textbooks and workbooks are multi-sensory materials but they are more highly abstract than other materials that have been discussed. They do present a systematic presentation of number and are valuable for this reason. Also they are tools of learning on the adult level. Here the teacher can supply a variety of well-written, graded practice material that will help the child master the skill that is to be learned.[1] Some children may not be able to progress to the adult level of operation, but the teacher should take them as far as their ability permits.

All arithmetic teachers should have laboratory equipment. If there is none, the teacher should begin to collect some of the necessary materials. Many things can be made by the teacher such as charts, graphs, and posters. Pictures may be collected that will illustrate words necessary to a mathematical vocabulary and pictures that will illustrate words necessary to a mathematical vocabulary and pictures that will illustrate some process. Manipulatory materials can be collected by the teacher or by the pupils

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[1] National Society for the Study of Education, Arithmetic in the Elementary School Curriculum, Fiftieth yearbook, Part II, Chicago: National Society for the Study of Education, 1951, 160.

who will enjoy locating and bringing them to school. As stated before, the pupils will enjoy making some of their own equipment such as counters, fraction boards, and notebooks. Some items can be bought at the dime store and are relatively inexpensive. Others made especially for school use can be purchased through the school from the manufacturer. Teachers need to make a collection of measures, such as measuring cups, pint, quart, and gallon containers, egg cartons, measuring spoons, foot rulers, and yard sticks. Many teachers neglect to use these aids because storage space is limited. The improved quality of learning on the part of the pupil makes the time and effort of setting up laboratory equipment worth while.

The laboratory equipment should be on tables around the room or on shelves where the children can have access to them during the learning period. The children should be free to leave their seats and check their answers by means of the aids. In no case should they be stored away in inaccessible cupboards or drawers.

If given a start by interested teachers, the laboratory equipment will probably like Topsy, "just grow."[1] But as

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[1] National Council of Teachers of Mathematics, Multi-Sensory Aids in the Teaching of Mathematics, Eighteenth yearbook, New York: Bureau of Publications, Teachers College, Columbia University, 1945, 26.

time goes on these materials can all be classified and arranged in such a way that their usefullness will increase.

The technique of teaching with multi-sensory aids divides itself naturally into three stages; the teacher's preparation, the presentation and the follow-up.[1]

> In preparing to use visual aids, the teacher must consider these steps: (a) familiarize himself with the content of the material, (b) decide upon the purpose or purposes in using the aid--introducing the unit, direct teaching, summarizing or reviewing, enrichment, or appreciation, (c) decide at what point or points in the unit to use the aid, (d) determine what the students should look for during the showing of the material.
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> The presentation may be motivated by one or more devices such as: (a) by developing the need for it, (b) by taking advantage of the interest or previous experiences of the students, (c) by advance assignments--individual, group, or class--based upon what is to be seen. . . the points on which the pupils are to concentrate their attention should be specifically stated in sentence form on the blackboard or in notebooks. It is advisable to drill upon difficult and new words that may be found in the material to be presented. It is also wise not to list too many points for observation during any one showing.
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> If at all possible, the material should be presented immediately after developing the points to be observed during the showing. (a) All apparatus should be ready before the presentation, and arrangements made for operating it, (b) if the material is to be shown more than

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[1] National Council of Teachers of Mathematics, Multi-Sensory Aids in the Teaching of Mathematics, Eighteenth yearbook, New York: Bureau of Publications, Teachers College, Columbia University, 1945, 365-366.

> once, it is wise not to interrupt by calling attention to special items during the first showing, (c) it is advisable, if it can be arranged, to preserve normal conditions by having the class meet as usual in the regular classroom for the presentation.
>
> In the follow-up, the discussion of the film should be started as soon as possible after the presentation is completed, preferably the same day, and should be based upon the points on which the students were to concentrate their attention. At the same time it will be possible to answer other questions arising from the discussion and to eliminate any erroneous impressions created during the presentation.
>
> The teacher should capitalize upon interests aroused by the visual material and the discussion to stimulate the students to further activity associated with the unit under consideration. The students should be held responsible for the information gained. In settling special problems or clarifying conceptions, it is not necessary to show all of the material.

Multi-sensory materials may be used in the introduction or culmination of a unit. If used as introductory material, it will stimulate interest in the unit, raise questions for discussion, and lead to future research. As a culminating activity, the multi-sensory material will help the child see the over-all picture and relate the parts learned to the whole. It can also serve as review material or be used to test generalizations and concepts formed during the unit of study. In this way it will indicate where the students are weak and need further study. Some teachers also use multi-sensory materials in the middle of a unit, to redirect interests into other channels that need to be explored, to

check on the pupil's readiness for more difficult material and to see that basic concepts have been formed, and to change routine.

Dale[1] feels that there will be an improvement in the quality of audio-visual materials available to teachers in the near future. Old silent films are being remade using modern techniques. During the war, the Office of Education and the War Department experimented in films for the armed forces. Much valuable experience and information were gained.

Textbooks, soon, will show the influence of audio-visual education. There will be a better use of maps, graphs, charts, diagrams, drawings, and photographs and the text will be more integrated with visual and auditory materials.

State Departments and large manufacturing companies are realizing the contribution that can be made to schools by developing new materials locally and regionally. Already many films have been made in regard to geographical features of a state or region and industrial growth in the past few years.

State and county libraries have been set up whereby

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[1] Dale, Edgar, Audio-Visual Methods in Teaching, New York: The Dryden Press, 1946, 524-530.

materials are loaned to small school districts that cannot purchase materials needed with limited budgets. In large cities, central libraries have been built so that any of the schools in the city can borrow materials needed. By sharing, more materials can be purchased and the cost to the school district is less.

A great deal has also been done in adult education. Many films are made especially for teachers. Other films are being developed by industrial concerns for the education of their workers. Churches are using audio-visual materials to advantage.

CHAPTER III

USE OF MULTI-SENSORY MATERIALS IN THE CLASSROOM

The different types of supplementary materials and devices which will be discussed in this chapter include the following:

1. Concrete materials which may consist of real objects or representations of real objects which pupils may manipulate in gaining first hand experiences.
2. Measuring instruments which may be provided for the pupils or constructed by the pupils.
3. Pictures--provided for the pupils or made by the pupils to represent mathematical ideas.
4. Charts, diagrams, and graphs.
5. Business forms used in the community--checks, deposit slips, withdrawal slips, monthly statement, bills, insurance policies.
6. Advertisements, handbills, clippings, catalogs, pamphlets, which contain information which may be useful in illustrations or formulating current arithmetical problems.
7. Posters, displays, exhibits, scrapbooks.
8. Field trips, interviews, special reports.
9. Dramatizations of business procedures.
10. Analyses of life situations having quantitative aspects.
11. Films, filmstrips, slides.
12. Records and recordings.

Concrete Objects

Concrete materials which pupils can manipulate and arrange in various ways are valuable in the primary grades where a background of meanings is being developed. Children may count and group such objects as chairs, coins, buttons, toothpicks, circular discs, or any number of objects that may be obtained at the dime store. The teacher should always use concrete material when a demonstration with them will clarify new work and give it meaning.

