A Study of Stern Structural Materials in Arithmetic in the First and Second Grades

Hilda N. Arnold

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A STUDY OF STERN STRUCTURAL MATERIALS
IN ARITHMETIC IN THE FIRST AND SECOND GRADES

Research 699
July 1962
Hilda N. Arnold
A STUDY OF STERN STRUCTURAL MATERIALS
IN ARITHMETIC IN THE FIRST AND SECOND GRADES

A Research Project Submitted
In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Education

The State University College
at Brockport, New York

by
Hilda N. Arnold
July 1962

Director of Graduate Studies

Faculty Advisor
Preface

This research deals specifically with an experiment in exploring the possibilities of using the Stern Structural Arithmetic Materials as basic instructional equipment in all first and second grades in the Rochester City School District. Number 41 School is one of the experimental schools in this project and the recordings in this paper deal specifically with the findings at this focal point.

The time limit has been set tentatively for three years. The first year, 1960-61, the materials were introduced in one first and one second grade. The same procedure was used this current year, 1961-62. Next year, 1962-63, all first grades and all second grades will use these materials. The present first grade will continue to utilize Stern Structural Materials in second grade. This sequential order of teaching will tend to give more validity to the experiment since the children will have been exposed to the Stern Structural Materials for two successive years.

This research tends to indicate that Stern Structural Materials are fully in accord with modern trends and possibilities as a new approach to primary arithmetic learnings.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. RECOGNITION OF THE PROBLEM</strong></td>
<td></td>
</tr>
<tr>
<td>Understandings Basic to Experiment</td>
<td>1</td>
</tr>
<tr>
<td>A Scientific Approach to Problem Solving</td>
<td>4</td>
</tr>
<tr>
<td>Child Development and the Arithmetic Program</td>
<td>6</td>
</tr>
<tr>
<td>Curriculum Provision for Growth</td>
<td>9</td>
</tr>
<tr>
<td><strong>II. DEFINITION OF THE PROBLEM</strong></td>
<td>11</td>
</tr>
<tr>
<td>Understandings Basic to the Organization of the Curriculum for Effective Teaching</td>
<td>11</td>
</tr>
<tr>
<td>Need for Materials in the Primary Grades</td>
<td>12</td>
</tr>
<tr>
<td>Description of Stern Structural Materials</td>
<td>14</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>17</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>18</td>
</tr>
<tr>
<td><strong>III. PROCEDURE</strong></td>
<td>21</td>
</tr>
<tr>
<td>Research Design</td>
<td></td>
</tr>
<tr>
<td>A. Description of Groups</td>
<td>21</td>
</tr>
<tr>
<td>B. Time Schedule</td>
<td>23</td>
</tr>
<tr>
<td>C. Criteria for Selection of Teacher</td>
<td>24</td>
</tr>
<tr>
<td>D. Evaluation Techniques</td>
<td>24</td>
</tr>
<tr>
<td>Assumptions of the Experiment</td>
<td>24</td>
</tr>
<tr>
<td>Delimitations of the Experiment</td>
<td>26</td>
</tr>
<tr>
<td>Presentation and Analysis of Data</td>
<td>26</td>
</tr>
<tr>
<td>A. Ability Tests</td>
<td>26</td>
</tr>
<tr>
<td>B. Achievement Tests</td>
<td>27</td>
</tr>
<tr>
<td>C. Teacher Judgment</td>
<td>28</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>PAGE</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>IV. SUMMARIES OF FINDINGS</td>
<td>32</td>
</tr>
<tr>
<td>Conclusions of Experiment to Date</td>
<td>32</td>
</tr>
<tr>
<td>Implications for Practice</td>
<td>35</td>
</tr>
<tr>
<td>Recommendations for Further Study</td>
<td>38</td>
</tr>
<tr>
<td>Conclusion</td>
<td>39</td>
</tr>
<tr>
<td>V. BIBLIOGRAPHY</td>
<td>41</td>
</tr>
<tr>
<td>VI. APPENDICES</td>
<td>45</td>
</tr>
<tr>
<td>TABLE</td>
<td>PAGE</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>I. Otis Alpha Distributions by Quotients</td>
<td></td>
</tr>
<tr>
<td>Grades 1 and 2</td>
<td>29</td>
</tr>
<tr>
<td>II. Comparative Distributions - S.R.A.</td>
<td></td>
</tr>
<tr>
<td>Grade 1 - Arithmetic Computation</td>
<td>30</td>
</tr>
<tr>
<td>Arithmetic Concepts</td>
<td></td>
</tr>
<tr>
<td>III. Comparative Distributions - S.R.A.</td>
<td></td>
</tr>
<tr>
<td>Grade 2 - Arithmetic Computation</td>
<td>31</td>
</tr>
<tr>
<td>Arithmetic Concepts</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER I
RECOGNITION OF THE PROBLEM

This chapter identifies the basic understandings which led to the source of the problem and stimulated the research.

**Understandings Basic to Experiment**

Mathematics has been a major cultural force in Western civilization and is a live, active and growing subject. There is a greater need today than ever before for the individual to be able to attack and solve his own problems. The complexity of modern day living, the tremendous impact on our way of living by recent discoveries, and the daily changes which occur so rapidly, make it imperative that the individual gain a mastery of the basic numerical facts and principles and an appreciation of the relations among number quantities. Scientific changes dominate our present culture and create a greater need for accurate knowledges concerning our number operations. Present day tensions and concerns require immediacy in applying accuracy in computation and in the manipulation of numerical concepts. Yes, even little children are interested in missiles, rockets, and satellites. They want to know how to build them and send them to the moon. But, how far is the moon? How long will it take to get to the moon? What has John Glenn's orbital flight taught us about space travel? Future space explorations and pioneering in new technical areas will require more scientific information and facility in applying number
knowledges, principles of mathematics, and analytical procedures.

