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DIFFERENCES BETWEEN THE INQUIRY-DISCOVERY AND THE TRADITIONAL APPROACHES TO TEACHING SCIENCE IN ELEMENTARY SCHOOLS

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DIFFERENCES BETWEEN THE INQUIRY-DISCOVERY AND THE TRADITIONAL APPROACHES TO TEACHING SCIENCE IN ELEMENTARY SCHOOLS

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BACKGROUND OF THE PROBLEM

Efforts to define the role of the schools have existed from the very beginning of the first schools. Although this is a difficult task, it is one that must be pursued in order to set reasonable goals and select satisfactory methods by which to fulfill the role expectations of the schools.

An extensive analysis of this problem has been made by the Educational Policies Commission,[1] which reported in 1961 that, "The purpose which runs through and strengthens all other purposes--the common thread of education--is the development of the ability to think." The emphasis throughout the report was on the importance of the development of

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[1]Educational Policies Commission, The Central Purpose of American Education. Washington, D.C.: National Education Association and American Association of School Administrators, 1961.

the rational powers. These rational powers were defined as: . . . "recalling and imagining, classifying and generalizing, comparing and evaluating, analyzing and synthesizing, and deducing and inferring."[2]

While it may be questionable that this statement comprehensively describes the role of the schools, it is quite acceptable that the development of the ability to think and the strengthening of the rational powers are prime goals of the schools. A major concern of the schools thus becomes that of selecting those activities which are most likely to contribute to the fulfillment of these goals.

Determining how the curriculum of the elementary school can be related to such goals is an important consideration. Since the curriculum is the machinery by which such goals are achieved, it is essential to examine the make-up of the elementary school curriculum to discover aspects of it which can contribute to developing the ability to think.

A rather obvious observation to most people who are relatively familiar with the elementary school curriculum is that many subjects within the curriculum can be geared to develop the rational powers. Those with first-hand experience in elementary schools will also conclude that in the teaching of any of these subjects far more time is

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[2] Ibid.

spent in elementary classrooms developing one rational power than all the other nine combined. That rational power is recall.

In discussing the amount of time and energy given to recall-type activities in the elementary school classroom, Miller reports,

> That the learning of facts, definitions, concepts and general ideas is absolutely necessary for pupil growth cannot be denied, but that this should be the near single concern of the school is surely open to doubt. Discriminating, recognizing, and remembering must always be basic mental activities for learners, but these are not the only mental abilities that should be exercised. Studies of actual classroom teaching indicate that pupils receive a disproportionate amount of such memory testing questions and assignments.[3]

While it is questionable that a percentage figure can be accurately set concerning the amount of time given to development of each of the rational powers, it has been estimated that as much as eighty or ninety per cent of instructional time is commonly used on activities which tend to develop only recall.[4] Undoubtedly recall is important, but the other nine rational powers must receive a far greater proportion of time if children are to be taught to think.

One subject contained in the elementary school curriculum which lends itself well to the development of

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[3]Miller, George L. "The Teacher and Inquiry," Educational Leadership, April, 1966, p. 552.

[4]Renner, John W. "Lockstep Teaching," The Pedagogic Reporter, March, 1966, Vol. XVII, p. 3.

critical powers and the ability to think is science. Science is taught in most elementary schools, is usually taught at all grade levels, and as any other elementary school subject, is taught in a variety of ways. A perusal of elementary school science texts available suggests that science content is usually presented in a manner which demands recall of factual information and includes a few experiments which tend to be pre-determined by the authors of the texts. Laboratory procedures which allow pupils to experiment are "fixed." That is, the experiments are strategically located throughout the text, a procedure is suggested in the teacher's edition, the materials to be used are spelled out, and the expected results and conclusions to be drawn are listed for the teacher. These results and conclusions are usually thoroughly discussed in the pupil's text on the next few pages if they haven't been given in advance.

This "traditional" textbook, factual-recall, exposition method of teaching science does not develop many of the rational powers. It also does not take advantage of a child's natural curiosity when he soon learns that all the answers to his questions can be found in the "cookbook". Karplus, in reporting about elementary school science teaching, says.

> One great weakness of current practice seems to be an almost exclusive reliance on textbooks and other such authoritative sources of information. Those sources for science learning, however, are quite impotent compared to the direct experiences

> that nourish the pupils' intellectual development of "common sense" rationality. Instead of guiding this development in the direction of modern scientific understanding, therefore, the present-day science courses create a second, separate, relatively abstract structure which is not used outside the school situation and which eventually atrophies.[5]

The child really needs to be encouraged to find his own answers to problems and to determine how to do this systematically and scientifically. He needs to be introduced to scientific methods of problem pursuit and allowed to practice them under the teacher's guidance.