Measuring Instruments

The use of various measuring instruments in concrete situations is valuable as the children become familiar with them and how they are used in every day life. There should be many opportunities to use these instruments and if possible the children should make some of their own. Brueckner and Grossnickle[1] list some of these instruments and devices for measurement:

1. Quantity: abacus, adding machine, number charts, dial telephone, tallying devices, automobile license plates, street numbers, fact finders, counting blocks
2. Length: ruler, yardstick, tape measure, meter stick, standards for measuring height, micrometer, pedometer,

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[1] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 476.

		speedometer
3.	Time:	calendar, clock, watch, stop watch, sun dial, shadow stick, candle clock, hourglass time table, metronome, school clock system, standard time chart
4.	Value:	coins, bills, checks, wampum, tax tokens, stamps, tickets, bonds, price lists, tokens, price tags, cash register
5.	Weight:	postal scales, balances, spring scales, nurses' scales, grocer scales, druggist scales, pressure gauges, height-weight charts, pictures of scales for weighing large amounts, labels showing weights of things
6.	Area:	square inch cards, square foot cards, sizes of rugs and rooms, house plans, garden plans, maps
7.	Volume:	pint, quart, gallon measures; cup, teaspoon, tablespoon; cooking measures; cans by sizes; peck and bushel measures; boxes, cases, bottles; water meter, gas meter, rainfall gauge; cubic inch blocks
8.	Temperature:	thermometer, clinical thermometer, cooking thermometer, thermostat, automobile temperature gauge, furnace guage.

Devices

1. Abacounter[1]

The abacounter is a device designed to make the facts, concepts, and operations of arithmetic concrete, real, meaningful, and understandable. The abacounter is made up of two sections: (1) on the left--a counting frame, or counting rack, consisting of horizontal rods and beads; (2)

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[1] Conference on Arithmetic, Arithmetic 1949, supplementary Educational Monograph, Published in Conjunction with School Review and the Elementary School Journal, No. 70, Chicago: The University of Chicago Press, 1949, 87.

on the right--a simplified abacus, consisting of vertical rods and beads.

The counting frame on the left consists of horizontal rods. Each rod contains ten beads, all of the same color (usually black or the natural color of wood), separated by a metal spacer into two groups of five each. The function of the spacer is to make the child conscious of the importance of the sub-group five. It also enables him to take in at a glance a group consisting of 6-10 beads without resorting to touching or counting each of the beads, since the spacer decomposes every group above 5--for example, 7 into 5 plus 2, or 8 into 5 plus 3, etc. The value of each bead in this section is the same, that is, one, irrespective of the row it is on, since this section is a counting frame, not an abacus.

The rods of the counting frame are also spaced in groups of five. The child learns that, just as 10 may be considered as two groups of 5 each, so 100 may be divided into two groups of 50 each. This grouping of horizontal rods also helps the child to learn to take in at a glance a group of 5 rods or 50 beads without resorting to counting, to pointing, or touching of the rods. The pupil is thus resorting to counting, to pointing, or touching each of the rods. The pupil is thus encouraged to develop habits on a higher plane of complexity.

2. The simplified abacus[1]

The right-hand section of the abacounter consists of seven vertical rods. Each rod is easily and quickly removable so as to afford the teacher the maximum degree of flexibility in using the instrument. Each rod contains twenty beads of the same color, (a different

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[1] Conference on Arithmetic, Arithmetic 1949, supplementary Educational Monograph, Published in Conjunction with School Review and the Elementary School Journal, No. 70, Chicago: The University of Chicago Press, 1949, 93-4.

color on each rod), separated into four groups of five beads each by three spacers. The second spacer, between the tenth and the eleventh beads, is twice as long as the other two, thus impressing again on the child's mind the importance of 10 in our number system. Moreover, these spacers will ultimately enable the child to take in at a glance the number of beads in any group one to twenty without counting them.

A panel on the lower half of the abacus can be removed and attached with great ease. Its primary function is to enable the teacher to conceal or reveal as many of the beads and columns as may be deemed desirable at any stage of the pupils' development.

Since the construction of the right-hand section of the abacounter is based on that of the true abacus, the value of the beads on the same vertical rod is the same. However, the value of each bead on the rod to its left is ten times as great. Similarly, the value of each bead on the rod to the right is only one-tenth as great as that of each bead on the original rod.

The third vertical rod from the right is to be considered as the units' column. The value of each bead on this rod will be one; that is, the same as the value of each of the beads on the horizontal rods on the counting frame. But the value of each bead on the rod immediately to the left of the units' rod is, of course, ten. Likewise, the value of each bead on the rod to the left of the tens' rod is one hundred, and so on. The value of each bead on the rod to the right of the units' rod is however one-tenth of a unit, and each of the beads to the right of the latter represents one-hundredth.

It is also obvious that the values assigned to the various colors are arbitrary. It is however, important to preserve the following essential elements of the abacus. (1) The color of the beads on the vertical rod in the units place should be the same as that of the beads

on the horizontal rods on the counting frame, usually either black or the natural color of wood, (2) no matter where the units rod is placed, the value of each bead on the rod immediately to its left must be ten.

3. Dollars and cents abacus[1]

An abacus for dollars and cents can be built with an oblong piece of wood and seven upright wires. The two right hand spindles for cents should have beads of one color, and the others on the right a second color so that it will be easy to distinguish dollars from cents.

4. Roman numerals abacus[2]

This abacus is also easy to make with an oblong piece of wood and four upright wires. The first wire should hold beads for thousands, the next hundreds, the third tens, and the one on the right hand side ones. On the side of the block below each wire can be printed, M, C, X, and I.

5. Calculator[3]

This is similar to the abacus described above and is a block of wood with four upright wires. The first wire on the left is for thousands, the next for hundreds, the third for tens, and the fourth for ones. Colored beads should be used for counters with a different color for each spindle. This simple calculator can lead children to real insight into the meaning of our number system. The children enjoy using it.

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[1] Hooper, A., The River Mathematics, New York: Henry Holt and Co., 1945, 30.

[2] Ibid., 9.

[3] Carr, Alice Rose, "Using a 'Calculator' to Develop Basic Understandings and Meaning of Arithmetic," Mathematics Teacher Vol. 43:195-6 (May, 1950).

Geometric Forms

Children will enjoy the study of geometric forms used or seen in daily living. Pictures of church windows, and geometric forms in nature may be collected and made into a scrapbook. In the winter time, the students like to make drawings of the forms of snow crystals. Fruits cut to show the arrangement of the seed pods will make interesting material for the bulletin board or scrapbook. Pictures of other geometric forms such as flowers, buildings, weaving, design, machinery, architecture, and house furnishings can be added from time to time.

Scrapbooks

Pupils may make drawings to illustrate mathematical words such as many, few, some, small, large, tall, short, both, two, equal, and bigger. Other words that can be illustrated are pair, duet, brace, trio, quartet, herd, and flock. Stories about number can be found and added to the scrapbook. The children can do research on Roman numerals and how our measures came to be. Pictures of man's achievements made possible by mastery of mathematics, engineering, astronomy, and medicine would be interesting.

Maps and Globes

Maps help the student grasp place relations. Maps and globes can be used to indicate location, direction, distance,

areas, land and water forms, rainfall, distribution of crops, geographical features, population distribution, and trends through the periods of history.[1] All maps should be accurate and well printed and the title should tell at a glance what the map is about. The scale should be sharply indicated and easy to follow, the symbols should be standard ones or adequately explained, and parallels and meridians, equator, tropics and so forth should be shown. It is necessary that pupils grow in the ability to read and interpret maps and globes. The students should be able to construct maps to illustrate their own work. All work in using maps and globes should be purposeful activity and meaningful to the pupil. The teacher should explain the use of the legend or the key and relate it to the information contained in the map. The use of color should be explained as well as the conventional way to indicate directions on any map. Work should also be done with globes in order to establish the fact that the earth is a sphere.

