AN EXAMINATION OF CERTAIN THEORIES AND TENDENCIES IN
TEACHING ARITHMETIC AS FOUND IN VARIOUS
EDUCATIONAL PERIODICALS DURING THE
PERIOD OF 1934-1941

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THESIS

Presented to the Graduate Council of the North
Texas State Teachers College in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

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Murphy, Texas

September, 1942
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CHAPTER I

INTRODUCTION

Statement of the Problem

Arithmetic has had a place in the public-school curriculum from the beginning of direct training and has been considered one of the fundamental subjects. For some reason or other, it has always been classed with formal subjects. It has had a part in the cultural development of civilization by enriching individuals' minds, quickening their appreciations, refining their sensibilities, disciplining their minds, and developing their ability to live and to make a living.

Modern American life and enterprise have been brought to a critical juncture by science, technology, and power production. A new civilization has been created by these forces of social modernism. Events have compelled even conservative teachers and other educators to acknowledge the necessity of rethinking and recasting old methods and procedures in the terms of a new social order in which the skills of enterprises are vast, and in which the tempo of life is swift. As a result, arithmetical teachers are
constantly faced with questions as to the amount of arithmetical knowledge needed for actual, social, and business usages.

At the present time, we are confronted with many evidences of curriculum investigation and revision, because a definite need of revision and reorganization has been seen in every phase of the educational program. Educators have come to realize that changes in the social and economic order necessitate correspondent educational changes, particularly in the subject matter of arithmetic.

The problem of this study has been centered around the modern tendencies in teaching arithmetic. An effort has been made to determine certain prevalent theories, methods, and procedures used in studying and teaching this subject as they have appeared in various periodicals dealing with school problems within the past six years. The writer endeavored to find answers to such questions as the following: (1) What type of subject matter has been taught in this field recently? (2) When was it taught? (3) How was it taught? (4) Why was it taught?

Significance of the Study

Methods advocated by leaders in the field of arithmetic and published in the leading magazines of the teaching profession are mainly of practical and vital concern to the teachers and to the maker of the arithmetical course of
study. The conceptions that the teacher has of arithmetic determine the kinds of quantitative situations he provides for his pupils. In fact, they also determine the types of experiences he wants his pupils to have in those situations; and, in addition, they determine the kinds of arithmetical ideas and abilities he expects them to derive from the instruction. No more crucial problem faces the arithmetic teacher or the curriculum committee than that of determining what view of arithmetic they shall adopt. This is determined, to some degree, by the opinions of educators, as they appear in various educational magazines and bulletins. For that reason, this compilation of recent trends in teaching arithmetic appears to have some significance.

Purpose of the Investigation

It is generally agreed that teachers and curriculum experts are determining an arithmetic curriculum which is to be effectively adapted to our changing civilization. This form of reconstruction is taking place in practically all modern public schools. (Emphasis is being placed upon developing instruction that meets the interests and needs of the pupils within all situations without undue reference to traditionally-taught subject matter. This recent movement to render elementary education more practical has led to many changes, particularly in the field of mathematics.)
A complete reorganization is under way for the purpose of more effectively adapting instruction to fit present-day educational philosophy and methods.

The purpose of this study is to analyze certain recent trends in the teaching of arithmetic, particularly those trends which have dealt with the reconstruction of the curriculum, and to determine to what extent the advocated theories seem to have been put into practice in the elementary school, according to reports in various school magazines and bulletins.

A secondary purpose of this study is to obtain significant data from the opinions and recommendations of teachers of arithmetic, and to compile the results in such a way that they might be of service to those interested in teaching this subject.

Definition of Terms

An understanding of any problem demands definitions of terms related to the problem. Most of the terms used in this study are self-explanatory. However, some are more or less ambiguous, and it seems desirable to limit their meaning in this particular study.

1. Arithmetic is the subject usually referred to as the science of numbers. It is used interchangeably with the term "mathematics."

2. Theories are interpreted to mean principles which
have been proposed and advanced. They pertain to the study and teaching of arithmetic.

3. Practices mean the exercise or application of principles in the mathematical curriculum.

Sources of Data

Information for this study was secured altogether from secondary sources. Data in various periodicals related to educational practices and principles, as well as data in magazines and bulletins devoted exclusively to mathematics, were consulted. Books were referred to for information on the history of mathematics and for the writer's background of the study.

Scope of the Problem

In this short study it is impossible to cover all phases of modern tendencies in the teaching of arithmetic. Consequently, an effort has been made to compile samplings of representative theories, principles, and practices on the following major problems: (1) the history of arithmetic and of curriculum revision; (2) modern definitions of the subject and its aims and purposes; (3) contents of the modern arithmetic curriculum, including criteria for determining contents, modern characteristics of contents, and a few examples of modern contents; and (4) modern methods of teaching the subject.
CHAPTER II

BRIEF HISTORY OF ARITHMETIC AND CURRICULUM REVISION

Early Arithmetic

In this short investigation, no attempt is made to describe the origin of arithmetic in detail. Books have been written on the subject, and yet the whole story may not have been told. In a study like this, however, it seems that a few words should be said about what has already been done to bring arithmetic to its present status. History tells this story; it tells how numbers began. Mathematics is a social study that has a remarkable past. The evolution of the number system is an illuminating chapter of social progress in the world. Sanford shows that:

[mathematics is] a moving stream instead of a stagnant pool; a stream which has been constantly fed by pure springs throughout the centuries of its progress; a stream which nevertheless has often become so saturated with sediment as to unfit its waters for human absorption; and a stream that needs constant filtering if it is to serve this latter purpose.¹

Although from a very early period people seem to have been interested in abstract relationships between numbers,

¹Vera Sanford, A Short History of Mathematics, p. iii.
it is generally conceded that the origin of mathematics was probably utilitarian.\(^2\)

The study of mathematics was carried on by the priests in Babylonia and Egypt. It is very likely that they made little distinction between the utilitarian and the theoretical phases of the subject. In Greece, the theoretical side was closely associated with number mysticism and eventually the two were merged. However, they were treated separately and under different situations. "The practical computations of the merchant were called logistic; the theoretical work of the scholar was called arithmetic."\(^3\)

The need for arithmetic was first felt in the field of commerce, in which mathematics is an important tool. It must be remembered, however, that arithmetical processes have varied throughout their development, but that the basic need has been substantially the same since their advent. Histories of great mercantile families and records of property which belonged to temples are found in the clay tablets of ancient Babylonia. Egyptian commerce was relatively slight until foreign rulers came into the country in 1600 B. C. For a long time after that, trade was not encouraged to a great extent. The situation changed when Pythagoras and others traveled to Egypt in order to study under the Egyptian priests. The Phoenicians carried on active over-land trade by caravans. In addition, they

\(^2\)Ibid., p. 72.  \(^3\)Ibid.
sailed ships to Spain and England for the purchase of silver and tin. Their greatest service in the development of commerce, however, was the designing of ships which were skillful -- so skillful that Solomon had the Phoenician builders build for him. In Greece, commerce was encouraged because there was a lack of certain products in the homeland. The Romans were predominantly interested in agriculture, but trade led them into developing commercial activities.4

In early times, much of the trading was done at the great fairs of various countries and it was done by barter. This was a method in which goods were exchanged directly for other commodities which had the same value. Later on, in the development of commerce, weights, measures, and coinage furnished many problems that demanded a knowledge of arithmetic for their solution.5 The Hindu-Arabic numerals, which replaced the ancient computation system of Europe, originated in the third century B.C. in India.6 It is to be noted, then, that our number system had an origin that was independent of the European system which it replaced.

"Algorisms" characterized the fourteenth century. These works were interesting commentaries on the slow progress of the Europeans as they adopted the new system of numbers and numerals.

6Ibid., p. 93.
Besides containing a discussion of the new numerals, the algorisms frequently included problems showing the application of mathematics to business; and, as if to show that mathematics was not a purely utilitarian subject, puzzles and recreations were given with their full solutions. An anonymous algorism of the fourteenth century now in the Library of the Vatican measures out a single unit of a liquid by means of jugs whose capacities are 8, 5, and 3. The same manuscript also gives the puzzle of the wolf, the goat, and the cabbage that must be ferried across a stream in a boat that will hold but one besides the boatman, the problem lying in the fact that, left alone, the goat would eat the cabbage and the wolf would devour the goat.\(^7\)

Not fewer than three hundred books in arithmetic had been printed in Europe prior to 1600. An interest in education and the increase in commercial activity of the world were the two main causes for this productivity.\(^8\)

The preceding historical facts indicate that the fundamental ideas of computation were known and used at an early period. Systems developed slowly and probably came into use long after a need for them was felt. The reason for the delay in developing the systems was probably due to the fact that the men who were likely to make the development were not concerned with ordinary business affairs.

The preceding data also illustrate the type of arithmetic that was needed to meet the everyday problems of people in the earlier periods. Consequently, it may be said that the history of arithmetic reflects the history of commerce at many points. External conditions of course

\(^7\text{Ibid.}, \ p. \ 29.\)  \(^8\text{Ibid.}\)
varied from time to time, but major problems have continued through the centuries, and required the use of numbers for their solution.

Curriculum Revision

In this investigation, no efforts have been made to discuss the details of the arithmetic curriculum revision. Mention is made of only a few of the steps that have been taken toward modernizing the subject.