The science program at the elementary school level needs to be one in which the children become involved. They should not be outsiders, watching the teacher perform "magic" with science materials. Children in the elementary school classroom are not very good spectators and they should not be expected to be. Supporting the position that children should be involved in science education, Scott states,

> If science is to mean something other than a class lecture period or pages of factual material in a textbook, young children must be involved in it. To recite the virtues of the scientist in his laboratory, or to tell children that experimentation is fun and productive is grossly insufficient. Even the display of an experiment performed by the teacher falls short of the mark. To the greatest extent possible, all of the senses of the child must be involved if the flavor of science is to be known. There is no known way to obtain such involvement short of the child's direct participation. In

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[5]Karplus, Robert, "Theoretical Background of the Science Curriculum Improvement Study." Journal of Research in Science Teaching, October, 1965, p. 8.

> designing a science program for the elementary school, the first and most important part of the equipment for any activity is the child himself.[6]

It seems true that the traditional, expository, pure textbook teaching of science does not involve the children as they should be involved, nor does it adequately develop all of the rational powers. The question arises concerning whether there is a method of teaching science which does involve the children, helps them develop the ten rational powers and, thus, helps them learn to think.

One of the "new" approaches to teaching elementary school science is the program being developed by the Science Curriculum Improvement Study (SCIS). It is apparent, when reviewing the SCIS materials, that within the major objectives of the project, an important consideration is that of the development of the rational powers. This program encourages pupil involvement, takes advantage of the child's curiosity, emphasizes inquiry-discovery teaching, or, in essence most of the things that haven't been encouraged by the traditional, textbook emphasis science teaching.[7]

The directors of the SCIS program give the following general overview of their program:

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[6] Scott, Lloyd, "Science is for the Senses," Science and Children, March, 1965, p. 22.

[7] Haney, Richard E. The Changing Curriculum: Science. Washington, D. C.: Association for Supervision and Curriculum Development-NEA, 1966, pp. 14-15.

> The general strategy of the Study is to confront the elementary school children with firsthand experiences of natural phenomena and with intellectual challenges that will stimulate their further cognitive development.[8]

The children are involved in situations giving them firsthand experience with natural phenomena and are led to investigate this phenomena for themselves as well as interpret the investigation results. In other words, children are taught science through investigation. The experiences the child has are purported to encourage the development of the rational powers and increase intellectual development. Other goals of the SCIS program are to give the child experience with all phases of his environment and to aid him in developing a conceptual framework which will be useful to him in the future.[9]

A very important part of the SCIS program of teaching science to elementary school children is that of providing the opportunity for the children to have an abundance of five "essential science experiences."[10] Active involvement in these experiences will present the child with opportunities to use all of his rational powers and thus, more nearly

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[8]Karplus, Robert, "Science in the Elementary School," New Developments in Elementary Science: A Conference. Frontiers of Science Foundation of Oklahoma, February, 1964, p. 44.

[9]Haney, op. cit., pp. 14-15.

[10]Renner, John W. and William B. Ragan, Teaching Science in the Elementary School, New York: Harper and Row, Inc. In press.

assure the development of his ability to think. These five "essential science experiences" are: observation, measurement, experimentation, interpretation of data, and prediction.

Implementation of the SCIS program of elementary science is being carried out by several centers throughout the United States. One of these centers is located at the University of Oklahoma. Program director at that institution is John W. Renner, Professor of Education at the University of Oklahoma and Chairman of Science at the University Schools. Renner has conducted several workshops in the Oklahoma area and has been using SCIS materials in the elementary science methods courses at the university. Because of this, many area teachers are either supplementing their school's science program with SCIS materials or they are making complete use of the SCIS program for elementary school science.

STATEMENT OF THE PROBLEM

The purpose of this study was to investigate and analyze the teaching procedures of two groups of science teachers at the elementary school level. One group of teachers included those who had received instruction in the inquiry-discovery approach to elementary school science teaching. These teachers had received instruction in the Science Curriculum Improvement Study (SCIS) methods and were familiar with the materials developed by that and other similar groups. The second group included a like number of teachers of elementary science who had not received instruction in the SCIS methods and materials, nor any other "new" approach to elementary school science.

The study was designed to determine whether the teachers who had been instructed in the SCIS program were encouraging their pupils to indulge in a significantly larger number of the "essential science experiences" than those teachers who had not had instruction in any "new" science program.

The study was designed to assure that the two groups of teachers were similar in as many aspects as possible. Each group contained a like number of teachers from each grade level; a similar number of schools was involved; the number of years of teaching experience was considered; and all of the teachers were members of the same school system. The teachers who received instruction in the SCIS program were all instructed by the same teacher, and were all currently involved in in-service instruction in SCIS work.

THE HYPOTHESES

1. There is no significant difference in the number of times pupils are provided the five "essential science experiences" in those classes taught by teachers who have been educated to use traditional, textbook-centered science instruction procedures and those classes taught by teachers

who have been educated in the SCIS, inquiry-discovery approach to science instruction.

2. There is no significant difference in the number of times pupils are presented with questions which demand use of higher cognitive powers to respond in those classes taught by teachers who have been educated to use traditional text-book centered science instruction procedures and those classes taught by teachers who have been educated in the SCIS, inquiry-discovery approach to science instruction.