Models and Mockups

Models are recognizable imitations of the actual subject or object; a mock-up is the rearranging of the essential

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[1] Wesley, Edgar Bruce, Teaching Social Studies in High Schools, Boston: D. C. Heath and Co., 1950, 365.

elements of the original so that the operation of such is clearer to the learners. A model is a valuable teaching aid if it:

1. Concentrates the attention of the group on a particular subject,
2. Shows processes or sequence of events or happenings,
3. Presents processes invisible or complex,
4. Saves questions and gives instructor more time,
5. Can be used for review or re-explanation of operation.

Models should be a true representation as to proportion and color. It should be pleasing and interesting for the learner to watch, study and use. It must have the proper amount of detail and should lend itself to use in more than one situation. It should be easy to move from place to place, and be easy to demonstrate to the learners.[1]

Clippings and Posters

Clippings can be made of such items as weather reports, advertisements, tables, graphs, diagrams, cartoons, pictures, maps, bank statements, reports of the cost of damage by fire and other causes, and local events. Articles from

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[1] Wesley, Edgar Bruce, Teaching Social Studies in High Schools, Boston: D. C. Heath and Co., 1950, 358.

school magazines may have interesting facts about number. Children may collect and bring to school pamphlets, posters, catalogs, reference books, almanacs, and governmental bulletins. All clippings should be meaningful. Sometimes a a good collection of jokes about mathematics will add atmosphere. All clippings should be commented upon before being posted.

Posters are valuable if brought out and displayed at the psychological moment and only then. Posters should be changed often and not left up so long that they are disregarded by the pupils. The slogan should be short and meaningful. All words and the illustrations should be clearly seen from all parts of the room.

Charts and Graphs

It is necessary for children to be able to interpret charts and graphs as the encounter them in their reading of reference books, newspapers, and other printed matter. Ability to use charts or graphs should be developed through practice work in workbooks and textbooks. Prepared materials should be used so that all the pupils may work together at the same time under the direction of the teacher. It is too difficult to develop mastery along this line if the pupils are working on a variety of graphs found in different reference books. This can be done later when all have a

basic knowledge of this type of material.

The pupils' collection of graphs and charts on the bulletin board or in a scrapbook should be kept up to date and meaningful. Only if the pupil contributing the material, can interpret it to the class, should it be given a place in the collection.

The students should have experience with various kinds of graphs: the circular, the bar, and the line graph. Graphs can be kept of the weather, school expenses, attendance, allowances, time budgets, growth of plants or bulbs, and so on.

Steinhaus[1] describes a visual aid that will help pupils understand the bar graph. It is made of a plank of wood on which small ridges are built up. These separate the beads that are used to show the varying parts of the graph. If each bead is given a certain value it soon becomes clear to the child how the bar graph is made and its relationship to number.

If charts can make the work more meaningful, the teacher should make these herself if none are manufactured. These charts can be made to show the steps in a new process

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[1] Steinhaus, H., Mathematical Snapshots, New York: G. E. Stechert and Co., 1938.

and if colored will be more effective.[1] If discussed and planned by the pupils after a discovery period, they will be more meaningful.[2]

Pictures

Pictures can be used to help the pupil see the meaning of numbers, fractions, and geometric designs. Basis for discussion on arithmetic in daily life, is one of their uses. Flat pictures can be used to supplement the textbook and to introduce new applications of arithmetic. Pictures are of value in motivating interest and learning and their realism reduces misinterpretation and verbalism. Lesson assignments, reviews, and tests can be given through pictorial materials.

Pictures should give a generally true and accurate impression of the relative size of the objects therein. The pupil's fund of knowledge should be increased and it should foster creative activities.

The picture should be of good quality technically and artistically. Colors should be clear and accurate.

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[1] Hall, Jack V., "A Self-Starter Approach to Fractions," Mathematics Teacher Vol. 43:331-3 (November, 1950); Hall, Jack V., "Color Clarifies Arithmetic Processes," Elementary School Journal 50:96-8 (October, 1949).

[2] Michaelis, John U., Social Studies for Children in a Democracy, New York: Prentice-Hall, Inc., 1950, 316-317.

Careful planning on the use of pictures should be made by the teacher. There must be a definite purpose in mind for the use of the material.[1] The teacher must show the pupil how to study the pictures, what to look for, how to compare and criticize, and how to relate the pictures to other curriculum materials. In group study, all the pupils must be able to see them. For individual study, they should be placed on a reference table or bulletin board where they are easily available to the pupil. The teacher should accompany the pictures with verbal explanations.

Books and Reference Materials

The teacher should secure from the library books about topics being studied that will enrich the work for the pupils and help familiarize them with the social aspects of the topics. In social studies books, there are discussions on money, ways of telling time, banking, and arithmetic in medicine and measurement. The time may not be far distant when special arithmetic readers will be published, containing interesting materials about the development of many institutions now inadequately discussed in arithmetic textbooks.[2]

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[1] Horn, Ernest, Methods of Instruction in the Social Studies, New York: Charles Scribner's Sons, 1937, 379-380.

[2] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 487.

In encyclopedias the pupils can find well written articles about many topics studied in arithmetic. Reports based on these articles can be given by the more able students. All pupils should be allowed to explore reference materials because a greater interest is created in arithmetic.

The modern textbook should contain well-graded step-by-step development of the fundamental processes, so clearly and meaningfully presented that the average pupil is able to proceed at his own rate with a minimum of help from the teacher. Ample practice exercises to develop skill should be provided. Special attention should be given to the meaning of the number system. Problems about the social aspect of arithmetic should parallel the development of the number processes. Practice materials should develop skill in reading tables, graphs, charts, maps, and other kinds of materials found in general reading. Special provisions should be made for individual differences, including such materials as diagnostic tests, starred problems for special investigation and report, and other kinds of activities for the more able pupils.[1]

Workbooks should be so well organized and prepared that

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[1] Brueckner, Leo J., and Grossnickle Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 488.

they are practically self-instructive and their use should enable the teacher to adapt instruction to the needs, rate of learning, and interests of individual pupils. There is a danger, however, that the use of inferior kinds of workbooks will lead to isolated and meaningless drill assigned indiscriminately as a form of busy work. Practice should grow out of needs derived from meaningful experience.[1] To make effective use of workbooks and practice materials, the teacher should first make a careful study of the individual pupil to discover his needs and the type of instruction necessary to eliminate his weaknesses. Unfortunately, a workbook does not include exercises that will remove causes of difficulty.[2]

Some teachers apparently believe that assigning a large amount of drill guarantees that effective learning will take place. Unguided drill actually strengthens inefficient habits and skills because the pupil repeats the same errors and faulty procedures again and again with no improvement in performance. Unless the teacher discovers his fault through diagnosis and the correct procedure is understood before practice is assigned, the practice will be useless and perhaps

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[1] Brueckner, Leo J., and Grossnickle, Foster E., How to Make Arithmetic Meaningful, Philadelphia: John C. Winston Co., 1947, 493.