In 1902, the reorganization of mathematics had its beginning in America. On this date, E. H. Moore of the University of Chicago delivered an address on "The Foundation of Mathematics" before the American Mathematical Society. The lecture was presented in two parts. The first was a general discussion of pure and applied mathematics, and the second dealt with the change in the teaching of elementary mathematics. After these two important addresses, it appeared that mathematics teachers began to be aroused to improve methods and results of teaching. 9

In 1908, an international committee on the teaching of mathematics was formed in the city of Rome. The committee received reports from many leading countries which showed the types of work done in all types of schools throughout the world. From these reports, mathematics teachers were

9Texas Mathematics Teachers' Bulletin, XV, 21.
given a broader view of what was being done in the field. Comparisons were made and probably many changes came about in the mathematics curriculum as a result of these comparisons. 10

Since 1908, many societies for the improvement of teaching mathematics in the United States have been organized. In 1916, the American Mathematics Association organized the National Committee on Mathematics Requirements. The National Council of Teachers of Mathematics is another organization which has greatly benefited the teachers of mathematics and has sponsored ideas and methods of improved teaching in the field. 11 It was established for the following purposes:

To create and maintain interest in the teaching of mathematics, to keep the values of mathematics before the educational world, to help the young and inexperienced to become a good teacher, to improve teachers, and to raise in general the level of instruction in mathematics. 12

Other organizations in the southern, central, and western states which sponsor the development of mathematics include the Central Association of Science and Mathematics Teachers, the Association of Teachers of Mathematics in New England, and the Association of Teachers of Mathematics in the Middle States and Maryland. The Mathematics Association of America, the National Council of Teachers of

11Texas Mathematics Teachers' Bulletin, XV, 22.
12Ibid.
Mathematics, and the Central Association of Science and Mathematics Teachers maintain branches and sections in the Southwest.\textsuperscript{13}

The Texas State Teachers Association, an organization formed by teachers in Texas and for the benefit of teachers, has maintained an interest in the subject of mathematics for a long time. Articles appear in the Texas Outlook, the official monthly magazine of the association, from time to time, and they serve as a reflector of modern principles and practices.

The Texas Mathematics Teachers' Bulletin is an interesting magazine published by the University of Texas. It is published weekly and edited by members of the University staff. Mathematics teachers have the privilege of using this bulletin as a medium of expressing their own ideas.

The official publication of the Central Association of Science and Mathematics Teachers is School Science and Mathematics, a monthly magazine for teachers. This publication and a similar one, The Mathematics Teacher, seem to contain more material on elementary arithmetic than do the previously-named periodicals. Many other educational publications devote space to an analysis of modern

\footnote{Evelyno Strictland, "An Investigation of Present-day Theories and Practices of the Mathematics Curriculum with Special Reference to the Secondary Schools in Texas" (Unpublished Master's Thesis, Graduate Division, Texas State College for Women, Denton, Texas, 1940), pp. 30-31.}
arithmetical tendencies, all of which make the reader realize that an unusually rapid change is taking place in the subject matter of arithmetic and in the method of presentation of the subject matter. Several years ago, practically all teachers subscribed to the subject-matter curriculum.

They exalted specific skills which they sought to develop and they believed that each big skill was the sum of latent skills, and that mastery of a field of subject matter was the total of subordinate masteries in constituent areas.

Today, with almost the same universality, students of arithmetic adhere to some types of "Gestalt psychology." They are more interested in wholes than in parts, more convinced of the efficacy of insight than of the sufficiency of the reputation, more concerned with understanding than with skill, and more than ever reverent of the mysteries.\textsuperscript{14}

\textsuperscript{14}R. R. Buckingham, "Trends and Solutions in Arithmetic Curriculum," \textit{Mathematics Teacher}, XXI (April, 1938), 330.
CHAPTER III

CERTAIN METHODS OF TEACHING ARITHMETIC

It has been stated previously that no effort has been made to compile complete data on any phase of the investigation; such a task presents unsurmountable obstacles. The tabulations and discussions that follow are mere samplings of the theories and opinions of specialists and classroom teachers regarding modern methods in arithmetic instruction, as they have appeared in various educational periodicals during the period, 1934-1941.

Table 1 presents a listing of certain tendencies in the teaching of arithmetic, and the number of approvals of each tendency discovered in the articles in periodicals examined for this investigation. The tendencies themselves were formulated by the writer from the material contained in articles published in professional magazines.

An examination of the data in Table 1 leads to the conclusion that many of the contributions to periodicals considered in this study emphasized that an understanding of the meaning of concepts is essential in arithmetic instruction; that functional mathematics is more desirable than
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<th>Tendencies</th>
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<td>Practically all number work should be concrete in the primary grades and</td>
<td>11</td>
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<td>should be taught informally</td>
<td></td>
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<tr>
<td>Much arithmetic instruction should be designed and planned in advance,</td>
<td>3</td>
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<tr>
<td>although it may be taught informally and incidentally</td>
<td></td>
</tr>
<tr>
<td>Meaning of concepts is essential in arithmetic instruction</td>
<td>30</td>
</tr>
<tr>
<td>Individual instruction is generally superior to group instruction</td>
<td>3</td>
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<tr>
<td>Functional arithmetic is more desirable than factual arithmetic</td>
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<td>Certain topics in arithmetic should be deferred to higher grades</td>
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<td>The pupils' degree of arithmetic readiness should determine the methods</td>
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<td>and materials of the arithmetic curriculum</td>
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<tr>
<td>Pupil experience and other utilitarian and practical factors should be</td>
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<td>the criteria for the selection of arithmetic content and for the</td>
<td></td>
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<td>determination of methods of instruction</td>
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<td>The isolated problem has little or no value</td>
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<td>Individual differences should be considered in arithmetic instruction</td>
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<tr>
<td>Integration of arithmetic with other subjects or fields of experience is</td>
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<tr>
<td>desirable</td>
<td></td>
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<tr>
<td>Drill in arithmetic should be a tool, and a review, not mere memorization</td>
<td>11</td>
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<td>and repetition</td>
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<th>Tendencies</th>
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<td>An attractive teacher who is interested in mathematics and who has mastered the fundamentals of the subject is an important factor in the arithmetic program</td>
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...factual mathematics; that the pupil's arithmetic readiness should determine the subjects, contents, and the methods of instruction; that pupil experience and other utilitarian and practical factors should be the criteria for the selection of arithmetic content and for the determination of methods of teaching; and that integration of arithmetic with other subjects or fields of experience is desirable.

Organization of Instruction

The organization of instruction in arithmetic seems to center around three prevalent theories: (1) the organized or planned theory, (2) the incidental theory, and (3) the theory which holds that meaning is essential in arithmetic instruction.

The organization of planned theory. -- In an organized program of arithmetic instruction, the course of study has been designed and outlined in advance and is followed more or less closely in the classroom instruction. However, it is to be emphasized that, although the program has been organized in advance, it does not preclude the privilege or
the possibility of using opportunities for motivation, nor
the use of everyday life situations in the plan of instruc-
tion.

In discussing the question of whether an incidental or
organized program of arithmetic teaching is more ef-
fective, De May is of the opinion that all number work in
the first grade should be planned carefully if it does not
arise naturally.\(^1\) It should be taught informally and inci-
didentally as a part of larger experiences and integrated in
every way possible with other work in the grade. In order
to make meaningful the number symbols and their uses, the
teacher must keep before her eight essential objectives:

1. To teach number meanings before presenting
   number symbols.
2. To advance in well-prepared steps from the
   concrete to the abstract.
3. To teach grouping and its importance.
4. To present symbols only after concrete and
   semi-concrete ideas of numbers have been established.
5. To tie up the concrete idea with the symbol.
6. To get the child to have the concepts of
   twoness and threeness.
7. To give meaning to such symbols as are needed
   in the first two grades.
8. To teach enough reading vocabulary to pro-
   vide for problem work.\(^2\)

In the last few years, there has been a widespread
rebellion against formal instruction in arithmetic for the
lower grades. Buswell says:

\(^1\text{Amy J. De May, "Arithmetic Meanings," Childhood Edu-}
\text{cation, XI (June, 1935), 408-412.}\)

\(^2\text{Tbid., p. 412.}\)
These investigations of number abilities and interests of young children reveal a surprisingly large content, so large in fact, that were the school to defer completely its treatment of arithmetic, the children would, of their own accord, necessarily build up some type of experience in this field. 5

Substantiating the preceding theory, Buckingham says that if arithmetic is to serve its best purpose, it should be taught early.

I have no patience with those who would defer the right kind of arithmetic to the middle grades. Concrete arithmetic should begin as early as any educational experience begins. 4

Clayton asserts that in certain schools, no form of arithmetic is taught in the first and second grades. 5 Experimentation in meaning and understanding of numbers are provided the children in their everyday activities. The second-grade children learn addition facts up to ten and the corresponding subtraction facts. This is done by working these facts into the classroom activities and averting too much drill. In the third grade, long column additions have been eliminated, and emphasis has been placed on accurate work in a few important topics.

In many schools the instruction in arithmetic is based on the child's degree of maturity. In California, for instance, textbooks in arithmetic are not issued to children

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below the third-grade level. All work in the primary grades is informal, but not necessarily incidental.\textsuperscript{6}

Closely related to the preceding theories regarding arithmetic in the primary grades is Laughlin's opinion that rational number should be taught in the kindergarten and through the elementary school because quantitative thinking is a part of children's everyday life.\textsuperscript{7} Yet, the first-grade, second-grade, and third-grade pupils should do very little in formal arithmetical processes.