This is the culture of science and mathematics which exits in our ever increasing numerical and scientific world. One is impressed to see today's children interested in solving problems of speed and distance because they are intrigued with number relationships. Their immediate experiences of exploration and discovery lead them to discover the how and why of the problem at hand.

Tremendous advances have been made possible by mathematical research. It has been noted by mathematician, G. Baley Price, that

"the changes in mathematics at the present time are so extensive, so far reaching in their implications and so profound that they can be described only as a revolution. The twentieth century has been the golden age of mathematics since more mathematics and more profound mathematics has been created in this period than the rest of history."

A look backward to see what caused this greater need for expert mathematicians and more highly skilled technicians would clarify our thinking. The technological revolution had set up the structure for our country to rise to a powerful industrial society and to become the outstanding economic nation of the world. With the shifting of our culture from the agrarian frontier life to urban industrial life came the modern indus-

trial community, improvement in machinery and production, transportation and communication. The time from the "Machine Age" to the "Atomic Age" of today is known as the "Great Transition". Today we are living in the second scientific and technological revolution which is characterized by great shift in thought from mechanism to organism which is marked by "the electro-chemical-mathematical" discoveries of the physical sciences and the "organic-homeostatic" emphasis in biology. Social changes have progressed at a slower pace and education must now help to build the necessary understandings if we are to use our technical achievements democratically.

"In the slower moving past, educators had been accustomed to giving students specific mathematical tools and skills designated to handle specific jobs and specific problem situations. However, with the exploding growth of automation - still only in its infancy - and its insatiable demand for new tools and new skills, with modern business and industry already dependent upon Linear Programming Decision and Game Theories and a growing variety of statistics, and with increasing demands of science for proficiency in higher mathematics, school officials become concerned that jobs and problem situations for which the traditional tools were created might not even exist in the next 10 or 15 years. Since it was impossible, in such a rapidly changing society, to determine specifically what tools and skills would be needed in the future, it was decided to provide the student with sufficient understanding of the "whys" and "hows" of mathematics to enable him to develop the tools himself, as needed. "Discovery" and "understanding" become the key notes for Greater Cleveland Mathematics Program."^2

The primary purpose of education was to make the people literate and to instruct them in reading, writing and arithmetic. As our educational system expanded to include high school, as an opportunity for all people, the curriculum grew to include subjects that would meet the needs of students in understanding and solving their problems. Teaching was a way of giving information, assigning work, and testing or examining to determine how much the student had mastered. With more knowledges gained in the sciences and study of man, we now see that to teach is to lead or guide the learnings by providing the best possible conditions for the growth and development of the individual.

A Scientific Approach to Problem Solving

Some basic understanding which led to interest in this experimentation were the emphasis of the new social sciences and the need for the discovery and application of natural laws of behavior of the individual and his society. Modern classrooms encourage the scientific approach to problem solving. A natural approach to teaching the scientific method is to help children recognize a problem and discuss ways in which they can find answers to their problems. The method of helping children "to find out" is one which leads children to explore, observe, manipulate and discover. First grade children differ widely in their understanding of numbers and in their ability to use arithmetic. The alert teacher will need to determine which experiences and how many are needed for each child in
order to build a genuine understanding of the number concepts. Opportunities are provided for learning experiences which require a child to think through a problem by feeling, experimenting and working out a logical solution. According to Harold Rugg:

"A problem is solved only when the learner understands what he has done and why his actions were the appropriate ones. The test is whether the pupil's method of solution can be used again."1

Problem solving in arithmetic in the primary grades deals with real problems closely related to the child's experiences. The emphasis in teaching problem solving is on the understanding and on the meaning of the problem situation and the thinking which takes place to find the best solution. In the first grade children are encouraged to formulate their number stories for others to share and solve. Dramatization helps to clarify thinking and enables the child to visualize the problem. Children learn the terminology needed for arithmetic and are able to grow in the ability to use the skills in reading and writing problems in the second grade. Problems, both real and imaginary, provide a means of introducing new ideas and procedures as well as providing practice for principles and methods already presented. As the child grows in his ability to use his skills and knowledges learned in solving the problems at hand, he will be able to meet and solve more difficult problems at increasingly higher levels of maturity.

By using the Stern Structural Materials the children are prepared step by step for solving problems. The structural method encourages the child to turn the language of the problem into the actual demonstration of what is happening in the problem. This is done with the materials as the child manipulates them himself as the problem unfolds. Key words are not used as a choice of process. The child views the problem as a whole to analyze the meaning, and then to record the numerical content as an arithmetical example.

Child Development and the Arithmetic Program

Educational experiences, to be most effective, must be based upon the growth characteristics of the children for whom they are planned and the patterns by which they develop. Although there is a common growth pattern for children, each child grows according to his own unique pattern. The alert teacher must be aware of the basic need of each child so that learnings can be positive. If arithmetic is to help equip children for life, then the emphasis must be on reality - reality in terms of the child's needs at home and in school. The teacher must look to the daily living of her children to discover which experiences best lend themselves to her plan of teaching. She must then find the most suitable materials which will contribute to the planned arithmetic experiences. Materials which will work for the children in concrete situations help them to relate the real to abstract symbols. The use of concrete materials is
very important in introducing new concepts and ideas in arithmetic.

"Usually, children move from the concrete experience of manipulating the real thing to the abstract experience of using number symbols. But the way in which they move, and the rates at which they move, are much more a matter of the child's growth pattern than of outer control. To assume that all children must spend the same amount of time manipulating the real thing before they can use representative materials, or that they must all use representative materials before abstract symbols, denies the facts of individual child development quite as much as did the earlier practice of requiring all children to do the same abstract drill."