[2] Ibid., 496.

actually harmful. The successful use of workbooks and prepared practice exercises requires the teacher to supplement the text with a variety of experiences, materials, exercises, and methods adapted to the needs of the individual.[1]

Excursions and Field Trips

Through excursions and field trips, the pupils come into direct contact with situations in which number is used in daily living. Excursions should be used when they will make a greater contribution to learning than will any other school activity. Careful preparation should be made for the excursion so that the pupils will know what is to be accomplished and they should volunteer to accept responsibility to get information. After the excursion, findings should be discussed and the information gathered, organized, and systematized. Generalizations should be made and questions that cannot be answered listed as topics for research.[2]

Dramatizations

Dramatizations of uses of arithmetic are very interesting to pupils. Through these activities they can learn

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[1] Brueckner, Leo J., and Grossnickle, Foster E., op. cit., 497.

[2] Horn, Ernest, Methods of Instruction in the Social Studies, New York: Charles Scribner's Sons, 1937, 410-3.

readily how to proceed in social situations, such as ordering and buying things at some store, making and checking change, telephoning, buying streetcar tokens, paying fees at the library, and finding the cost of mailing a letter. Children can also dramatize such imaginative situations as how the Indians told time, how barter was used in trade, the Chinese water clock and other old ways of telling time, strange ways of measuring distance, how zero was invented, and why we need the thermometer.[1]

Business Forms and Exhibits

Samples of the business forms of various kinds used in the community should be gathered by the teacher and pupils: A discussion of the function of a particular blank, the items included on it, and the ways in which it is used make arithmetic more interesting.

Children can enjoy making exhibits. They may be borrowed from libraries and museums or exhibits can be made from free samples given by various manufactureres. Many children have stamp or coin collections that they can share with others.

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[1] Brueckner, Leo J., and Grossnickle, Foster E., op. cit., 480.

Analyzing Imaginary Situations

Parents and teachers should give children a chance to dramatize imaginary situations so that they will have some basis of action when they come face to face with the real problem. They might discuss the cheapest way to travel between two cities, find the cost of school supplies, choose and find the cost of refreshments for a social party, or plan the cost of Christmas presents.

Motion Pictures

Motion pictures contribute much to the accuracy, richness, and significance of the concepts being learned by the pupils. Thinking is made more effective, verbalism is reduced, and experience becomes more meaningful. Interest is easily aroused and maintained. There is greater retention of information, particularly in the case of children of average and lower intelligence.

Motion pictures can be used to advantage in connection with the social phase of arithmetic. Activities of the post office, the grocery store, the bank, the builder, the farmer, the scientist, the technician, and many other agencies can be shown in detail. The mathematical phase must be brought to the attention of the pupils by well-directed questions.[1]

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[1] Brueckner, Leo J., and Grossnickle, Foster E., op. cit., 479.

Films are valuable because they make situations life-like and natural, present a great deal of content in a short time, and aid students of lower mental ability. The students remember the ideas presented for a long time and attitudes, emotions, and conduct are greatly influenced.[1]

Films should fit the teaching-learning objectives and the subject matter should be appropriate. The subject matter should be up-to-date, authentic, and appropriate to the learner's level of understanding.[2] The film itself should be of high quality with good photography, sharp pictures, clear and loud sound, and be free from scratches, tears, and blemishes. There should be good continuity between the scenes.

The teacher should be sure that there is an atmosphere for learning and not for entertainment. The pupils should be prepared for the film and should know why it is being shown and what they are to look for. The pupils should look for specific facts, the main ideas, important relationships, unusual scenes, special terms, and so on. Different groups of children can be designated to look for different things and be ready to report after the showing on their findings.

Follow-up activities might include group or panel

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[1] Dale, Edgar, Audio-Visual Methods in Teaching, New York: The Dryden Press, 1946, 183-191.

[2] Ibid., 191-195.

discussions, reports, trips, experiments, dramatizations, constructions of exhibits, quizzes, reading or research.

Filmstrips

Filmstrips can be used for motivation, teaching, or review. The whole group may be shown the filmstrip or only one individual at a time. Usually children of the third or fourth grade can learn to manage the filmstrips themselves. In contrast to motion pictures, the filmstrip can be stopped to advantage at any place for discussion. Filmstrips are less expensive and can be stored easily. Many schools buy their own and rent the more expensive motion pictures. As with films, there should be an adequate preparation of the pupil to view the filmstrip and an appropriate follow-up activity.

Tape Recordings

Recordings are valuable in presenting information, provoking discussion, or developing appreciations. Reels of tape are small and compact and can be used over and over again. Teachers should be sure that the subject matter of the recordings is consistent with the specific objectives of the learning situation. It should be authentic, technically satisfactory, and appropriate to the level of ability of the learners. Teachers should plan the preview, preparation of the learners, presentation and follow-up discussion or

activities.

2" x 2" Slides

A wide variety of graphic representations may be reproduced in 2" x 2" slide form. Photographs, cartoons, drawings, diagrams, charts, and maps may be photographed and mounted as slides. Slides have great flexibility in that they can be arranged in any order and edited or reduced in number for varied occasions and conditions. Slides are valuable in that they can be used for motivation in introducing a unit, for teaching and expanding a unit, and for review purposes. A common basis of experience is reached and they are especially meaningful to students at lower levels of mental ability or rates of learning. The rate of presentation can be varied and controlled to meet the needs of the group and the showing can be repeated as a whole or in part with little effort. The sequential steps in a process can be analyzed and the size of the object can be reduced or enlarged.

Slides must be used only if they are purposeful and give added meaning to the lesson. Interest should be motivated. The slides should be authentic, unified, of good quality, and adapted to the age level of the pupils.

Opaque Projections

In introducing new and more difficult assignments, the

delineascope or opaque projector can be used to illustrate appropriately solved problems. The simultaneous attention of the entire class makes less repetition necessary and promotes a better fundamental understanding. Problems and drawings illustrating rules can be projected for additional emphasis and make the study more interesting. Corrected problems can be shown by the teacher and reasons for errors discussed. If the same error was made by many of the pupils, they can be shown simultaneously instead of individually.

Problems and Activities

In the teaching of number facts it is important not to neglect to use verbal problems. Good problems are an important aid in making number facts significant.

> Many children on entering school can give the right answer to such a problem as, "If you have five cents and your father gives you three cents more, how many cents will you have then?" Yet these children will generally be unable to answer the abstract question, "Five and three are how many?" The point is that the problem has more reality. With the material which it names and the scene which it evokes, the pupil is familiar. He identifies himself with it. He is the hero of the story, the fortunate possessor of five cents and the still more fortunate recipient of three cents more. The resulting inventory of his wealth is natural and inevitable. It is also correct.[1]

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[1] National Council of Teachers of Mathematics, The Teaching of Arithmetic, Tenth yearbook, New York: Bureau of Publications, Teachers College, Columbia University, 1935, 57.

Textbooks are often at fault in their large number of problems that involve adult activities and in their relatively small number of problems that concern the needs, activities, and interests of children. It is hopeless to expect children to be interested in problems which pertain wholly to activities foreign to their experiences. Lack of interest means a consequent carelessness in reading habits, an inaccurate interpretation, and an incorrect solution.[1]

When the textbook is the source of the problems, the teacher's first duty is to see that each problem is made concrete to her pupils and that the words of the problem call up in the pupils' minds the correct ideas and images. Often the best way to make a problem or a group of problems real is to dramatize the situations involved. Many lists of problems in our newer arithmetics lend themselves readily to this idea. Although it is necessary to resort to dramatization more frequently in the lower grades, it should also be used in the upper grades with problems based on unfamiliar situations.[2]

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[1] National Council of Teachers of Mathematics, Selected Topics in the Teaching of Mathematics, Third yearbook, New York: Bureau of Publications, Teachers College, Columbia University, 1928, 224.

