71-27,605

COFFIA, William J., 1929-
THE EFFECTS OF AN INQUIRY-ORIENTED CURRICULUM IN SCIENCE ON A CHILD'S ACHIEVEMENT IN SELECTED ACADEMIC AREAS.

The University of Oklahoma, Ed.D., 1971
Education, curriculum development

University Microfilms, A XEROX Company, Ann Arbor, Michigan

© Copyright by
William J. Coffia
1971

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE EFFECTS OF AN INQUIRY-ORIENTED CURRICULUM IN SCIENCE ON A CHILD'S ACHIEVEMENT IN SELECTED ACADEMIC AREAS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF EDUCATION

BY

WILLIAM J. COFFIA

Norman, Oklahoma

1971

THE EFFECTS OF AN INQUIRY-ORIENTED CURRICULUM
IN SCIENCE ON A CHILD'S ACHIEVEMENT
IN SELECTED ACADEMIC AREAS

APPROVED BY

John W Renner

Eunice Lewis

Thomas J. Hill

Gerald Kluge

Don G Stafford

DISSERTATION COMMITTEE

ACKNOWLEDGMENTS

This writer would like to express sincere appreciation to the many people who contributed directly or indirectly to the development and completion of this paper. Without their encouragement, assistance, and patience the study would not have been realized.

To Dr. John W. Renner, the writer's major professor and committee chairman, a very special and sincere expression of gratitude for his most competent and professional direction throughout my pursuit of the doctoral degree. Sincere appreciation is also expressed to Dr. Thomas J. Hill, Professor Eunice Lewis, Dr. Donald Stafford, and Dr. Gerald Kidd who graciously agreed to replace Dr. Harold Huneke, for their contributions as advisory committee members and assistance in the completion of this study.

A special note of thanks is expressed to the principals, teachers, and pupils of the two schools of this study. Only through their cooperation was it possible to complete the research. Also, sincere gratitude is expressed to Mrs. Dorothy Jones who gave many helpful suggestions and to Mrs. Jane Harvey for invaluable assistance in preparation of the manuscript.

To my wife, Jean, and other members of my family a very special thanks for continuous encouragement, patience, and understanding throughout all phases of my graduate study.

To My Wife

Jean

TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

LIST OF ILLUSTRATIONS

THE EFFECTS OF AN INQUIRY-ORIENTED CURRICULUM IN SCIENCE ON A CHILD'S ACHIEVEMENT IN SELECTED ACADEMIC AREAS

CHAPTER I

BACKGROUND AND NEED FOR THE STUDY

Introduction

The astute observer of the American educational scene of today would note many changes as he compared it with that of ten to fifteen years ago. In an increasing number of classrooms there is less emphasis on subject matter per se, less reliance on a single textbook, and less stress on the accumulation of facts learned by rote. The learner is an active participant in the learning process. He is subjected to more emphasis on thinking and reasoning, enjoys more freedom to work and explore solutions to problems through the use of guesses, data, and hunches, and has an opportunity to experience the thrill and joy of discovery. Essentially, through exploration, invention, and discovery, i.e. inquiry, the child is engaged in educational experiences designed to develop the rational powers.[1] In fact he is learning how to learn through an evolvement of reliance on the process of inquiry.

The value of learning by inquiry has been recognized for many years by educators and learning theorists. Taba[2] in tracing the rudiments of learning by inquiry identifies several prominent proponents. Mary E. Boole, wife of George Boole, French logician, published in 1904 a booklet, Preparation of the Child for Science in which she expressed a concern for ways by which children can be led to extract the truth. In John Dewey's[3] teaching and writing, inquiry as a method of learning was paramount. In developing the theoretical concept of the nature of inquiry, he identified learning with thinking, and thinking with active discovery of relationships and organizing principles. Hilgard[4] in developing fourteen points of agreement from several learning theories identifies one as:

> Transfer to new tasks will be better if, in learning, the learner can discover relationships for

---

[1]The rational powers as defined by the Educational Policies Commission are: recalling and imagining, classifying and generalizing, comparing and evaluating, analyzing and synthesizing, and deducing and inferring.

[2]Hilda Taba, "Learning by Discovery: Psychological and Educational Rationale," Elementary School Journal, March, 1963, pp. 308-316.

[3]John Dewey, How We Think (Boston: D. C. Heath and Company, 1910).

[4]Ernest R. Hilgard, Theories of Learning (2d ed.; New York: Appleton-Century Crofts, Inc., 1956), pp. 485-487.

himself, and if he has experience during learning of applying the principles with a variety of tasks.

The idea that the principal function of instruction was to develop in the student's mind several modes of inquiry, however, did not coalesce until around the middle fifties and early sixties. In 1956, a group of physicists under the leadership of Jerrold Zacharias and Francis L. Friedman formed a committee known as the Physical Science Study Committee. The committee had the commitment that instruction in physics should not be to teach subject matter directly but to employ an indirect teaching style. Indirect teaching of content refers to concentration on teaching methods of thought as against teaching endless facts.[1]

In ensuing years the curriculum reform movement has spread in all directions; the elementary schools, colleges and universities, the social sciences and humanities, and perhaps most significantly of all, into the fundamental field of how and why human beings are able to learn anything at all. Goodlad[2] reports that "approximately fifty per cent of the children and teachers in the United States are directly affected by the curricular reform movement." Clinchy[3] in identifying areas of commonality among the more

---

[1]Arthur Foshay, "How Fare the Disciplines?," Phi Delta Kappan, March, 1970, p. 349.

[2]John I. Goodlad, "Implications of Current Curricula Change," The Education Digest, March, 1967, pp. 12-15.

[3]Evans Clinchy, "The New Curricula," The Revolution in the Schools. Edited by Ronald Gross and Judith Murphy (New York: Harcourt, Brace and World, 1969), p. 220.

prominent and influential reform programs points out that "The current reforms almost always involve not only a radical new approach to the content but also explorations into new and different ways of teaching and learning."

Thus the prevailing attitude of scholars and schoolmen involved in curriculum reform is that not only what is taught is important, but how it is taught is also of paramount interest. They feel that new content included in courses of study, while it is surely important, is in some sense less crucial than the way a scholar goes about finding the answer to a problem.

Phenix[1] contends that "instruction in the characteristic methods of inquiry in the disciplines enlists the vital participation of the student and thus speeds the acquisition of meaning." Silberman[2] maintains that children should attend schools that are centers of inquiry rather than buildings for one-way transmission of knowledge. Education should be teaching people how to learn by giving them the kind of intellectual discipline that will enable them to apply man's accumulated knowledge in recognizing and solving problems as they arise.

---

[1]Philip Phenix, Realms of Meaning (New York: McGraw-Hill Book Company, 1964), p. 341.

[2]Charles Silberman, "Murder in the Schoolroom: How the Public Schools Kill Dreams and Mutilate Minds," Atlantic Monthly, June, 1970, pp. 82-96.

Ostensibly, learning by inquiry is somewhat contrary to the traditional style of teaching which has been limited to the rote acquisition of information, repetitive drill, and rule memorization. Renner[1] gives a succinct description of the educational scene in America today:

> The schools of the late 1960's then, are deep into the process of changing themselves from a type of institution which looked upon its primary role as being that of telling the learners what they should know into a type of educational environment which permits the individual to develop the ability to use his mind.

Even though advocated by many prominent proponents the efficacy of learning by inquiry is yet to be fully substantiated. Do children learn more efficiently? Does inquiry learning maximize transfer of learning? Is inquiry learning compatible with the goal of Education as set forth by the Educational Policies Commission? The Commission[2] states "the development of every student's rational powers must be recognized as centrally important." A defensible conjecture, it seems, is that inquiry learning will contribute to the development of the rational powers more so than other strategies such as expository-type or demonstration-type instruction.

Development of defensible and reasonable schemes of interpretation are crucial elements in the process of

---

[1] John W. Renner, Address given at the Annual Meeting of the American Association for the Advancement of Science, Section Q, in Dallas, Texas, December 27, 1968.

[2] Educational Policies Commission, <u>The Central Purpose of American Education</u>, NEA, Washington, D.C., 1961, p. 12.

learning by inquiry. Can inquiry learning foster the development of effective intuitive thinking through the development of self-confidence on the part of the student? Will the student develop the concept that "right or wrong answers" are not relevant to the process of inquiry? Renner and Ragan[1] point out the importance of learning by inquiry from the viewpoint of what it will do for the child that other methods would have difficulty providing. They contend that:

1. Discovery[2] has the "potential" of developing the ability to learn.

2. Discovery learning experiences can lead the learner to discover the structure of the discipline.

3. Discovery learning develops in the individual those abilities which will provide him with a good memory.

Bruner[3] hypothesizes:

> Inquiry is a necessary condition for learning the variety of techniques of problem solving, of transforming information, for better use, and indeed for learning how to go about the task of learning.

Not all authorities completely agree with the foregoing point of view. Some admit that inquiry has

---

[1]John W. Renner and William B. Ragan, Teaching Science in the Elementary School (New York: Harper and Row, Publishers, 1968), pp. 89-97.

[2]Note: In this sense discovery and inquiry are used synonymously.

[3]Jerome S. Bruner, The Process of Education (New York: Vintage Books, 1960), p. 65. Parenthetical statement has been introduced for emphasis and clarity by the present author.

advantage under certain conditions for certain purposes but warn against elevating it into a panacea. Ausubel[1] expresses several reservations in regard to inquiry-oriented teaching. They are:

1. The technique is generally unnecessary and inappropriate for teaching subject-matter content except when pupils are in the concrete stage of cognitive development.

2. Discovery is not indispensable for intuitive understanding, and need not constitute a routine part of pedagogic technique.

3. Through proper expository teaching, students can proceed directly to a level of abstract understanding that is qualitatively superior to the intuitive in terms of generality, clarity, precision, and explicitness.

Ausubel[2] further criticizes the approach as not taking into account the inordinate time and cost involved; also by the fact that children tend to jump to conclusions, to generalize on the basis of limited experience, and to consider only one aspect of a problem at a time.

Friedlander[3] says:

> However well we structure the preliminary materials from which discoveries are to be launched, there is an indefinitely large number of possibilities for disturbing a productive train of thought. Often the student's thinking may go off in directions that lead to needless complications.

---

[1]David P. Ausubel, "Some Psychological and Educational Limitations of Learning by Discovery," The Arithmetic Teacher, XI (May, 1964), pp. 290-302.

[2]Ibid.

[3]Bernard F. Friedlander, "Today's Innovations in Teaching," NEA Journal, LXIV (March, 1966), p. 14.

Lack of research evidence in support of the inquiry method is commonly agreed upon by the authorities. Taba[1] asks:

> Is it possible that the current models of inquiry and discovery, developed in the neat field of mathematics and science, may not be applicable to the untidy field of social and human problems?

Friedlander[2] expresses a position that our faith in the discovery method of learning is based on the assumption that the student is more likely to retain insight he has developed on his own, and that no extensive hard evidence exists to support this view.

A criticism expressed of the curriculum reform groups was that they failed to present evidence that superior achievement outcomes were attributable to the influence of new instructional techniques or materials in question, rather than to the fact the experimental group was the recipient of some form of conspicuous special attention. Massialas and Zevin[3] point out that it would be desirable to conduct longitudinal studies of students who have been exposed to the process of inquiry. Perhaps this would

---

[1] Louis I. Kuslan and A. Harris Stone, Readings on Teaching Children Science (Belmont, California: Wadsworth Publishing Co., Inc., 1969), p. 59.

[2] Friedlander, op. cit., p. 14.

[3] Byron G. Massialas and Jack Zevin, Creativity Encounters in the Classroom: Teaching and Learning Through Discovery (New York: John Wiley and Sons, Inc., 1967), p. 263.

ameliorate the Hawthorne effect to see whether the novelty of the approach accounts for the difference.

Albeit there are differences of opinion among authorities as to the efficacy of inquiry-oriented teaching it is generally agreed that it has a proper place among the accepted pedagogic techniques, and has come to be established as an effective instructional strategy. Only through continued research can the various techniques be analyzed to identify particular behaviors they may elicit.

Purpose of the Study

Renner and Stafford[1] hypothesize "that an inquiry-centered experience in science education prepares a teacher to teach all subjects from an inquiry point of view." Implied in this hypothesis, to this writer at least, is that if all subjects are taught from the inquiry point of view, then the students' educational experiences will be enhanced. Recognizing it is almost certain that a single study cannot test with conclusiveness the proposed hypothesis, this study was designed to investigate the efficacy of an inquiry-oriented science curriculum on the general educational achievement of students. The purpose of this study was to contribute to further understanding the relationship between certain variables and inquiry as a strategy for instruction.

---

[1]John W. Renner and Donald G. Stafford, "Inquiry, Children and Teachers," The Science Teacher, April, 1970, p. 57.

Statement of the Problem

The problem was to determine if an inquiry-oriented curriculum in one subject matter area (science) of study transfers to other areas thereby resulting in more effective learning. The study attempted to determine if there is any significant difference in the achievement patterns of children who have completed four years of an inquiry-oriented science curriculum and students who have not experienced an inquiry-oriented curriculum. More specifically, the effects of the inquiry method were investigated by comparing the attitudes, understandings, and skills of fifth grade students who have participated in an inquiry-oriented science curriculum since grade one with fifth grade students who had not experienced such a curriculum.

Hypotheses To Be Tested

The general hypothesis tested in this study was that the achievement of children who have had longitudinal experience in an inquiry-oriented curriculum in science for four years is no different from the achievement of children in a traditional curriculum. The experiment specifically tested the following:

Ho_1: The scores for the experimental group on the mathematics concepts test are higher than the scores for the control group.

Ho_2: The scores for the experimental group on the mathematics skills test are higher than the scores for the control group.

Ho_3: The scores for the experimental group on the mathematics applications test are higher than the scores for the control group.

Ho_4: The scores for the experimental group on the social studies content test are higher than the scores of the control group.

Ho_5: The scores for the experimental group on the social studies skills test are higher than the scores of the control group.

Ho_6: The scores for the experimental group on the reading word meaning test are higher than the scores for the control group.

Ho_7: The scores for the experimental group on the reading paragraph meaning test are higher than the scores of the control group.

Major Assumptions

1. The Science Curriculum Improvement Study, elementary science course for the first four grades is conducive to inquiry-centered teaching.

2. The tests utilized in this study were properly administered and scored.

3. Academic achievement of subjects is accurately reflected in the scores of the examinations administered.

4. The amount of time spent in each curricular area of this investigation was not controlled. It was assumed that this factor did not invalidate the results.

Delimitation of the Study

The study involved 115 fifth grade pupils--forty-six in one group and sixty-nine in the second group. Criteria for inclusion in the investigation were that each subject must have completed four years in his school beginning with grade one and have a test score in each academic area under consideration. The forty-six pupils who had completed grades one through four in an inquiry-centered science program comprised the experimental group for this investigation. Sixty-nine pupils from a different school than the experimental group and who had not experienced an inquiry-science curriculum comprised the control group. Since the implementation of innovative science programs of the nature of the one considered in this investigation is limited, the sampling procedure was restricted by the availability of subjects.

Methodology and Design

In order to take advantage of existing conditions in the selected schools an ex post facto type of research was utilized in this study. Kerlinger[1] describes ex post

[1]Fred N. Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart and Winston, Inc., 1967), p. 360.

facto research as "research in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables." Kerlinger further states that

> . . . the most important social scientific and educational research problems do not lend themselves to experimentation although many of them do lend themselves to controlled inquiry of the ex post facto kind.

In this regard ex post facto research is to a degree more important than experimental research.[1]

The design of the study is of the ideal or "best" design of educational and social scientific research. Employed is the classical design of experimental group-control group where, theoretically, all possible independent variables are controlled.[2]

Criteria for selection of subjects for this investigation were as follows: (1) Select fifth grade pupils from both schools who had attended their respective school for four successive years. (2) From criterion one, include only those pupils who had a complete test score in each academic area investigated.

The procedure described is compatible with the classical design. Assignment for this study is dependent upon selection of an inquiry-oriented science curriculum as an independent variable. Thus, the design of the study

---

[1] Ibid.

[2] Ibid., p. 303.

is one of two independent samples with the assignment of two treatments (inquiry vs. traditional).

The 1964 edition of the Stanford Achievement Test was identified as appropriate for gathering data to test hypotheses one through seven. Standardization of the Stanford series was based on a sample of 1000 cases drawn randomly from 76 school systems, grades 1-9. The estimates of reliability range from .66 to .96 with a median of approximately .88.

The Stanford test is recommended for use in the analysis of group differences among school subjects. It is further recommended for use in "evaluating instructional methods and materials, and as a source of information on which to base curriculum changes."[1]

Portions of Intermediate I Battery for grades four and five were administered to the control group and the experimental group in late September. Scores in language, arithmetic computation, arithmetic concepts, and social studies were obtained. Only raw scores were considered in the statistical treatment of the data.

In the judgment of this writer, after reviewing several standardized test batteries and consulting critiques of authorities, the Stanford series appeared to be the most sensitive to changes in curricula content and sequence that

[1]Oscar Kriesen Buros (ed.), The Sixth Mental Measurements Yearbook (Highland Park, New Jersey: The Gryphon Press, 1965), pp. 110-128.

has occurred in recent years, and hence most compatible with purposes of this investigation.