PROCEDURE

Fifteen teachers who had been educated to teach by the SCIS, inquiry-discovery approach were selected to represent all grade levels from one to six. These teachers were chosen by the director of the SCIS program from all of the SCIS-educated teachers in the Norman, Oklahoma school system. A second group of fifteen teachers was selected by the director of elementary education for Norman's schools by choosing teachers who were teaching at the same grade level, with similar experience, and within the same building as those chosen for the SCIS group. This first group shall hereafter be called the SCIS group and the latter is called the traditional group.

Each of the thirty teachers was then contacted personally by the writer for the purpose of explaining the nature of the observations to be made and to schedule two observations of their classes. The two observations of a science lesson were scheduled exactly one week apart, at the time science was normally scheduled by each teacher. The teachers were requested to have as nearly normal a science lesson as possible.

Two instruments were used for the collection and recording of data taken from the observations. One of the instruments was designed for categorization of different science experiences encouraged by the teacher. The second instrument was designed for categorization of different types of questions posed by the teacher.

Because of the use of two observation instruments, both of which demanded the observer's full attention, the science lessons were recorded on a small portable tape recorder. This allowed for the more careful analysis of the teacher's questions at a later time when the session could be played back for review. After each day's observations, the tape recordings were replayed, the questions written out, and the analysis of the questions was made that same day so that the lessons were fresh in the observer's memory. Because an accurate analysis of the questions is partly contingent upon knowing the nature of the discussion, the response of the pupils, and the expectation of the teacher, the tape recordings helped to more nearly insure accuracy when they were reviewed the same day of the lessons.

Tallies were made on the observation instruments for only thirty-five minutes of each science lesson. When the lessons were longer than this, the observer simply waited until the conclusion of the lesson before leaving the room. Observations were made for at least thirty-five minutes in every session.

Teachers were told of the intended use of the tape recorder for the observations. They were assured that the tapes were to be replayed for the sole purpose of taking additional data from them and would then be permanently erased. Teachers were urged to explain to their pupils that an observer would visit their class twice, that a tape recorder would be used but that no one else would hear it, and that they should disregard the observer's presence as nearly as possible. It should be noted that most of the classes were commonly visited by other persons and that it was apparent that neither the observer or tape recorder seemed to appreciably affect the teachers' activities or the pupils' behavior.

DEFINITIONS AND ASSUMPTIONS

The following definitions are given for the purposes of this study:

1. Science Curriculum Improvement Study (SCIS). One of the "new" science projects which incorporates the inquiry-discovery approach to teaching elementary school science.

2. SCIS-educated Teachers. Teachers who have had special instruction in methods of teaching elementary school science by the inquiry-discovery approach, are making use of SCIS materials, and are being guided and supervised in SCIS teaching procedures by a regional director of the project.

3. Traditional Science Teachers. Teachers who have neither received special instruction in the SCIS or any other "new", inquiry-discovery approach to teaching elementary school science. Their science program is basically that which is taken from the science textbook.

4. The Five Essential Science Experiences. Observation, Measurement, Experimentation, Interpretation of Data, and Prediction.

The following assumptions are made for the purpose of this study:

1. That two of the major objectives of the SCIS project are: (1) to further the development of the child's ability to think and that ability can be described as the rational powers of the mind, and (2) to familiarize the child with all phases of his environment and the method chosen to do this is by exposing the child to the five "essential science experiences."

2. That an appreciable determination of actual development of the rational powers can be ascertained by categorization

and analysis of questions using Harris and McIntyre's "Teacher Question Inventory."[11]

3. That the "Teacher Observation Inventory" has provided a method for categorization of the five "essential science experiences."

4. That the pupils of the SCIS-educated teachers were being taught by the inquiry-discovery approach.

5. That the traditional science teachers were not using the inquiry-discovery approach.

6. That the presence of the observer did not decidedly affect the teachers' teaching procedures and the pupils' behavior.

JUSTIFICATION FOR THE STUDY

Any effort to upgrade the standards of teaching any one of the important disciplines being taught at the elementary school level will be effected through the changed behavior of the teachers. There is absolutely no guarantee that a teacher who has been trained to teach elementary school science by a new approach will change from the approach previously used.

Historically, elementary school teachers have taught science from a textbook, making use of whatever materials they can procure for experimental purposes.

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[11]Harris, Ben M. and Kenneth E. McIntyre, "Teacher Question Inventory," Austin: University of Texas, 1964.

Generally, elementary school science has been content-centered with the central goal that of factual accumulation and recall.

A number of "new" science projects are being experimented with. They tend to be process-centered and most of them purport to make use of the inquiry-discovery approach to teaching. Teachers who have taught the traditional, textbook-centered science program are being educated in the "new" science projects and it is assumed that after the instruction they will give up the traditional approach for the "new" approach. This assumption is questionable since account must be given to the very threatening nature of change.