A knowledge of the growth characteristics can be of great value in understanding children. These growth characteristics offer a key to the interest, needs and motivations of children. Every child will not be at the particular level of attainment because children grow and develop at different rates, but children at any age group are more alike than different. The following characteristics are some of the most important growth factors identified in children which need to be considered by teachers and parents in interpreting and guiding behavior with particular reference to the arithmetic program. These apply to children as a group at the various levels.

The Six Year Old's--

- growth proceeds more slowly than heretofore
- bodily lengthening out appears
- large muscles are better developed than smaller ones

1. Peggy Brogan and Lorene Fox, Helping Children Learn, p. 147.
permanent teeth begin to appear
heart is in a period of rapid growth
eyes are not fully mature

At First Grade Level — Six Year Olds are:

exuberant and active, yet tire easily
eager to learn and enthusiastic
usually ready to read and write and work with
numbers
often discouraged if required to perform mental
or physical tasks beyond their maturity
able to identify a penny, nickel and dime
able to learn their telephone number and address
in need of first hand concrete experiences with
many opportunities to feel, touch, handle,
experiment and explore
likely to include number and measure in their
play activities
ready for an extension of number experiences

The Seven Year Old's

growth is slower but steady
control of fine muscles is developing
molars are usually in
eyes are not always ready for near work
eye-hand coordination is improving
mind is active

At Second Grade Level — Seven Year Olds are:

active but need periods of rest
anxious to do things well
able to use their hands quite well
reaching out for independence in wanting toddler
discovery for themselves
anxious to do things well and learn best
in concrete terms where they can be active
while learning
beginning to understand more about time
and money values
increasingly interested in group activities —
such as, buying and selling, and making change
able to make up and solve simple number stories
beginning to recognize the usefulness of
numbers
in need of encouragement and recognition
talkative and often exaggerate
increasingly sensitive to feeling and attitudes of others.¹

"Research has shown that certain maturational periods provide the most advantageous times for influencing the child's behavior and growth through environmental stimulation. A consideration of the relative effects of nature and nurture on the child's growth has stimulated a large number of scientific studies. An obvious outcome of this approach to childhood education is the determination of the child's abilities at appropriate intervals of development. The modern parent or teacher uses his ingenuity to ascertain the child's current interests and then attempts to capitalize on these inclinations toward psychological activity."²

Curriculum Provision for Growth

A sequential presentation of basic learning experiences in a planned systematic organization of basic lessons in number concepts, computation, and problem solving is most important at first and second grade levels. The curriculum introduces the new concepts at the child's level of understanding and presents desirable experiences as a guide for the teacher for the necessary practice and attainment of the required skills. The relations of the pupil's readiness to learn and his interest in learning to curricular scope and sequence make it imperative to re-examine and revise methods, techniques, and materials periodically to insure the latest and best of the times.

Stern Structural Materials have followed the pattern of

1. Compiled and adapted from a variety of sources.
Field Theories of Learning by insight.

"Gestalt Theory in which experiences, information, and activities group themselves in a pattern or field new to the learner, forming a configuration or gestalt. This theory emphasizes "wholes," i.e., the grasping of the whole field or idea and its surroundings. The parts get meaning from membership in the whole. As such, it is an extension and elaboration of John Dewey's learning by reconstruction of experiences."\(^1\)

In this type of learning one can readily see the importance in using original problems as well as planned problems in mathematics in contrast to the formal rules and drill in learning number facts. Teaching arithmetic is something that can work for children and is exciting and challenging. This concept of learning recognizes that even young children live in a world which contains "whole things" and "parts of things." The child is surrounded by groups which have meanings and relationships directly or indirectly. Children learn about number relationships through their own investigations, experiences, and insight gained by solving problems and transferring the knowledges to other situations. Number is a kind of language which describes and prescribes. It tells size, rate, distance and shapes and validates the relationships and order of things. By using numbers and manipulating number relationships, the child increases his power of understanding and application to other problems becomes more effective. Consistent evaluation by teachers and pupils indicate what has been learned and what needs to be retaught in preparation for the next step.

---

1. J. Minor Gwynn, Curriculum Principles and Social Trends, p.62
CHAPTER II

DEFINITION OF THE PROBLEM

The statement and definition of the problem are presented and analyzed in this chapter. Hypotheses and Assumptions are described in relation to problem solving.

Understandings Basic to the Organization of the Curriculum for Effective Teaching

What a child needs and what society expects him to acquire are the two factors which influence the selection of subject matter and activities as suggested by New York State in the curriculum areas of the elementary school. In arithmetic, the subject matter must be taught in an orderly arrangement of cumulative learnings in the various areas included in the arithmetic program according to grade level. In the first and second grades, these areas include specific understandings of the number system, number concepts, computation, measures, comparisons and problem solving. The school must accept responsibility for securing suitable and adequate curriculum materials for the teacher for the development of these learnings. Syllabi, textbooks, and general reference materials are seldom adequate in themselves.

It is in regard to the development of desirable attitudes and habits, social contacts, individual growth and group living that the elementary school has changed most in recent years. New approaches and changes in method have improved the quality of teaching and learning. The principal, supervisor, teacher,
and all concerned with the improvement of instruction can participate in planned professional studies. Significant improvements in instruction will ensure only as instructional problems are adequately researched. Then valid evidence will be available with which to make wise decisions and the selection of materials.

"Curriculum improvement may be considered a means of professional growth, even though its real purpose is the growth of pupils. The principal may be interested in the improvement of methods and the enrichment of curriculum materials, but he must not lose sight of the fact that the teachers will know better how to use these materials if they share with the principal in the responsibility of securing, organizing and formulating them for teaching purposes."

Need for Material in the Primary Grades

Arithmetic experiences in the first grades are informal in nature, but not incidental. First, the teacher must include opportunities for the child to get the most benefit from the arithmetic content of his everyday experience both in and out of school. Major emphasis should be on oral presentation of number experiences or stories. The child sees the problem and presents it in his own words. Dramatization of number experiences with suitable and appropriate concrete materials help to clarify understandings and build number concepts. At second grade level children will get ready to move from concrete experiences to the semi-concrete and then toward the abstract.