Statistical Treatment

The purpose of this study was to determine whether differences in two samples constitute convincing evidence of a difference in two different methods of instruction and materials utilized. The nature of this study and existing conditions in the two schools dictated the selection of a statistical test applied to an independent samples design. According to Siegel[1] in an independent samples design the two samples may be obtained by either of two methods: (a) they may each be drawn at random from two populations, or (b) they may arise from the assignment at random of two treatments. In either case it is not necessary that the two samples be of the same size.

The usual technique for analyzing data from two independent samples is to apply a "t" test to the means of the two groups.[2] However, since all of the assumptions of the "t" test could not be guaranteed in this study, an alternative test was chosen. For the purpose of testing hypotheses Ho_1, Ho_2, Ho_3, Ho_4, Ho_5, Ho_6, and Ho_7 the Mann-Whitney U Test was employed. The procedure for applying the U test is to first combine the observations or scores

---

[1] Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill Book Company, 1956), p. 95.

[2] *Ibid.*, p. 96.

from both groups, and rank these in order of increasing size. Next focus on one of the groups, say the one with n_1 cases. The value of U is given by the number of times that a score in the group with n_2 cases precedes a score in the group with n_1 cases in the ranking.

According to Siegel,[1]

> The Mann-Whitney U Test is one of the most powerful of the nonparametric tests, and is a most useful alternative to the parametric 't' test when the researcher wishes to avoid the 't' test assumptions. . . .

He further points out that the Mann-Whitney U Test has a power efficiency of 95.5 per cent and as the sample sizes increase (n_1, n_2, ≥ 20) the sampling distribution rapidly approaches the normal distribution with

$$\text{Mean} = \mu_U = \frac{n_1\ n_2}{2}$$

$$\text{Standard deviation} = \sigma_U = \sqrt{\frac{(n_1)\ (n_2)\ (_1 + n_2 + 1)}{12}}$$

Where n_1 = number of subjects in the smaller of two independent groups, and n_2 = the number of subjects in the larger. When $n_2 > 20$ the significance of an observed value of U may be determined by

$$z = \frac{U - \mu_U}{\sigma_U} = \frac{U - \frac{n_1\ n_2}{2}}{\sqrt{\frac{(n_1)\ (n_2)\ (n_1 + n_2 + 1)}{12}}}$$

The value of U is determined by

---

[1]Siegel, op. cit., p. 116.

$$(1) \qquad U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1 \quad \text{or}$$

$$(2) \qquad U = n_1 n_2 + \frac{n_2 (n_2 + 1)}{2} - R_2$$

Where R_1 = sum of ranks assigned to the group whose sample size is n_1, and R_2 = sum of ranks assigned to n_2.

However, since the normal approximation to the sampling distribution of U was used in testing the hypotheses of this study (1) above was utilized for computing U.[1] Also, since the proportion of tied rankings was relatively large for the data of this study the following formula was used for determining z. The formula in effect provides a correction factor for ties which produces a slightly larger z. This in turn provides for a more exacting statistical test.

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\left(\frac{n_1 n_2}{N(N-1)}\right)\left(\frac{N^3 - N}{12} - \sum T\right)}}$$

$N = n_1 + n_2$ and $T = \frac{t^3 - t}{12}$ where t is the number of observations tied for a given rank, $\sum T$ is found by summing the T's over all groups of tied observations, and N is the number of subjects in the combined groups.

The probability associated with the occurrence under Ho of values as extreme as an observed z may be determined

---

[1] *Ibid.*, p. 121.

by reference to a table of probabilities for the normal distribution. For the purposes of this study the table provided by Siegel was utilized.[1]

There are two types of errors which may be committed in arriving at a decision about the null hypothesis. The first, Type I error, is to reject the null hypothesis, when in fact it is true. The second, Type II error, is to accept the null hypothesis, when in fact it is false.

It seems, to this writer at least, that committing an error of Type II would be most detrimental in any investigation that considered innovative educational programs. Implementation of newer curricula requires not only a commitment on the part of personnel, but also requires substantial expenditure of time and funds. If an error of Type II is committed, then basically what it is saying to the implementer is that the innovative program holds little or no promise when in fact precisely the opposite may be true. Faced with the fact (erroneous as it may be) that the program is not succeeding or has not produced significant differences the implementer is likely to discourage any further experimentation which could conceivably result in irreparable damage to the total educational process.

In regard to this study an error of Type II would be especially relevant for the experimental school. Since a significant commitment to program innovation requiring

[1] Ibid., p. 247.

substantial expenditures of effort and funds has been made it is deemed essential to reduce the chances of making an error of Type II to the greatest possible extent.

Committing an error of Type I does not produce the same ramifications as does a Type II error. Since each school has previously made a commitment to program, no additional expenditure of effort of an immediate nature would be required. Also, if for some reason it is suspected that extraneous events have contributed to committing an error of Type I the investigation could be easily replicated with more exacting controls. In the interim both schools could continue in their respective programs without realizing any serious effects.

In light of possible consequences of committing either of the two types of errors in regard to educational decision making this investigator proposes to establish a relatively stringent confidence interval. The probability of making a Type I error (rejecting Ho when it is true) will be .10. Also since the hypotheses of this study do indicate a predicted direction of the difference of the two samples a one-tailed test will be utilized.

Organization of the Study

The report of this investigation consists of four additional chapters, a bibliography, and an appendix. Chapter II presents a survey of the relevant research germane to the problem. Chapter III contains a description of the procedures employed in the investigation. The data are presented and analyzed in Chapter IV. The summary, conclusions, and recommendations, based upon the analyses and interpretation of the data, are presented in Chapter V.

CHAPTER II

SURVEY OF RELATED LITERATURE

This study was primarily concerned with determining the effects of inquiry teaching on the academic achievement of children. Literature which relates to the central purpose of this investigation is reviewed below. The survey will include references to the importance of inquiry learning as expressed by individuals as well as groups.

What Is the Inquiry (Discovery) Approach?

The concept of inquiry or discovery learning ostensibly means different things to different people. In the literature, the ideas are frequently used interchangeably with such terms as the "inductive" approach, or as "guided discovery" and as the opposite of "rote." Davis[1] contends "there are many different kinds of 'discovery' experiences, and we confuse the issue badly when we treat discovery as a single, well defined kind of experience." Renner and Ragan[2] make a distinction between "inquiry" and

---

[1]Robert Davis, "Learning by Discovery," Madison Project Report, Webster College, Webster Groves, Missouri.

[2]Renner and Ragan, *op. cit.*, p. 14.

"discovery" only to the extent that the dictionary definition of "discovery" (the act of discovering) includes obtaining insight or knowledge for the first time, whereas "inquiry" is defined as a request for information. They further point out that from a teaching point of view, the differences are very slight and need not be of concern.

Renner,[1] however, has very recently modified the foregoing viewpoint to the extent that discovery is considered as an integral component of the entire inquiry process rather than as an equivalent with inquiry. He contends that:

> After you have developed basic and probably initial understanding regarding a new phenomenon, you try to extend those understandings by discovering all you can about the object, event, or situation from the frame of reference of the new conceptual invention. You have, in short, asked the object, event, or situation about itself, and that is inquiry.

Kersh[2] maintains that "discovery" and "rote" are probably not opposite terms as generally thought. He claims that it would be more correct to confine the term, discovery, to that phase in learning which precedes the learner's making the desired response and the other, rote, to the phase when a learner is memorizing or developing skill.

---

[1]John W. Renner and Don G. Stafford, "Elementary School Science," Bios, XLI, No. 4 (December, 1970), p. 170.

[2]Bert Y. Kersh, "Learning by Discovery: What Is Learned," The Arithmetic Teacher, XI (April, 1964), p. 227.

Karplus and Adkin[1] in their way of describing discovery make a distinction between "discovery" and "invention." They say,

> In the development of a concept, it is useful to distinguish the original introduction of a new concept, which can be called invention, from the subsequent verification or extension of the concept's usefulness, which can be called "discovery."

In general, authorities agree that a discovery approach is being used when content is presented to pupils so that they are challenged to think about relationships, to look for patterns and clues, and to draw logical conclusions for themselves. In this method no wordy explanations introduce the activities, nor are rules for memorization presented.

Suchman[2] identifies three conditions necessary in order for inquiry or discovery to take place.

1. First, there must be a focal point, something that captures the children's attention, holds it, and motivates them to dig.
2. Probably the most important condition of all is freedom. In order for inquiry to take place, there must be freedom for the individual to reach out in his own way, at his own pace, for

---

[1]Robert Karplus and J. Myron Adkin, "Discovery or Invention," <u>The Science Teacher</u>, XXIX (September, 1962), p. 45.

[2]J. Richard Suchman, "Learning Through Inquiry," <u>The Oregon Program, A Design for the Improvement of Education</u> (Salem: Oregon State Department of Education, 1964), pp. 41-42.

the kinds of information that he determines he needs next.

3. Finally, it is necessary to put the child in a responsive environment. The idea of a response coming back from the system is essential to the learning of how the system operates . . . the response is in terms of the data that the children get back when they ask for data. If they cannot get that response, they have no basis for building or testing theory.

Early Interest in Inquiry

The literature reveals that for many years there has been an interest in the inquiry approach to learning. Among the more prominent personalities who, in their writings, advocated use of the strategy either directly or indirectly are Rousseau, Montessori, and Pestalozzi.

Rousseau in his book Emile condemned artificial education and developed a theory based on three premises one of which is "instruction should be active and based on the child's experience." Pestalozzi urged that all instruction begin with the simplest elements in the learner's environment and gradually proceed to the abstract and complex.[1]

---

[1]Gerald Gutek, An Historical Introduction to American Education (New York: Thomas Y. Crowell Company, 1970), pp. 172-183.

Cognizance of the potential of inquiry can be found among the ideas of Montessori.[1] She contended that:

> The fundamental principle of scientific pedagogy must be, indeed, the liberty of the pupil. . . An adult must assist a child in such a way that he can act and carry out his own work in the world.

Current Interest in Inquiry

Interest in learning by inquiry is not limited to individual educators and psychologists. As early as 1952, the University of Illinois began to prepare materials and teachers to improve the teaching of mathematics. A major guiding principle of the University of Illinois group was that the student will come to understand mathematics if he plays an active part in developing mathematical ideas and procedures. Beberman[2] says,

> We believe that a student will come to understand mathematics when his textbook and teacher use unambiguous language and when he is enabled to discover generalizations by himself . . . for new discoveries are easier to make once previous discoveries are crystallized. . . .

The University of Illinois group is only one of several that have worked on the improvement of teaching mathematics. The School Mathematics Study Group has prepared textbooks and other materials which carefully sequence

---

[1]Robert E. Buckenmeyer, "Discovery in the Child," The Constructive Triangle, VI, No. 2 (December, 1970), p. 2.

[2]Max Beberman, An Emerging Program of Secondary Mathematics (Cambridge: Harvard University Press, 1958), p. 1.

and structure basic mathematical concepts and involve the student in discovery of basic mathematical ideas.

Spitzer[1] has noted that:

> Controlled research studies, comparing pupil achievement in programs emphasizing an exploratory type of procedure with programs of a non-exploratory nature, have given a slight edge to the exploratory programs. When comparisons are made through other data-gathering means such as observations of pupil resourcefulness, confidence, and general interest in mathematics, the results have been even more definitely in favor of programs emphasizing exploration and discovery.

Preference among educators for teaching by discovery is not by any means limited to mathematics. In 1963 the Chemical Education Material Study produced a course in chemistry which utilized movies, text, and laboratory manual. Through laboratory experiments the student discovers the basic ideas of the course. One could name other science curriculum reform groups, for example, the American Institute of Biological Sciences Project in the teaching of biology, which placed high priority on discovery learning.[2]

Curriculum reform groups have made an impact not only at the secondary school level, but at the elementary

---

[1]Herbert F. Spitzer, Teaching Arithmetic, No. 2 of What Research Says to the Teacher, Department of Classroom Teachers, American Educational Research Association of the National Education Association (Washington, D.C.: National Education Association, 1962), p. 8.

[2]Lee S. Shulman and Evan R. Keislar, Learning by Discovery: A Critical Approach (Chicago: Rand McNally & Co., 1966), p. 39.

level as well. Prominent among the science groups are the Science Curriculum Improvement Study (SCIS)[1] the AAAS Commission on Science Education which developed Science-A Process Approach, and the Elementary Science Study. Each recognizes the importance of learning by inquiry as, perhaps, is illustrated in the three steps utilized by the Science Curriculum Improvement Study in introducing children to science:

1. Preliminary explorations, where children explore the elements of the new concept.

2. Invention - the teacher introduces the new scientific concept that explains what the children have observed.

3. Discovery lessons - this experience helps the child to recognize that the new concept has applications to situations other than the original or initial meaning.[2]

In recent years authorities have recognized the importance of inquiry in developing curricula for the preschool and kindergarten age children. Estvan[3] suggests that "development of inquiry behavior is one of the most important functions of early childhood education." He

---

[1]SCIS was the curriculum which the children in the experimental group experienced. The SCIS is described in detail in Appendix A.

[2]Albert H. Shuster and Milton E. Ploghoft, The Emerging Elementary Curriculum (2nd Ed.; Columbus, Ohio: Charles E. Merrill Publishing Co., 1970), p. 337.

[3]Frank J. Estvan, "Teaching the Very Young: Procedures for Developing Inquiry Skills," The Phi Delta Kappan, L, No. 7 (March, 1969), p. 390.

further suggests the following four goals for teaching inquiry skills to pre-school children:

1. Cognitive objectives that deal with knowledge and understanding. A basic step in learning to conduct inquiry is to acquire a meaningful grasp of the terms involved.
2. Affective objectives centering on the child's interest in discovering answers for himself and his persistence in the face of frustration . . . Instead of terminating behavior, behavioral goals for young children might be: The child repeats his procedures when his first attempt fails.
3. Psychomotor objectives include all the skills involved in the inquiry process: formulating a question, collecting information, working with data, and confirming surroundings.
4. Objectives for data-collecting skills can be expressed in terms of the number of senses involved and the child's ability to participate in experiments.

Another program for pre-school age children that places emphasis on inquiry as a strategy for instruction is the Heuristic School of the University of Oklahoma Laboratory Schools. The hypothesized philosophy of the Heuristic School is that multi-age grouping in a free inquiry-oriented atmosphere will produce the type of intellectual development described by Piaget and described by society more efficiently and completely than a homogenous age grouping. One of the stated purposes of the school is to develop in each child the ability and confidence to inquire.[1]

Lavatelli[2] in summarizing the implications of Piaget's theory for early childhood curricula suggests that the teacher's role is to stimulate and guide. The teacher must have confidence in the child's ability to learn on his own rather than being provided the right answer or being told he is wrong. When the child is wrong, the teacher should ask questions or give clues so that more data are assimilated. The child must be convinced by his own actions.

Recent Investigations

Renner and Stafford[3] summarized some of the most recent findings of research regarding the use of the inquiry-oriented material. Stafford utilized a unit entitled Material Objects from the Science Improvement

---

[1]The Philosophy of an Heuristic School, The University of Oklahoma Laboratory School, Norman, Oklahoma, 1970.

[2]Celia Stendler Lavatelli, Piaget's Theory Applied to an Early Childhood Curriculum (Boston: American Science and Engineering, Inc., 1970), p. 48.

[3]Renner and Stafford, op. cit., pp. 55-57.

Curriculum Study as the focus of his investigation. He used one hundred twenty first graders, sixty of whom were taught "Material Objects," and sixty of whom were taught from a textbook. The findings indicate that children taught by inquiry show a more rapid intellectual development than do those children not having such experiences. The authors (Renner and Stafford) also report another study of thirty classes of elementary children studying science in grades one through six. Fifteen classes were taught by teachers who had been exposed to inquiry-oriented methodology. The other fifteen had no such educational experience. The results of this investigation revealed that the inquiry oriented teachers provided the children significantly more of the essential science experiences than did the traditional group and they also encouraged pupils to become involved in experiences and find their own answers to problems.

Porterfield[1] tested whether or not teachers who had an inquiry experience in science education taught reading in such a way that rational power development would be facilitated. Porterfield found that the influence of materials was not a factor. The inquiry group of teachers

---

[1]Denzil Porterfield, "The Influence of Preparation in the Science Curriculum Improvement Study on the Questioning Behavior of Selected Second and Fourth Grade Reading Teachers." Unpublished doctoral dissertation, University of Oklahoma, 1969.

asked questions which called for higher levels of thought than did the control group. The general pattern was that inquiry-trained teachers asked questions aimed at levels above recognition and recall.

Schmidt[1] in studying the modifications of instructional patterns in science and social studies classes as a result of inquiry-teaching training found that teachers asked fewer recall and convergent questions. Schmidt also noted that the teachers asked more questions that required pupils to operate at higher levels of the rational powers. Those modifications noted by Schmidt occurred in social studies classes as well as science classes. The social studies classes were using traditional materials, whereas the science classes were using inquiry-centered materials.

Butts and Jones[2] investigated whether children were better able to deal with science problems as a result of training in inquiry. Subjects for the investigation were one hundred nine sixth grade children in which one-half was involved in planned guidance designed to enhance their problem-solving behaviors. The remaining pupils served as

---

[1]Frederick B. Schmidt, "The Influence of a Summer Institute in Inquiry-Centered Science Education upon the Teaching Strategies of Elementary Teachers in Two Disciplines." Unpublished doctoral dissertation, University of Oklahoma, 1969.