This study has been designed to determine whether one group of teachers has changed significantly from the traditional approach to teaching elementary school science and is indeed teaching as they have been educated to teach by the SCIS, "new" science project. Besides showing whether the teachers have evidenced greater use of the "new" science approach, the study is designed to show whether this SCIS approach places greater demands upon the child's higher cognitive powers and thus encourages him to learn to think more effectively.

The Educational Policies Commission has this to say about the "new" science projects:

> In the modern world the approach of rational inquiry--the mode of thought which underlies

> science and technology--is spreading rapidly and, in the process, is changing the world in profound ways. . . The spirit of rational inquiry, driven by a belief in its efficacy and by restless curiosity, is therefore commonly called the spirit of science.[12]

The Commission suggests that the values through which men have traditionally found direction for their lives are being challenged by this spirit of science. Traditional value words such as love, honesty, beauty, and patriotism are not found as part of its goals for man. In reviewing the Commission's booklet concerning this spirit of science, Fox reports,

> But other profound values are characterized by the enterprise called science, and are highly desirable as the content of education:
> 1. They long to know and to understand
> 2. Questioning of all things
> 3. Search for data and their meaning
> 4. Demand for verification
> 5. Respect for logic
> 6. Consideration of premises
> 7. Consideration of consequences
>
> (The spirit of science) can enable entire peoples to use their minds with breadth and dignity and with striking benefit to their health and standard of living. It promotes individuality. It can strengthen man's efforts in behalf of world community, peace, and brotherhood. It develops a sense of one's power tempered by an awareness of the minute and tenuous nature of one's contributions. Insofar as an individual learns to live by the spirit of science he shares in the liberation of mankind's intelligence and achieves an invigorating sense of participation in the spirit of the modern world. To communicate the spirit of science and to develop people's capacity to use its values should therefore be among the

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[12] Educational Policies Commission, Education and the Spirit of Science, Washington, D. C.: National Education Association, 1966, p. 1.

> principal goals of education in our own and every country.[13]

If this should be among the principal goals of education in our country and if the "new" science projects are making these kinds of goals attainable by the competent pursuit of the projects' directions, then it seems that a study which tries to determine whether one of the "new" projects is reaching these goals is well justified.

ANALYSIS OF DATA

The composite of the tallies made under each category on the observation instruments was used in the statistical analysis of data. The composite figure compiled for each category of the SCIS-educated teachers groups was compared with the composite figure of its counterpart of the traditional science teachers group.

The z score for comparison of observed data was the statistical instrument used for analysis of data. The level of confidence for z was set at 0.05. The formula for z is as follows:[14]

$$z - \frac{P_1 - P_2}{\sqrt{(P_c\ q_c)\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}}$$

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[13] Fox, Fred W. "Education and the Spirit of Science--The New Challenge," The Science Teacher, Nov., 1966, pp.58-59.

[14] Guilford, J. P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill, Inc., 1966, pp. 185-187.

where P_1 = proportion in one category

P_2 = proportion in other category

where $P_c = \dfrac{X_1 + X_2}{N_1 + N_2}$

X_1 and X_2 are the frequencies in each category

N_1 and N_2 are the total frequencies for each variable

where $q_c = 1 - P_c$

FURTHER ORGANIZATION OF THE STUDY

Chapter II is devoted to a review of the literature which pertains to the "new" science. Literature concerning the importance of effective questioning by the teacher is reviewed briefly.

The instruments used in the study, the data collected, and the analysis of the data are presented in Chapter III. Chapter IV contains the findings of the study, the summary, conclusions drawn, and recommendations for further research.

CHAPTER II

THE INQUIRY-DISCOVERY APPROACH TO TEACHING SCIENCE

This chapter is concerned with the rational foundations of the inquiry-discovery approach to teaching science in elementary schools. The first section deals with the general characteristics of the inquiry-discovery approach as contrasted with the expository or traditional approach. The second section deals with essential experiences included in the elementary-school science program. The third section deals with the role of questions in science teaching.

GENERAL CHARACTERISTICS OF THE INQUIRY-DISCOVERY APPROACH

The discussion of inquiry-discovery teaching is intended to both identify what this approach really is and to present evidence of the kinds of contributions this approach is making to improve the teaching of science in the elementary schools. For purposes of this study, the terms inquiry and discovery are used inter-changeably to mean the approach to teaching that places much more of the burden of the teaching-learning act upon the learner. While its opposite, the expository approach, is teacher dominated, the inquiry-discovery approach is more a matter of the learner "rearranging or transforming evidence in such a way that one is enabled to go beyond the evidence so assembled to additional new insights."[1]

When presenting the affirmative case for discovery teaching, it is common to find a comparison between discovery and expository or traditional teaching being made. Carin and Sund comment on the placement of emphasis in the traditional and discovery approaches,

> Schools have . . . traditionally overemphasized this product of science, the subject matter, and underemphasized or forgotten the process of science. A look at the process by which the subject matter is obtained reveals the dynamic nature of the scientific process, for facts become valid and cumulative only after they survive unrelenting scrutiny. Thus, scientific facts--although extremely necessary for any scientific investigation--are only a product of the greater contribution of modern science, the process of inquiry.[2]

Schwab identifies some of the basic weaknesses of the traditional approach when he comments,

> It is the almost total absence of this portrayal of science which marks the greatest disparity between science as it is and science as seen through most textbooks of science. We are shown conclusions of inquiry as if they were certain or nearly certain facts. Further, we rarely see these conclusions as other than isolated independent "facts." Their

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[1] Bruner, Jerome S. "The Act of Discovery," Harvard Educational Review, Volume 31, 1961, p. 27.