Studebaker agrees that a certain portion of the arithmetic program should be planned, but he is of the opinion that there should be no formal instruction in the first grade.\textsuperscript{8} "The only formal work in arithmetic that can be adequately mastered by first graders is the addition facts which sum up to ten or under."\textsuperscript{9}

Breed and Ralston made a report which dealt with their experiment in the problem of guiding learning activities in addition.\textsuperscript{10} The problem was to determine whether the

\textsuperscript{6}C. W. Webb, "Significant Trends in the Teaching of Arithmetic," Texas Outlook, XXIII (October, 1939), 34.

\textsuperscript{7}Putler Laughlin, "The Teaching of Arithmetic," School Science and Mathematics, XI (May, 1940), 361.


\textsuperscript{9}Carleton Washburne, "The Values, Limitations, and Applications of the Finding of the Committee of Seven," Journal of Educational Research, XXIX (May, 1936), 703.

\textsuperscript{10}Frederick Breed and Alice L. Ralston, "Direct and Indirect Methods of Teaching the Addition Combinations," Elementary School Journal, XXXVII (December, 1936), 283-294.
addition combinations should be taught directly or indirectly. The experiment was conducted in one of the public schools of Tipton, Oklahoma, with groups of pupils from the high-first and low-second grades. In analyzing the general results of the experiment, it was found that the indirect method of teaching the addition combinations was found to bring better results in complex addition and in general skill on addition combinations. In other words, the experiment indicated that integration of arithmetic with other fields of experience was desirable, and that functional arithmetic was more desirable than factual arithmetic.

The incidental theory. -- This theory is centered around the thesis that pupils incidentally absorb all the arithmetical knowledge that they need, and that there is no use for it to be systematically taught. Exponents of this theory contend that arithmetic instruction should come about as a result of the natural activities and interests of the child.\(^{11}\)

In the extreme incidental program of education and teaching, the aim is to utilize the natural interests of pupils in numbers as they present themselves in the classroom activities. Therefore this theory means that number learning is a by-product of the children's classroom activities. "It is a program in which things happen without much design."\(^{12}\)

\(^{11}\)Webb, op. cit., p. 33.  \(^{12}\)De May, op. cit., p. 412.
Wrightstone expresses his opinion regarding the effectiveness of the incidental theory in the following statement: "When pupil efficiency can best be secured through incidental reviews in practical situations, the modern teacher is to exclude unnecessary traditional topics and materials."\(^{13}\)

In an experiment reported by Morrison, which deals with guiding learning activity in addition and which determines whether the addition combination could be taught directly or indirectly,\(^{14}\) and whether the one hundred combinations should be taught in isolation or incidentally, the following conclusions were reached:

1. The interest method or the incidental method yielded better results in complex addition and as good or better results on the addition combinations.

2. The incidental method led to better results both in complex addition and in skill on the addition combinations with the brighter pupils.

3. With the slower pupils, the incidental method yielded as good results as the direct method in complex addition, while the direct method yielded better results on the isolated combinations.


4. In general, the results favored the indirect or incidental procedure.

Harap and Barrett advocate that "the fundamentals can very satisfactorily be learned in a progress of arithmetic units based on real situations in which arithmetic is learned as it is used -- and before it is used."\textsuperscript{15} Benezet noted the children's progress in an experiment in which the pupils had practical experiences in arithmetic in the first five grades, followed by formal instruction in three following grades.\textsuperscript{16} Orleans recommends the value of the incidental method when he says that "teachers should do less 'teaching' so that the pupils may do more 'learning' by themselves."\textsuperscript{17}

The theory of meaning. -- Members of the Committee on Arithmetic of the National Council of Teachers of Mathematics say that in the instruction of arithmetic, meaning is essential. They contend that meaningless drill is of questionable value, but they feel that there is a place for practice and for various attacks in order that the child may secure insights and meanings. In most cases, there should be planned instruction to augment incidental learning.\textsuperscript{18}


\textsuperscript{17}Joseph B. Orleans, "Testing the Ability to Study," Mathematics Teacher, XXIX (February, 1936), 176.

\textsuperscript{18}Webb, op. cit., p. 33.
The wise teacher is the one who knows when and how the social situations involving arithmetic should be employed to give significance to work with numbers, and when and how the more abstract processes should be employed to give greater meaning and understanding to social situations. Nelson says that it is desirable to carry the meaning of numbers to the pupil in such a way that the ordinary natures of quantity may be understood and visualized even by young pupils.\textsuperscript{19} It is desirable to use an understanding basis for problems rather than to rely on the memorization of rules.

Stewart asserts that an intimate relationship exists between knowing and doing in the ideal arithmetic class.\textsuperscript{20} Breslich says that "more attention is paid to the development of understanding of mathematical concepts and laws."\textsuperscript{21} Reid found that concrete uses far exceeded abstract uses in day-by-day activities.\textsuperscript{22} When the meaning was clear, larger

\textsuperscript{19} A. C. Nelson, "The Order of Teaching," \textit{Mathematics Teacher}, XXXII (February, 1939), 135.


\textsuperscript{22} Florence E. Reid, "Incidental Number Situations in First Grade," \textit{Journal of Educational Research}, XXX (September, 1936), 38-43.
numbers were readily used, but fractional concepts were infrequently used.

In an investigation of the concepts of magnitude among young children, Thrum found that an understanding of the meaning of the concepts was necessary. Butler agrees with the preceding statement in the following assertion: "It is reasonable to assume that a child will be able to analyze a situation involving familiar elements more easily than a situation involving elements which are not familiar to him."24

In an experiment, Kramer found that the percentage of error in problem solution was increased by difficulty or unfamiliarity of vocabulary. In a similar investigation, Knight found that an understanding of number names and relations was necessary to the pupils' satisfactory achievement.26

Judd emphasized the desirability of greater emphasis on the informational type of arithmetic -- the type that


requires the understanding of number concepts. 27 Bucking-
ham, 28 Buswell, 29 and Grossnickle 30 agree with Judd. In
conjunction with these opinions, Harap and Mapes declare
that arithmetic which is based on meaningful situations in
the child's experience is highly beneficial. 31 Russell ex-
presses the opinion that an understanding of mathematical
concepts is more important than the factual statement of
the problem.

The child can compare groups of practical num-
bbers up to ten with remarkable accuracy, although he
has a visual knowledge only of three or perhaps
four... The seven-year-old child uses such terms
as many, most, and more. The words same and equal
are not fully compressant... 32

27 Charles H. Judd, "Informational Mathematics Versus
Computational Mathematics," Mathematics Teacher, XXX
(April, 1929), 187-196.

28 P. R. Buckingham, "Informational Arithmetic," Tenth
Yearbook of the National Council of Mathematics Teachers,
pp. 51-73.

29 G. T. Buswell, "The Relation of Social Arithmetic
to Computational Arithmetic," Tenth Yearbook of the Na-
tional Council of Mathematics Teachers, pp. 74-84.

30 F. K. Grossnickle, "Concepts in Social Arithmetic
for the Eighth-grade Level," Journal of Educational Re-
search, XXX (March, 1937), 486.

31 Henry Harap and C. E. Mapes, "Drill Is Not Al-
ways Necessary for the Masters of Facts," Journal of Edu-
cational Research, XXIX (May, 1936), 692.

Journal of Educational Research, XXIX (May, 1936), 662-
683.
In a study of fractions in the sixth grade, Priscon found that improper fractions presented the most serious difficulties. There seemed to be either a lack of clear understanding of what the fraction meant, or a lack of thorough knowledge of the whole number complications in the whole number process. In division, the children indicated a lack of the understanding of the processes involved. They did not seem to know the reason for inverting the divisor. As a result of the experiment, Priscon makes the following suggestion:

Teachers must be prepared to teach the pupil what he needs and not what the course of study, or syllabus, or the textbook happens to contain. If a pupil does not know the combinations of all four operations, his teacher should find out immediately, and then work with that pupil, not on common fractions or decimal fractions, but the fractions not known.

Other exponents of the meaning theory in arithmetic instruction include the following: Powers and Engle, Short,

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33C. Girerd Priscon, "Common Fractions," Grade Teacher, LVIII (October, 1940), 56.

34Ibid.


Reeves, 37 Reid, 38 Studebaker, 39 Duncan, 40 Whitaker, 41 Nelson, 42 Rosander, 43 Russell, 44 and Mallory. 45

Morrison reports and analyzes an experiment in mass method versus individual method in teaching multiplication to fourth-grade pupils in Massachusetts. 46 In the group

37 William David Reeves, "What Are We Going to Do about It?" Mathematics Teacher, XXXII (February, 1936), 181-184.

38 F. E. Reid, "Incidental Number Situations in the First Grade," Journal of Educational Research, XXX (September, 1936), 42.

39 Studebaker, op. cit., p. 199.

40 Myrtle Duncan, "Meaningful Symbols as a Better Preparation for Junior and Senior High School Mathematics," Mathematics Teacher, XXXII (February, 1939), 169.