[2] The National Council of Teachers of Mathematics, Selected Topics in the Teaching of Mathematics, Third yearbook, New York: Bureau of Publications, Teachers College, Columbia University, 1928, 224.

The pupil should have a large share in discovering and stating the problems that are to be attacked, for the ability to state a problem clearly is the best evidence that students are ready and competent to work upon it. The teacher, out of his fuller knowledge, should guide the students in planning their attack and should suggest important problems that may otherwise be overlooked.[1]

All projects should involve the four steps of purposing, planning, executing, and judging. These four steps may be expanded into many subsidiary steps of which the following are typical.[2]

1. Select projects that have educative values. Pupils cannot be trusted to understand this principle. The teacher must exercise guidance.
2. Select projects that have significance for the particular group.
3. If possible secure the wholehearted acceptance of the project by every pupil. The simultaneous prosecution of several projects assists the teacher in meeting this requirement.
4. Insist upon the formulation of a plan before overt steps are taken. In many instances this may well be a drawing, a list of steps, a list of materials, a picture, or other specific indications of what is to be done.
5. Relate the project to the purpose behind its initiations, and recur to it frequently enough to prevent the project from becoming mere activity.
6. Either supply or see to the collecting of all

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[1] Horn, Ernest, Methods of Instruction in the Social Studies, Chicago: Charles Scribner's Sons, 1937, 248.

[2] Wesley, Edgar Bruce, Teaching Social Studies in High Schools, Boston: D. C. Heath and Co., 1950, 365.

necessary materials in ample time to prevent interruptions and delays.

7. Supervise the pupils in manipulative skills closely enough to prevent waste of materials and guard against accidents.
8. The relation between the plans and the developing project should be constantly checked. Modifications in the plans should be noted and the reasons explained.
9. The evaluation of the project should be made, in the first instance, by the pupils. They should estimate the qualities of what they have done before the teacher gives his evaluation.
10. The pupils should also state the values, for themselves, of the information, interests, skills, and attitudes that have been modified by the project.

Much has been said in recent years about making arithmetic meaningful. Making arithmetic meaningful, however, is more than explaining the number system and the processes with numbers. Critical meaning has to be stressed. But emphasis has to be placed upon relating new experiences to old experiences, upon a gradual step-by-step development of the process, upon the importance of having pupils discover new truths for themselves, upon the futility of mechanical tricks and devices, upon the need for telescoped reteaching rather than the traditional "test-and-drill" kind of review, and upon other important matters related to the all important objective of helping pupils learn.[1]

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[1] Conference on Arithmetic, Arithmetic 1949, supplementary Educational Monograph, Published in Conjunction with School Review and the Elementary School Journal and edited by G. T. Buswell and Maurice L. Hartung, No. 70, Chicago: University of Chicago Press, 1949, 19.

Today the merit of the teacher is often evaluated by his superiority in terms of the extent to which he employs "modern" methods. Does the teacher take the class on excursions or field trips visiting the bank, post office, store, or a factory? Does he encourage and use collections of materials, data, pictures, etc., which help children learn the social uses of arithmetic? Does he use experiments or laboratory problem-solving methods to help pupils acquire mathematical understanding? Does he seize opportunities for a project or comprehensible activity in which arithmetic is used in a genuinely functional way? Finally, does he use modern films and filmstrips which are designed to make arithmetic meaningful? If the teacher does all these things, the chances are that he is a superior teacher, but it does not necessarily follow that he is maximizing total achievement.[1]

There is no one method or any single type of instructional material which will suffice in all situations. The skillful teacher selects methods and materials in terms of the outcomes to be achieved and of the needs and interests of the children. If instruction in arithmetic is to insure a steady growth in understanding number relationships, a

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[1] Conference on Arithmetic, Arithmetic 1949, supplementary Educational Monograph, Published in Conjunction with School Review and the Elementary School Journal and edited by G. T. Buswell and Maurice L. Hartung, No. 70, Chicago: University of Chicago Press, 1949, 83.

wide variety of instructional materials must be used to enrich and to supplement the learner's experiences.[1]

Multi-sensory aids have been thought of as devices to help pupils get their answers. Their most important use is to show the thinking which lies back of the answers that pupils get. When used with intelligence and insight, they may contribute much to superior teaching.

In summary, the purposes of this research were met in that the scope of the writer's knowledge was broadened in (1) the use of multi-sensory materials in teaching, (2) the philosophy of visual education, and (3) the newest theories of teaching arithmetic in the intermediate grades.

Secondary sources of information were used in the research: namely, books, pamphlets, and periodicals. In the listing of multi-sensory aids that can be used in the classroom, manufacturers' catalogues were also referred to for the most recently made articles.

In the appendices that follow are found a listing of aids that are valuable to the teacher in enriching the arithmetic curriculum. Appendix A contains a listing of films and filmstrips, Appendix B a listing of pictorial and manipulatory devices, and Appendix C a miscellaneous list of multi-

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[1] National Society for the Study of Education, The Teaching of Arithmetic, Fiftieth yearbook, Part II, Chicago: National Society for the Study of Education, 1951, 155.

sensory materials taken from manufacturers' catalogues.

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APPENDIX A

Appendix A includes in this listing of multi-sensory materials of value to teachers of arithmetic films and filmstrips.

Reference: Grossnickle, Foster E., and Metzner, William, The Use of Visual Aids in the Teaching of Arithmetic, Brooklyn: Rambler Press, 1950.

Films

1. Addition is Easy. Coronet Films — Collaborator: F. Lynwood Wren

   This film demonstrates how addition is done through a problem involving a situation in which a boy wishes to purchase a set of paints and a baseball bat. He must determine if he has enough money in the bank to make the purchases. The relative values of coins is effectively illustrated and used in developing the basic concept of column addition with carrying. The film can be used most effectively in grades 3-4. Cost $45 in black and white. $90 in color. Teachers guide available.

2. Borrowing in Subtraction. Teaching Film Custodians, Inc.

   This film develops in detail the concepts of ones, tens, and hundred, in a three place number. The picture presents concretly the need and the principle of transfer (changing of numbers) in compound subtraction. The problem involves the example $13^{4}-78$ and the step by step process of subtraction is logically shown and developed although this film may be shown after children have commenced work on a simple subtraction in which no transfer is necessary. It will have greater value if children understand one-place transfer. This film is excellent for review purposes. The vocabulary is on a third grade

level. The film is best used in grades three to five. A teachers guide is available. For cost consult Teaching Film Custodians, Inc.

3. Fractions. Johnson Hunt Productions series of eight films Written by: Silas E. Johnson Dale Carpenter Ruth Lana

This series is designed specifically to aid the teacher of the upper elementary school grades in summarizing and developing concepts and processes which have been presented in classroom instruction. The material in the film moves too rapidly for even an alert child to follow in detail without previous classroom preparation. These films are highly effective, however, for remedial work and general review in the junior and senior high schools. They are excellent for teacher training to show how to use concrete materials effectively. The photography is excellent. The color prints are recommended since color adds to the effectiveness of the three dimensional animation that is employed. However, the black and white prints are satisfactory. The commentary is clear and appropriate to the grade levels. A teaching guide is available. Cost $85 in color and $45 in black and white.