[2] Carin, Arthur and Robert B. Sund, Teaching Science Through Discovery, Columbus, Ohio: Charles E. Merrill Books, Inc., 1964, p. 4.

> coherence and organization--the defining marks of scientific knowledge--are underemphasized or omitted. And we catch hardly a glimpse of the other constituents of scientific inquiry: organizing principles, data, and the interpretation of data.[3]

A major differentiation made between the traditional approach and the "new" science inquiry-discovery approach is the concern shown in the new projects for studying science as a process as opposed to the traditional emphasis placed on science as products. Traditional, textbook-centered science teaching is criticized for being dogmatic and unscientific with a strong attitude suggesting "this is it." Unless children are allowed to experience and see the skills and attitudes which make up the process of scientific investigation they miss a fine opportunity to become interested in science.

When children recognize that a scientist's success is not measured by how much information he has stored in his memory, but instead his work involves wondering about phenomena, observing, controlling experiments, being willing to withhold judgment, admitting he is wrong when there is proof he is, and recognizing the limitations of science, these children are on the way to a more accurate perception of science. Then, when they are allowed to be a part of this process of scientific investigation, inquiry-discovery begins to happen for each of them. This experience cannot

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[3] Schwab, J. J. "The Teaching of Science Enquiry," *The Teaching of Science*, Cambridge: Harvard University Press, 1962.

happen via the lecture or by just reading a textbook to learn facts. Children must experience the process in the classroom or the laboratory.[4]

Actually, teaching by the inquiry-discovery approach is only a matter of capitalizing on one of children's strongest traits, curiosity. Children are natural experimenters and scientific investigators. From babyhood on, children become acquainted with their environment by exploring it in various ways. They test almost anything accessible by feeling, studying, moving, handling, striking, and usually by tasting it. Older children continue to make use of all of their senses to discover new things. They are able to add the questioning technique and soon learn a number of ways to satisfy their almost insatiable curiosity by inquiring and discovering. An alert teacher will recognize the numberless discoveries she can help children make.[5]

Suggesting that we have not taken advantage of this natural curiosity of the child by developing the discovery approach to science teaching in our textbook-centered classrooms, Huey reports,

> The rush for more science learning in the elementary school has been characterized by confusion as to what science really is and what

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[4]Boulos, Sami I. "Are You Teaching Science Unscientifically?" Science and Children, April, 1965, p. 25.

[5]Langdon, Grace and Irving W. Stout, Teaching in the Primary Grades, New York: The MacMillan Company, 1964, pp. 205-07.

> the young scientist can do. Too often emphasis has been put on science as a body of knowledge to be memorized. This knowledge is often planned to have the glamor of "experiments" which frequently are merely rigged performances that carry more of the spirit of magic than of thoughtful investigation. Too often even the magic is missing, and science becomes something to be learned the hard way, leaving the thrill of discovery to the professional scientist.[6]

Another point of departure from which consideration can be given to the merits of discovery teaching of science is whether the subject matter is to be thought of as a content subject or as a skill subject. Certainly the teaching methods are strongly dependent upon the answer to this question.

Traditionally, science has been taught as a content subject rather than a skill subject with the task of the teacher perceived and defined as helping the children remember facts, principles, and generalizations taken from the text. At the same time mathematics and reading have been taught as skill subjects with the teacher guiding the children to discover how to learn and how to function. Taught in this manner, mathematics and reading have assumed an important place in the child's life. They are useful, interesting, and practical. They become tools for further learning as well as skills for everyday enjoyment.

Considering the argument for viewing science as a skill subject instead of a content subject, Fish states,

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[6]Huey, J. Frances, <u>Teaching Primary Children</u>, New York: Holt, Rinehart, and Winston, Inc., 1965, pp. 53-4.

> Is it any wonder that science has not become a functional part of the lives of today's pupils as the other skill subjects have? Is it any wonder that the skills and methods pupils use in acquiring a knowledge of science facts, principles, and skills differ sharply from the methods scientists use in their search for new knowledge? If science is to become functional, it must be experienced, and it must be experienced as a skill subject.
>
> We should remind ourselves also that teachers of skill subjects have discovered that the subject matter of a skill subject can serve as a medium for the development of skills and at the same time provide a rich source for the development of concepts.[7]

A commonly recurring theme found within most of the new science projects' statements of purposes and objectives is one suggesting that the learner benefits from more than just the acquisition of important facility with processes and products of science.[8] The very idea that using the discovery approach to study science is likely to positively affect the development of all the rational powers is an example of the potential transfer value of this approach to learning. Stressing the importance of inquiry-discovery teaching as a device for more adequate development of the rational powers, the Educational Policies Commission cites the following possible effect to expect from this development:

> . . . the rational powers are central to all the other qualities of the human spirit. These powers

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[7]Fish, Alphoretta S. "Structuring an Elementary School Science Program," The Elementary School Journal, February, 1963, p. 279.