Arithmetic can be made more meaningful through the provision of many experiences, using concrete and semi-concrete materials to develop understandings. The move from the concrete to the semi-concrete and eventually to the abstract symbols should be gradual and adapted to the needs of the child. It is believed that more effective learning takes place through seeing configurations, patterns, and relationships of numbers and facts. Through many dramatic and manipulative experiences children can be led to see relationships and arrive at generalizations from which insights and understandings develop and upon which other learnings are built. 1

Second, the teacher must plan experiences systematically in everyday lessons which will include number ideas and number processes. Instructional materials other than teacher-made are needed to guide concept building by providing concrete experiences and the ability to combine and recombine these experiences in many situations.

"Exploratory materials are those materials of instruction used by children during periods of readiness and exploration. They are not only visible but most of them may be felt, touched and handled. They are the non-reference, non-pictorial type. This classification contains both real objects that may represent an idea and objects that are useful in daily living." 2

Other instructional materials include the instruments of measure, such as clocks, scales, thermometers, cups and bottles and many others which children need to learn to use intelligently.

It is important that children be introduced to as many of these instruments as possible in the classroom and understand the purpose and use of each one.

Stern Structural Materials are scientifically designed to emphasize group recognition as one of the first skills in arithmetic. The mathematical characteristics and thought processes of arithmetic are studied with concrete devices that reveal all abstract properties of numbers. Since each new presentation of materials has a definite purpose, the experiments or experiences reveal what is to be learned and the children discover the number facts and principles by themselves. The transition from concrete structural devices to mastery of arithmetic can be made more easily because of the mental computation which is stimulated by oral discussions, questions and figuring.

Description of Stern Structural Materials

Stern Structural Materials give a new approach to the teaching of arithmetic. Based on pupil discovery and experimentation, they center on concrete teaching devices, which for the first time in arithmetic instruction, have all the properties of abstract numbers.

Catherine Stern is an advocate of structural arithmetic in the United States. She was a former research assistant to Max Wertheimer, one of the founders of Gestalt psychology, and has developed materials and a method of instruction which incorporates its principles. In 1944, Miss Peggy Bassett, her daughter
Toni Gould and Catherine Stern opened the Castle School, an experimental school in which these teaching devices were used experimentally by Miss Marjorie Dunn (The Windward School, White Plains), Mrs. Hallett Gerusco (Flower Hill Elementary School, Port Washington, L. I.), Miss Elizabeth Baldwin (The Spencer School, New York City), and Dr. Charlotte Grave (Director, Child Research Clinic, Langhorne, Pa.).

The Teacher's manual serves as a guide for the introduction to the materials and preparation of the lessons for the teacher to follow.

The following teacher's manual are recommended:

- **Experimenting with Numbers** for use with beginners
- **Discovering Arithmetic, Book 1** for first grade
- **Discovering Arithmetic, Book 2** for second grade

Pupil's workbooks are suggested to be used with the materials.

- **Discovering Arithmetic, Book 1** for first grade
- **Discovering Arithmetic, Book 2** for second grade

The Stern Structural Materials consist of the following basic equipment which may be purchased as a set: Kit I, Part A and B, Kit II, or individual pieces, from Houghton Mifflin Company.

**Kit I** - (Part A and B) consists of:

1. Counting Board - large gray slotted board
2. Number Guide - gray masonite slat with black numbers; fits into Counting Board
1 Set of Unit Blocks 1-10 - wooden blocks for all colors and sizes to 10
1 Unit box filled with 10 Unit Blocks - dark blue wooden tray filled with wooden blocks of all colors and sizes to 10
1 Unit Box filled with 100 Cubes - dark blue wooden tray filled with single cubes of all colors
1 Set of Pattern Boards 1-10 - small gray boards with white blanks
1 Set of Number Cases 1-10 - wooden trays of all colors and sizes to 10
2 Sets of Number Markers 1-10 - small gray wooden blocks with black numbers
4 Miscellaneous Markers: +, -, =, o - small gray wooden blocks with black symbols
1 Number Rack - hinged standard painted gray and yellow with black numbers
1 Number Track, first section - wood, dark blue, with gray bumper ends
3 Sets of Subtraction Shields 1-10 - colored paper cutouts
1 Set of 24 Number Slides - yellow cardboard cards with black numbers and symbols
1 Stop and Go Cube - red and green wooden cube
2 Jumpers - wire
1 12-page Teacher's Manual for use with beginners, entitled: Experimenting With Numbers

Kit II consists of:

1 Number Holder - gray wooden stand with "tens" and "units" in black
1 Set of 48 Number Cards - yellow cardboard cards with black 1- and 2- place numbers
1 Number Track, complete 10 wooden sections numbered from 1-100, with 2 gray bumper ends
5 Jumpers - wire
1 20-Case - large gray wooden tray
1 Stop and Go Cube - red and green wooden cube
1 Unit Box filled with 19 Unit Blocks - dark blue wooden tray filled with wooden blocks of all colors and sizes to 10
11 10-Blocks - dark blue wooden blocks 10 units long
10 9- Blocks - black wooden blocks 9 units long
10 8-Blocks - orange wooden blocks 8 units long
10 2-Blocks - purple wooden blocks 2 units long
30 Cubes - 10 green wooden cubes, 10 red cubes, 10 dark blue cubes
Statement of the Problem

Since mathematics is a basic tool which permeates our everyday life and activity, it is a necessity for every child to know the basic principles of arithmetic, to acquire mastery of the fundamental processes, and to apply these knowledges in the solutions of his problems.