[2]David P. Butts and Howard L. Jones, "Inquiry Training and Problem Solving in Elementary School Children," Journal of Research in Science Teaching, IV, No. 1 (1966), pp. 21-27.

a control group. The results of the study indicated that elementary school children exposed to guidance, do show behavior patterns indicative of more effective problem solving. Evidence did not support the assertion that a child's intelligence, sex, chronological age, or science factual knowledge are significant factors in his benefiting from inquiry training.

Suchman[1] in summarizing the results of three pilot studies reports that inquiry skills of fifth grade children can be improved over a period of fifteen weeks by following certain prescribed methods. He further states that children who receive training in inquiry develop a fairly consistent strategy which they can transfer to new problem situations. They make fewer untested assumptions, formulate more hypotheses, and they perform more controlled vs. uncontrolled experiments in the course of their inquiry. Suchman also warns that inquiry skills cannot be successfully taught to this age group as an isolated content area. Inquiry training and abundant opportunities to attain new concepts through inquiry, seem to produce increments in the understanding of content as well as an important new grasp of the method.

A growing awareness on the part of educators in disciplines other than mathematics and science as to the

---

[1]J. Richard Suchman, "Inquiry Training in the Elementary School," The Science Teacher, XXVII, No. 1 (November, 1960).

need for newer innovative instructional strategies is represented in the following statement by Wesley:[1]

> The student would be the great beneficiary of the abolition of history as courses. Freed from compulsion, from the futile effort to remember, he would begin to explore history, utilize it for answers to his questions, to experience the thrill of discovery. He would be transformed from a dull underling to a self directed inquirer.

Research findings indicate that inquiry can be successfully utilized in the study of historical concepts. Smith and Cox[2] summarize several studies conducted in Indiana since 1960 which suggest that inquiry can take place in existing history courses. The courses reported in the studies were generally taught in a topical fashion with a high priority placed upon the development of concepts and inquiry skills. The investigators concluded that the inquiry groups when compared with matching control groups, had at least as much factual information and made significantly greater progress in mastering skills of inquiry.

Massialas[3] reports findings on the effect of learning by discovery in research conducted in high school English and social studies in the Chicago area. Without exception students were able to become actively engaged in

---

[1]Edgar B. Wesley, "Let's Abolish History Courses," Phi Delta Kappan, XLIX (September, 1967), p. 8.

[2]Frederick R. Smith and C. Benjamin Cox, New Strategies and Curriculum in Social Studies (Chicago: Rand McNally & Co., 1969), p. 116.

[3]Massialas and Zevin, op. cit., pp. 74-133.

the inquiry process. The method of discovery had a highly motivating effect on the student and personal involvement was demonstrated. Little encouragement was needed to keep the students working to solve problems and there was exhibited a genuine effort at teamwork and a pooling of labor and talents. Peer discussion outside the class definitely increased. In support of the findings by Massialas, Bradley[1] reports the findings of a study conducted by Maws. In this study an investigation was made on the effectiveness of lessons in social studies designed to improve critical thinking of primary and middle grade students. Results of the study revealed much improvement in thoughtful consideration of problems, the tendency to suspend judgment and a desire to obtain more evidence before forming conclusions. Long[2] conducted an experiment with twelve sixth, three fourth, and three fifth grade students, at Webster College Experimental School in St. Louis, which centered around developing a curriculum in behavioral science. The students eventually planned as well as carried out their own experiments. The results of the study revealed a surprising grasp of the materials and the development of broad principles of behavior on the part of the students. The

---

[1]R. C. Bradley, "Improving the Social Studies Curriculum at the Elementary School Level," The Education Digest (May, 1968), pp. 41-44.

[2]Barbara Ellis Long, "Behavioral Science for Elementary School Pupils," The Elementary School Journal (February, 1970), pp. 253-259.

success of this project led to a pilot program to be implemented by the St. Louis Public Schools in 1970-71.

A study made by Rizzuto[1] examined the effects of inductive and deductive methods of teaching language structure by comparing two groups of eighth grade students. One group was taught by the expository treatment and the other by the discovery method. The results demonstrated a definite superiority for the inductive (inquiry) method over the expository technique in the learning of the concepts of language structure.

Meconi[2] investigated the effects of inquiry teaching on mathematically gifted students at the junior high school level. The study utilized three different instructional strategies--rule-and-sample given, the guided discovery approach, and the pure discovery approach. His central findings were summarized into three main points: (1) All three approaches led to learning in terms of measures of time and error, (2) there were no significant differences in the approaches on a problem solving test of immediate transfer and on a retention test four weeks later, and (3) the pure-discovery approach was the most effective as

---

[1]Malcom F. Rizzuto, "Experimental Comparison of Inductive and Deductive Methods of Teaching Language Structure," Journal of Educational Research (February, 1970), pp. 269-273.

[2]L. J. Meconi, "The Mathematically Gifted Student and Discovery Learning," The Mathematics Teacher (December, 1967), pp. 862-865.

far as time taken to learn and to solve problems was concerned. The last point suggests that more efficient learning could take place if mathematically gifted students were permitted to employ the pure discovery approach in order to gain knowledge.

During the past ten years there has been intense interest on the part of individuals as well as groups, as to the effect of inquiry-oriented instruction. Opponents of the technique contend that it is too time consuming, costly, and that one need not discover for himself everything anew but that he can profit from the experiences of others. Proponents of the technique argue that inquiry skill is an important end in its own right. It deserves attention and students should have some practice at discovering answers to questions for themselves. One must learn to produce rather than to reproduce answers and knowledge.[1]

Shulman and Keisler[2] suggest that progress on the issue of effects of inquiry learning transcends the rote versus discovery issue. Energy should be directed to operationally defined issues and hypotheses. As an example the idea of positive transfer or the ability to go beyond the data or to go beyond the specifics is commonly cited in suggested research. This suggests an immediate issue. How

---

[1]Shulman and Keislar, <u>op. cit.</u>, p. 36.

[2]<u>Ibid.</u>, p. 75.

can a student be taught problem strategies which will transfer positively to new problems or show a savings in further learning? This study proposes to focus on providing answers to the foregoing questions through an investigation of the effects of an inquiry-oriented science curriculum (SCIS) on a child's achievement in other curricular areas.

CHAPTER III

PROCEDURES OF THE STUDY

This section describes the major procedures utilized in the investigation of the stated problem. The procedures included: identification and selection of the problem, identification of the instruments and sampling procedures, administration of instruments, and statistical treatment of the data.

Identification of the Problem

The selection of the problem was followed by an extensive review of the literature related to strategies for instruction and consultation with authorities in curricular innovation. Inquiry as an instructional strategy and its impact on learning was identified as an area of concern that merited additional study.

Description of the Instrument

For the purposes of this study portions of the 1964 edition of the *Stanford Achievement Test* were utilized. In order to gather data for testing hypotheses relating to mathematics and reading subtests from the Intermediate I battery, Form W was administered. The Intermediate I

Arithmetic Tests were designed for use from the beginning of grade 4 to the middle of grade 5. They consist of tests in Arithmetic Computation, Arithmetic Concepts, and Arithmetic Applications. The battery was standardized on the basis of a random sample of 1,000 pupils in grade 4. Reported reliability co-efficients are: (1) Computation - .88, (2) Concepts - .86, and (3) Applications - .86. Validity for the battery was established through an examination of appropriate courses of study, and textbooks as a basis for determining the skills, knowledge, and understandings to be measured.

The Arithmetic Computation subtest measures proficiency in the computational skills of addition, subtraction, multiplication, and division. It consists of 39 multiple choice items with a "not given" (NG) included as one of the choices.

The Arithmetic Concepts subtest consists of 32 multiple choice items covering such topics as place value, Roman numerals, operational terms, meaning of fractions, per cent, number names, and number series. To a limited extent geometric terms, directed numbers, and inverses are considered.

The Arithmetic Applications subtest consists of 33 multiple choice items which deal with problems of "real" life. Pupils are required to apply mathematical knowledge and ability to think mathematically in practical situations which concern such areas as volume, ratio, graphs, tables, scales, per cent, business, averages, and problems with geometric figures.

The Intermediate I Reading Tests were designed for use from the beginning of grade 4 to the middle of grade 5. They consist of tests in Word Meaning and Paragraph Meaning. The battery was standardized on the basis of a random sample of 1000 pupils in grade 4. Reported reliability coefficients for Word Meaning is .90 and for Paragraph Meaning is .92. Validity was established through an analysis of actual content of each subtest in relation to the objectives of instruction.

The Word Meaning subtest consists of 38 multiple choice items designed to measure knowledge of synonyms, simple definitions and ready associations. Also included are items designed to measure higher-level comprehension of the concepts represented by words, and fullness of understanding of terms.

In the Paragraph Meaning subtest effort has been made to devise paragraphs interesting to pupils with an appropriate vocabulary level that places a premium on genuine comprehension of the material read. The test provides a measure of the pupil's ability to comprehend connected discourse involving levels of comprehension varying from extremely simple recognition to the making of inferences from what is stated in several related sentences.

For the data concerning achievement in social studies Form W of the Intermediate II battery was administered. The Intermediate II Social Studies Test was primarily designed to use from the middle of grade 5 to the end of grade 6. The battery was standardized on the basis of a random sample of 1000 pupils in grade 5. Reported reliability coefficient is .89 for the middle of grade 5. The Social Studies Test is divided into two parts. Part A: Content which covers the general areas of history, geography, and civics. A stated goal of the authors for this subtest is to test "knowledge in action." Part B: Study Skills in the Social Studies includes twenty-nine items which are classified as interpretation of graphs and tables, reading of maps, and interpretation of a political poster. As in the case of Arithmetic and Reading content validity was the mode of validity established.

Selection of Samples

Selection of samples for the purposes of this study involved two schools. One of the schools is in the process of implementing a totally inquiry-centered science program. The other school is best described as a quality school that is maintaining a traditional curriculum.

The school utilizing an inquiry-centered science program (referred to in this study as the experimental group) has implemented the Science Curriculum Improvement Study (SCIS) materials. The Science Curriculum Improvement

Study which was initiated in 1962 and represents a change in elementary school science from a subject matter organization to a program based on a sequence of units which foster inductive thinking; i.e., Inquiry. The SCIS curriculum uses a materials-centered approach which permits children to explore, observe, and manipulate selected materials and, with some teacher guidance, a scientific concept is introduced (invention). Through a series of related experiences the concept is reinforced, and finally the children learn that this new concept has applications to many situations (discovery). Thus there are basically three steps followed in introducing children to the science curriculum: (1) Preliminary explorations, where children explore the elements of the new concept; (2) Invention--the teacher introduces the new scientific concept that explains what the children have observed; and (3) Discovery lessons--this experience helps the child to recognize that the new concept has applications to situations other than the original, or initial meaning.[1]

Karplus describes the Science Curriculum Improvement Study as being concerned with the development of scientific literacy. This term refers to sufficient knowledge and

---

[1]J. David Lockard (ed.), Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments, A Joint Project of the American Association for the Advancement of Science and the Science Teaching Center (College Park, Md.: University of Maryland, 1968), p. 332.

understanding of the fundamental concepts of both biological and physical sciences to insure effective participation in twentieth century life.[1]

The selection of samples for this research was necessarily restricted due to the fact that a limited number of schools have implemented a curriculum of the nature of the one needed for this study. This necessitated the selection of a school involved in utilizing the SCIS curriculum for four years. This was followed by the selection of a school that is described as traditional in approach with regard to program, but was approximately equivalent to the SCIS school in regard to type (suburban) and socio-economic level.

Comparability of Experimental and Control Groups

The very nature of this investigation and existing conditions in the selected schools dictated utilization of an ex post facto research design. Ex post facto research is defined by Kerlinger[2] as,

> that research in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables. He then studies the independent variables in retrospect for their possible relations to, and effects on, the dependent variable or variables.

---

[1]Science Curriculum Improvement Study, Robert Karplus, Director, University of California, Berkeley; funded by the National Science Foundation, 1962.

[2]Kerlinger, *op. cit.*, p. 360.

Inherent in any ex post facto research interpretation are three basic limitations: (1) the inability to manipulate independent variables, (2) the lack of power to randomize, and (3) the risk of improper interpretation. Compared with experimental research ex post facto research lacks control; this lack is the basis of the third limitation: the risk of improper interpretation.[1]

In order to minimize the basic limitations of ex post facto research and thus reduce the probability of improper interpretation the investigator incorporated the following procedure into the study. First, to minimize the role of readiness as an intervening variable in achievement, it was established that the two groups did not differ in their readiness for first grade instruction. Secondly, a general description of the academic programs in mathematics, reading, and social studies to which the pupils were exposed for four years was made. In this manner the plausibility of approximately equal treatments, other than the variable of science instruction, for the two groups was established.

Due to existing conditions in the schools selected for this investigation intelligence as a variable could not be controlled because one of the schools did not have intelligence scores available. However, each school administers the Metropolitan Readiness Tests to all pupils

---

[1] Ibid., p. 371.

entering the first grade as a part of its total testing program. In both schools the tests are administered in the month of September; thus, no differential in time is involved. Hence scores on the Metropolitan Readiness Tests were used to test if there was a difference between the experimental and control groups in readiness for academic instruction.

The Metropolitan Readiness Tests consist of six tests: Word menaing, Listening, Matching, Alphabet, Numbers, and Copying. For each test a score is determined by the number of items right with provisions for combining the individual scores to give a total Readiness score. This total score is then converted to letter ratings on a convenient five-point scale, from E (low) to A (high), for various total-score ranges as is indicated in the following table.[1]

TABLE 1

LETTER RATING AND READINESS STATUS CORRESPONDING TO VARIOUS RANGES OF TOTAL SCORE

Score Range	Above 76	64-76	45-63	24-44	Below 24
Letter Rating	A	B	C	D	E
Readiness Status	Superior	High Normal	Average	Low Normal	Low

[1]Modified from Manual of Directions, Metropolitan Readiness Tests (New York: Harcourt, Brace and World, Inc.), p. 11.

For the experimental group usable Total Readiness scores for forty subjects were determined. Due to inconsistencies in recording, only forty-four subjects in the control group had Total Readiness scores that could be used with confidence. The judgment was made that the readiness scores for approximately eighty-seven per cent of the experimental group and approximately sixty-four per cent of the control group were adequate for this aspect of the study.

The number of pupils in each letter grade category for each group was determined and cast into a 2 x 5 contingency table as follows.

TABLE 2

NUMBER OF SUBJECTS IN VARIOUS LETTER RATING READINESS CATEGORIES FOR THE EXPERIMENTAL AND CONTROL GROUPS

Group	Letter Rating					Total
	A	B	C	D	E	
Experimental	16	9	11	4	0	40
Control	23	14	5	2	0	44
Total	39	23	16	6	0	84

Since the data on Readiness have been converted to frequencies in discrete categories the χ^2 test was used to determine if significant differences existed between the two groups. The hypothesis under test is: There was no significant difference at the first grade level between the experimental group and the control group in readiness for academic instruction. The hypothesis was tested by

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Where O_{ij} equals observed number of cases categorized in ith row of jth column and E_{ij} equals number of cases expected under Ho to be categorized in ith row of jth column. The Values of χ^2 are distributed approximately as chi square with df = (r - 1) (k - 1), where r equals the number of rows and k equals the number of columns in the contingency table.

TABLE 3

LETTER RATING READINESS CATEGORIES:
OBSERVED AND EXPECTED FREQUENCIES

Group	Letter Rating					Total
	A	B	C	D	E	
Experimental	16 18.6	9 11.0	11 7.6	4 2.9	0 0	40
Control	23 20.4	14 12.0	5 8.4	2 3.1	0 0	44
Total	39	23	16	6	0	84

In Table 3 the observed frequencies are cast in the upper left quadrant of each cell for each category. The expected frequencies, determined by multiplying the two marginal totals common to a particular cell, and then dividing this product by the total number of cases, appear in the lower right quadrant of each cell.

$$\chi^2 = \frac{(16 - 18.6)^2}{18.6} + \frac{(9 - 11.0)^2}{11.0} + \frac{(11 - 7.6)^2}{7.6}$$
$$+ \frac{(4 - 2.9)^2}{2.9} + \frac{(23 - 20.4)^2}{20.4} + \frac{(14 - 12.0)^2}{12.0}$$
$$+ \frac{(5 - 8.4)^2}{8.4} + \frac{(2 - 3.1)^2}{3.1}$$
$$= 5.09$$

The computed $\chi^2 = 5.09$ with $(2 - 1)\ (5 - 1) = 4$ degrees of freedom is not significant for $p \leq .10$. Thus, the hypothesis--there is no significant difference between the experimental group and control group in total readiness for Academic instruction--was not rejected. Since it is not possible to say that the two groups were different in terms of readiness in the first grade it is reasonable to conclude that neither enjoyed a decided advantage at the beginning of formal instruction.

School Organization

With minor exceptions each school involved in this investigation is organized around the self-contained classroom concept. In the self-contained classroom one teacher, with the help of specialists in certain fields such as music and art, is responsible for all areas of instruction.

One exception to this type organization is that the children in the experimental group were involved in a multi-age, multi-grade team-teaching plan during the fourth grade. This involved approximately 220 third and fourth graders organized for instruction under the guidance of eight teachers and one teacher serving as team teacher. Each teacher of the team was responsible for a particular group of pupils and theoretically performed in such a manner that maximum use of talent was realized. Since this type of organization did not necessarily represent a significant departure from the self-contained classroom, it was not considered a major influencing factor in this investigation.

Curricular Areas of the Two Schools for the Period of This Investigation

Since this study involved an analysis of achievement patterns of children in Mathematics, Social Studies, and Reading over a four year period a description of programs utilized by each school is presented below. The pattern of presentation consists of describing the program of each school in each curricular area.