43 A. C. Rosander, "Mathematical Analysis in the Social Sciences," Mathematics Teacher, XXIX (February, 1936), 294.


46 Morrison, op. cit., p. 345.
taught by the individual method, the motivation was pupil-induced rather than teacher-induced. The teachers in the experiment concluded that the permanent gain of the individual group was higher than the permanent gain of the mass group. In agreement, Studebaker seems to think that formal, individual instruction in various subjects should not be altogether abandoned in favor of group or generalized activity units.\footnote{Studebaker, op. cit., p. 199.}

\section*{Social Utility in Arithmetic}

Wilson believes that functional arithmetic is more desirable than factual arithmetic.

Experiencing and use are the factors that determine the measures or units of measure that are known by children and adults; . . . the teaching of denominate numbers and measures in the schools has small effect beyond little knowledge unless experience and use have come to the pupil.\footnote{D. Wilson, "Teaching Denominate Numbers and Measures," Educational Method, XVI (January, 1937), 181.}

Similarly, Kinney believes that the subject-matter field of mathematics should bring out the social concepts in modern society.\footnote{Lucien B. Kinney, "The Social-civic Contributions of Business Mathematics," Mathematics Teacher, XXIX (March, 1936), 361.} This principle is substantiated by Studebaker in the following excerpt:

So long as children can add one-half and one-half on paper but cannot fill an ordinary drinking glass full of water with approximate accuracy or cut a pie into quarters with the degree of skill
needed at the meal table, we must plead guilty to the charge of failing to raise mathematical instruction to the functional level. 50

Snedden emphasizes the need for functional arithmetic. He declares that "it is rare for any of us in our everyday purchasing activities to employ computations more difficult than those included within the usual arithmetical courses for the first four grades." 51 Wilson and Dabymple say that needed mastery in fractions for common usage should be limited to one-halves, one-thirds, one-fourths, one-eighths, and one-twelfths. 52 They also say that subtraction by a fraction almost never occurs in everyday adult life. They conclude that any further progress in fractions should be purely information and that unusual fractions should be left to the learning of the pupil, when and if needed.

Although no one person or organization can completely express the modern trends in methods of teaching arithmetic, it is believed that the following summary of the opinions expressed by the National Council of Teachers of Mathematics is representative of modern tendencies:

1. Arithmetic is a systematic pattern of thinking about the situations of life in which magnitude and quantity are essential elements.

50 Studebaker, op. cit., p. 302.
2. The functions of instruction in arithmetic are to provide instruction about the nature and uses of the number in everyday experiences, and to help the child to use quantitative procedures in the solution of his problems and of the problems of society.

3. There are two phases of arithmetical instruction, the mathematical and the social. The purposes of the mathematical phase are to train the pupils to attack problems mathematically. The purpose of the social phase is to help the children to understand the contribution that the subject has made possible to the progress of the human race; these insure meaning and significance in arithmetical processes as the children engage in them.\footnote{R. L. Morton, "The National Council Committee on Arithmetic," \textit{Mathematics Teacher}, III (February, 1938), 267-268.}

The committee suggests that since arithmetic is an important means of interpreting children's and adults' quantitative experiences and of solving their quantitative problems, the content should be determined on the basis of its social usefulness. The following recommendations are made:

1. Mathematical processes have a high degree of permanence and coherence, but in their social applications, certain topics may deserve more emphasis in one generation than in another. The basic mathematical concepts and processes remain the same from one generation to another, but the application and utility of them may vary.

2. One effective means of showing children the social significance of arithmetic is to acquaint them with the history of number and with the contributions of number to our civilization. . . .

3. Intelligent mastery of the fundamental processes of arithmetic is dependent upon a thorough grasp of:

   (a) the meaning of number as such,
   (b) the meaning of our number system,
   (c) the meaning of the processes by which numbers are related and to some extent the meaning of the forms used in computation.
Under the influence of the drill theory, the computation skills of arithmetic have been over-emphasized. More attention needs to be given to the non-computational values of arithmetic, such, for example, as are found in the quantitative thinking which should accompany intelligent reasoning.\(^{54}\)

In comparison, Sueltz summarizes modern theories of functional arithmetical work in the following statement:

1. Greater emphasis is placed upon basic concepts, ideas, information, and mathematic principles and relationships than is placed upon intricate and little-used computation.

2. People are beginning to realize that arithmetic plays an important role in the lives of children. It has its inception in the kindergarten and the pre-school experiences of the pupil.

3. On the low-grade level concepts, ideas, information, and vocabulary are introduced long before the final stages of mastery computation are attempted.

4. On the upper-grade level problem-solving becomes much broader and includes such elements as reflection, judgment, and thinking.\(^{55}\)

Other exponents of the functional purpose of instruction in arithmetic include the following: Mallory,\(^ {56}\) Clark,\(^ {57}\) and Charlesworth.\(^ {58}\)

**Deferment of Certain Topics**

Evidences that instruction in mathematics shall see some further changes are found in numerous criticisms made

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\(^{54}\)Ibid., p. 271.

\(^{55}\)Ben A. Sueltz, "Recent Trends in Arithmetic," *Mathematics Teacher*, XXXIII (February, 1940), 277.

\(^{56}\)Mallory, op. cit., p. 24.

\(^{57}\)John R. Clark, "Should Textbook Problems Be Abolished?" *Education*, XXXIV (April, 1934), 456.

regarding its study. One of the most-discussed criticisms is that arithmetic, as it has been taught for the past decade or so, is too difficult for the children to whom it is taught, and that it does not meet the needs and interests of the pupils. It is not unusual for as many as twenty-five or thirty per cent of the pupils enrolled in mathematics courses to withdraw or fail in the work. It is generally believed that the causes of so many failures may be attributed to the fact that many difficult topics in arithmetic, which are found in textbooks and courses of study, are above the maturity level of the child who is required to learn the topic.59

The amount of number work needed by the average pupil in his life outside the school is small, if compared to the amount of arithmetic taught in the average classroom. This implies that too many difficult problems are taught too early in the grades. It is unwise to try to teach a child something before he is able to understand the problem. The inference is that the proper placement of arithmetical topics according to the child's mental age and according to his readiness will probably remove the chief cause of failure in the grade school. It will also do away with the plan that causes many pupils to be rushed through arithmetic to such a degree that at the end of the seventh

grade, they have failed to gain a knowledge of the fundamentals. As a result, they enter high school unable to go ahead with mathematics.

Comparative difficulty, as a basis for grade placement of arithmetical topics, has been attacked because it does not take into consideration individual differences of the pupils within the grade. As a result, much discussion has centered around the deferment of various topics in arithmetic to higher grades. Buswell says that the reason some people argue that arithmetic should be deferred is the fact that there has been a practice of teaching number combinations and number relations as abstract verbal statements without any concrete background.

Arithmetic should not be deferred beyond the primary grades; it should be properly selected and organized to build on the interests and needs that research has shown children possess at the age of entering school. 60

Clayton says that long division is more efficiently and pleasantly learned in the fifth grade than in the fourth grade, and that the harder phases of this subject, which at one time were taught in the fourth and fifth grades, are learned with greater efficiency in the sixth grade. 61 At the present time there is a tendency to teach long division before the child is taught short division,


or to teach short division by the long-division process. When children are not directed as to which method to use, they use the long-division process. An increasingly large number of teachers believe that the main part of long division should come in the sixth grade, and that the main part of decimals should come in the seventh grade. Studebaker and Sisam agree with the preceding theories regarding deferment of certain topics.

In a general way, Buswell summarizes modern trends in grade placement of subject matter in the following statements:

1. Arithmetic needs overhauling as well as deferring.
2. The most valuable in arithmetical instruction is a program of arithmetic in the primary grades developed completely from grade experiences from children and focused primarily upon understanding basic quantitative relationships which are within the experience of young children.
3. The development of such a concrete program at the primary level would provide an understanding which would make the work of the middle grades less difficult and would make unnecessary the deferring of some topics which are now being pushed farther ahead.
4. At the upper grade level certain topics in arithmetic may profitably be deferred and presented during the high school period.

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62Weeb, op. cit., p. 34.  
63Ibid.  
64Studebaker, op. cit., p. 200.  
66Buswell, "Deferred Arithmetic," Mathematics Teacher, XXXI (February, 1938), 198.
Brownell makes the following statement concerning the placement of topics or the grade placement of numbers:

Vary your instruction; supplement the textbook presentation; devise new materials; insert new steps and then teach again. When you are convinced that nothing else will relieve the situation, change the grade placement of topics, but only as a last resort. Moving topics upward is an easy way out, but it may be nothing more than a retreat from your problem. At best it is but a superficial solution, and in the end it may raise more problems than it solves.67

Readiness

Arithmetic readiness is an important problem to be considered before the grade placement of materials and topics is determined. In a discussion of this subject, Moody says that readiness for the formal study of arithmetic presupposes that the child has had much incidental and concrete experience in the necessary concepts, operations, and processes involved.

Readiness is a rectangular process involving biological, psychological, sociological, and educational aspects. Emphasis is placed on the normal biological and psychological organism functioning in a social and educational environment.68

In a discussion of arithmetic readiness, Dickey says that education is rapidly changing its emphasis in the direction of vigilant insistence on meaningful experience as


a true picture of all sound learning. The combined effect of the change in philosophy, psychology, and education over the past ten years has been to direct attention to a search for the various levels of maturation or stages of readiness in the learner. Thus, workers interested in the teaching of arithmetic are now keenly interested in grade placement. "Readiness is the bridge connecting the observable behavior of the learner with the organized overt behavior operating on his level of maturation."  