In recent years the term "structure" has been appearing more frequently in the literature on the teaching of arithmetic than it did in the past. This is a new trend which applies the terms 'insight' and 'structure' and indicates that the Gestalt theories are becoming more acceptable in arithmetic today. The school of thought, known as field psychology, placed an emphasis on such ideas as:

1. "A problematic situation is an unstructured situation. Insecurity accompanies unstructuredness. When the problem is structured we feel secure; we have solved the problem; we have learned.

2. Repetition may change the way we have structured a situation. However, the better the structure, the less the change brought about by repetition and fewer repetitions required.

3. Changes in structure come about, at least in part, according to principles of patterning in perception (that which we see). In other words, the problems of acquiring knowledges are believed to be closely related to the laws governing perception.

4. When we feel secure, having structured a problematic situation, we say we have developed an insight into the problem. Insight is dependent upon the awareness of relationships between parts, and of parts to whole.
Learning is structuring, forming patterns, making configurations.¹

According to Catherine Stern there are three major aims in the teaching of arithmetic:

"First, understanding of the general ideas and thought processes that are inherent in the system of numbers. Second, mastery of computation. Third, mastery of applied arithmetic, or problem solving. Structural Arithmetic is an entirely new approach to the teaching of arithmetic which is dedicated to the achievement of these aims by all children."²

Hypotheses

The report of this study, the purpose of which is to investigate the effectiveness of the Stern Structural Materials for first and second grades, is concentrated in the following areas.

1. Stern Structural Materials will provide the best possible teaching methods and learning situations which will stimulate interest and arouse curiosity in the classroom for the acquisition of the arithmetic content outlined for first and second grade in A Guide for the Development of the Arithmetic Program in the Elementary School, Rochester, New York.

Hypothesis #1 - Stern Structural Materials create higher interest in arithmetic in the first and second grades.

2. Stern Structural Materials and the teacher's edition to the workbook provide the primary teacher with a professional teaching aid which may be used in the daily planning, organizing, and executing of daily lessons for systematic experiences in arithmetic teaching.

Hypothesis #2 - Teachers find the manual, which is known as the teacher's edition to the workbook, Discovering Arithmetic - Book 1 and 2, a helpful and valuable teaching aid in the presentation of daily lessons.

3. Stern Structural Materials provide systematic concrete materials for the child to explore and experiment with by feeling, using, and manipulating, thereby giving accurate knowledges concerning arithmetical concepts and understandings which will lead him to the semi-concrete and then to the abstract.

Hypothesis #3 - Stern Structural Materials can be employed by the child socially in his group and individually by himself where he can feel,
use and manipulate the materials.

4. Stern Structural Materials provide a type of manipulative material and visual aid which is widely accepted in the teaching of arithmetic, but evaluation needs to be continued to determine the effectiveness of these selected materials.

Hypothesis #4: The experimental groups score higher on standardize tests which evaluate computation and concepts than the control groups.
CHAPTER III

PROCEDURE

This chapter deals with the method of the experiment, the relationship existing between the groups involved, and the assumptions and delimitations which have been noted.

Research Design

An experiment may be defined as objective observation of phenomena which may occur in a strictly controlled situation in which one factor is varied and the others are kept constant.

After careful study of the curriculum with one of the major objectives of improving instruction to meet the optimum growth and understanding of pupils in arithmetic, the experimental use of the Stern Structural Arithmetic Materials was initiated by the Consultant of Elementary Education, Mrs. Lillian Brooks, her staff, and principals of experimental schools.

Informational meetings at the first and second grade levels, were organized for principals and teachers of participating experimental schools at which Mrs. Toni Gould, the daughter of Catherine Stern, discussed, presented, and demonstrated with a group of Rochester children, unknown to her previously, the use and possibilities of these materials.

A. Description of Groups

This experiment will utilize two groups at each of
the first and second grade levels - an experimental group and a control group.

1. Experimental Groups

The experimental group is a typical first grade class of approximately thirty children. As the organization was planned for the entire school, three first and three second grade classes were set up. One grade was selected at random to become a first grade experimental group known as EI. In like manner, a second grade was selected to be the experimental second grade known as E II. The second year of the experiment, 1961-62, the original first grade E I group automatically became the second grade E II group. The use of the Stern Structural Arithmetic Materials, Kit I, and the workbook Discovering Arithmetic - Book I and the teacher's edition of the accompanying workbook will be used exclusively with the E I group. Likewise, the use of the Stern Structural Arithmetic Materials, Kit II and the accompanying workbook will be used for the second grade experimental group. No other text or materials will be used.

2. Control Groups

As the organization was planned as previously stated, one grade was selected at random to become a first grade control group known as C I, and a second grade was selected to be the control group known as C II. The control groups will continue as before using any other materials which has been available.

B. Time Schedule

The time involved in this study will be three years:

1960-61: Stern Structural Materials were presented and demonstrated to the teachers who were to be pioneers in this experiment. Group E I and E II used Stern materials exclusively.


1962-63: All first grades and all second grades will use Stern materials.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Grades Involved</th>
<th>Grade</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-61</td>
<td>1</td>
<td>First</td>
<td>Introductory</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Second</td>
<td>Introductory</td>
</tr>
<tr>
<td>1961-62</td>
<td>1</td>
<td>First</td>
<td>Introductory</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Second</td>
<td>Continuation</td>
</tr>
<tr>
<td>1962-63</td>
<td>All</td>
<td>First</td>
<td>Introductory</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>Second</td>
<td>Continuation</td>
</tr>
</tbody>
</table>
G. Criteria for Selection of Teacher

The teacher is a key person in the experiment since her judgment will be a determining factor in the final acceptance of the Stern Structural Materials. Interest and enthusiasm in the new materials and a desire to use them would be a primary requisite of the teacher. Willingness to give additional time in preparing lessons and keeping accurate records is most important but also demanding. An unbiased opinion and sincere evaluation in observing and solving problems with new and unfamiliar materials is necessary. Is she ready to experiment with the latest research developments? Is she seriously engaged in the possibilities of these new materials or is it something added to an already overcrowded program?