Mathematics--During the past two years, which would involve grades three and four for the subjects in this study, each school employed a mathematics program that is "modern" in philosophy and approach. Commercially published text series that are patterned very closely along the lines recommended by the several curriculum reform groups which were engaged in improving mathematics instruction during the early and middle sixties were used. In either case the publishers credit such groups as the School Mathematics Study Group, Ball State University, and other similar organizations for valuable suggestions in the development of their respective programs. One indicator of the popularity of the mathematics series adopted by the two schools is that at least five of the larger school systems of the state have selected one of the two groups.

During the period of grades one and two for the subjects in this study there was a slight difference in type of mathematics programs in use. The experimental school utilized a commercially published series different from the present one, which again must be described as "modern," whereas pupils in the control school experienced a program that is described as transitional. However, an examination of the table of contents for grade two of each series does not reveal a great difference in material presented. In addition to consideration of traditional topics such as writing, numerals, counting, two and three digit addition and subtraction, multiplication, and measurement, both series included so-called modern topics. Representative of those incorporated are commutativity, associativity, number sentences, sets, geometry, and inequalities and equalities. Of course, since one series was modern and the other transitional, there existed a difference in basic philosophy and organization of topics. The modern series was developed from a point of view that is more compatible with an inquiry or discovery approach to learning. The control group series incorporated modern concepts, where possible, but the basic emphasis remained on drill and mastery of facts. Yet, for the purpose of this investigation, the differences in mathematics curricula identified are not considered significant. Neither group enjoyed a decided advantage in terms of mathematics programs during the four years under consideration in this study.

Social Studies--An investigation of textbooks, supplementary materials, and interviews with teachers and principals reveal that both schools subscribed to the idea of Expanding Horizons for instruction in Social Studies. More explicitly, home, school, and the local community are emphasized in grades one and two, other communities in grade three, the state in fourth grade, the United States in the fifth grade, and other countries in the sixth grade. This approach is compatible with Plan One recommendations of the Oklahoma Curriculum Improvement Commission on elementary school curriculum for the social studies. The Commission's[1] suggested sequence follows the generally

---

[1] The Oklahoma Curriculum Improvement Commission, The Improvement of Instruction in Geography, History, Political Science, Economics, and Related Areas Grades K-12, Oklahoma State Department of Education, Oklahoma City, Oklahoma, 1966, p. 9.

established pattern of beginning with a study of the home and expanding the scope of the offerings as the students mature. In either school the basic approach to social studies is approximately the same. Instruction in grades one and two appears rather informal. There is considerable reliance on teacher ingenuity in regard to materials and approach. Formal use of textual materials does not occur until around the third grade. Even though the schools use different commercially produced materials, no major dissimilarities in social studies curricula is evident.

Reading--Chall[1] in discussing the findings of the Columbia Reading Study by Barton and Wilder reports that reading instruction in almost all schools starts from a similar basis; i.e., basal readers from a graded series are used by ninety-eight per cent of first grade teachers and by ninety-two to ninety-four per cent of second and third grade teachers. A basal reading series is an attempt to give teachers and pupils a total reading program embodying a system for teaching reading (in the teacher's manuals), a collection of stories and selections for pupils to read (the readers), and exercises for additional practice (the workbooks). The schools involved in the study are not exceptions to these findings. Each has utilized the basal reader approach for basic instruction in reading. In fact

[1]Jeanne Chall, Learning to Read, the Great Debate (New York: McGraw-Hill Book Company, 1967), pp. 187-188.

the commercially produced reading series adopted by the schools were two of the most widely used during the late 1950s and early 1960s. Furthermore, according to the Barton and Wilder survey made in 1964, about seventy-seven per cent of nine hundred reading experts felt that for all practical purposes, the basal series were pretty much alike.[1] In general, the basic format of each lesson in the basal series used by the schools involved a four-part procedure from the first lesson in the first preprimer through the last one in the 3-2 reader for the third grade.

1. Preparation for reading the story. Here the teacher establishes background by asking questions to arouse interest. The guidebooks usually provide exact phrases for the teacher to use.

2. Presentation of new words and practice on them. The guidebooks tell the teacher which words to teach and how they should be practiced.

3. Guided reading and interpreting the story. Here the teacher is given specific questions to ask and is told what points to emphasize while the children read the story. This section also includes suggestions for rereading the story.

4. Follow-up activities. A series of suggested activities and exercises follows each story. These usually

---

[1] _Ibid._, p. 201.

include one or two exercises in the correlated workbook.[1]

Primarily the basic approach emphasized by the utilized series uses a sight or word method to teach reading in grades 1, 2, and 3. Although the total program includes some instruction in letters and sounds, children are taught to recognize words as wholes first. The philosophy of basal reading programs emphasizes the total program where all aspects of reading are incorporated. Very little attention is given to teaching of phonics in the basal series approach. Emphasis on phonics suggests a difference in philosophy of the two schools involved in this study. The experimental group, in addition to embracing the basal series approach, used a supplementary reading series that heavily stressed phonics. The nature and degree to which it was used could not be determined by this investigator. Its use, however, did not appear to be a significant factor in regards to the hypothesis of this study. This conclusion is substantiated by the findings of Porterfield[2] which indicated inquiry training rather than materials had greater influence on teachers in regard to asking questions designed to elicit higher levels of thought on the part of pupils.

In light of the evidence presented it is concluded that the two groups were comparable with respect to Readiness for learning and curricular treatment. The variable

---

[1] Ibid., p. 202.

[2] Porterfield, op. cit.

of inquiry as a teaching-learning strategy is thus identified as the principal significant difference between the two groups. In every identifiable respect inquiry is the one treatment imposed on the experimental group that was not peculiar to the control group.

Administering the Instrument

Most of the standardized and special tests utilized by the two schools chosen for this study were administered by the classroom teachers. In order to achieve some uniformity and consistency the classroom teachers in the schools of this study administered the tests in their individual classes. Prior to the testing this researcher reviewed with the teachers the Directions for Administering manual published by the authors of the test series. Thus, directions for completing the tests were understandable to each child and all questions regarding procedure were answered or clarified.

Administration of the battery was completed during the week of September 14, 1970 for the control group and the week of September 21, 1970 by the experimental group. The scheme of administration in both cases was completion of the Reading test on Tuesday, Social Studies on Wednesday, and Mathematics on Thursday.

In both schools the total fifth grade population was tested in each curricular area under investigation. For the control group the total number of pupils tested was approximately one hundred and fifty-five. Of this total only those students who had been in the school since grade one and who completed all the subtests administered were selected. This consisted of 69 pupils which included 27 boys and 42 girls. In the experimental group 47 subjects had been in the school for four years. However, one pupil did not complete the full battery of tests; thus, the group was comprised of 46 students which included 22 boys and 24 girls.

Statistical Treatment

The tests were scored and evaluated by the investigator and then descriptive and statistical treatments of the data were utilized for their relevance to the purpose of this study. In order to analyze academic achievement in the seven curricular areas of the two selected groups, the difference between mean raw scores was used. The Mann-Whitney U test was used to test the significance of the difference between the mean scores of the two groups utilizing the .10 level of confidence. Description and interpretation of the statistical findings involving the groups in each curricular area are presented in Chapter IV.

The population to which this investigator desired to apply the results consisted of all pupils who had completed four years of an inquiry-oriented science curriculum. Any generalizations to other populations, other curricula, other grade levels, other independent variables, or to other criteria for pupil achievement must be based on logic because they were not justified statistically in this investigation.

CHAPTER IV

ANALYSIS OF DATA

This study was concerned with an investigation of the efficacy of inquiry as a strategy for instruction. Involved in the study was an analysis of the achievement patterns of children in an inquiry-oriented science curriculum as compared with children who have not studied such a curriculum.

The problem was to determine whether there were any significant differences in the achievement scores in reading, mathematics, and social studies of two groups of children. One group was comprised of fifth-grade children who have been in an inquiry-oriented science curriculum since the first grade (the experimental group). The second group consisted of fifth-grade children who have not been in an inquiry-oriented science curriculum since grade one (the control group).

This section is concerned with the presentation of descriptive and statistical analyses and interpretations of the collected data. Basically the statistical problem was to analyze the difference in the mean scores after administering selected batteries of the Stanford

Achievement Series and test for significance. The analysis consisted of testing for the significant difference in the mean scores for the two groups in the following areas: 1) mathematics skills, concepts, and applications, 2) social studies, skills, and content, and 3) reading for word meaning and paragraph meaning.

In order to determine if the difference between the two groups was significant, the Mann-Whitney U Test described by Siegel[1] was utilized. The Mann-Whitney U Test involves the ranking of two sets of scores. To apply the U test the raw scores from both groups were combined and then ranked in order of increasing size. Care was exercised in order to retain each score's identity as either an experimental group score or a control group score. The value of U was computed by using the following equation.

$$U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1$$

where $n_1 = 46$, $n_2 = 69$ and R_1 equals the sum of the rankings of the experimental group scores. Tied rankings were assigned the average of the tied ranks.

Since the proportion of ties was relatively large for these data the following formula was utilized for determining z.

[1]Siegel, <u>op. cit.</u>, pp. 116-126.

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\left(\frac{n_1 n_2}{N(N - 1)}\right)\left(\frac{N^3 - N}{12} - \sum T\right)}}$$

where $N = n_1 + n_2 = 115$ and $T = \frac{t^3 - t}{12}$ and t is the number of observations tied for a given rank. $\sum T$ was found by summing the T's over all groups of tied observations.[1]

The ratings assigned to the raw scores of the mathematics computation subtest are shown in Table 4. For these data, $R_1 = 2765.5$ and $R_2 = 3904.5$.

$$U = 46 \times 69 + \frac{46(46 + 1)}{2} - 2765.5$$

$$U = 1489.5$$

$$\sum T = 674$$

$$z = \frac{1489.5 - 1587}{\sqrt{\left(\frac{46 \times 69}{115 \times 114}\right)\left(\frac{115^3 - 115}{12} - 674\right)}}$$

$$z = -.56$$

$$|z| = .56$$

Reference to a table of probabilities for the normal distribution reveals that z = .56 has a one-tailed probability under Ho of p = .2877. Since p = .2877 is larger than the predetermined confidence interval of $\alpha = .10$, the hypothesis Ho_1 of no difference between the

[1]Ranking of the combined raw scores and $\sum T$'s were calculated by utilizing an IBM 1130 computer.

TABLE 4

RANKS OF RAW SCORES ON THE MATHEMATICS COMPUTATION SUBTEST FOR THE EXPERIMENTAL AND CONTROL GROUPS

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
36	113.5	37	115
36	113.5	35	112
33	110	33	110
32	106	33	110
30	100	32	106
30	100	32	106
30	100	32	106
30	100	32	106
28	94	31	103
28	94	30	100
27	90.5	29	97
26	88	28	94
25	84	28	94
25	84	28	94
24	80.5	27	90.5
23	78	26	88
23	78	26	88
23	78	25	84
22	75	25	84
22	75	25	84
22	75	24	80.5
21	70.5	21	70.5
21	70.5	21	70.5
20	66	21	70.5
19	61.5	21	70.5
18	55.5	20	66
18	55.5	20	66
17	49.5	19	61.5
17	49.5	19	61.5
16	43.5	19	61.5
16	43.5	19	61.5
16	43.5	19	61.5
16	43.5	18	55.5
14	35.5	18	55.5
13	29	18	55.5
12	20.5	18	55.5
12	20.5	17	49.5
12	20.5	17	49.5
10	11.5	17	49.5
10	11.5	16	43.5
10	11.5	16	43.5

TABLE 4 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
9	7	15	39
8	5	15	39
6	1.5	15	39
6	1.5	14	35.5
	R_1 = 2765.5	14	35.5
		14	35.5
		13	29
		13	29
		13	29
		13	29
		13	29
		13	29
		13	29
		13	29
		12	20.5
		12	20.5
		12	20.5
		12	20.5
		11	15.5
		11	15.5
		10	11.5
		10	11.5
		10	11.5
		9	7
		9	7
		7	3.5
		7	3.5
			R_2 = 3904.5

experimental group and the control group in mathematics computation is accepted.

The ratings assigned to the mathematics concepts subtest are shown in Table 5. For these data $R_1 = 2579.5$ and $R_2 = 4090.5$.

$$U = 46 \times 69 + \frac{46(46 + 1)}{2} - 2579.5$$

TABLE 5

RANKS OF RAW SCORES ON THE MATHEMATICS CONCEPTS SUBTEST FOR THE EXPERIMENTAL AND CONTROL GROUPS

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
32	114.5	32	114.5
31	112.5	30	110
31	112.5	30	110
29	104.5	30	110
29	104.5	29	104.5
29	104.5	29	104.5
27	92.5	29	104.5
27	92.5	29	104.5
27	92.5	29	104.5
27	92.5	28	98.5
26	87.5	28	98.5
26	87.5	28	98.5
25	82.5	28	98.5
25	82.5	27	92.5
23	75.5	27	92.5
22	71.5	27	92.5
22	71.5	27	92.5
21	66.5	25	82.5
20	61	25	82.5
20	61	25	82.5
20	61	25	82.5
20	61	25	82.5
20	61	25	82.5
19	53	24	77.5
19	53	24	77.5
18	44.5	23	75.5
18	44.5	22	71.5
18	44.5	22	71.5
17	36	22	71.5
17	36	22	71.5
17	36	21	66.5
17	36	21	66.5
17	36	21	66.5
17	36	20	61
15	24.5	20	61
15	24.5	19	53
14	21	19	53
13	17.5	19	53
13	17.5	19	53

TABLE 5 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
12	14.5	19	53
11	12	19	53
11	12	19	53
11	12	18	44.5
10	8	18	44.5
9	4.5	18	44.5
8	3	18	44.5
	R_1 = 2579.5	18	44.5
		17	36
		17	36
		17	36
		16	29
		16	29
		16	29
		16	29
		16	29
		15	24.5
		15	24.5
		14	21
		14	21
		13	17.5
		13	17.5
		12	14.5
		10	8
		10	8
		10	8
		10	8
		9	4.5
		7	1.5
		7	1.5
			R_2 = 4090.5

$U = 1675.5$

$\sum T = 486$

$$z = \frac{1675.5 - 1587}{\sqrt{\left(\frac{69 \times 46}{115 \times 114}\right)\left(\frac{115^3 - 115}{12} - 486\right)}}$$

$z = -.51$

$|z| = .51$

The one-tailed probability of $z = .51$ under Ho is $p = .3085$. Since $p = .3085$ is greater than $\alpha = .10$ the hypothesis Ho_2 of no significant difference between the control group and the experimental group in mathematics concepts is accepted.

The ratings assigned to the mathematics application subtest are shown in Table 6. For these data $R_1 = 2911.0$ and $R_2 = 3764$.

$$U = 46 \times 69 + \frac{46(46 + 1)}{2} - 2911.0$$

$$U = 1344$$

$$\sum T = 300$$

$$z = \frac{1344 - 1587}{\sqrt{\left(\frac{46 \times 69}{114 \times 115}\right)\left(\frac{115^3 - 115}{12} - 300\right)}}$$

$$z = -1.39$$

$$|z| = 1.39$$

The one-tailed probability of $z = 1.39$ under Ho is $p = .0823$. Since $p = .0823$ is less than $\alpha = .10$ the hypothesis Ho_3 of no significant difference is rejected in favor of the alternative hypothesis. It is concluded that the scores of the experimental group are stochastically higher than the scores of the control group on the mathematics applications subtest.

TABLE 6

RANKS OF RAW SCORES ON THE MATHEMATICS APPLICATIONS SUBTEST FOR THE EXPERIMENTAL AND CONTROL GROUPS

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
33	115	32	113.5
32	113.5	30	110
31	112	30	110
30	110	29	105
29	105	29	105
29	105	29	105
28	99	29	105
28	99	29	105
27	94.5	28	99
26	89	28	99
26	89	28	99
26	89	27	94.5
25	83	27	94.5
25	83	27	94.5
24	79	26	89
24	79	26	89
23	75.5	26	89
23	75.5	26	89
23	75.5	25	83
22	70.5	25	83
22	70.5	25	83
21	66	24	79
21	66	23	75.5
21	66	23	75.5
20	62	22	70.5
20	62	22	70.5
19	57	22	70.5
19	57	20	62
18	53	20	62
18	53	20	62
17	47	19	57
17	47	19	57
17	47	19	57
17	47	18	53
17	47	17	47
16	40.5	17	47
14	34	17	47
14	34	17	47
14	34	16	40.5
13	27.5	16	40.5

TABLE 6 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
12	22.5	16	40.5
8	9.5	15	38
8	9.5	14	34
7	4.5	14	34
7	4.5	14	34
5	2	14	34
	R_1 = 2911.0	13	27.5
		13	27.5
		13	27.5
		13	27.5
		13	27.5
		12	22.5
		12	22.5
		12	22.5
		11	18
		11	18
		11	18
		11	18
		11	18
		10	14.5
		10	14.5
		8	9.5
		8	9.5
		8	9.5
		8	9.5
		8	9.5
		8	9.5
		6	3
		4	1
			R_2 = 3764.0

The ratings assigned to the social studies content subtest are shown in Table 7. For these data $R_1 = 2888.5$ and $R_2 = 3781.5$.

$$U = 46 \times 69 + \frac{46(46 + 1)}{2} - 2888.5$$

$$U = 1366.5$$

$\sum T = 674$

$$z = \frac{1366.5 - 1587}{\sqrt{\left(\frac{69 \times 46}{115 \times 114}\right)\left(\frac{115^3 - 115}{12} - 674\right)}}$$

$z = -1.26$

$|z| = 1.26$

The one-tailed probability of $z = 1.26$ under Ho is $p = .1038$. Since $p = .1038$ is greater than $\alpha = .10$ the hypothesis Ho_4 of no significant difference between the control group and experimental group in social studies content is accepted.