Washburne also believes that it is necessary for the teacher to understand the children's readiness for learning a given arithmetic topic. He says that there is an imperative need for knowing the pupils' needs as well as their readiness.

Schools continually give too little attention to both factors, not only in arithmetic but in all other school subjects. They attempt to teach children before the children have reached the necessary mental maturity; they attempt to build on inadequate foundations. The result is waste, inefficiency, and frequent failure.  

Brownell emphasizes the fact that many people are beginning to ask the reason for confining fractions to the fifth and sixth grades. They say that even children at

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70 Ibid., p. 593.  
71 Washburne, op. cit., p. 697.
the primary level can understand something about this subject. Investigations show unmistakably that primary-grade children can be profitably taught systematic arithmetic when the problem of readiness alone is considered. There may be reasons for postponing such subjects, but it cannot be attributed to the lack of readiness. In accordance with this theory, Buckingham recommends that teachers should begin arithmetic as soon as the child comes to school, if he is ready and has use for the subject.\textsuperscript{73}

Pupil Experience as a Determinant of Subject-matter Selection

In the progressive or newer-type schools, the general practice is to organize mathematical material in relation to pupils' interests and activities rather than in an unalterable, logical arrangement of subject matter. This type of curriculum permits the pupils to achieve equivalent or slightly superior arithmetic knowledge and skill.\textsuperscript{74} Wesley suggests that numerous opportunities for number experiences arise in the everyday life of young children.\textsuperscript{75} Certain other educators, among whom are Whiteman,\textsuperscript{76}


\textsuperscript{74}Wrightstone, \textit{op. cit.}, p. 381.


Charlesworth,77 Gould,78 and Noyes,79 agree with this statement.

McMurry confirms the theory that arithmetic should deal with vital subjects, child experiences, and everyday problems.80 In agreement, Studebaker prophesies that in the future,

Instead of such topical sequences as rectangles, angles, circles . . . we shall find an organization based on such topics as ways of earning a living, budgeting the family income, buying on the installment plan, planning a savings program. . . . 81

Meeks found that:

The use of mathematical puzzles and games in the class period will serve to pick up flagging interests and to motivate drill work, and to provide enriched activity for the pupil who can do his work in less time than the average member of the class.82

White made an investigation and concluded that a large percentage of children select the right process in solving an arithmetic problem when the situation in the problem is based on child experience.83 It was probably a similar

77 Charlesworth, op. cit., p. 625.


81 Studebaker, op. cit., p. 201.


83 Helen M. White, "Does Experience in the Situation Involved Affect the Solving of a Problem?" Education, XXXIV (April, 1934), 452.
finding that induced Orleans to suggest that the classroom should assume the atmosphere of a workshop. 84

Sprague explains the reason that arithmetic content should be based on the child's life experiences in the following excerpt:

Every individual is fundamentally selfish to the extent that he is essentially interested in matters which concern him personally . . . why not then appeal to the individual pupil as a means of motivating interest in problem solution? One way of doing this is by restating verbal problems so that the names of pupils are used . . . For variation, problems may be chosen that appeal to the interest of particular groups. . . . Problems concerning aviation, games won and lost by athletic teams . . . are likely to interest groups of boys. 85

Connor and Hawkins champion the modern method of selecting arithmetical content in the following sentences:

The best material for use in teaching problem solving in arithmetic, then, seems to be problems selected by pupils themselves from their environment to illustrate the processes they are experiencing to learn to use in problem solving . . . 86

Woody also believes that arithmetical problems should be tangibly related to everyday surroundings. 87 Howe recommends that "to make the work clearer and more meaningful, a motivated problem unit full of practical home-life


87 Woody, op. cit., p. 464.
arithmetic problems may well be used as a background."88

Other exponents of the child-experience method of selection of arithmetical content include the following:
Shea,89 Reeve,90 Wilson,91 Duncan,92 and Wrightstone.93

The Isolated Problem

In the progressive schools, the isolated problem has been abandoned, but in many schools the traditional textbook problems are still in use, although they have little value.94

James describes the isolated problem as a "source of confusion."95 Allphin says it is "a thing apart . . . cold,

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88 Florence R. Howe, "Delving into Real Life through Arithmetic Problems," Education, XXXIV (April, 1934), 477.
89 Mary A. Shea, "An Informational Unit in Arithmetic," Education, XXXIV (April, 1934), 478.
92 Duncan, op. cit., p. 170.
pulseless." Russell says that its use should be discouraged; and Wilson doubts its effectiveness.

The Consideration of Individual Differences in Arithmetic Instruction

Although few references to individual differences in arithmetic instruction were found in the research on the present problem, the writer deemed it wise to include the available data. The scarcity of information on the subject was attributed to its extensive discussion under the general topics in psychology and education.

Woody emphasizes the importance of the consideration of individual differences, particularly when a pupil "fails" in arithmetic. He says that

... a real diagnosis of the difficulty requires a detailed study of the whole child functioning in its total school and home environment as well as in the particular subject or phase of a subject presenting difficulty.

Guiler found that wide individual differences characterized the amount of improvement made in an experiment in teaching fractions in the sixth, seventh, and eighth grades.

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98 Guy M. Wilson, op. cit., p. 460.


100 W. S. Guiler, "Improving Ability in Fractions," Mathematics Teacher, XXIX (February, 1936), 232.
Integration

Within the past few years, much discussion has centered around integration in the curricula of the public schools. In the beginning of the movement, little consideration was given to integrating arithmetic with other subjects. Later, however, much experimentation was carried on in the field of mathematics.

Exponents of the value of integration in arithmetic include the following: Wrightstone, Brown, Moore, Faubel, Studebaker, Woody, De May, Harap and Barrett, and Benezet.

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104 Ruth Faubel, "Arithmetic Worked up from Art," School Arts, XXXV (September, 1935), 52.
105 Studebaker, op. cit., p. 201.
107 De May, op. cit., p. 412.
108 Harap and Barrett, op. cit., p. 189.
109 Benezet, op. cit., pp. 241-244.
Drill

Drill is a general term to cover all instructional devices which are designed to bring about repetition and unvarying practice on the part of the child. In the case of arithmetic, drill takes the form of flashcard exercises, rapid oral games, timed written tests, memorizing tables, and similar procedures.\textsuperscript{110}

Brownell seems inclined to believe that a certain amount of drill is necessary.\textsuperscript{111} At least, he infers that some planned work should be included in arithmetical instruction. He says that teachers are not likely to recognize the need for systematic instruction in quantitative thinking, if they allow the social ends of arithmetic to dominate their planning. In addition, he says that they are prone to overlook the fact that arithmetic has meanings and relationships which necessitate thorough instruction, as do other branches of knowledge, because arithmetic is an organized body of concepts, principles, and processes.

Stretch's opinion regarding drill parallels the preceding theory. "While drill does not yield an insight into number meanings, it does assist the pupils to form efficient

\textsuperscript{110}Lorena B. Stretch, "The Value and Limitations of Drill in Arithmetic," \textit{Childhood Education}, XI (June, 1935), 413-416.

habits of number manipulation and keep these habits at a high level of usefulness."\textsuperscript{112}

A similar opinion regarding drill is expressed by Wilson in the following excerpt:

\textit{The cold-storage view of little-used topics in arithmetic must be replaced by an informational reference viewpoint. Drill must be deferred and kept well behind meaning and must be limited to useful tool materials.}\textsuperscript{113}

Wilson summarizes his theories regarding drill in the following statements, which are not quoted directly, but which contain the essence of his discussion:

1. All systematic drill should be deferred until the third grade.

2. Older children need multiplication as well as addition and subtraction. These children learn very little division, since apparently they have little use for it.

3. Adults do not need much division. Therefore, if long division is taught at all, it should begin in the fifth or sixth grade at the earliest.

4. The frequency of adult usage of the four fundamentals is as follows: (1) multiplication, (2) addition, (3) subtraction, and (4) division. Most adult usage of fundamentals is fairly simple in form. Multiplication

\textsuperscript{112}Stretch, op. cit., p. 415.

\textsuperscript{113}Guy M. Wilson, "Useful Drill," Journal of the Mathematics Education Association, LVIII (March, 1938), 84.
usually has one, two, or three multipliers. Most addition is only two or three columns. Subtraction is largely for counting change. Division is usually simple, having one or two digits in the divisor.

5. Beyond the fundamentals there remain the processes of percentage and interest. These are not child processes. They are strictly adult. If percentage and interest are taught, they can be included in a reasonable manner, in grades seven and eight.

6. Fractions should never be included in a drill program. They are taught better through well-planned informational units.