4. Introduction to Fractions. Johnson Hunt Productions

The first film in the series introduces fractions as an integral part of our daily living and explains how fractions are written. A fraction is defined as a part of something. The fact that a fraction also indicates division is purposely ignored. It gives the definition of numerator and denominator, and explains the necessity for having these two terms. Improper fractions and mixed numbers are briefly introduced to clarify their relationships to the basic concept of a fraction. Several simple problems in determing the value of a fractional part are presented in situations which might occur in the home and are developed step by step. The last one introduces the concept of a complete unit as a fraction of a group. The film may be used effectively for review in grades four to five. It may be used as a preview and orientation to the subject for beginning classes, but the children should not be expected to understand all of it. Cost $45 in black and white, $85 in color; teachers guide available.

5. Maps Are Fun. Coronet Films Collaborator: Viola Theman

The objective of this film are: to teach how to read maps; to teach how to make maps; to teach the concept that maps are efficient means of communicating certain ideas and to interest pupils in the story that maps can tell. The vocabulary is simple and does not assume previous knowledge of maps. It may be used profitably to show pupils the need for understanding number relationships and development of skill in measurement. Grades 4-9. Cost $45 in black and white, $90 in color; teachers guide available.

6. Measurement. Coronet Films Harold P. Fawcett

This film presents in a convincing manner the importance of measurement in our society. It illustrates the use of such measures as time, liquids, temperature, weight, and measurement of length, areas, and volume. The importance of standardized measure is also emphasized. This fact is exceedingly valuable for motivating the pupils to learn more about the science of measurement. It is recommended for grades five to nine. $45 in black and white, $90 in color; teachers guide available.

7. Parts of Nine. Young America Films

This film develops the meaning of the number nine through the use of concrete materials involving the preparation of a birthday party. The ideas presented in this film are: nine in serial relation to eight; nine as three groups of three each; addition and subtraction facts involved in ine. The addition and subtraction are developed in relation to each other for each of the combinations in nine. This film is excellent for teacher training. It is also recommended for use in grades one and two and review in other grades. $40 in black and white; teachers guide available.

8. Parts of Things. Young America Films

This film develops the meaning of one-fourth and one-half of single things, as an early introduction to fractions. The entire story is told through the medium of simple line drawing animation. The teaching technique employed is excellent, showing the gradual development from experience situations, through concrete objects and

semi-concrete representation to the abstract idea. The film is recommended for grades two to four. $40 black and white; teachers guide available.

9. Simple Fractions. Knowledge Builders

This film was designed to show the meaning of fractions. Animation is used in repeated examples to show the roles played by the numberator and denominator. Simple additions are made reasonable by showing parts being combined. Concrete objects are used in the gradual development of abstract ideas of such things as one-half, two-thirds, three-fifths, five-sixths, and six-sevenths. The photography is satisfactory but the commentary becomes too complex at times for elementary school pupils. Since so much material is covered the film is best used for review purposes. It is recommended for grades five to eight. $40.

10. Subtraction is Easy. Coronet Films Collaborator: F. Lynwood Wren

This film is a companion film to addition is easy and reviews the problem of purchasing paints and a baseball bat but involves another situation in which the boy must decide whether or not he has enough money to buy a baseball after making his other purchases. The film is suitable for use in the course of classroom instruction in the fundamentals of subtraction regrouping and using a ten, and place value. The relative values of coins is utilized to illustrate transformation of tens to ones. The film is best adapted for grades three or four. $45 in black and white, $90 in color; teachers guide available.

11. The Teen Numbers. Young America Films

This film develops the meaning of place values in our number system. The meaning of the numbers one to nine is shown through grouping objects and by indicating these numbers in a series. The meaning of the numbers ten to nineteen is developed as groups of ten and ones, and as they are shown in relation to the single-digit number one to nine. This film may be used after the pupils have learned to count to twenty, recognize the symbols through twenty and have learned the meaning of the numbers through ten. This is an excellent film to go along with the class instruction where children have

abundant opportunity to manipulate objective materials. The film is recommended for use in grades two to three. $40 in black and white; teachers guide available.

12. We Discover Fractions. Collaborator: Harold P. Fawcett
Coronet Films

The purpose of this film is to introduce in more concrete terms the ideas of division into equal parts of a unit, and then to teach the appropriate symbols to use to express this idea. The meaning of numberator and denominator is explained. This film may be used as an introduction to the study of fractions; as a means of enriching this study; as a review of the meaning of fractions; and for teacher training purposes. This film may be used in grades four to six. $45 in black and white, $90 in color; teachers guide available.

13. What is Four? Teaching Film Custodians Young America Films

This film illustrates four in a number of concrete and semi-concrete situations and then proceeds to an abstract presentation of four based on the visual treatment of these concrete situations. The film is divided into two parts. Part one should be used for beginning pupils who have some number experience but who are not ready for the use of symbols to indicate addition and subtraction facts. Part two will help pupils who are ready for the systematic introduction of the symbols used in addition and subtraction. This last part should provide a meaningful basis for the development of abstract number. The large number of concepts discovered in this film would make it more suitable for review purposes than for introductory procedures. This film is excellent for teacher training purposes. Grade level: primary. $48 in black and white, part one only, $36; teachers guide available.

Glass Slides

1. Number Combinations. 3¼" x 4" lantern slides
Keystone View Co., 1948

The complete set of slides has been designed for use with a Tachistoscope and provide practice and drill for

maintenance and mastery of the number combinations. There are 43 slides in the series which includes over four hundred covering the range of possible combinations in addition, subtraction, multiplication, and division. The combinations have been graded from the easiest to the most difficult according to ratings of difficulty based on repetion as the chief instructional tool for learning. Using this criteria of difficulty there is a distribution of frequency of the appearance of the more difficult combinations. Suitable masks used with an overhead projector permit the exposures of one combination at a time. The tachistoscope is a quick shutter, camera-like device attached to a lantern slide projector which makes possible exposures on the screen of from one full second to one-hundredth of a second, depending upon the purpose involved. Properly used the tachistoscope can be a valuable aid in helping pupils master the number combinations but there is no advantage in imposing routine repetition until the pupil understands thoroughly what he is learning. This series of slides may be used from grade two and up. $29 for complete set of 43 slides; teachers guide available.

Filmstrips

1. A Number Family in Addition. Popular Science Publishing Co. 37 frames

This filmstrip is valuable in showing teachers how to present a basic number fact in addition. Beginning with a special situation that calls for the use of the number act, the family of sevens is analyzed to show all the basic facts which make seven. Manipulatory materials are used to represent the number facts in semi-concrete form, followed by the symbolic representation of each fact. The last few frames direct the pupils to make problems that use the number facts.

2. Adventure with Number. Popular Science Publishing Co. series of six filmstrips

This series will be extremely valuable to teachers looking for ways of teaching arithmetic meaningfully. The filmstrips show children using number in familiar situations, then reviewing these experiences using manipulatory materials of a semi-concrete nature, and, finally, using number in the abstract. The films are designed to

go along with the regular classroom instruction and provide the pupils with many opportunities to use number in new situations. They are valuable in helping pupils gain insight into number since each topic or process is developed not only to show relations between number but also to help pupils understand the social applications of number. When these filmstrips are used at the conclusion of the developmental study of a topic, they are excellent means of evaluating achievement. Color. Primary grades. Geachers guide by Foster E. Grossnickle.