[8]Blackwood, Paul E. The Changing Curriculum: Science, Edited by Richard E. Haney. Washington, D.C.: ASCD-NEA, 1966, p. vii.

> flourish in a humane and morally responsible context and contribute to the entire personality.
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> . . . A person with developed rational powers has the means to be aware of all facets of his existence. In this sense he can live to the fullest. He can escape captivity to his emotions and irrational states. He can enrich his emotional life and direct it toward even higher standards of taste and enjoyment. He can enjoy the political and economic freedoms of the democratic society. He can free himself from the bondage of ignorance and unawareness. He can make himself a free man.[9]

To suggest these things are primary goals of discovery teaching at the elementary school level would at least be highly questionable. But to fail to recognize the potential effect this kind of teaching-learning act may eventually have on the elementary child would be equally remiss. The presumption that discovery teaching does more effectively encourage the development of all of the rational powers seems to be valid, as does the argument made by the Educational Policies Commission concerning the advantage that full development of these powers can have for the individual.

Considering another advantage of discovery teaching, Bruner hypothesizes,

> It is my hunch that it is only through the exercise of problem solving and the effort of discovery that one learns the working heuristics of discovery, and the more practice, the more

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[9]Educational Policies Commission, <u>The Central Purpose of Education</u>. Washington, D.C.: National Education Association, 1961, pp. 8-9.

> likely is one to generalize what one has learned into a style of problem solving or inquiry that serves for any kind of task one may encounter--or almost any kind of task.[10]

Bruner also believes that the very nature of "figuring out" and "discovering" things for oneself is very likely to produce the effect of making information and material more accessible in memory.[11] Thus, two very important competencies, problem-solving and memory-strength are considered further by-products of discovery teaching.

Learning by discovery seems to be a kind of self-propelling experience for children, evincing the pure intrinsic motivation so strongly desired by teachers. The child is quick to recognize that there exists a part of himself within something learned because of his own initiative and then perception. Children need to experience this sense of control over the learning situation which can come about by their understanding the contribution they make in discovering for themselves. The learning involved in a child's discovery becomes that child's possession. Because he is aware of the context from which the learning came, he is more likely to understand its relationship to other learnings and be urged on to concomitant insights. And, as Lindberg says, "If we help boys and girls to learn the processes of discovering knowledge and ways of working for

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[10] Bruner, op. cit., 1965, p. 618.

[11] Ibid., p. 620.

themselves, we need not give our energies to finding fascinating ways to hold their interest or whip up their enthusiasm. The strong urge to pursue learning comes from within."[12]

Taba, in similar context to the above statement, reports,

> Learning by discovery, being an active process, is likely to mobilize the competence motive as a drive for learning behavior, freeing the learning act from the immediate stimulus control and establishing the cognitive control of the individual.[13]

Another phase of child development recognized by the schools as highly important is that of emotional growth and stability. It is not too much to expect that in the teaching of any subject some positive contribution to the child's emotional welfare should be made. In the area of science instruction, discovery teaching is once again cited for making this kind of contribution. Learning by discovery is emotionally satisfying and rewarding to the learner. The fact that any discovery by a child is likely to have much the same effect the original discoverer may have experienced is testimony to the good feelings generated by discovery teaching. Furthermore, Fish affirms,

> The teacher who provides for discovery-learning is aware that she is nurturing pupil

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[12]Lindberg, Lucile, "Learning Through Searching," Childhood Education, October, 1961, p. 60.

[13]Taba, Hilda, "Learning by Discovery: Psychological and Educational Rationale," The Elementary School Journal, March, 1963, p. 314.

> self-realization. For she provides opportunity for the pupil to evaluate his learning experience and thus discover that he is learning and that learning is satisfying. She helps the pupil see a relationship between learning, responsibility, self-discipline, and increased independent action.[14]

That there can be strong positive feelings about the teaching-learning process is encouraging. For too long and by too many, learning has been a "have to" instead of a "get to" experience. Snow refers to the pure joy of discovery as qualification enough for scientific inquiry when he writes,

> Anyone who has ever worked in any science knows how much esthetic joy he has obtained. That is, in the actual activity of science, in the process of making a discovery, however humble it is, one cannot help feeling an awareness of beauty.[15]

The review of literature to this point has intended to reveal the direction the new inquiry-discovery science projects are taking as they seek to develop a more effective approach than the traditional, textbook-centered, expository approach to science teaching at the elementary school level. While it is important to note that intentions and directions do not insure success, it is gratifying to recognize the widespread interest that is being manifest in experimental projects in elementary-school science. It should also be mentioned that, obviously, without this intense, vigorous,

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[14] Fish, *op. cit.*, p. 278.