TABLE 7

RANKS OF RAW SCORES ON SOCIAL STUDIES CONTENT SUBTEST FOR THE EXPERIMENTAL AND CONTROL GROUPS

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
34	114.5	34	114.5
32	110	33	113
32	110	32	110
32	110	32	110
30	102.5	31	106
30	102.5	31	106
30	102.5	31	106
29	100	30	102.5
28	98.5	28	98.5
27	94.5	27	94.5
27	94.5	27	94.5
27	94.5	25	87
27	94.5	25	87
26	90.5	25	87
26	90.5	25	87
24	81.5	25	87
24	81.5	24	81.5
24	81.5	24	81.5
24	81.5	23	76

TABLE 7 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
23	76	23	76
23	76	23	76
22	67	22	67
22	67	22	67
21	58.5	22	67
21	58.5	22	67
20	53	22	67
20	53	22	67
20	53	22	67
19	42.5	22	67
19	42.5	22	67
19	42.5	22	67
19	42.5	22	67
19	42.5	21	58.5
19	42.5	21	58.5
19	42.5	20	53
18	30	20	53
18	30	20	53
17	21	20	53
17	21	19	42.5
17	21	19	42.5
17	21	19	42.5
16	16.5	19	42.5
16	16.5	19	42.5
14	11.5	19	42.5
11	4	19	42.5
9	1	18	30
	R_1 = 2888.5	18	30
		18	30
		18	30
		18	30
		18	30
		18	30
		18	30
		18	30
		17	21
		17	21
		17	21
		15	15
		14	11.5
		14	11.5
		14	11.5
		14	11.5

TABLE 7 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
		14	11.5
		13	8
		12	6.5
		12	6.5
		11	4
		11	4
		10	2
		R_2 =	3781.5

The ratings assigned to the social studies skills subtest are shown in Table 8. For these data $R_1 = 2924.50$ and $R_2 = 3737.5$.

$$U = 46 \times 69 + \frac{46(46 + 1)}{2} - 2924.50$$

$$U = 1330.5$$

$$\sum T = 486$$

$$z = \frac{1330.5 - 1587}{\sqrt{\left(\frac{69 \times 46}{115 \times 114}\right)\left(\frac{115^3 - 115}{12} - 486\right)}}$$

$$z = -1.47$$

$$|z| = 1.47$$

The one-tailed probability of $z = 1.47$ under Ho is $p = .0708$. Since $p = .0708$ is less than $\alpha = .10$ the hypothesis Ho_5 of no significant difference is rejected in favor of the alternative hypothesis. It is concluded that the scores of the experimental group are stochastically higher than the scores of the control group on the social studies skills subtest.

TABLE 8

RANKS OF RAW SCORES ON SOCIAL STUDIES SKILLS SUBTEST FOR THE EXPERIMENTAL AND CONTROL GROUPS

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
28	115	27	114
25	111.5	26	113
24	109.5	25	111.5
24	109.5	23	107
22	104	23	107
22	104	23	107
22	104	21	100.5
19	91.5	21	100.5
19	91.5	21	100.5
19	91.5	21	100.5
19	91.5	20	97
18	84	20	97
18	84	20	97
18	84	19	91.5
18	84	19	91.5
17	76	19	91.5
17	76	19	91.5
17	76	18	84
17	76	18	84
17	76	17	76
16	66.5	17	76
16	66.5	17	76
16	66.5	17	76
16	66.5	17	76
16	66.5	16	66.5
16	66.5	16	66.5
16	66.5	16	66.5
14	54	15	59.5
14	54	15	59.5
14	54	15	59.5
13	47.5	15	59.5
12	40.5	14	54
12	40.5	14	54
12	40.5	14	54
12	40.5	14	54
12	40.5	13	47.5
11	34.5	13	47.5

TABLE 8 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
10	28	13	47.5
10	28	13	47.5
10	28	13	47.5
10	28	12	40.5
9	18.5	12	40.5
9	18.5	12	40.5
8	10.5	11	34.5
8	10.5	11	34.5
6	3	11	34.5
	R_1 = 2924.5	10	28
		10	28
		10	28
		10	28
		10	28
		9	18.5
		9	18.5
		9	18.5
		9	18.5
		9	18.5
		9	18.5
		9	18.5
		9	18.5
		8	10.5
		8	10.5
		8	10.5
		8	10.5
		7	6
		7	6
		7	6
		6	3
		6	3
		5	1
			R_2 = 3737.5

The ratings assigned to the reading word meaning subtest are shown in Table 9. For these data R_1 = 2808.50 and R_2 = 3861.5.

$$U = 46 \times 69 + \frac{46(46 + 1)}{2} - 2808.50$$

$$U = 1446.5$$

$$\sum T = 386$$

$$z = \frac{1446.5 - 1587}{\sqrt{\left(\frac{69 \times 46}{115 \times 114}\right)\left(\frac{115^3 - 115}{12} - 386\right)}}$$

$$z = -.80$$

$$|z| = .80$$

The one-tailed probability of z = .80 under Ho is p = .2119. Since p = .2119 is greater than $\alpha = .10$ the hypothesis Ho_6 of no significant difference between the experimental group and the control group in word meaning is accepted.

TABLE 9

RANKS OF RAW SCORES ON READING WORD MEANING SUBTEST FOR THE EXPERIMENTAL AND CONTROL GROUPS

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
38	115	37	113.5
37	113.5	36	110
36	110	36	110
36	110	36	110
35	105.5	35	105.5
35	105.5	34	101
35	105.5	34	101
34	101	34	101
34	101	33	96
32	91	33	96
32	91	33	96
31	85	33	96
31	85	33	96
30	80	32	91

TABLE 9 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
29	77	32	91
29	77	32	91
28	70.5	31	85
28	70.5	31	85
28	70.5	31	85
28	70.5	31	85
28	70.5	31	85
27	62	30	80
27	62	30	80
26	57	29	77
25	51.5	28	70.5
25	51.5	28	70.5
25	51.5	28	70.5
25	51.5	28	70.5
24	45	28	70.5
24	45	27	62
24	45	27	62
23	40.5	27	62
22	33	27	62
22	33	27	62
22	33	26	57
22	33	26	57
22	33	25	51.5
22	33	25	51.5
22	33	25	51.5
20	22.5	25	51.5
20	22.5	24	45
19	19	24	45
18	16.5	23	40.5
17	14.5	23	40.5
15	10.5	23	40.5
12	4	22	33
R_1 =	2808.5	22	33
		22	33
		22	33
		21	26
		21	26
		21	26
		20	22.5
		20	22.5
		19	19
		19	19
		18	16.5

TABLE 9 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
		17	14.5
		15	10.5
		15	10.5
		15	10.5
		15	10.5
		15	10.5
		14	6
		14	6
		14	6
		11	3
		7	2
		4	1
		R_2 =	3861.5

The ratings assigned to the reading paragraph meaning subtest are shown in Table 10. For these data R_1 = 2846.00 and R_2 = 3824.

$$U = 46 \times 69 + \frac{46(46 + 1)}{2} - 2846.00$$

$$U = 1409$$

$$\sum T = 173$$

$$z = \frac{1409 - 1587}{\sqrt{\left(\frac{69 \times 46}{114 \times 115}\right)\left(\frac{115^3 - 115}{12} - 173\right)}}$$

$$z = -1.02$$

$$|z| = 1.02$$

The one-tailed probability of $z = 1.02$ under Ho is $p = .1539$. Since $p = .1539$ is greater than $\alpha = .10$ the hypothesis Ho_7 of no significant difference between the experimental group and the control group in paragraph meaning is accepted. This finding, however, will be discussed in further detail in the following sections.

TABLE 10

RANKS OF RAW SCORES ON READING PARAGRAPH MEANING SUBTEST FOR THE EXPERIMENTAL AND CONTROL GROUPS

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
59	115	57	114
53	104	56	113
53	104	55	111
53	104	55	111
52	100.5	55	111
50	98	54	108
50	98	54	108
48	91	54	108
48	91	53	104
48	91	53	104
48	91	52	100.5
47	86	50	98
47	86	49	95.5
47	86	49	95.5
46	82	48	91
45	78.5	48	91
44	75	48	91
44	75	46	82
43	69.5	46	82
42	65	46	82
42	65	46	82
41	61.5	45	78.5
39	56	44	75
39	56	44	75
39	56	44	75
39	56	43	69.5
39	56	43	69.5
38	50.5	43	69.5
38	50.5	43	69.5
38	50.5	43	69.5
36	46	42	65
36	46	41	61.5
36	46	41	61.5

TABLE 10 - Continued

Experimental		Control	
Raw Scores	Rank	Raw Scores	Rank
35	43	41	61.5
35	43	39	56
34	40	39	56
34	40	38	50.5
33	36	37	48
33	36	35	43
33	36	34	40
29	26.5	33	36
26	15	33	36
26	15	32	33
24	12	31	32
20	8.5	30	30.5
20	8.5	30	30.5
	R_1 = 2846.0	29	26.5
		29	26.5
		29	26.5
		29	26.5
		29	26.5
		28	22.5
		28	22.5
		27	19
		27	19
		27	19
		27	19
		27	19
		26	15
		25	13
		23	10.5
		23	10.5
		19	6.5
		19	6.5
		18	5
		17	3.5
		17	3.5
		16	2
		13	1
			R_2 = 3824.0

Displayed in Tables 11 through 17 are the means, variances and standard deviations in the curricular areas under consideration in this investigation. Note that with the exception of Mathematics Concepts, the mean score of the experimental group exceeds that of the control group in each case. A further analysis reveals that the standard deviation of the experimental group, except for Mathematics Computation and Mathematics Concepts, is less than that for the control group.

TABLE 11

MEAN, VARIANCE, AND STANDARD DEVIATION OF THE EXPERIMENTAL (N=46) AND CONTROL (N=69) STUDENTS ON THE MATHEMATICS COMPUTATION TEST

	Mean	Variance	Standard Deviation
Experimental	19.86	68.29	8.26
Control	19.30	59.80	7.73

TABLE 12

MEAN, VARIANCE, AND STANDARD DEVIATION OF THE EXPERIMENTAL (N=46) AND CONTROL (N=69) STUDENTS ON THE MATHEMATICS CONCEPTS TEST

	Mean	Variance	Standard Deviation
Experimental	19.89	41.97	6.48
Control	20.46	40.78	6.39

TABLE 13

MEAN, VARIANCE, AND STANDARD DEVIATION OF THE EXPERIMENTAL (N=46) AND CONTROL (N=69) STUDENTS ON THE MATHEMATICS APPLICATIONS TEST

	Mean	Variance	Standard Deviation
Experimental	20.35	49.74	7.05
Control	18.43	55.84	7.47

TABLE 14

MEAN, VARIANCE, AND STANDARD DEVIATION OF THE EXPERIMENTAL (N=46) AND CONTROL (N=69) STUDENTS ON THE SOCIAL STUDIES CONTENT TEST

	Mean	Variance	Standard Deviation
Experimental	22.35	33.34	5.77
Control	20.89	31.86	5.64

TABLE 15

MEAN, VARIANCE, AND STANDARD DEVIATION OF THE EXPERIMENTAL (N=46) AND CONTROL (N=69) STUDENTS ON THE SOCIAL STUDIES SKILLS TEST

	Mean	Variance	Standard Deviation
Experimental	15.54	24.74	4.97
Control	14.19	29.45	5.43

TABLE 16

MEAN, VARIANCE, AND STANDARD DEVIATION OF THE EXPERIMENTAL (N=46) AND CONTROL (N=69) STUDENTS ON THE READING WORD MEANING TEST

	Mean	Variance	Standard Deviation
Experimental	26.61	38.15	6.18
Control	25.13	55.67	7.46

TABLE 17

MEAN, VARIANCE, AND STANDARD DEVIATION OF THE EXPERIMENTAL (N=46) AND CONTROL (N=69) STUDENTS ON THE READING PARAGRAPH MEANING TEST

	Mean	Variance	Standard Deviation
Experimental	40.20	80.61	8.98
Control	37.59	141.16	11.88

Tables 18 through 24 contain percentages of scores within a range of three standard deviations below the mean to three standard deviations above the mean in each curricular area. In both the experimental and control groups for each curricular area the distribution departs, to some degree, from a normal distribution. In a normal distribution, the range is from minus one standard deviation below the mean to plus one standard deviation above the mean which contains sixty-eight and twenty-seven hundredths per cent of the cases.

TABLE 18

PERCENTAGE OF SCORES ABOVE AND BELOW THE MEAN FOR THE MATHEMATICS COMPUTATION TEST

Group	Percentage						Total
	Standard Deviations						
	-3	-2	-1	1	2	3	
Experimental $\bar{X}$ = 19.86	0	15.22	32.61	34.78	17.39	0	100
Control $\bar{X}$ = 19.30	0	13.04	47.83	13.84	17.39	0	100

TABLE 19

PERCENTAGE OF SCORES ABOVE AND BELOW THE MEAN FOR THE MATHEMATICS CONCEPTS TEST

Group	Percentage						Total
	Standard Deviations						
	-3	-2	-1	1	2	3	
Experimental $\bar{X}$ = 19.89	0	19.57	30.43	28.26	21.74	0	100
Control $\bar{X}$ = 20.46	2.90	14.49	34.78	23.19	24.64	0	100

TABLE 20

PERCENTAGE OF SCORES ABOVE AND BELOW THE MEAN FOR THE MATHEMATICS APPLICATIONS TEST

Group	Percentage						Total
	Standard Deviations						
	-3	-2	-1	1	2	3	
Experimental $\bar{X} = 20.35$	2.17	13.04	32.61	34.78	17.39	0	100
Control $\bar{X} = 18.43$	0	14.49	37.68	21.74	26.09	0	100

TABLE 21

PERCENTAGE OF SCORES ABOVE AND BELOW THE MEAN FOR THE SOCIAL STUDIES CONTENT TEST

Group	Percentage						Total
	Standard Deviations						
	-3	-2	-1	1	2	3	
Experimental $\bar{X} = 22.35$	2.17	8.70	43.48	28.26	15.22	2.17	100
Control $\bar{X} = 20.89$	0	17.39	33.33	33.33	13.04	2.90	99.99

TABLE 22

PERCENTAGE OF SCORES ABOVE AND BELOW THE MEAN FOR THE SOCIAL STUDIES SKILLS TEST

Group	Percentage						Total
	Standard Deviations						
	-3	-2	-1	1	2	3	
Experimental $\overline{X}$ = 15.54	0	19.57	21.74	43.48	13.04	2.17	100
Control $\overline{X}$ = 14.19	0	14.49	40.58	26.09	17.39	1.45	100

TABLE 23

PERCENTAGE OF SCORES ABOVE AND BELOW THE MEAN FOR THE READING WORD MEANING TEST

Group	Percentage						Total
	Standard Deviations						
	-3	-2	-1	1	2	3	
Experimental $\overline{X}$ = 26.61	2.17	13.04	34.78	30.43	19.57	0	100
Control $\overline{X}$ = 25.13	2.90	14.49	30.43	33.33	18.84	0	99.99

TABLE 24

PERCENTAGE OF SCORES ABOVE AND BELOW THE MEAN FOR THE READING PARAGRAPH TEST

Group	Percentage						Total
	Standard Deviations						
	-3	-2	-1	1	2	3	
Experimental $\overline{X} = 40.20$	4.35	8.70	39.13	32.61	13.04	2.17	100
Control $\overline{X} = 37.59$	1.45	13.04	31.88	36.23	17.39	0	99.99

In the curricular area of Mathematics Computation both distributions depart from normality to a slight degree. For the experimental group the total distribution lies within the range of -2σ to $+2\sigma$ with approximately 67.39 per cent contained between -1σ to $+1\sigma$. The control group, on the other hand, tends to be positively skewed with the scores falling in the range -2σ to $+3\sigma$. Approximately 66.67 per cent lie in the range -1σ to $+1\sigma$.