7. Decimals require reading knowledge only, no drill.

8. Drill is likewise not a suitable method for teaching compound numbers, weights, or measures.

It appears that some confusion exists in regard to the meaning of drill. To some, it is mere memorization and rote repetition, but to the majority drill means a continuous review. Regarding the former interpretation, Harap and Mapes say that mere repetition does not appear to aid mastery; it must be purposeful review.114

Brownell and Chazal are of the opinion that

In spite of long-continuous drill children tend to maintain the use of whatsoever procedures they have found to satisfy their number needs . . . drill

makes little, if any, contribution to growth in quanti-
titative figures by supplying maturer ways of drill-
ing with numbers . . . drill is extremely valuable
for increasing, fixing, maintaining, and rehabituat-
ing efficiency otherwise developed. 115

To summarize, it may be said that in the extreme drill
tory, arithmetic contents are analyzed by units which are
usually similar and relatively connected. The child is re-
quired to master these units whether or not they are under-
standable to him because the teacher feels that the child
will need them in his adult life. Modern educational prin-
ciples have caused this theory to lose some of its popu-
laritv, but it is not yet abandoned. It does not fit in
with modern educational philosophy because it tends to neg-
lect the social phase of arithmetic. It does not help the
child to understand the ways in which the race has been
benefitted by numbers, and it does not help him to under-
stand that he needs to develop the ability to apply the use
of numbers in solving his everyday problems. 116

The Teacher and Arithmetic
Instruction

Wiggins says that the one singularly essential factor
in the building of a good mathematics program is a teacher
who is interested in the subject, and who has a mastery of

115 William A. Brownell and Charlotte B. Chazal, "The
Effects of Premature Drill in Third-grade Arithmetic," Jour-
nal of Educational Research, XXIX (September, 1938), 26.

the subject and a realization of its applications. It is believed that a successful teacher of arithmetic must not only be highly trained in the subject, but also he must have an enthusiasm for teaching the subject, and must, in addition, have an insight into the psychology of learning.

A vicious, widespread practice is that of assigning a teacher who has had no special training in arithmetic to teach a class in this subject. In many instances he knows little about the subject and sometimes is not even interested in the field. It seems, then, that the problem of improving the methods of mathematics should begin with the improvement of the teachers of mathematics. Bond classifies arithmetic teachers into three major groups; however, the members in each group generally do not adhere strictly to the point of view of either group to the exclusion of others. Consequently, it is a borderline going from each group to the other. The procedures carried on by the three major groups of teachers are generally of the following three types:

1. One group of teachers spend the major part of their time for arithmetic upon "facts" and "processes" of computational arithmetic.
2. Others give little instruction in number directly. What training there is in number comes as an incident to other situations that are engaging the children's interests at the moment.

3. Still other teachers make a conscientious effort to build a meaningful science of number that will meet the needs of otherwise well informed citizens of modern society.\textsuperscript{118}

Beatty says that mathematics teachers may continue to teach the highly isolated mathematics which has so long been invoked, or they may reorganize the subject of instruction in terms of present-day problems.\textsuperscript{119} As another alternative, they may broaden the scope of arithmetic instruction so as to give pupils actual experience in the economic, psychological, and cultural setting in which quantitative thinking is necessary.

Morton makes the following recommendations regarding the training of arithmetic teachers:

1. The minimum experience in mathematics of college grade for teachers of arithmetic should be organized in a year's work of six to ten semester hours.
2. The college mathematic experiences of arithmetic should be secured through the medium of courses specially organized for this purpose.
3. The teacher of the college mathematics course which is designed for prospective elementary teachers should be a special selection for this purpose; there are many teachers of college mathematics who will not qualify.
4. A college course in mathematics designed for the professional preparation of teachers in arithmetic should be organized cooperatively by a group of mathematicians. Such a course should be planned

\textsuperscript{118}E. A. Bond, "Improving Instruction in Arithmetic," Mathematics Teacher, XXXIII (January, 1946), 195.

\textsuperscript{119}W. W. Beatty, "The Role of Mathematics in the Twentieth Century Curriculum," Mathematics Teacher, XXXII (February, 1937), 218.
as a six-semester-hour course with prescribed additions for making it an eight-hour-course or a ten-hour-course.\textsuperscript{120}

Mallory believes that a teacher's personality is a very important aspect of arithmetic instruction.\textsuperscript{121} In addition, other factors should be considered.

Preparation means first a thorough mastery of the subject matter; a genius cannot teach others a subject he does not know himself. Preparation implies sincerity of purpose; the teacher should have a will to teach, not merely to hold a teaching position in order to make a living while he is doing or preparing to do something else.\textsuperscript{122}

\textbf{A Few Examples of Modern Arithmetic Instruction}

The rapid evolution in elementary-school arithmetic methods is probably a result of the teacher's recognition that a high per cent of all sensory impression is visual.\textsuperscript{123} Training in abstract thinking is very desirable for adults, but for the child, the ability to think abstractly is a difficult accomplishment. Because of a child's limitations of ability to think abstractly, he uses imagery as a principal work of thought and is the accumulation of ideas. As a result, visual materials have become highly important in the teaching of arithmetic.

\begin{itemize}
\item \textsuperscript{120}R. L. Morton, "Mathematics in the Training of Arithmetic Teachers," \textit{Mathematics Teacher}, XXXII (January, 1939), 100-110.
\item \textsuperscript{121}Mallory, op. cit., p. 23.
\item \textsuperscript{122}Anonymous, "All Non-mathematicians Barred," \textit{School Science and Mathematics}, XXXV (June, 1935), 661.
\item \textsuperscript{123}Verti Buchanan, "Arithmetic Unit Work," \textit{Texas Outlook}, XX (May, 1936), 29.
\end{itemize}
Buchanan describes a home-building project used in a seventh-grade arithmetic class. In the activity the pupils were brought face to face with problems that were important in everyday living. They discussed lumber, paint, paper, terracing, sodding, concrete, walls, lights, wires, and every other item connected with home building.

The result of the discussion was a plan for building a modern home. Many plans were drawn by the pupils and discussed from the standpoint of style, economy, convenience, and adaptability to the size of the lot selected. A table was used for the lot. After the pupils agreed upon a plan they began to collect materials. When they started the measuring and sawing of materials, great care was used to make every piece as planned and drawn. As the pieces were produced they were discussed and defined as belonging to a specific group, such as rectangles, squares, triangles, or other surfaces. The areas of the parts were figured by use of formulae applicable to each particular surface and the information was kept in a notebook. When the pieces were assembled the total external surface was easily found. From this information they were able to estimate cost of papering and painting. After the house was completed, the yard was terraced and sodded with green grass and concrete walks were built. The plan of the house and lot was drawn to a scale of five-sixths of an inch to one foot. All materials and cost of labor were figured at current prices.

The results obtained in the home-building project are important because the plan involved a genuine purpose and much activity on the part of the pupils. The house is a product which they consider their very own. They have before them a real situation which they have met.124

The construction of the house helped the children to gain control of the facts and processes used by contractors in the modern buildings. It acquainted the pupils with

124 Ibid.
business and industrial methods. It taught them the uses of tables, of measurements, of charts, and of simple tools of measurement. They became acquainted with areas of squares, rectangles, and triangles, and with the volumes of solids. The entire unit developed an ability of accuracy in the development of concrete material.

Another example of making arithmetic interesting was carried on in the Brownsville, Texas, public schools and reported by Osborne. A miniature city was built as an arithmetic project. In carrying on business of the town, the pupils figured profit, loss, commission, retail, and wholesale prices, successive discounts, made checks, borrowed money, made out promissory notes and chattel mortgages, and figured amounts of sand, gravel, and cement needed in paving streets and walks. The culminating activity was an exhibit of the completed city, together with maps and plans of the parks, homes, and business sections. The unit was very interesting, and the children lived in learning situations. They experienced arithmetic.

MaThoney reports that units using the experiences of children and making use of life situations involving numbers were successfully carried out with an unselected group.

of first-grade children. In the beginning, during the first two months, time was spent in gaining concepts of numbers of one through ten. It was found that the most effective use of doing this was to use the children themselves and the tools with which they were becoming familiar, such as books, pencils, desks, and chairs. The work was supplemented by the use of jingles involving number sequence, and the jingles were accompanied by number action. Bookkeeping was introduced in order to determine what experiences children were having with money. Reports were made daily regarding the errands the children had run, the money that they had spent, and the money that they had received. Fourteen Jewish children were given experience in number work in connection with the Feast Chanukah, which embraces the custom of giving gifts similar to the custom of exchanging Christmas gifts. A custom of this feast is that of lighting candles. The first day one is lighted, the second day two are lighted, and so on through the eighth day. Each one of the Jewish children kept an account of the candles lighted and each one made a report on the following morning.

In the same class, one boy was starting his business career as a bootblack. He brought his shoe-shine box to

126 Olive G. Mahoney, "Number Experiences," Grade Teacher, LVI (November, 1938), 32.
school and three children were selected to get a shine. The first paid five cents to get his shine. Toy money was just as good as real money in such an experience. The second paid a dime and received a nickel in change. The third paid five pennies, and took them from a pocketbook which contained twelve pennies. Such procedures added number facts to the already growing amount of information which the child had accumulated through other procedures.\footnote{127}

Another example of meaningful and social arithmetic is presented in a discussion by Wegner, in which he said that in Roslyn Heights, New York, the schools are attempting to give the pupils true, meaningful experiences in mathematics.\footnote{128} The school children are permitted, as far as possible, to participate in the daily school program. For instance, certain pupils' obligations are fixed by time schedules; the stock-room and the library are in charge of certain grades; school supplies are regularly requisitioned and costs figured; a school bank is maintained; and a careful savings-account record kept. Some of the upper grades have organized a 4-H Club, and some of their activities are to draw a plan of the school grounds and plant flowers and care for the grass. The

\footnote{127} Ibid., p. 74.  
\footnote{128} F. R. Wegner, "Arithmetic Skills," \textit{Grade Teacher}, XLVIII (April, 1941), 61-75.
children also take extensive motor trips and figure the cost of the trips, mileage, and approximate cost of their lunches and drinks. They make their own health examinations and conduct their own height and weight measurements as well as determine the age-weight relationship. Every morning milk is delivered to all the rooms, and this gives an opportunity for counting and determining the cost.