[15] Snow, Charles P. "Appreciation in Science," *Science*, January 27, 1961, pp. 256-59.

optimistic press for curriculum improvement there would very likely be no discernible move forward. Close to follow major curriculum revisions will be equally ambitious evaluation schemes which will keep a close check on the real progress in relation to the expectations of the initiators of change.

Kersh summarizes the aims of discovery teaching as follows:

> To summarize the claims for learning by discovery, then, we may say this: The claim is that when the student learns by independent discovery he (a) develops an interest in the task, (b) understands what he learns and so is better able to remember and to transfer what is learned, and (c) learns something the psychologists call a "learning set" or a strategy for discovering new generalizations.[16]

ESSENTIAL SCIENCE EXPERIENCES

The purpose of this section of the review of literature is to define the nature of the new science projects and their general content and to identify the experiences that are considered essential for a successful inquiry-discovery approach to elementary-school science instruction. By drawing from a number of writers who are commenting on and are concerned about the new science projects, it is hoped that the five "essential science experiences" extrapolated from the goals and objectives of the SCIS project are shown to be compatible with the general theme of the rest of the new science projects.

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[16]Kersh, Bert Y. "Learning By Discovery: What is Learned?" The Arithmetic Teacher, April, 1964, p. 227.

It should be recalled that these "essential science experiences" are the basis for one of the observation instruments used in the study to determine whether SCIS-educated teachers are encouraging more pupil participation in these experiences than the traditional science teachers. These experiences are: observation, measurement, experimentation, interpretation of data, and prediction.[17]

To more accurately suggest what may properly be included in the study of science, Blackwood gives the following definition of science:

> Science is man's relentless search for verifiable patterns, concepts, descriptions, or explanations of phenomena in the universe. Science is an enterprise, an activity of people. Science is people searching. It is men, women, and children investigating, inquiring, and seeking verifiable knowledge.[18]

Perhaps, key words in this definition, at least as it pertains to this study, are the words activity and enterprise. The question then becomes one of how the new science projects presume to supply the activity and manage the enterprise. A further comment by Blackwood suggests that children need to be helped toward becoming more mature "practitioners" of the methods of discovery and inquiry. He says,

> If we recognize that children are not studying science primarily to become scientists and that

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[17]Renner and Ragan, <u>op. cit</u>.

[18]Blackwood, Paul, "Science Teaching in the Elementary School," <u>Science and Children</u>, September, 1964, p. 22.

> science teachers may use a variety of methods and materials not necessarily used by scientists, then it seems safe to say that in good science teaching children should make inquiries and investigations, should make descriptions and explorations, and should make predictions. It might follow that teaching which denies children a variety of opportunities to "be like scientists" is neither science nor science teaching.[19]

This approach would necessarily place emphasis on the process of science which seems to be a central theme of the new science projects. Much emphasis is placed on process, skill development, and pupil involvement. Writers for the new projects continually call attention to the methods of teaching which call for more pupil involvement. Discussing the lack of involvement in the traditional science teaching approach and some transfer value that more involvement may have when used properly, Fish and Saunders report,

> Science instruction has usually neglected the "involvement" phase of inquiry where involvement has referred to more than the mere doing of the inquiry. Yet, "involvement" can be seen as the "excitement" component or product of such inquiry. Moreover, "excitement" could be seen as the goal of science instruction. In this manner continued inquiry is assured.[20]

Continued inquiry is likely to be assured if the learner is excited about the experiences he has in science instruction, but it is even more likely to be pursued if

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[19] Ibid., p. 24.

[20] Fish, Alphoretta S. and T. Frank Saunders, "Inquiry in the Elementary School Science Curriculum," School Science and Mathematics, January, 1966, p.16.

the pupils and teacher can see carry-over value in this strategy, also. The teacher will appreciate the efficacy of this approach even more as he encourages its use to help the child change his style of learning to a more scientific one in other subjects as well. Capitalizing on two of the essential science experiences, the collection and analysis of data, should help the learner be a more critical purveyor of all subject matter. Suchman has found this to be true in his work with inquiry-discovery training. He says,

> Research in inquiry training has given ample proof that if children are given enough opportunities to practice and evaluate strategies of data collection and analysis, they begin to change their entire approach to learning. First, they assume more of the responsibility for gathering and processing information. Secondly, they become more analytical, in the sense that they do not accept what they see at face value, but attempt to break it down in terms of variables and conceptual schemes. They learn through experience that this kind of attack is generally more productive and exciting.[21]

Science experiences should provide the elementary child with facilities which better prepare him for further study. It is interesting to note comments being made by learning theorists about the new science instruction, i.e., the inquiry-discovery approach. Gagné is interested in the potential value the new approach to studying science processes in this manner (observation, inference, communication, measurement, and so on) may have for the elementary school

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[21]Suchman, J. Richard, "Developing Inquiry Skills in Children," <u>The Instructor</u>, March, 1964, p. 144.