For Mathematics Concepts (Table 19) both distributions are approximately ten per cent below that of the normal distribution for the range of -1σ to $+1\sigma$. There is an observable discrepancy between the two distributions whereas the experimental group clusters from -2σ to $+2\sigma$ as compared with the control group scores which tend to trail off in the negative direction. (Figure 2)

Quite the opposite occurs in the behavior of the

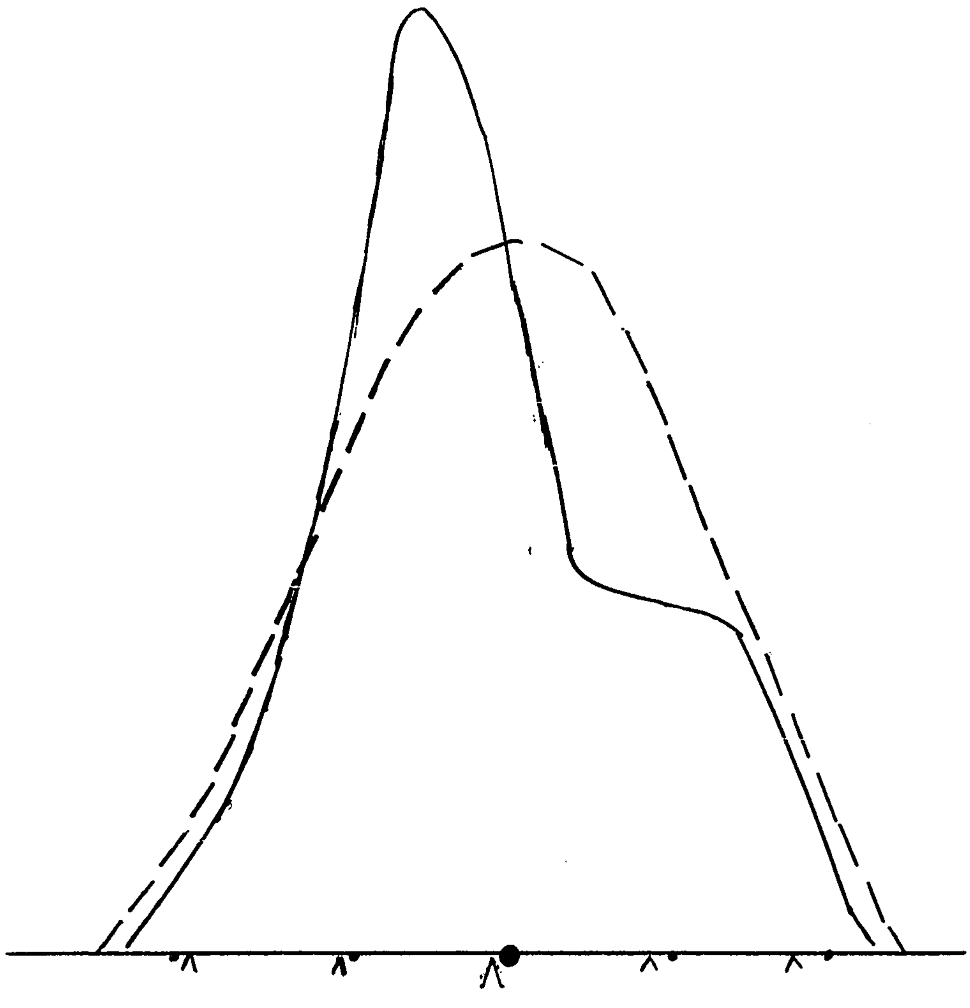

Fig. 1.--Distribution of scores on the Mathematics Computation Subtest for the experimental and control groups.

——Control group
Λ...Control group mean. ^...Deviations from the mean.
- - -Experimental group
●...Experimental group mean. •...Deviations from the mean.

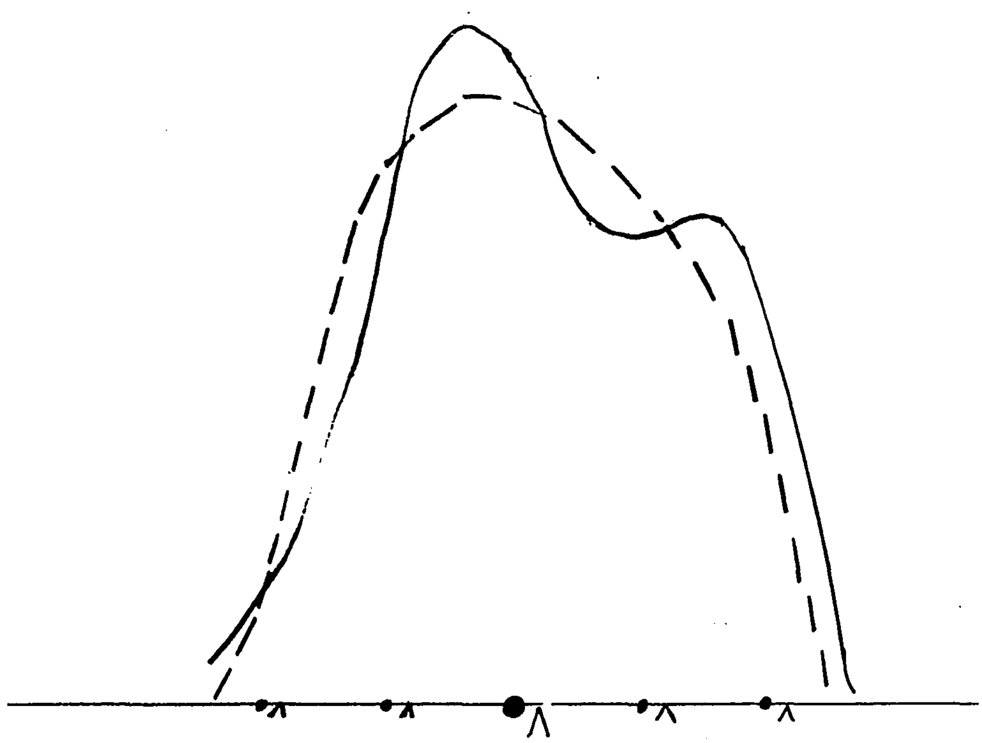

Fig. 2.--Distribution of scores on the Mathematics Concepts Subtest for the experimental and control groups.

——Control group
Λ...Control group mean. $\wedge$...Deviations from the mean.
– – – Experimental group
●...Experimental group mean. •...Deviations from the mean.

distribution for Mathematics Applications (Table 20). For the experimental group 67.39 per cent of the scores lie in the range -1σ to $+1\sigma$ and only 59.42 per cent of the scores for the control group fall in this range. It is readily apparent from Figure 3 that not only do these distributions depart from normality, but there appears a fairly distinct difference in the behavior of the two distributions. The experimental group distribution appears rather stable with a very slight negative skewness, whereas the control group distribution is rather erratic. In the range from the mean to $+1\sigma$ there is a severe dip in the curve. (See Figure 3) The range $+1\sigma$ to $+2\sigma$ contains 26.09 per cent of the scores which is an excessive amount. These observations and possibly others tend to support the finding of a statistically significant difference between the two groups.

In the distributions for Social Studies Content, Table 21 and Figure 4 do not reveal any particular patterns of unusual behavior. The experimental group distribution is very slightly leptokurtic and closely approximates normality. The control group is very close to behaving normally except for a tendency toward negative skewness. It is interesting to note here that albeit the two distributions do not appear to differ greatly the score for the statistical test was very close to being significant.

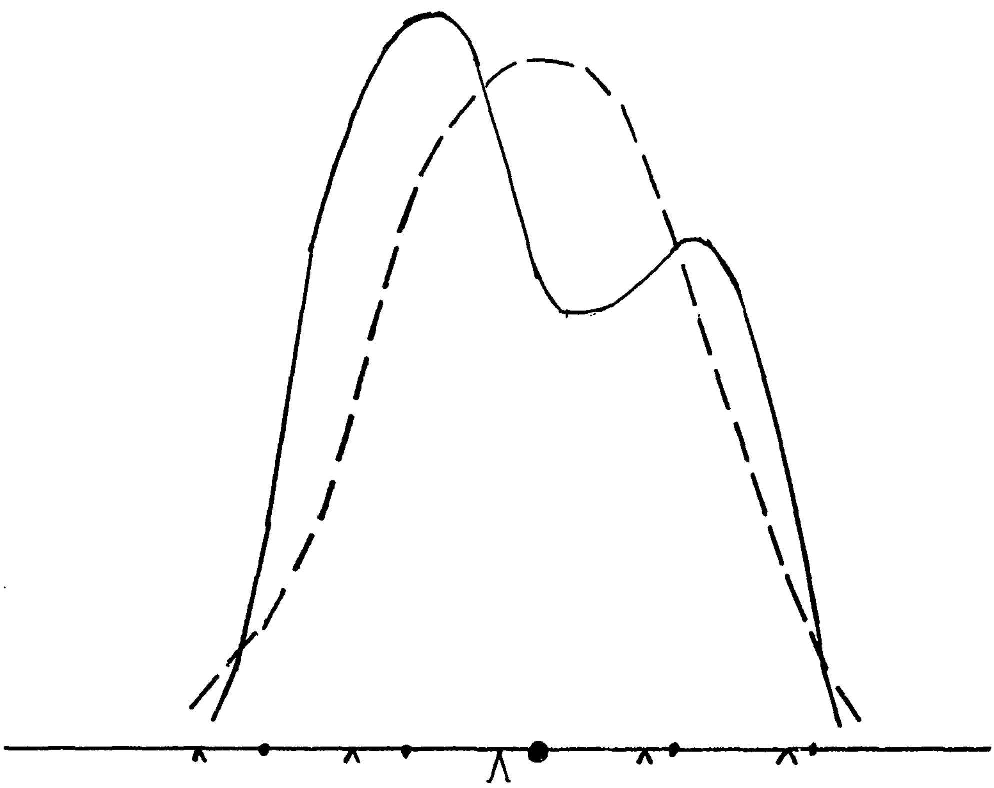

Fig. 3.--Distribution of scores on the Mathematics Applications Subtest for the experimental and control groups.

——Control group
Λ...Control group mean. Λ...Deviations from the mean.
— — —Experimental group
●...Experimental group mean. •...Deviations from the mean.

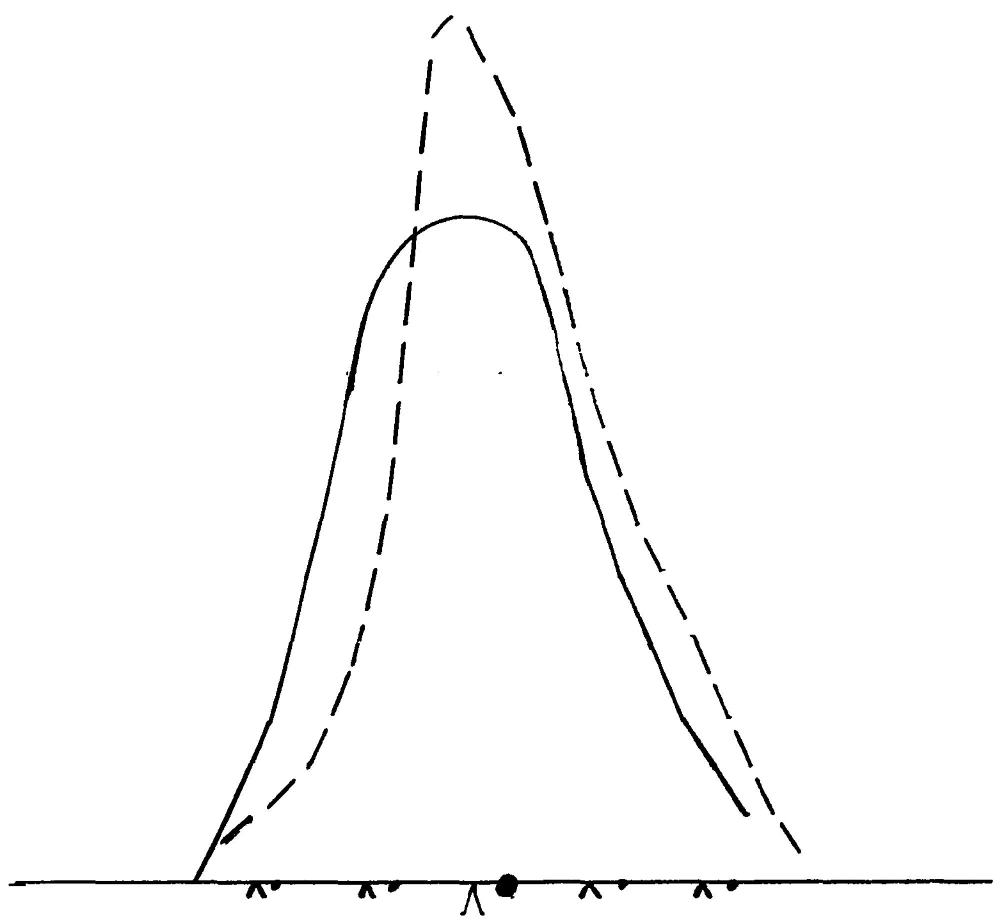

Fig. 4.--Distribution of scores on the Social Studies Content Subtest for the experimental and control groups.

———Control group

Λ. . .Control group mean. Λ . . .Deviations from the mean.

- - -Experimental group

● . . .Experimental group mean. ● . . .Deviations from the mean.

A casual inspection of Table 22 does not reveal any major discrepancies in the behavior of the distributions for Social Studies Skills. Each appears to tend toward a slight negative skewness with 65.22 per cent of the scores for the experimental group in the -1σ to $+1\sigma$ range as compared to 66.67 for the control group. However, in the interval from the respective means to $+1\sigma$ the percentage of scores for the experimental group is almost double that for the control group. Figure 5 very clearly depicts a dissimilar behavior between the two distributions. The experimental group tends to a negative skewness as compared with the seemingly positive skewness of the control group distribution. Of course this apparent difference was substantiated in the statistical test which was significant at the pre-determined level of confidence.

In the curricular area of Reading a most interesting event that perhaps can be described as paradoxical occurred. As is apparent in Table 23 and Figure 6, the distributions tend to be very similar for Word Meaning. The percentage of scores within various intervals of respective means are very close to equality. In fact there is only a slight difference between the means and no particular disturbing discrepancy in variances and standard deviations as reported in Table 16.

Even though the statistical test did not reveal

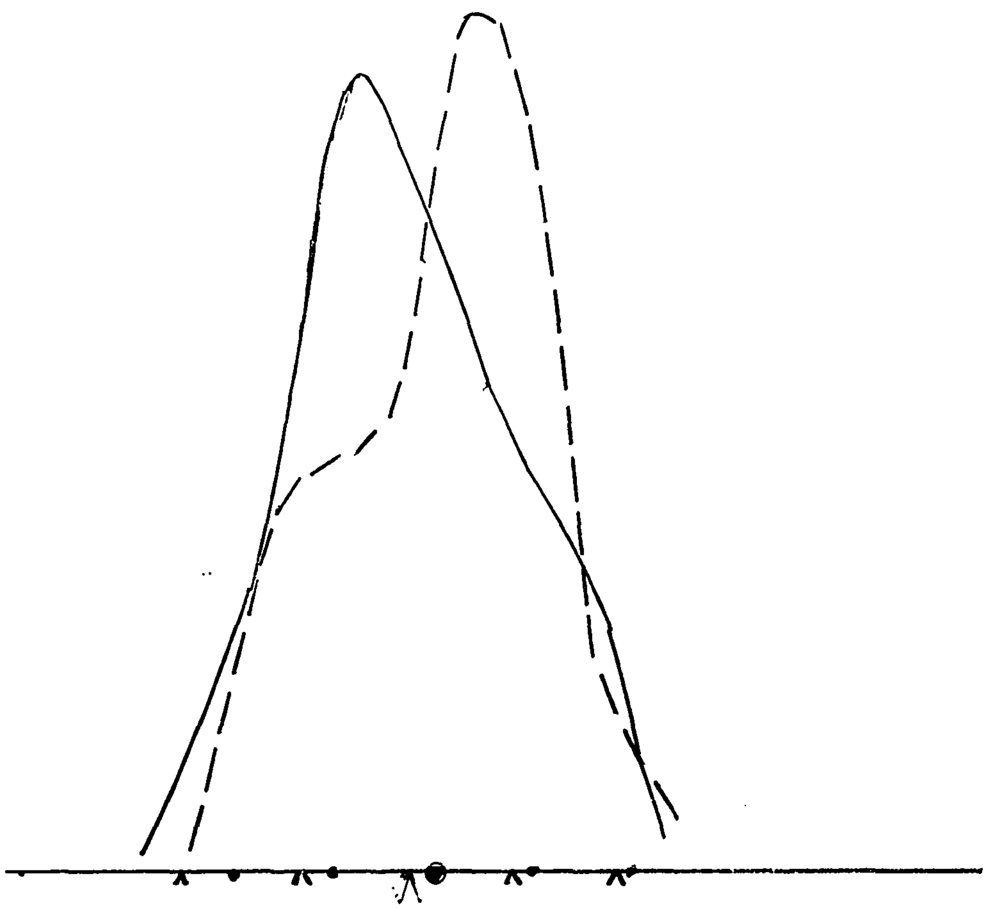

Fig. 5.--Distribution of scores on the Social Studies Skills Subtest for the experimental and control groups.

____Control group
Λ...Control group mean. Λ...Deviations from the mean.
_ _ _Experimental group
●...Experimental group mean. •...Deviations from the mean.