3. Primary Arithmetic. Popular Science Publishing Co.

Each filmstrip is pictorial and beside each frame are points for the teacher to bear in mind and suggestions for use for directing pupil response. In addition developmental activities are suggested which should follow the showing of each filmstrip. The photography is very good and the drawings colorful. The teachers guide supplied with this set gives suggestions for using each filmstrip. Names of the filmstrips are: What Numbers Mean, Zero a Place Holder, A Number Family in Addition, Compound Subtraction, The Threes, and The Twos in Division. $30. Each filmstrip $6.

4. Encyclopedia Britannica Filmstrips.
Encyclopedia Britannica Films
series of sixteen

These sixteen filmstrips are to be used in developing an understanding of the meaningful sequence and use of number. The photographs are clear, simple drawings and pictured in black and white and logically arranged in each strip to permit their use in conjunction with classroom instruction. It is not expected that these filmstrips will take the place of concrete materials used by pupils to discover the meaning of number, but they do show the teacher the type of procedure to use to present particular phases of a topic. Each strip is a teaching unit and generally too long to be covered profitably in one lesson. Careful preparation on the part of the teacher before using each filmstrip is essential if the greatest value is to be obtained. A more interesting and active learning situation is possible if these filmstrips are used in a lighted room where children at their desks use concrete materials and do the writing follow-up the directions give on each filmstrip. These filmstrips are also excellent for review purposes. Since

each lesson leads directly into the lesson that follows it with simple teaching techniques employed in each strip, it is essential that the complete series can be purchased. The series is designed for use in grades one to three. Individual strips cost $3 each, the complete series $43.20; no teachers guide available.

5. Eye-Gate House Filmstrips. Eye-Gate House, Inc. series of nine

This series of nine filmstrips in color has been designed to help build up the concepts and fundamental ideas of fractions. The illustrations are colorful and provide a rich and varied supply of concrete visual examples. Most of the fractions used as examples have one-digit denominators. The sequence of frames in each filmstrip should prove of great value to teachers desiring to improve their techniques in presenting the varied topics. All of the pictures are within the child's range of experience and interest. These filmstrips may be used for both initial presentation and review. Fourth to sixth grade. $22.50 for complete set; teachers guide available.

APPENDIX B

Appendix B includes in this listing pictorial and manipulatory devices which can be purchased from various supply houses such as charts, posters, fraction boards, abacounters, number boards, and counting frames.

Reference: National Society for the Study of Education, The Teaching of Arithmetic, Fiftieth yearbook, Part II, Chicago: National Society for the Study of Education, 1951.

Manipulative Materials

1. Concrete Materials.

   Such concrete materials as one inch cubes, sticks, beads, clock faces with both Arabic and Roman numerals, and toy money are necessary items in an arithmetic laboratory. (Materials of this kind are readily secured from most supply houses).

2. Arithmetic Readiness Kit.

   The kit consists of ten wooden blocks, 2" by 2" by 3/4" with a hole through the center, a stringing lace, small individual number cards, and a small supply of play money. The material may be used to develop the serial idea of numbers from one to ten and to show relationships among the basic coins. Grade one. Noble and Noble Publishing Inc., Irving Place, New York 3, New York.

3. Counting Discs.

   These discs are made of durable fiber about 1¼" in diameter in a solid color. They lend themselves to counting, discussion of number facts, and to giving demonstrations of the fundamental operations as far as three place numbers. Grade level: one. John C. Winston Co.

4. Exton's Parts-Imparter.

This set of materials includes a nine inch "Double Disc" and two "Equivalence Wall Charts" for teacher use and classroom demonstration. There is available for the pupil a 4½" "Double Disc" which corresponds to the teacher's model. These materials are used to teach parts of a whole, fractions, percentage, decimals, angles, degrees, and equivalence. Grade level: four to nine. Stanley Bowmar Co., 2067 Broadway, New York 23, New York.

5. Fraction Chart.

This chart consists of a twenty-one inch square blackboard, on which are fastened six slides. Die-stamped cards representing fractional parts of one whole may be fitted into each of these slides. The chart is designed to stand vertically. The fraction cards furnish a basis for teaching the concept of fractional parts of a unit, for changing fractions to higher and lower terms, and for adding and subtracting fractions. Grade level: four to nine. John C. Winston Co.

6. Fraction Wheel.

This set of discs has ten seven-inch circles which have been segmented by die cutting to show halves, fourths, eighths, sixteenths, thirds, sixths, ninths, twelfths, fifths, and tenths. The kit box has a self-contained easel so that materials may be used for classroom demonstration. Grade level: four to nine. Ideal School Supply Co.

7. Fractional Parts.

This set of fractional parts consists of forty-nine pieces: twenty one-inch squares, and seven four-inch discs, including one whole disc and six which are dissected, respectively, into halves, fourths, eighths, thirds, sixths, and fifths. The squares and discs are die stamped on a single sheet of heavy cardboard with face and reverse side of contrasting colors. Each disc section has its size imprinted on its face. The set is designed for pupil use and provides the material necessary for a meaningful study of fractions. Grade level: four to nine. John C. Winston Co.

8. Fractional Parts Enlarged.

A set of these materials consists of a display board, 19" x 28", which is lined on one side with black velour, and an assortment of eight-inch discs, dissected discs, and two-inch squares. These squares and discs are lined on both sides with velour paper in contrasting bright colors. The discs and squares adhere firmly when placed on the display board which can be held in almost a vertical position. These discs provide a complete set of materials which the teacher may use to demonstrate the concept of a fraction, fractional relationships, and all operations with common fractions. Grade level: four to nine. John C. Winston Co.

9. Fractions Made Easy.

This set of materials includes twelve cards, each four inches square, on which are printed basic units in the shape of squares, triangles, and circles. These units are divided into equal parts respectively, halves, fourths, eighths, sixteenths, thirds, sixths, and twelfths. Cutouts of different colors, but corresponding to the shapes illustrated on the unit cards are used by the pupils to discover fractional relationships. Grade level: four to six. Ideal School Supply Co.

10. The Hundred-Board.

The hundred-board consists of a framed cardboard twenty inches square equipped with one hundred cardboard discs and two cards twenty inches square. The one card is a counting card which contains the numbers one to one hundred, printed in sequence, ten numbers to a line. The other card is a product card and it shows the multiplication products to ten times ten. The hundred-board is designed for demonstration purposes to teach counting, to develop the basic facts meaningfully in all four processes, as well as to develop some of the concepts, processes, and relationships, that are involved in decimal fractions and in percent. Grade level: one to eight. John C. Winston Co.

11. Modernized Abacus.

This abacus has a solid backing which supports four vertical wires with different colored beads to represent the first four places in our number system. Nine beads

of the same color are on each wire with a top tenth bead of the next succeeding color. The tenth bead completes the ten and shows by its color that ten beads are equal to one bead of the next higher order. Grade level: one to nine. John C. Winston Co.

12. Moto-Math Set.

This set consists of a blackboard graph card, 32" x 34" made of twenty gauge steel plate with nine hundred seventy-seven holes one-sixteenth of an inch in diameter, and various accessories which may be quickly mounted on the board by means of split pins. The accessories which may be used in the teaching of arithmetic include (a) counting discs of hard vulcanized white fiber one and a half inches in diameter and one-sixteenth of an inch thick with a one-sixteenth of an inch hole in the center for a split pin with which to mount them on the graph chart in any desired arrangement; (b) fraction discs which are twelve inches in diameter, one of red fiber and the other white. This material is useful in teaching fractional parts of a unit; and (c) the abacus which consists of three strands of ten large beads each, finished in bright red, blue, and yellow enamel (a special spring holds each bead in any desired position on the wires when mounted vertically). Grade level: one to nine. Yoder Instruments, East Palestine, Ohio.