The teacher in the control group is another key person who is interested in helping in the experiment. Her willingness to cooperate and compare methods and observations will be helpful in the final adoption of the Stern Structural Materials.

D. Evaluation Techniques

Standardized Tests were given to all groups involved in the experiment. The Otis Ability test and the Science Research Associates Achievement test were administered.

Teachers observations and judgments were recorded periodically.

Assumptions of the Experiment

In order to observe the experiment scientifically and to
Judge the results objectively for basic informational purposes, the following assumptions have been considered:

A. The four first and second grades involved in this study are typical of any such average, urban middle class first and second grades in any school system and would react normally to any new instructional materials.

B. The children in these groups are in the normal age range for each first and second grade level and have been organized equally as to ability and past achievement and are ready to develop number concepts in relation to the philosophy of child development.

C. An average teacher with little or great experience might utilize these structural arithmetic materials and find opportunities for curriculum development with them by using the manual of directions for guidance and the workbook for independent pupil participation.

D. The attractiveness and brightness of the structural materials would arouse curiosity and interest on the part of the children and create a natural desire for exploration and discovery.

E. The administration would give support to the experimental program by guiding teachers, inform-
ing parents and offering help and suggestions whenever needed.

Delimitations of the Experiment

A. A relatively small number of children (60) are being used at present.

B. A relatively small number of teachers (2) are involved in the initial experiment and are evaluating in terms of their own classroom only.

C. Instructional time is limited for group and individual experimentation. Stern experimental group is exposed to materials during independent work time.

D. The creativity of the teacher may be limited if she follows only the prescribed use of these materials as directed in the manual.

E. A teacher of the control group might like to use Stern Structural Materials.

F. Teachers of control and experimental groups are equally motivated and skilled in using and adapting materials.

Presentation and Analysis of Data

A. Ability Tests

The Otis Alpha Group Ability test was administered to the first and second grades of the experimental and control groups in the Stern Structural Material
experiment in February 1961. (See Appendix A) An Analysis of the findings reveal that the frequencies observed were typical of the expected quotients of the pupils in this middle class school area. See Table I)

B. Achievement Tests

The S.R.A. Achievement Tests were administered to the first grade and second grade participating in the experiment and the control groups in May and June, 1961. (See Appendix A) An Analysis of the achievement in the areas of Concepts and Computation indicated the following:

Grade 1.

No significant differences were found to exist between the control and the experimental group.

A tendency in the experimental group to have a smaller percentage of children working at the 10th percentile or below is noted in Computation. This was reversed in Concepts. A greater percentage of the children in the control group were working in the 90-99%ile. (See Table II)

Grade 2.

No significant differences were found to exist between the control and the experimental
A tendency of the control group to have smaller percentages in groups below the 10th %ile and greater percentage in the 90-99 %ile is noted. A tendency of the experimental group to have greater percentages in groups below the 10th %ile and a smaller percentage in the 90-99 %ile is noted. The fact that these children had only an introductory course to introduce these materials in second grade may account for this. (See Table III)

C. Teacher Judgment

A questionnaire on the evaluation of the Stern Structural Materials was presented to the teachers. (See Appendix B)

Teachers observed that Stern Structural Materials had created higher interest because of attractiveness and appeal of concrete materials. One teacher felt that materials of a particular kind did not make much difference as long as concrete materials were used purposefully. The Teacher's guide was most helpful in specific help for lesson presentations. Teachers felt that limitation of time was a factor which needed more study. No significant increase in scores was noted by testing. The tests in the Stern Discovering Arithmetic Workbook 2 were helpful to diagnose individual weaknesses.
TABLE 1
Otis Alpha Distributions by Quotients (Verbal) Grade 1
Stern Arithmetic Experiment February 1961

* See Appendix C for %ile and letter rating comparisons
TABLE II
Comparative Distributions - SRA. Arithmetic Computation - Grade 1
Stern Arithmetic Experiment - May-June 1961 Control & Experimental Groups

<table>
<thead>
<tr>
<th>Percentile Groups</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>99-99</td>
<td>7.9</td>
<td>6.3</td>
</tr>
<tr>
<td>90-99</td>
<td>12.6</td>
<td>11.8</td>
</tr>
<tr>
<td>80-89</td>
<td>16.6</td>
<td>16.4</td>
</tr>
<tr>
<td>70-79</td>
<td>19.1</td>
<td>19.1</td>
</tr>
<tr>
<td>60-69</td>
<td>21.7</td>
<td>21.7</td>
</tr>
<tr>
<td>50-59</td>
<td>23.6</td>
<td>23.6</td>
</tr>
<tr>
<td>40-49</td>
<td>25.3</td>
<td>25.3</td>
</tr>
<tr>
<td>30-39</td>
<td>27.1</td>
<td>27.1</td>
</tr>
<tr>
<td>20-29</td>
<td>28.8</td>
<td>28.8</td>
</tr>
<tr>
<td>10-19</td>
<td>30.5</td>
<td>30.5</td>
</tr>
<tr>
<td>Below 10</td>
<td>32.2</td>
<td>32.2</td>
</tr>
</tbody>
</table>

Comparative Distributions - SRA - Arithmetic Concepts - Grade 1
Stern Arithmetic Experiment - May-June 1961 Control & Experimental Groups