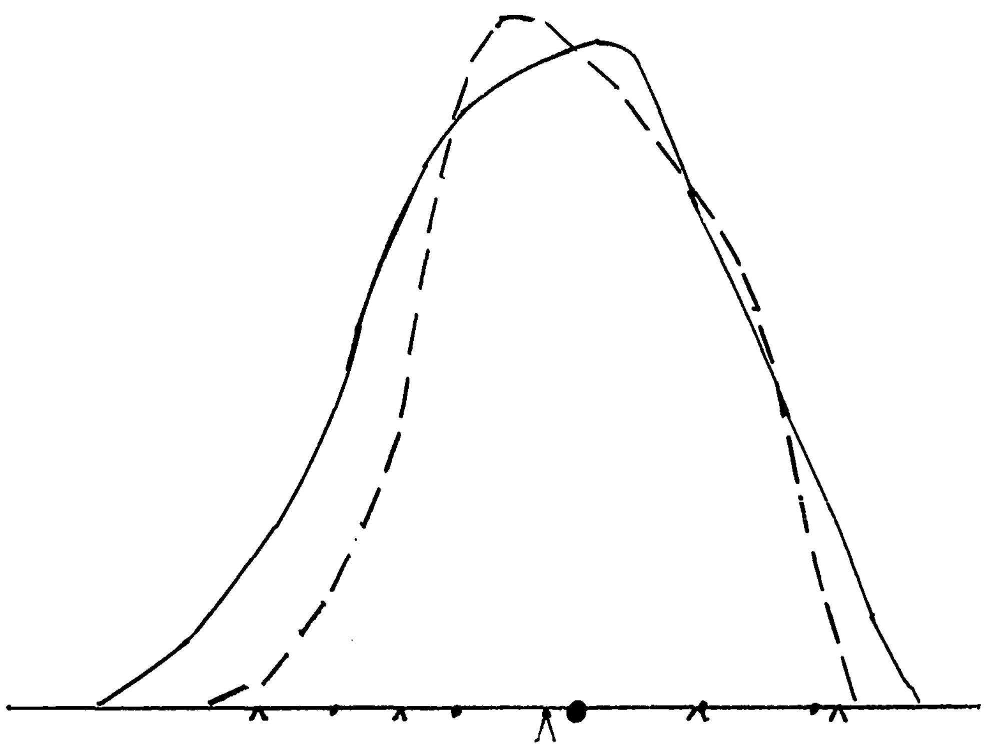

Fig. 6.--Distribution of scores on the Reading Word Subtest for the experimental and control groups.

____Control group
Λ...Control group mean.   Λ...Deviations from the mean.
___Experimental group
●...Experimental group mean.   ●...Deviations from the mean.

a significant difference between the two groups in Paragraph Meaning there is very strong evidence that suggests quite the opposite. The distribution of scores for the experimental group across the range -3σ to $+3\sigma$ deviates from normality with a tendency toward a leptokurtic curve and a rather abnormal loading in the -2σ to -3σ of 4.35 per cent. This compares with only 1.45 per cent for the control group in the same interval. (See Table 24) At the opposite end of the range, however, the percentage of scores for the experimental group exceeds that of the control group by approximately the same amount. With respect to comparison, differences between the two groups in one particular interval tends to negate differences in another interval. Figure 7 reveals a tendency for the experimental distribution to be leptokurtic as compared to the control which appears platykurtic. This observation is supported by the discrepancy of variances and standard deviations as reported in Table 17. In fact the ratio of the variance of the control group to that of the experimental (the F-test) exceeds that value required for significance at the .05 level in favor of the experimental group.

Summary

The investigation revealed that there were significant differences in the achievement of children in the experimental group as compared with pupils in the

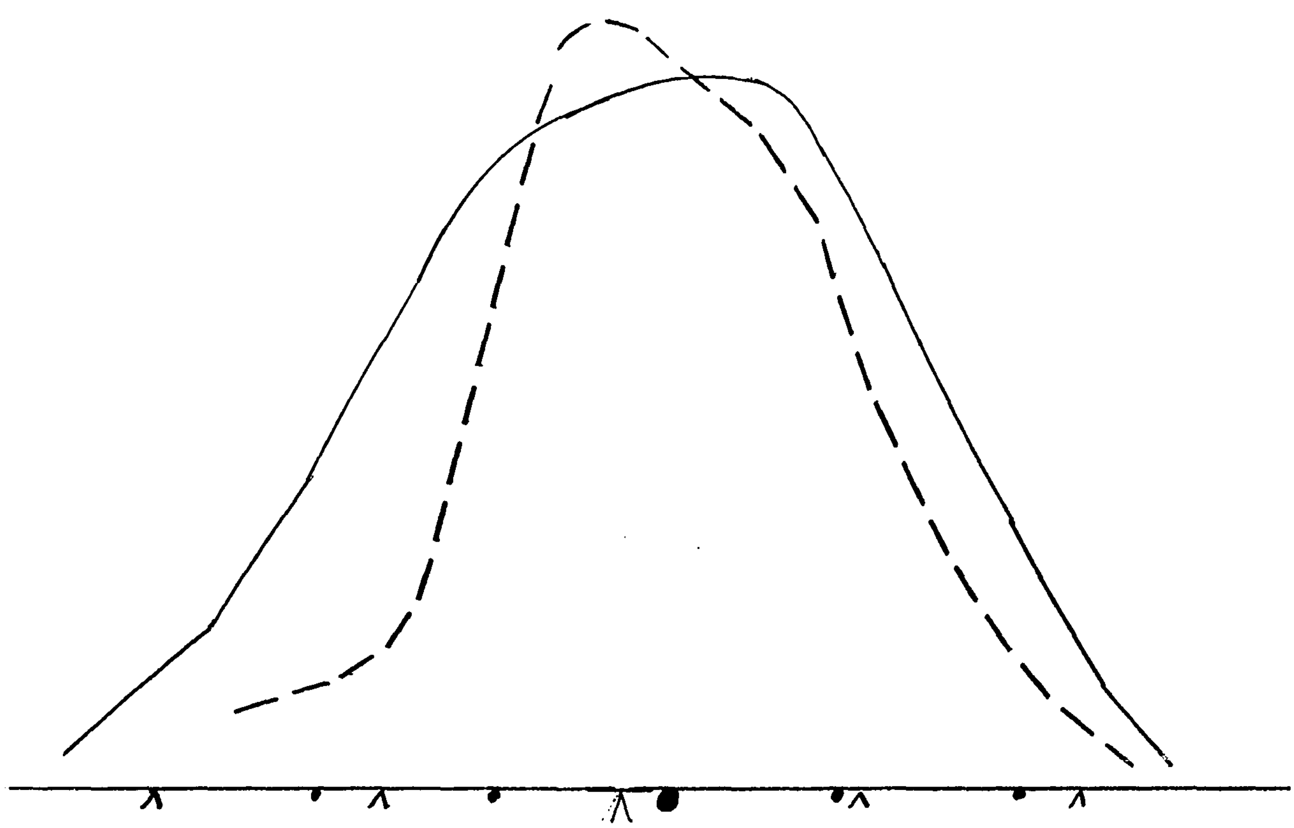

Fig. 7.--Distribution of scores on the Reading Paragraph Subtest for the experimental and control groups.

——Control group
Λ...Control group mean. Λ...Deviations from the mean.
- - -Experimental group
●...Experimental group mean. ●...Deviations from the mean.

control group. The general hypothesis therefore, was rejected in favor of the alternative. The evidence very strongly suggests that children in an inquiry-oriented curriculum are inclined to make better use of the rational powers of analyzing, synthesizing, and generalizing. This fact was manifested in the pattern of differences that occurred in the curricular areas of mathematics computation, social studies skills, and to a degree paragraph meaning. In these areas there exists a thread of commonality which requires a demonstration of the student's ability to consider information provided and manipulate it in a problem-solving situation. This observation was an important finding of the research.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter contains a summary of the purposes and procedures of the investigation, the findings gleaned from an analysis of the data collected and conclusions based on the findings. Recommendations for further exploration are also included.

The primary concern of the study was inquiry as a strategy for instruction. It was designed specifically to investigate the degree to which an inquiry-oriented science curriculum contributes to learning in other subject-matter areas.

Serving as a guiding principle in the conception and development of the study was the question, "Do children exhibit any significant behavioral changes as a result of longitudinal experience in inquiry-oriented instruction?" or its alternate, "Does inquiry, in fact, contribute to learning how to go about the task of learning?" the latter being Bruner's hypothesis. The major focus was behavioral change exhibited by children who had been exposed to an inquiry-oriented science program from grade one through grade four. Changes in behavior in the academic areas of reading, mathematics and social studies, as reflected in achievement measured by standardized tests in common use were scrutinized. The study was designed to investigate the degree to which an inquiry-oriented science curriculum contributes to learning in these other subject matter areas. The design of the study prescribed the testing of a general hypothesis; i.e., the academic achievement of fifth grade pupils who had experienced four years of an inquiry-oriented science curriculum is not different from the academic achievement of children who had not experienced inquiry-oriented science for an equal length of time.

In addition to the general hypothesis, seven sub-hypotheses were examined. (1) Ho_1: The scores for the experimental group on the mathematics concepts test are higher than the scores of the control group. (2) Ho_2: The scores for the experimental group on the mathematics skills test are higher than the scores of the control group. (3) Ho_3: The scores for the experimental group on the mathematics applications test are higher than the scores of the control group. (4) Ho_4: The scores for the experimental group on the social studies content test are higher than the scores of the control group. (5) Ho_5: The scores for the experimental group on the social studies skills test are higher than the scores of the control group. (6) Ho_6: The scores for the experimental group on the reading word test are higher than the scores of the control group. (7) Ho_7: The scores for the experimental group on the reading paragraph test are higher than the scores of the control group. Since there was an implied difference in direction a one-tailed statistical test was utilized. All hypotheses were tested at the .10 level of confidence.

Summary

This investigation involved 115 fifth grade pupils from two elementary level schools. Forty-six pupils from the school utilizing an inquiry-oriented science curriculum comprised the experimental group. Sixty-nine subjects from the other school, which did not use an inquiry-oriented science curriculum, comprised the control group. The principal criterion for a subject's inclusion in the study was that he must have attended the school for four continuous years, beginning with grade one, and have a complete score on each test administered.

The Stanford Achievement Series, 1964 edition, was administered to each group of pupils during the month of September--first month of entry into the fifth grade. Scores in mathematics concepts, skills, and applications, and word meaning and paragraph meaning were obtained by utilizing Form W of the Intermediate I battery. Data concerning achievement in social studies skills and content were obtained by administering Form W of the Intermediate II battery. According to information available from previous test scores, teachers, and principals, all of the students included in the study were progressing normally in their school work. None had exhibited any evidence of experiencing unusual or abnormal discipline, social or emotional problems.

Using the Stanford Achievement Series, raw scores of the two sample groups were analyzed. The statistical analysis consisted of testing for significant differences in academic achievement among the subjects selected for investigation. Since several assumptions for a parametric statistical test could not be met, the Mann Whitney U Test was selected for testing the hypotheses of the study. Basically this consisted of combining the raw scores of the two groups on a particular test, ranking the pooled scores, separating into original groups maintaining ranks, and then performing the necessary statistical test. This technique was employed in each curricular area investigated.

Findings

This study revealed the following major findings:

1. It was found that there was no significant difference in mathematics concepts of the two groups of pupils investigated in this study. Thus the null hypothesis was accepted. This finding was a mild surprise, since

inquiry as a strategy for instruction appears to be compatible with the development of conceptual understandings. However, it must be kept in mind that the instrument utilized for the study may not reflect totally and accurately a pupil's behavior in this regard.

2. There was no significant difference in mathematics skills between the two groups. Thus the hypothesis was accepted.

3. There was a significant difference in mathematics applications between the two groups of this study. The hypothesis was rejected and evidence is supportive of the assertion that inquiry experience enhances one's ability to manipulate data in problem solving situations.

4. No significant difference between the two groups in social studies content was evident. Thus the hypothesis was accepted. However, the data do present a very definite indication of approaching significance. The computed statistic was very close to the critical value of significance.

5. A significant difference in the curricular area of social studies skills was determined. The evidence supports rejection of the hypothesis. This finding is analogous to that of mathematics applications. Social studies skills involve interpretation of graphs, tables, reading maps, and interpreting posters which essentially require ability to assimilate data for

purposes of testing hypotheses.

6. There was no significant difference between the two groups in the academic area of word meaning. Thus the hypothesis was not rejected.

7. A statistical difference between the two groups in paragraph meaning was not determined. However, available evidence very strongly suggests some reservation about accepting the null hypothesis. Erratic behavior of the two distributions reveals a difference that tends to favor the experimental group.

Conclusions

As a result of the statistical treatment in all seven academic areas investigated, the hypothesis was not totally rejected. The evidence very strongly suggested a difference between the two groups in the areas of mathematics applications, social studies skills, and, to a degree, paragraph meaning. On the other hand, no significant difference was determined in mathematics skills and concepts, social studies content, and word meaning.

1. Of particular interest is the observation that in academic areas where differences were determined --mathematics applications, social studies skills, and paragraph meaning--there is a thread of commonality. In the case of mathematics applications, performance on the instrument was determined by ability to apply mathematical

knowledge and to think mathematically in practical situations. The social studies skills test has a stated goal, by the authors, of testing "knowledge in action." The paragraph meaning test purported to provide a measure of the pupil's ability to comprehend connected discourse involving varying levels of comprehension. The thread of commonality, then, is that each area requires a level of thought that transcends mere recognition and recall. Apparently, children who have had an inquiry experience tend to utilize the higher powers of thinking more effectively than those who have not experienced inquiry.

2. The finding of no significant difference in social studies content, mathematics skills, and word meaning was not particularly astonishing. Again there exists a thread of commonality in that each area emphasized proficiency in skill development. For mathematics, computational skills are stressed, word meaning considers knowledge of synonyms and simple definitions, and, basically, social studies content is factually oriented. In this regard, it is interesting to note that children in an inquiry program perform at least as well as children in a compltely traditional setting. In fact a defensible conjecture would be that the traditional group would perform better, since the tests tend to reflect outcomes expected in non-innovative programs. Obviously, quite the opposite is evident; the children in an experimental

science program performed adequately in all areas and exceeded the traditional groups in others.

Recommendations

The following recommendations are made on the basis of outcomes determined in this investigation and review of related literature.

1. There is obviously a place for inquiry type instruction. However, in order to expedite the learning process some determination should be made as to selection of varied techniques, in terms of objectives.

2. Since inquiry experience definitely enhances the teaching-learning process, a course, or perhaps courses, taught in an inquiry mode should be required of all prospective teachers regardless of anticipated teaching level.

3. School administrators would be well advised to establish inservice programs focusing on inquiry as a strategy for instruction.

4. Existing conditions in the two schools of this investigation precluded consideration of multi-ethnic groups. Studies should be considered that would include various socio-economic levels as well as different racial groups.

5. Since inquiry as a strategy for instruction has been incorporated into early childhood education recently, this study should be replicated with children

who have had inquiry experience in pre-school.

6. Inquiry-oriented science was the focal point of this study. However, since science was not included in the academic area investigated, inquiry-oriented science curricula should be analyzed in light of expected outcomes as compared with a traditional program.

7. Development of the abilities to inquire and think on higher levels of the rational powers[1] should be given priority in the educational goals of teachers and administrators.

---

[1]The rational powers as defined by the Educational Policies Commission are: recalling and imagining, classifying and generalizing, comparing and evaluating, analyzing and synthesizing, and deducing and inferring.

BIBLIOGRAPHY

Books

Beberman, Max. An Emerging Program of Secondary Mathematics. Cambridge: Harvard University Press, 1958.

Bruner, Jerome. The Process of Education. New York: Vintage Books, 1960.

Bruner, Jerome S. "The Act of Discovery," Human Learning in School. (Readings in Educational Psychology.) New York: Holt, Rinehart, and Winston, Inc., 1963.

Buros, Oscar Kriesen (ed.). The Sixth Mental Measurements Yearbook. Highland Park, New Jersey: The Gryphon Press, 1965.

Chall, Jeanne. Learning to Read, The Great Debate. New York: McGraw-Hill Book Company, 1967.

Clinchy, Evans. "The New Curricula," The Revolution in the Schools. Edited by Ronald Gross and Judith Murphy. New York: Harcourt, Brace, and World, 1964.

Dewey, John. How We Think. Boston: D.C. Heath and Company, 1910.

Educational Policies Commission. The Central Purpose of American Education. Washington, D.C.: National Education Association, 1961.

Gutek, Gerald. An Historical Introduction to American Education. New York: Thomas Y. Crowell Company, 1970.

Guilford, J.P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill Book Company, 1965.

Hilgard, E.R. Theories of Learning. 2d ed. New York: Appleton-Century-Crofts, Inc., 1956.

Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart and Winston, Inc., 1967.

Kuslan, Louis I. and Stone, A. Harris. Readings on Teaching Children Science. Belmont, California: Wadsworth Publishing Co., 1969.

Lavatelli, Celia Stendler. Piaget's Theory Applied to an Early Childhood Curriculum. Boston: American Science and Engineering, Inc., 1970.

Lockard, J. David (ed.). Sixth Report of the International Clearinghouse on Science and Mathematics Curricular Developments, A Joint Project of the American Association for the Advancement of Science and the Science Teaching Center. College Park, Md.: University of Maryland, 1968.

Massialas, Byron G. and Zevin, Jack. Creativity Encounters in the Classroom: Teaching and Learning through Discovery. New York: John Wiley and Sons, Inc., 1967.

Phenix, Philip. Realms of Meaning. New York: McGraw-Hill Book Company, 1964.

Renner, John W. and Ragan, William B. Teaching Science in the Elementary School. New York: Harper and Row Publishers, 1968.

Shulman, Lee S. and Keisler, Evan R. Learning by Discovery: A Critical Approach. Chicago: Rand McNally and Co., 1966.

Shuster, Albert H. and Ploghoft, Milton E. The Emerging Elementary Curriculum, 2d ed. Columbus, Ohio: Charles E. Merrill.

Siegel, Sidney. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill Book Company, 1956.

Smith, Frederick R. and Cox, Benjamin. New Strategies and Curriculum in Social Studies. Chicago: Rand McNally and Co., 1969.

Suchman, J. Richard. "Learning through Inquiry," The Oregon Program, A Design for the Improvement of Education. Salem: Oregon State Department of Education, 1964.