13. Number Fact Finders.

Fact finders are designed for pupil use in counting and learning the number combinations. A fact finder consists of a number of movable beads on a wire rod. A fact finder for learning the concepts commonly taught in the first year is eight inches long and has twenty three-eight inch beads. Grade level: one. John C. Winston Co.

14. Number Frames.

Number frames are designed for use by the teacher to demonstrate counting and to illustrate number groups. These aids are enlarged models of fact finders. John C. Winston Co.

15. Place-Value Pockets.

Place-value pockets consist of a wooden frame twenty-four inches long to which are attached three wooden

pockets labeled "Hundreds", "Tens", and "Ones", respectively, for inserting markers. It may be used to demonstrate place value, to illustrate carrying in addition and multiplication, to show transformation in subtraction, and to give meaning to placement of quotient in division. Grade level: two to six. John C. Winston Co.

16. Teach-a-Number Kit.

The kit consists of a set of wooden blocks one and a half inches by one and three-fourths inches in which a different colored block is used for each digit from one to ten. Each block is labeled with the numeral and the word it represents. The blocks vary in thickness. The block to represent one is one-fourth inch thick and the block to represent each succeeding number increases one-fourth inch in thickness. Pupils may learn the value and meaning of numbers through comparison of sizes of blocks. Grade level: primary. Teach-a-Number Game, 725 Polydras Street, New Orleans, La.

17. Ten-ten Counting Frame.

This counting frame, eight and one-half inches by nine inches is made of wood and it supports ten wires, each of which holds ten one-half inch beads. Its principal uses are to provide a counting activity and to emphasize the fact that our number system is a system of tens. Grade level: primary. Milton Bradley Co.

18. The Twenty Board.

This board consists of a framed cardboard rectangle large enough to hold twenty cardboard discs in two rows of ten discs each. Its chief use is to illustrate the addition facts with sums in the teens and the corresponding subtraction facts. Grade level: primary. John C. Winston Co.

Pictorial Materials

1. Bulletin Board Charts on Arithmetic.

These charts, ten inches by thirteen inches are printed on light cardboard in attractive shades. Twenty different posters are included in a set and titled: Measures I, Measures II, A Time Chart, Linear Measure, Roman

Numerals, Change for a Dollar, Kinds of Subtraction, Temperature, Weight, Liquid and Dry Measure, Measurement by Counting, Decimals, Using Decimals I, Using Decimals II, A Fraction Chart, More Fractions, Adding Fractions, Interest Problems, A Long Division Chart, Percentage Equivalents I, and Percentage Equivalents II. Grade level: one to nine. F. A. Owen Publishing Co., Dansville, New York.

2. Fraction Cards.

This set of ten cards, five and one-half inches by six inches pictures units in the shape of squares, triangles, and circles divided to represent halves, fourths, and thirds. These cards are suitable for class use in teaching the fractional concept. Grade level: two to four. Steck Co., Austin, Texas.

3. One Hundred Chart.

The chart, twenty-five inches by twenty-nine inches is printed on heavy paper and is designed for classroom use. The main purpose of this material is to help teach counting to one hundred and to visualize number symbols in the process. Grade level: one to three. Milton Bradley Co.

4. The One Hundred Chart and the Two Hundred Chart.

The one hundred chart consists of ten strips three inches by twenty-two inches. A row of ten red dots is printed on each strip. A wall chart is required to display the material properly. The two hundred chart includes all the material listed for the one hundred chart and supplies, in addition, a chart with one hundred red dots arranged in rows of ten. These charts are valuable in teaching the meaning of two-place and three-place numbers. Grade level: one to four. Steck Co., Austin, Texas.

Source: Modern School Products Co.
"Plastic Plated Graph Charts," Mathematics Teacher Vol. 40:293, No. 5., (1947).

These charts are mounted on three-sixteenth of an inch laminated mounting boards and are durably bound with tape. They may be written on with wax crayons and erased with a dry cloth or written on with washable inks

and removed with soap and water. The charts are ruled in one inch squares with every fifth line heavier. Room is left on the left side for names. Cost: $7.75 each and crayons of five colors, 35 cents. Modern School Products Co., P. O. Box 2606, Cleveland, Ohio.

Source: D. T. Davis Company.

Math-O-Block

The blocks, graduated in height, are so designed that two one-inch blocks will equal a two-inch block. Three three-inch blocks will equal a nine-inch block, etc. In reality any simple equation in addition, subtraction, multiplication or division can be demonstrated in a physical concrete way, to show and prove how arithmetic functions. The related value of each digit is also revealed by weight and color so that, with size, there are altogether three definite factors employed to indicate this all-important point. Math-O-Blocks are brightly, cheerfully, and harmoniously colored with the finest lacquer that is soft to the touch, permanent in its lustre and non-toxic to children. The notations are imprinted in contrasting colors that simultaneously blend pleasingly with the background. There are 23 blocks in a set of Math-O-Blocks, nine one-inch, four two-inch, three three-inch, two four-inch, one each of number five, six, seven, eight, and nine-inch blocks.

APPENDIX C

From various manufacturers' catalogues have been compiled recent, miscellaneous materials not listed in Appendix A or B. Included are films, filmstrips, slides, and recordings.

Source: Jam Handy Catalogue
Introduction to Fractions

These five color stripfilms present beginning concepts of fractions. $19.50 or $4.20 each. Jam Handy Company.

Source: Society for Visual Education
Fraction Series

Photographs of real objects explain fractions and principles used in computation. Arranged according to basic curriculum units, these stripfilms introduce students to a study of fractions, explain various mathematical concepts which must be observed in the adding, subtracting, multiplying, and dividing of fractions and mixed numbers. Eight filmstrips, $24, each $3.25.

Source: Young America Films
History of Measures Series

Six filmstrips trace the history of our units and systems of measure. They are designed to enrich and supplement the arithmetic curriculum outline and textbook. Level: elementary school and high school. Cost: $16.50, each $3.50; teachers guide available.

Source: Popular Science Publishing Co.
How to Tell Time

Each filmstrip provides opportunities to pupils to practice telling time and does so with a device that permits classroom participation. Cost: two in series, $6, each $3; teachers guide available. Black and white, 90

frames.

Teach-O-Slides. Arithmetic.

Set of 50 color slides, $25. Level: grades one, two, and three.

Source: Young America Films
Drawing for Beginners.

Four films in the series; one on the circle, the rectangle, the square, and the triangle. Cost: $40 each. Teachers guide available.

Source: Coronet Films
Let's Count.

In this film, children learn the difference between ordinal and cardinal numbers, and how easy it is to use tally marks and numberical symbols to answer the question, "How Many?" Level: primary. Cost: $45 black and white, $90 color.

Source: Educational Services, Selected Listing of Educational Recordings and Filmstrips for More Effective Learning, Washington, D. C.: Educational Services, 1950-1951.

Mr. Arithmetic (recording)

In the series are six double-faced ten inch unbreakable, vinylite records in an album. The addition facts from one to twenty, the subtraction facts from twenty to zero, and the multiplication facts from one to one hundred forty-four are given. Level: primary grades. Cost $10 complete series.