<table>
<thead>
<tr>
<th>Percentile Groups</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>99-99</td>
<td>6.6</td>
<td>5.6</td>
</tr>
<tr>
<td>90-99</td>
<td>11.4</td>
<td>11.4</td>
</tr>
<tr>
<td>80-89</td>
<td>16.3</td>
<td>16.3</td>
</tr>
<tr>
<td>70-79</td>
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<tr>
<td>60-69</td>
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<td>50-59</td>
<td>25.1</td>
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<tr>
<td>40-49</td>
<td>26.7</td>
<td>26.7</td>
</tr>
<tr>
<td>30-39</td>
<td>29.3</td>
<td>29.3</td>
</tr>
<tr>
<td>20-29</td>
<td>31.0</td>
<td>31.0</td>
</tr>
<tr>
<td>10-19</td>
<td>33.5</td>
<td>33.5</td>
</tr>
<tr>
<td>Below 10</td>
<td>35.6</td>
<td>35.6</td>
</tr>
</tbody>
</table>

@Compa to the Computer
### Table III

Comparative Distributions - S.R.A. Arithmetic Computation - Grade 2
Stern Arithmetic Experiment - May-June 1941

<table>
<thead>
<tr>
<th>Group</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-79</td>
<td>15.8</td>
<td>15.6</td>
</tr>
<tr>
<td>80-89</td>
<td>15.0</td>
<td>14.3</td>
</tr>
<tr>
<td>90-99</td>
<td>8.7</td>
<td>7.7</td>
</tr>
<tr>
<td>10-19</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>Below</td>
<td>3.8</td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing comparative distributions](image-url)
CHAPTER IV
SUMMARIES OF FINDINGS

This chapter contains an evaluation of this research to date with implications for practice and recommendations for future study.

Conclusions of Experiment to Date

In order to judge the effectiveness of any new program, it must be carefully evaluated. The strengths of the Stern Structural Materials have been advantageous and desirable in accord with modern objectives in teaching arithmetic in the first and second grades. The following conclusions are presented with evidence that they may be of value to any other school system which may need to select new arithmetic materials.

**Hypothesis #1** - Stern Structural Materials create higher interest in arithmetic in the first and second grades.

**Conclusion #1** - Stern Structural Materials create higher interest in arithmetic in the first and second grades. The provision of Stern Structural Arithmetic Materials has provided the teacher with a new scientific teaching aid which has created high interest in arithmetic. The materials are colorful and interesting to primary children. Children are highly motivated with curiosity and desire to handle and manipulate these materials in the spirit of inquiry and discovery.
Hypothesis #2 - Teachers find the manual, which is known as the Teacher's Edition to the workbooks Discovering Arithmetic - Book 1 and 2, a helpful and valuable teaching aid in the presentation of daily lessons.

Conclusion #2 - Teachers find the manual, which is known as the Teacher's Edition to the workbooks Discovering Arithmetic - Book 1 and 2, a helpful and valuable aid in the presentation of daily lessons. The daily presentation of each lesson has been guided by the use of the teacher's manual using the suggested vocabulary and systematic experiences. The lessons are purposeful and the objectives are specified as a guide to sequential learnings.

Hypothesis #3 - Stern Structural Materials can be employed by the child socially in his group and individually by himself where he can feel, use and manipulate the materials.

Conclusion #3 - Stern Structural Materials may be employed by the child socially in his group and individually where he can feel, use and manipulate the materials. The child participates actively in a group where he is also exposed to the questions and problems of other children. He may further satisfy his curiosity by working with these materials during independent work time. Group action is a stimulating learning technique for the teaching situation.
Hypothesis #4 - The experimental groups score higher on standardized tests which evaluate computation and concepts than the control groups.

Conclusion #4 - The experimental groups did not score higher on standardized tests which evaluate computation and number concepts.

No significant differences were found in the S.R.A. achievement test results as the percentages of the class in the percentile groups were analyzed.

Teacher Observations

The following teacher observations of the experiment obtained through the use of a questionnaire are presented:

(See Appendix E)

1. Children look forward to arithmetic as their attention span is longer due to the manipulation of the materials. The color of cubes and groups gives number another medium for learning.

2. Teachers feel that the professional knowledge and guidance of experts in arithmetic as given in the manual is most helpful and gives the teacher confidence in pioneering in a new approach. However, it is felt that with mastery of the essential procedures, creativity and more flexibility in personal approach might be desirable.

3. The best possible teaching situations have been
noted in which the child observes the development of a principle by others and has the opportunity to discover for himself how this principle works. Individual needs are provided for the brighter child who understands the arithmetic principles as he brings his previous generalizations to a new problem and for the slower child who may need longer time and more experience to discover or understand a new concept.

A difference of opinion has been expressed as to the amount of time which should be devoted to group work.

4. Standardized test results are only one indication of achievement. The second grade teacher felt that scores may improve as children have the basic introductory course in first grade which the E II group did not have.

**Implications for Practice**

In keeping with the demands of the world today and the expected requirements in mathematics of our children in the future, there is much activity and interest in the development of new arithmetic programs. Implications indicate that Stern Structural Materials are fully in accord with modern trends and possibilities of scientific research.
A. Implications for Instruction

Stern Structural Materials provide the primary teacher with another medium in presenting and developing arithmetic understandings and skills. The beginning teacher gains confidence in working with instructional materials that are endorsed and expertly produced by mathematicians for the grade level which she is teaching. The creative and experienced teacher welcomes with enthusiasm the latest educational materials which will provide opportunity for experimentation and added stimulation to her classroom teaching.

Stern Structural Materials provide the child with appropriate materials for individual growth in arriving at the correct answer by his own mental method of reasoning and computing. Pre-computational thinking is emphasized. A good arithmetic program provides materials which makes it possible for children to experiment and discover most of the arithmetic which they need to acquire in the primary grades.

B. Implications for Supervision

A supervisor must always be informed and ready to investigate the latest and best instructional materials for the improvement of instruction.

1. Stern Structural Materials provide another addition to the instructional storehouse of techniques in developing mathematical competence.

2. Supervisory leadership in the selection and use of
Stern Structural Materials acquaints the classroom teacher with the possibilities and extent of these materials in the teaching-learning situation.