The Oklahoma Curriculum Improvement Commission, The Improvement of Instruction in Geography, History, Political Science, Economics, and Related Areas Grades K-12, Oklahoma City: Oklahoma State Department Education, 1966.

Articles and Periodicals

Ausubel, David P. "Some Psychological and Educational Limitations of Learning by Discovery," The Arithmetic Teacher, XI, (May, 1964), pp. 290-302.

Bradley, R.C. "Improving the Social Studies Curriculum at the Elementary School Level," The Education Digest (February, 1970), pp. 253-259.

Buckenmeyer, Robert E. "Discovery in the Child," The Constructive Triangle, VI, No. 2 (December, 1970).

Butts, David P. and Jones, Howard L. "Inquiry Training and Problem Solving in Elementary School Children," Journal of Research in Science Teaching, Vol. 4, No. 1 (November, 1960).

Davis, Robert. "Learning by Discovery," Madison Project Report, Webster College, Webster Groves, Missouri.

Estvan, Frank J. "Teaching the Very Young: Procedures for Developing Inquiry Skills," Phi Delta Kappan, L, No. 7 (March, 1969).

Foshay, Arthur. "How Fare the Disciplines," Phi Delta Kappan (March, 1970), p. 349.

Friedlander, Bernard F. "Today's Innovations in Teaching," NEA Journal, LXIV (March, 1964).

Goodlad, John I. "Implications of Current Curricula Change," The Education Digest (March, 1967), pp. 12-15.

Karplus, Robert and Atkin, M.J. "Discovery or Inventions," The Science Teacher, XXIX (September, 1962).

Kersh, Bert Y. "Learning by Discovery," The Arithmetic Teacher, XI (April, 1964).

Long, Barbara Ellis, "Behavioral Science for Elementary School Pupils," The Elementary School Journal (February, 1970), pp. 253-259.

Meconi, L. J. "The Mathematically Gifted Student and Discovery Learning," The Mathematics Teacher (December, 1967).

Renner, John W. and Stafford, Donald G. "Inquiry, Children and Teachers," The Science Teacher (April, 1970), p. 57.

Rizzuto, Malcom F. "Experimental Comparison of Inductive and Deductive Methods of Teaching Language Structure," Journal of Educational Research (February, 1970), pp. 269-273.

Silberman, Charles. "Murder in the Schoolroom: How the Public Schools Kill Dreams and Mutilate Minds," Atlantic Monthly (June, 1970), pp. 82-96.

Spitzer, Herbert F. Teaching Arithmetic, No. 2 of What Research Says to the Teacher, Department of Classroom Teachers, American Educational Research Association of the National Education Association. Washington, D.C.: National Education Association, 1962, p. 8.

Suchman, J. Richard. "Inquiry Training in the Elementary Schools," The Science Teacher, 27, No. 1 (November, 1960).

Taba, Hilda. "Learning by Discovery: Psychological and Educational Rationale," Elementary School Journal (March, 1963), pp. 308-316.

Wesley, Edgar B. "Let's Abolish History Courses," Phi Delta Kappan (September, 1967), p. 8.

Unpublished Material

Porterfield, Denzil. "The Influence of Preparation in the Science Curriculum Improvement Study in the Questioning Behavior of Selected Second and Fourth Grade Reading Teachers." Unpublished Doctoral dissertation, University of Oklahoma, 1969.

Renner, John W. Address given at the Annual Meeting of the American Association for the Advancement of Science, Section Q, in Dallas, Texas, December 27, 1968.

Schmidt, Frederick B. "The Influence of a Summer Institute in Inquiry--Centered Science Education upon the Teaching Strategies of Elementary Teachers in Two Disciplines." Unpublished doctoral dissertation, University of Oklahoma, 1969.

APPENDIX

APPENDIX A

DESCRIPTION OF SCIENCE CURRICULUM IMPROVEMENT STUDY (SCIS)

DESCRIPTION OF SCIENCE CURRICULUM

IMPROVEMENT STUDY[1] (SCIS)

In developing curricular materials for the elementary school science program, the SCIS personnel adhered to the basic notion that children should have experiences with physical and life science each year. The distribution of the science topics throughout the elementary school years by SCIS is as follows:

	Physical Science Units	Life Science Units
First Level	Material Objects	Organisms
Second Level	Interaction and Systems	Life Cycles
Third Level	Subsystems and Variables	Populations
Fourth Level	Relative Position and Motion	Environments
Fifth Level	Energy Sources	Communities
Sixth Level	Models: Electric and Magnetic Interaction	Ecosystems

The First Level[2]

Material Objects. In this unit children study common objects and special materials and describe them by their properties; such properties as color, shape, texture, hardness, and weight are considered. Properties are studied by the children as they observe, manipulate, compare, and even change the form or appearance of objects. As they

---

[1]John W. Renner and Don G. Stafford, "Elementary School Science," Bios, XLI, No. 4 (December, 1970).

[2]The descriptions of the twelve SCIS units included in this article have been adapted from Science Curriculum Improvement Study, Sample Guide, Rand McNally and Co., Chicago, 1970, pp. 10-15.

compare properties and recognize the differences among similarly shaped pieces of aluminum, brass, lead, steel, pine, walnut, and acrylic, children assimulate the concept of material. Property comparison also leads children to the concept of serial ordering.

The pupils also investigate the properties of solid, liquid, and gaseous materials. Each child has many opportunities to apply what he has learned about material objects, their similarities and differences, the changes that may be brought about, and the need for observable evidence to support his conclusions. Near the conclusion of the unit, the children are introduced to simple experimentation. Experiments are done with floating and sinking objects, and air.

Organisms. Children become familiar with some of the requirements for life as they set out seeds and watch the growth of plants. This experience is extended when the class builds aquaria with water plants, fish, and snails. Three natural events occurring in the aquaria are observed and discussed: birth of guppies and appearance of snail eggs, growth of guppies and snails, and death of organisms.

When they explore the school yard, nearby park, or nature area, children discover plants and animals living outside the classroom. The pupils are led to the concept of habitat as they compare these land organisms with those living in the aquaria.

After a few weeks, the algae in some of the aquaria increase in sufficient numbers to make the water green. The children usually notice this change and sometimes ask about its cause. Through a series of experiments and observations, they recognize the presence of tiny green plants called algae. Children may then find evidence that algae are eaten by Daphnia. When they discover that guppies feed upon Daphnia, the children can use this series of observations as a basis for understanding the concept of a food web depicting feeding relationships among organisms.

Detritus, the black material accumulating on the sand in aquaria after a few weeks, is a combination of feces and dead plants and animals. Children infer, as they compare seeds grown in sand with and without detritus, that it acts as a fertilizer, enhancing plant growth.

Each experience with living organisms should increase the child's awareness of differences between living organisms and nonliving objects.

The Second Level

The units studied in the second year are entitled Interaction and Systems and Life Cycles. In both units the theme is change which is observed as evidence of interaction or by the development of a plant or animal. The two units, therefore, require children to add the mental process of interpreting evidence to the observational skills they developed in the first year. As with the first-year units, these two units can be taught in either order or simultaneously. Simultaneous use of the units is very convenient because during the Life Cycles unit there are often periods of time when the living systems are static or growth is not obvious. During these times, activities from Interaction and Systems can be profitably integrated.

Interaction and System. The central concept of the entire SCIS program, interaction, is introduced in this unit. The children's work with objects and organisms in the first year has given them the background necessary for understanding the interaction relationship. In later units, the program will emphasize the application and refinement of the interaction concept as children investigate biological, chemical, electrical, magnetic, thermal, and mechanical phenomena.

The first two parts of this unit are devoted to the interaction and systems, concepts, respectively. The idea that a change may often be interpreted as evidence of interaction (for example,, when photographic paper turns dark on exposure to sunlight) is explained. The remainder of the unit is divided into four parts in which the children investigate interactions and systems, dissolving (copper chloride, aluminum), interaction-at-distance (interaction without the objects touching, as in magnetism), and electric circuits. The sequence of these investigations can be altered to suit the teacher's preference. Throughout, children observe and interpret evidence of interaction.

Scientific concepts are developed in the unit, as are the children's skills in (1) manipulating experimental equipment, (2) reporting observations, and (3) recording observations during experiments.

Life Cycles. The investigation of ecosystems begun in Organisms is continued in Life Cycles. The unit, however, focuses on individual organisms, which alone show the characteristics of the phenomenon called "life." At this time the interrelationships and interdependencies within the ecosystem have secondary importance.

Each kind of plant and animal has its own life cycle. By studying the life cycles of selected plants and animals, children observe the characteristics of living organisms. Seeds are planted and their germination observed. Plants are cared for until they reach maturity, produce flowers, and form a new generation of seeds. The fruit fly, frog, and mealworm are observed while they metamorphose. As one generation of organisms produces another, children are led to consider biotic potential and the effects of reproduction and death on a population. Finally, when some of the similarities and differences between plants and animals have been considered, and children have defined the two categories on the basis of their own observations, they proceed to the more general question. "What is alive?"

With each experience, a child's awareness of the differences between living and non-living objects should increase.

The Third Level

Subsystems and Variables. The subsystems concept is introduced to give the children a grouping of objects intermediate between a single object and an entire system. The grains of sand in a mixture of sand, salt, and baking soda, the salt in a salt solution, the Freon in a bag interacting with water, or the arm and rivets in a whilybird system are all examples of subsystems.

As the children experiment with solids and liquids, they use the techniques of sifting to separate solid powders and of filtering to separate an undissolved solid from a liquid. At the same time they recognize that dissolved solids in solutions cannot be separated by filtering. Instead, the presence of dissolved solids may be identified by a residue that remains after the liquid evaporates. There are further experiences with the liquid Freon, a material that not only evaporates quickly at room temperature, but that condenses to a liquid form when cooled with ice. The work with solutions and with Freon serves to deepen the children's awareness of the principle of conservation of matter, even though this is not stated explicitly in the unit. The technique of using a histogram to compare data is introduced when the children take temperature readings during the melting of ice and interpret their measurements.

In the last part of this unit, children investigate the whilybird (a rotating propeller-like device which is powered by a taut rubber band) and discover that its operation depends on many factors they can control and on a few they cannot. The variable concept helps them to identify and investigate factors influencing the motion of the whirlybird arm, including adding weights in the form of rivets to both sides.

Populations. In this unit attention is directed toward populations of organisms rather than toward individual plants and animals. Children observe the growth, eventual leveling off, and decline of isolated populations of Daphnia, aphids and fruit flies. They relate increased population sizes to reproduction and population decline to death.

The children build aquaria and terraria in which several populations live together. The aquaria contain populations of Daphnia, hydra, snails, algae, duckweed, and Anacharis. The terraria contain grass, clover, crickets, and chameleons. By observing the interacting populations in the aquaria and terraria, the children gain some understanding of the relationships among populations in nature. For example, the children observe that hydra eat Daphnia, with the result that the Daphnia population declines while the hydra population may increase. In the terraria, the children observe that crickets eat grass and clover and that when chameleons are added to the terraria they eat the crickets. Thus the grass and clover populations are reduced, and the cricket population is eventually wiped out.

The Fourth Level

Environments. The terraria children design and build at the beginning of the unit reflect their preconceptions regarding the needs of organisms. As a result, there is a wide disparity in the growth and survival of the organisms living in the terraria, and these differences can be correlated with variations in environmental factors such as temperature, amount of water, and intensity of light. The term environment is defined as the sum total of all the environmental factors affecting an organism.

Afterwards, the children seek to determine the responses of individual kinds of animals and plants to variations in the environmental factors. On the basis of experiments with isopods in a runway with graded temperature, the concepts of a temperature range and of an optimum range for that animal are introduced. In additional experiments, the children attempt to determine optimum ranges of other environmental factors for snails, mealworms, beans, grass, and clover. Before the unit is concluded, the children again construct terraria, but now they use their data on optimum ranges to plant a more favorable environment for their organisms.

Relative Position and Motion. In the Relative Position and Motion unit, activities dealing specifically with spatial relationships are introduced into the SCIS program. The investigations enhance the children's abilities to think critically, interpret evidence, and work independently. These are process objectives for the entire SCIS program. Children use reference frames to describe the position and motion of objects in their everyday environment.

Early in the unit, the artificial observer Mr. O serves the children as a reference object for describing relative position. Later they are introduced to polar and rectangular coordinates for a more exact description of relative position and motion. The children must apply the reference-frame concept in many activities, such as the following: (1) playing classroom games to locate objects, and solving puzzles that require matching of relative positions; (2) watching the Fun House film loop in which the camera rides along with the children to record unusual relative motion; (3) drawing and interpreting flip books; and (4) orienting themselves in Yellowstone National Park with the help of maps and coordinate grids, and surveying the school playground with a simple transit. The investigations in the last part, dealing with the motion and tracks of rolling and interacting steel balls, relate the ideas and techniques developed in early parts of this unit to the matter, interactions, and energy concepts of the physical-science sequence.

The Fifth Level

The Conceptual development of the SCIS program continues as examples of energy transfer are introduced in the physical-science unit Energy Sources and of food transfer (the organic equivalent of energy) in the life-science unit Communities.

Energy Sources. During the fifth year, the pupils continue their study of matter and energy in the Energy Sources unit and also extend their skills in conducting scientific investigations. Their attention is focused on the energy transformations that accompany the interaction of matter in solid, liquid, and gaseous forms. The children's qualitative descriptions of energy transfer from a source to a receiver prepare them for later quantitative investigations of energy exchange.

The introductory investigations employing rolling spheres and paper airplanes are used to review interaction, variables, and other concepts with which the children have become familiar. These experiences and work with rotoplanes (propeller-driven rotating platforms) provide background for the invention of energy transfer and the identification of energy sources and energy receivers.

The children apply the new concepts to situations in which motion or temperature change provide evidence of energy transfer. They experiment with (1) stopper poppers, in which compressed air serves as energy source; (2) spheres rolling down ramps and colliding with a movable target, in which the rolling spheres serve as energy source; (3) the dissolving of sodium thiosulfate or magnesium sulfate, in which the water or the solid material acts as energy source; and (4) the melting of ice, in which the ice serves as energy receiver.

Communities. In the Communities unit pupils investigate the food relations within a community of plants and animals. They experiment with germinating plants, discovering that food stored in cotyledons is consumed; however, another source of food, photo-synthesis, supports the plants' growth.

The children observe the feeding behavior of animals in terraria containing various plants and animals. They identify the food chains and infer that photosynthesis in green plants not only supplies food for the plants but indirectly also for the animals in the community. The children count the large number of wheat seeds eaten by crickets and the few crickets eaten by a single frog. On the basis of these data, the food pyramid is introduced.

When an animal or plant in the terrarium dies without being eaten by another animal, the children place the dead organisms in a vial and cover it with moist soil. They observe the organism's gradual decomposition along with the appearance of mold or an unpleasant odor. The children are told that organisms that satisfy their energy needs by decomposing the bodies of dead plants and animals are bacteria and molds.

The transfer of food through a community is illustrated by means of a chart showing the food relations among plants, animals, bacteria, and molds. The plants are identified as producers, the animals as consumers, and the molds and bacteria as decomposers. The interacting producers, consumers, and decomposers in a given area constitute the community.

The Sixth Level

The last year of the SCIS program contains both a climax and a new beginning. The study of Ecosystems in the life science sequence integrates all the preceding units in both physical and life sciences as the young investigators study the exchange of matter and energy between organisms and their environment. The physical science unit Models: Electric and Magnetic Interactions introduces the concept of the scientific model and thereby opens a new level of data interpretation and hypothesis making.

Ecosystems. Through the investigations in the Ecosystems unit, children become aware of the roles played by oxygen, carbon dioxide and water in the maintenance of life. When this understanding is combined with the habitat, populations, community, and other concepts introduced in the SCIS life-science sequence, the term ecosystem acquires its full meaning.

Initially, the children review the ideas introduced in the five earlier units by building a composite terrarium-aquarium. The organisms living in the containers represent plants, plant eaters, and animal eaters--organisms that flourish under varying environmental conditions. The ecosystem is defined as the system composed of a community of organisms interacting with its environment.

After they observe water droplets on the inside of the terraria-aquaria, the children clarify the role of water in an ecosystem. The water cycle refers to the succession of evaporation and condensation of water.

The pupils study the carbon dioxide-oxygen exchange between organisms and their environment. They test their own preconceptions about oxygen and carbon dioxide when they compare the gases formed by plants exposed to light and to the dark, by animals living in a community with plants, and by animals in isolation. The production and consumption of the two gases is described as the carbon dioxide-oxygen cycle.

Models: Electric and Magnetic Interaction. The activities in the Models unit are directed toward increasing the children's understanding of electrical and magnetic phenomena at the levels of concrete experiences and of abstract thought.

Children review some of their work in the Interaction and Systems and Subsystems and Variables units. Next, children explore the circuits' energy sources, constructing a battery (or electrochemical cell) to operate light bulbs and other circuit elements. Finally, the model concept is introduced in connection with mechnaical and electrical "mystery systems." The pupils must explain the systems in terms of assumed objects that cannot be seen directly.

The second part of the unit is devoted to magnetism and various models, such as the magnetic field and the magnetic poles. In Part Three, the children investigate more complicated electric circuits, and the electric current model is introduced to unify their theories. This distinction between series and parallel electric-circuit connections can be used for predicting the operation of light bulbs and other circuit elements if a consistent model for electric current has been chosen. In the concluding activities, electric energy sources and the chemical processes related to electric current flow are considered again.