The children get many of their best opportunities for arithmetic experiences from their social studies. For example, if it is necessary to draw a map, some time is devoted to the study and meaning of scale drawing. Gradually, the pupils are presented with the harder problems of life, such as the meaning of wages, living costs, and working hours. These activities enable the children to develop skill in ferreting out the facts and in determining a true basis for action.

The preceding examples of meaningful arithmetic instruction lead to the conclusion that in many communities the integrated curriculum makes possible the relation between arithmetic and other subjects. These examples also attach some question to Tidwell's thesis that the textbook largely dominates classroom projects in the American schools.129 However, it cannot be disputed that in some places, at least, textbooks are a powerful influence in

129 Clyde J. Tidwell, *State Control of Textbooks*, p. 3.
the field of instruction, and, to a large degree, they determine what arithmetic will be taught and how it shall be taught. Strickland suggests that there may be three reasons for these facts. The first is that mathematics teachers are inefficiently trained; the second is that competent and professional supervisors are not generally provided; and the third is that reference materials are generally scarce and inadequate.

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130 Strickland, op. cit., p. 42.
CHAPTER IV

THE ARITHMETIC CURRICULUM

Probably all educators agree that no curriculum can remain static and be continuously effective over a long period of time. During the last two or three decades, many signs of unrest and dissatisfaction have been in evidence among the teachers of arithmetic. The general public, as well as many educators, seems to be skeptical regarding the methods and the content of the arithmetic curriculum. In some instances, both have become skeptical regarding the value of teaching this subject in the public schools. Mathematics has been placed on trial, so to speak, because some people have said that it affords no practical value for the mass of our people. Both in public service and in private enterprise, the problem with which people are required to cope is varied and unprecedentedly complex. Its solution calls for an unprecedented richness of information, insight, and intelligence. The situation calls for an increased quantity and an intensified quality of educational instruction.
Many of the patterns of our educational system, like many of the patterns of our political and economic orders, were designed to meet the simpler and more highly personalized life of the pioneer era. And to a degree that seems to some indefensible they reflect also an era in which education was pre-dominantly a source of passive culture of a leisure class and of preparation for the learned professions. The schools must still keep going that relay race of human progress and spirit in which, from generation to generation, the seasoned wisdom and matured beauty of the centuries are handed on. For the learned professions the schools must now provide a richer and more rigid training than ever before. But the life that made these the dominant, if not exclusive demands upon education is not the life of contemporary America. And to the degree that we depress the present trends and persist in educating for social situations that no longer exist, we depress the effectiveness of education and intensify every latent skepticism of its processes.¹

Any subject in the public-school curriculum cannot be justified merely on the ground that it has been offered for a long period of time. On the other hand, no instruction can justly be eliminated because it represents tradition in the schools. Sounder reasons must be found.

It would be utterly impossible to disregard the entire arithmetic curriculum and form a new one, because the ultimate truths of numbers do not change. In truth, many people believe that a great amount of instruction which was formerly performed in arithmetic should not be eliminated but should be reorganized in such a way that the old subject matter will fit in with modern educational theories and tendencies, supplemented with needed new material.

¹Glenn Frank, "The Double Crisis of the Schools," Texas Outlook, XIX (April, 1935), 12.
The purpose of this chapter is to set forth some of the arithmetical curriculum principles that have been discussed by specialists and by arithmetic teachers in various school magazines and bulletins during the period of 1935 to 1941. Of course, it would be futile to try to mention all of the subjects discussed by all of the writers in all of the magazines. That would be an endless, tiresome, tedious, and probably unworthy undertaking. However, an effort has been made to present a sampling of the seemingly most significant problems in several of the outstanding educational publications. It is hoped that the compilation will help teachers to understand why arithmetic is the chief cause of children's failure to pass from one grade to another above the second grade, and why this subject is probably the most frequently disliked subject in the elementary curriculum. It is also hoped that the investigation will enable teachers to understand why it is often heard that pupils finish high school and go out into the world to find their training in arithmetic inexplicably unmeaningful and inadequate.

It is the writer's wish that this study may serve to inspire teachers to more thorough and more profound scholarship, so that they may better explore, with their students, this subject which, with the other sciences and

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the arts, is one of the most important concerns of mankind. "The best in the teaching of mathematics is yet to be." 3

Definitions of Arithmetic and Its Aims and Purposes

The Committee on Arithmetic of the National Council of Teachers of Mathematics has offered the following definition of arithmetic: "A systematic pattern of thinking about and attacking life situations which have as their essential element -- order, magnitude, or quantity." 4 From this definition it is to be seen that this group thinks that the teaching of the nature and the use of numbers in daily life is the primary function of arithmetic. This, of course, is to be done for the purpose of helping pupils to utilize quantitative procedures in achieving their purposes and those of the social order to which they belong.

In agreement with the preceding definition, Stretch defines arithmetic as "a system of quantitative thinking," 5 while Sueltz describes it as "the universal language of commerce." 6

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6 Sueltz, op. cit., p. 270.
There are many varieties of arithmetic. There is the arithmetic of the drill exponent -- a vast host of separate facts and skills to be mastered through ceaseless repetition. There is the arithmetic of the extreme activist or the incidentalist -- a few superficial notions to be acquired as occasion permits. There is the arithmetic of the mathematician -- a closely knit system of quantitative relationships to be learned only through intelligent appreciation of those relationships. There is the arithmetic of social usefulness and the arithmetic of the special arithmetic period with a single basic text. There is the arithmetic of meaning and understanding and the arithmetic of unintelligible tricks and number stunts. There is arithmetic as a "tool subject" and arithmetic as a mode of exact thinking.7

Other exponents of the functional purpose of teaching arithmetic are Hartung,8 Clark,9 and Nelson.10

An analysis of the aims and purposes of arithmetic, as found in recent educational publications, leads to the conclusion that the core of the elementary-school arithmetic curriculum should be social arithmetic. The work should center around the interests, needs, and development of the pupil. It should give him a large social insight and understanding of functions of numbers in daily life. The pupil should be given an opportunity not only to understand the functional value of various processes, but also he should be given opportunities to apply these processes


in a meaningful way. Such processes should be assigned to grade levels in which they can most readily and effectively be understood by the child.

The primary purposes of teaching mathematics should be to develop those powers of understanding and of analyzing the relations of quantity and of space which are necessary to an insight into and the control of our environment and an appreciation of the progress of civilization -- its various aspects are to develop those habits of thought and of action which will make those facts effective in the life of the individual.\(^\text{11}\)

Strictland says that it is to be inferred from an examination of both state and local courses of study that mathematics should teach the pupil to think and reason for himself, rather than to go through a process of memorizing.\(^\text{12}\) They should be urged to state principles and rules in their own language, rather than from memory.

When the question is asked, "Why do we teach arithmetic?" the answer is that our society is largely quantitative. In order to live effectively, we must be able to interpret accurately and to adjust correctly to this quantitative aspect of our society. When taught properly, arithmetic provides an individual with an expert method of thinking quantitatively, and provides him with a means of more adequate social participation. The inference is that the reasons for teaching arithmetic are mathematical

\(^{11}\) Leo J. Brueckner, "Deferred Arithmetic," Mathematics Teacher, XXXI (February, 1938), 292.

\(^{12}\) Strictland, op. cit., p. 61.
and social; but they are mathematical because they are social. A teacher surely is not justified in teaching arithmetic merely to produce mathematical skill. That skill must not be the end; it must be the means to an end.

Content of the Arithmetic Curriculum

It has been said that half of the arithmetic which is being taught today in the public schools should be postponed at least two years, and the other half should never be taught. A change in the philosophy and the psychology of education has taken place within the present century and primarily within the past decade. The emphasis has been shifted from traditional practices to personality development, with social utility playing an active part. The effect of the changes has directed attention to such problems as the child’s maturation, stages of readiness, and personality development.

By conducting inventories of the number of abilities of children before or just after their entrance into school, it has been found that the first-grade children already possess an equipment of number knowledge for actual use that is far larger than it was once supposed that they possess. Their abilities, for the most part, function satisfactorily only with concrete objects and in concrete

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13 Webb, op. cit., p. 33.
situations. They are not capable of learning abstract arithmetic when presented through the usual mechanical and drill techniques and devices. These children learn much about numbers when the instruction is presented informally and incidentally as a means of meeting the children's needs. Investigations also show that the older type of arithmetic instructions are not valuable in the lower grades.  

Today, the trend in the selection of the content of arithmetic is based on its social usefulness and on the possibility of effective use. For a number of years, there was an immense amount of relatively useless arithmetic found in textbooks, but scientific studies have been instrumental in limiting such items as the following: troy weight, mensuration, cube root, proportion, annual interest, compound interest (except savings), reduction and denominate numbers, and confusing problems of fractions and the fundamentals.  