3. Supervisors can be assured of the relative instructional effectiveness of Stern Structural Materials because they are carefully planned to curriculum scope with the emphasis on the social and physical sciences.

4. Supervision recognizes the relationship of social group activities and democratic problem solving opportunities which Stern Structural Materials provide in a modern challenging classroom.

5. Supervision, as a resource service, may enhance the value of an experiment with Stern Structural Materials within a school by informing and involving all teachers about the possibilities of these new and dynamic teaching materials.

C. Implications for Administration

An administration which is interested in helping to improve the quality of instruction should include provision in the school budget for the purchase of new experimental materials in arithmetic which have different approaches to the development and acquisition of mathematical content. The present day structured approach is emphasized in the Stern Structural Materials.

1. The ultimate responsibility for the adoption of
Instructional materials falls upon administration and supervision. The challenge is to find the best materials suitable to meet the educational needs for whom they are planned. Stern Structural Materials would be a most valuable asset to the development of an on-going arithmetic program.

2. The administration must secure full returns on investments made in instructional materials. Stern Structural Materials are durable, practical and accurately constructed. They will last for several years with care. Lost or worn out pieces may be replaced at a nominal price.

D. Implications for Teacher Education

Pre-service plans shall include provision for exhibiting and interesting teachers in the possibilities of Stern Structural Materials.

In-service plans should provide a program, such as workshops and study groups, where teachers may be oriented and informed in the use of Stern Structural Materials.

Recommendations for Further Study

A. The following general recommendations are suggested:

1. More groups of children will need to be exposed to these materials and results will need to be compared in order to determine whether or not the use of these materials has been advantageous and has
improved instruction.

2. More teachers and administrators will need to evaluate findings and observations more specifically.

3. More data is needed to evaluate specific strengths and weaknesses of the materials.

4. More information is needed to resolve the problem of finding adequate time in the daily program for the grouping of the children in providing for the manipulative materials.

B. The following specific recommendation is suggested:

If statistics show continued evidence of growth and learning on the part of the children, and improvement of instruction on the part of the teacher, a recommendation will be made to the Assistant Superintendent in Charge of Instruction and Curriculum that Stern Structural Arithmetic Materials be adopted as a teaching aid for all first and second grades in the City School District, Rochester, New York.

Conclusion

The elementary school must meet the challenge of the future by teaching and guiding the learnings of all children with the best possible materials, equipment, texts, and all teaching and learning aids to meet the demands which will be placed upon them by continued technological and scientific advances as man continues to pioneer in outer space in his
explorations and discoveries. Teachers must be aware of the cultural aspects of mathematics and its place in the daily lives of the children who live and work together in a democratic classroom.

"Related to physical existence, mathematics can serve as a humanly useful way for viewing arrangements of people, places and things. New information on the theory of Sets or any other mathematical theorizing will fall short if children are not helped at certain significant times in their learning to relate their grouping and regrouping of numbers to the actual grouping and regrouping in the world in which they live. Every time children come together and separate there is a mathematical formula underlying their action. Unless we learn to think of purpose and outcome of grouping as a necessary part of the mathematical formula, we are not creating the continuity to intelligent human existence."

BIBLIOGRAPHY

Banks, J. Houston, Learning and Teaching Arithmetic, Boston: Allyn and Bacon, Inc., 1959.


PERIODICALS


MISCELLANEOUS

(bulletin)

(curriculum)

(curriculum)

(pamphlet)

(report)

(report)

(workbooks)
## APPENDIX A

### Standardized Testing Schedule

<table>
<thead>
<tr>
<th>Grade</th>
<th>Test</th>
<th>Test Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Otis Alpha - Verbal</td>
<td>Feb. 1961</td>
</tr>
<tr>
<td></td>
<td>Form A</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>S.R.A. Arithmetic - Computation</td>
<td>May - June 1961</td>
</tr>
<tr>
<td></td>
<td>Form A</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Otis Alpha - Non-Verbal</td>
<td>Feb. 1961</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>S.R.A. Arithmetic - Computation</td>
<td>May - June 1961</td>
</tr>
<tr>
<td></td>
<td>Form A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S.R.A. Arithmetic - Concepts</td>
<td>May - June 1961</td>
</tr>
<tr>
<td></td>
<td>Form A</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B
Evaluation of Stern Structural Materials
Grades 1 & 2

1. Do you feel that the use of these materials has stimulated higher interest in the arithmetic program?
   What have you specifically observed?

2. Have you found the teacher's manual helpful?
   In what way?

3. Children have used these materials in a group and individually. What are the advantages or limitations of this procedure?

4. As you evaluate the children's abilities in concepts and computations, have you observed noticeable scores or higher ratings?
   Please state specific tests or procedures.

Grade ____________________________  Teacher ____________________________
APPENDIX C

Comparison of Percentiles and Letter Ratings

The following plan is used in using percentiles for grouping in Rochester City School District.

The letter rating will compare the percentile in which the child should be achieving according to his ability.

<table>
<thead>
<tr>
<th>Otis Letter Rating</th>
<th>S.R.A. Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>P90 - P99 = 3 grade levels advanced</td>
</tr>
<tr>
<td>B.</td>
<td>P75 - P89 = 2 grade levels advanced</td>
</tr>
<tr>
<td>H.O.</td>
<td>P60 - P74 = 1 grade level advanced</td>
</tr>
<tr>
<td>C.</td>
<td>P40 - P59 = on grade level</td>
</tr>
<tr>
<td>L.O.</td>
<td>P25 - P39 = 1 grade level low</td>
</tr>
<tr>
<td>D.</td>
<td>P11 - P24 = 2 grade levels low</td>
</tr>
<tr>
<td>E.</td>
<td>P1 - P10 = 3 grade levels low</td>
</tr>
</tbody>
</table>