There is a decided trend to postpone the teaching of many concepts until the child is sufficiently matured to make the development of the processes possible and meaningful.

Criteria for determining content. -- Probably the greatest criticism of the teaching of mathematics, according

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to modern tendencies in education, is that the study and
teaching of this subject do not consider the needs of the
children. It is often heard that unless a subject can help
the pupil to interpret his environment and enable him to
meet situations more easily and effectively, that subject
has no place in the modern educational curriculum.

Another criticism which is often heard is that the
subject of arithmetic is dull and uninteresting, and that
it is forced upon the pupils. All of this leads to the
problem of making the subject more practical and of vitaliz-
ing the curriculum in terms of the pupil's interests and
needs. There are two kinds of arithmetic, social arith-
metic, and formal arithmetic, and they are not antagonistic.
They should be used in a mutually reinforcing and enlight-
ening way.16

The past few years have witnessed a sharp tendency
toward greater recognition of the social value of arith-
metic. Certain topics, which were formerly important,
have been eliminated from arithmetical instruction because
they are not useful. They have been replaced by concen-
trated instruction on material which appears in connec-
tion with children's natural actions and needs.

The mathematical and the social purposes of arith-
metical instruction are complementary.

16J. T. Johnson, "Curriculum Revision in Elementary
Mathematics in Chicago," Mathematics Teacher, XXXI (March,
1938), 325.
To the extent that the child understands the mathematics of arithmetic, he is capable of more intelligent social participation; and the more successful he is in using his arithmetic, the more anxious he is to master the mathematics of arithmetic.\textsuperscript{17}

It seems, then, that a well-balanced curriculum should provide for instruction, both on the mathematical side and on the social side of arithmetic. In order to think expertly in quantitative situations, pupils must be shown how to think, and they must be given practice and guidance in this type of thinking. Individuals cannot be intelligent in dealing with problems that require such thinking if they lack insight into the nature of number.\textsuperscript{18}

If the mathematical end of the arithmetical instruction dominates the teacher's planning, he is apt to give inadequate consideration to the social purposes of the subject. If boys and girls are to be trained to employ their number knowledge for anything besides working problems in the book, they must have experiences in using arithmetic.

The social values of number can be appreciated only when number is used in a manner which is socially valuable.\ldots Arithmetic ideas and processes are taught, as it were, in vacuum, in the pious hope that once they have been learned apart from use they will somehow and sometime function in use.\textsuperscript{19}

\textsuperscript{17}W. A. Brownell, "Arithmetic in the Curriculum," \textit{Texas Outlook}, XIX (August, 1935), 46.

\textsuperscript{18}\textit{Ibid.}, pp. 46-47.

\textsuperscript{19}\textit{Ibid.}, p. 47.
It is to be inferred from this statement that it is fallacy to expect a child to show intelligence in using skills when no intelligence has been showing itself in the process of acquiring those skills.

As another criterion for determining the content of the arithmetic curriculum, Myers says that verbal problems should be interesting enough to cause the child to create in his imagination the real situation with which the problem arose. 20 In other words, it is not enough that the content be familiar; it must also have some emotional appeal. Many verbal problems could be employed for the use of all the number facts as soon as they have been definitely learned. The more unusual the problem is and the more it appeals to the pupil's imagination, the greater will be his response to its actual meaning. 21 Verbal problems should be written on the board, mimeographed, or printed rather than dictated. In dictation, the teacher endeavors to make the problem short so that the pupil can keep all of it in his mind. Short problems do not contain the most interesting and the most vital and vivid items. Longer problems contain an interesting appeal. 22 The purpose of making verbal problems interesting is to induce the pupil

20 Gilbert C. Myers, "Verbal Problems," Grade Teacher, LIII (February, 1938), 46.
21 Ibid.
22 Ibid.
to live in his imagination the incident described in the problem. 23

**Characteristics of the content of the modern arithmetic curriculum.** -- Within the last few years there has been a decided trend toward eliminating number content from the field of arithmetic in the primary grades. In its place, concrete arithmetic is taught, and the child is provided with a fund of rich number meanings and a wealth of number experiences in order that he may be able to think in quantitative terms. If a child is to be able to do this, he must have a suitable vocabulary. In other words, arithmetic is being taught not as numbers but as words. The child is able to find many numbers expressed as words in his reading texts, such as time, size, location, and quantity. Although certain readers contribute to the arithmetical vocabulary needed by the child in the primary grades, the teacher must supplement the information by providing opportunities for making numbers meaningful and for helping the child to become number conscious.

Wesley agrees with those who have said that the most recent trend in arithmetic is the tendency toward the elimination of abstract numbers in the content and replacing this elimination with natural situations. 24 Whether it is

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23 Ibid.

best to abstract early arithmetic from its social settings or not, the fact remains that the use of numbers in the child's home and community environment and the carrying out of his own plans and enterprises is probably the most vital part of the child's arithmetic experience.

In many curricula, the most familiar proof of the effective use of practical numbers in school is the fact that the pupils' activities touch directly on their daily lives. A few of these experiences are counting, telling time, playing games, playing house, playing store, and building things. If the teacher wishes to capitalize on the child's natural number contacts and provide or stimulate others, he must be aware of the following fundamental facts:

1. growth in number knowledge and ability requires a background rich in social experience;
2. effective guidance demands a knowledge of the various aspects of numbers and a realization of the value of cumulative experience as a working basis for the manipulation of numbers; and
3. sensitivity to fine distinctions and meaning in number concepts and vocabulary finds and creates many real opportunities for number experience.

Buckingham summarizes the opinions of many teachers when he describes the school's task in respect to arithmetic as follows:

There is an illiteracy in dealing with ideas expressed by numbers just as there is an illiteracy
in dealing with ideas expressed by words. In each case, computance, or literacy, is something more than the manipulation of symbols. It is an appreciation of the meaning attached to the symbols, and ability to apply the symbols in order to facilitate thought. 25

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this investigation was to compile and present the results of a survey made of the opinions, theories, and practices related to the teaching of arithmetic as found in certain periodicals published during the period of 1935 to 1941.

The introduction to the problem gives a brief outline of the study for the purpose of orienting the reader and making it possible for him to visualize quickly the scope of the problem.

The discussions of the historical background of arithmetic and of curriculum revision show briefly the early forms of the subject and early efforts toward revision. Data on modern theories and practices in the teaching of arithmetic consist of descriptions of the opinions and methods advocated by various arithmetic specialists, classroom teachers, and other educators who have prepared articles for various educational periodicals during the period 1935 to 1941.
Conclusions

An analysis of data secured in this investigation leads to the following conclusions:

1. A study of the early history of arithmetic leads to the conclusion that each nation of the ancient world invented its own number system, and thereby made a contribution to civilization. The subject has been shaped and determined by the needs of society and by the theories and practices of innumerable educators through long periods of development and adjustment. It is a social study with a remarkable history which indicates that fundamental ideas of computation were known and used at an early period.

2. From an analysis of the curriculum revision in the mathematical field, it is concluded that the reconstruction program in reality began in the early part of the twentieth century and has continued to operate until the present time.

3. It is concluded, in general, that the purpose of arithmetic is to train the individual to think and reason for himself in order that he may live satisfactorily, personally, and that he may contribute effectively to his group.

4. An analysis of data used in this study leads to the conclusion that the content of the arithmetic curriculum, in all of its phases, should be determined largely
by its social usefulness and should consist of number concepts and relationships which may be effectively used. If readiness in the use of subject matter is to be the aim in arithmetic, the activities included in the instruction must be natural activities, else the learner will not engage in them readily and will not understand them. Functional arithmetic is more desirable than factual arithmetic.

5. Among the causes for failure and the dislike of the subject are the following: (1) abstractness, (2) general uselessness to the child's daily needs, and (3) disregard of the child's psychological readiness.

6. Examples of arithmetic instruction based on children's interests and needs indicate that social arithmetic is valuable and desirable. Consequently, within the past few years there has been a decided trend to eliminate abstract numbers from the primary-grades arithmetic curriculum and to integrate the mathematics program throughout the elementary period with the larger school program.

7. It is concluded that readiness is the basis for the determination of grade placement of certain topics and the method of teaching.

8. When modern arithmetical methods are considered, it is concluded that, in general, the organization of instruction centers around the following three prevalent
theories: (1) the organized or planned theory, (2) the incidental theory, and (3) the theory of meaning.

9. Pupil experience and other utilitarian factors should be the criteria for the selection of contents and methods in the teaching of arithmetic.

10. An analysis of the preceding data leads to the conclusion that modern tendencies in methods of teaching arithmetic are a challenge for the teacher to recast the traditional methods and procedures so that he may retain whatever is in them of sound, vigorous, and consistent material, and yet at the same time make them pertinent to the everyday experiences of the pupil.

Recommendations

After a careful investigation and analysis of the data pertaining to the problem under consideration, the following recommendations are made:

1. All teachers of arithmetic should be aware of the ideals, goals, problems, and significant trends which the organized profession has approved and is striving to achieve.

2. All teachers of arithmetic should experiment with the modern theories, methods, and practices advocated by others in the mathematics field and incorporate into their own arithmetic programs those theories, principles, and
practices that are most desirable and most effective in local situations.

3. Further research should be done on the problem of determining what methods and materials are most worthwhile for the all-round development of pupils and for the advancement of arithmetic as an important part of the public-school curriculum.
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