child. He believes the student who has had these experiences in the elementary school should be capable of doing a better job with any given science at a higher grade level. Gagné suggests that far less time than would otherwise be required will be necessary for such a student to learn a given science when it is presented in accordance with its theoretical structure, much as the discovery-trained student has been taught. "Certainly he should have a better conception of science as a way of thinking and discovering," concludes Gagné.[22]

Another strength which should be noted about the science projects' approach to science instruction is the way they place emphasis on the natural activities of the child to help him learn, and then show how the systematic mastery of these activities turn them into skills for valuable future use for the learner. For example, the child is an active, interested observer of all things around him. Incidental, undisciplined observation provides the child with many exciting, profitable learning experiences, but the trained observer has just as much fun while he is systematically gaining far more information and many more insights.

The same idea holds true about measurement. Every child makes extensive use of measurement devices to serve

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[22]Gagné, Robert M. "Elementary Science: A New Scheme of Instruction," Science, January, 1966, p. 53.

his purposes in observing and experimenting with phenomena. The learner who is instructed in the proper use of measurement techniques, as is the case in most new science projects, has a distinct advantage in gaining more reliable information, besides becoming acquainted with an important scientific tool. Children are natural experimenters and spend much of their time with "trying-it-out" and "seeing-if-it-works" type activities. They need to be shown how to set up their experiments so that the information they gain has more value and can be more useful to them as they search for correct answers to their many questions. With a knowledge of how to make controlled observations through experimentation, the learner is familiarized with a tool of inestimable value and is introduced to a skill which will be exciting, challenging, and rewarding to his open, curious mind.

Children, naturally, arrive at conclusions and assumptions because of their observations and experimentation. It is questionable that, without training, they can be very accurate in these conclusions. With training in the necessary science experiences of data interpretation and prediction, the young learner is shown how to more accurately make use of the information he has gathered, by describing his observations carefully, asking questions and making thoughtful guesses, withholding hurried judgments, and properly explaining the basis for his inferences and predictions.

Commenting on this opportunity to take advantage of the child's natural interest in his environment to better prepare him to live in his environment, Huey reports,

> Observing, guessing, testing, discovering, thinking, about what happened, retaining the results for later use, the child, in his natural responses to his environment, is living the fundamental activities of the scientific method.
>
> Teaching science as a way of life involves helping children learn to make careful observations of details and to describe their observations carefully. It means encouraging them to ask questions and make thoughtful guesses, then helping them to find answers. It includes thinking about causes and using results in everyday situations.
>
> The over-all scientific attitude of "try it and see," "don't be too sure until you find out," "see if you can find out from someone who knows," is an important factor in the development of children's life-long habits of responding to problems, to humor, to folklore, to tradition, to anxieties.
>
> Science taught as a way of life has untold potential for helping children develop moral responsibility, good social habits, emotional security, and intellectual skill in attacking everyday problems.[23]

There is much to be said about the value of learning the basic skills of scientific investigation so that they serve as worthy tools for more enjoyable as well as more profitable everyday life. Americans have always insisted that the schools should be practical and, thus, should strive to prepare youth for life outside the school confines. A perennial statement to be found in the goals for schools concerns "preparation for life." Today, in the new goals

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[23]Huey, op. cit., pp. 53 and 99.

for education and in definitions of the schools' curriculum is the insistence that the school should not be just the preparation for life, but should be life itself. There should be a healthy mixture of the two to more adequately complement basic principles of learning and to meet the needs of the children.

When taught properly, science can contribute to these ends, especially when the learner is given the opportunity to practice in the classroom what he is learning and is going to use later. Carin and Sund discuss how they believe this can be done, saying,

> Science education should stress the spirit of discovery characteristic of science. Both teachers and students find that science teaching and learning become a chore when approached as a series of facts to be memorized and regurgitated back on exams; nothing is more contrary to the spirit of science than the lecture-memorize-test method. This does not mean that concepts, theories, principles, and content areas are abandoned in our science curriculum; to the contrary, they can be learned better when approached from a discovery method. The student, while learning concepts, develops his skills in observing, checking, measuring, criticizing, and interpreting discoveries as well as other skills inherent in the prepared or scientific mind. Students cannot learn nor grasp the true spirit of science unless they engage in discovery.[24]

It should be obvious that efforts to stay current on all of the information being made available on even the most specific area of study are almost futile. Today is a time of the "knowledge explosion." Because it is recognized

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[24] Carin and Sund, op. cit., p. 11.

that being well informed in a field of study is a formidable task, it should be comforting to know about the contribution the inquiry skills can make. As Phenix says, "If one possesses the tools of inquiry, he is not in need of a large store of accumulated knowledge."[25]

When stressing the significance and importance of these tools of inquiry as aids to the learner it might be well to further clarify their role in comparison to how we typically view the role of books. The role of books in the inquiry-discovery approach to teaching elementary-school science is stated concisely in Szent-Györi's comment: "It is thought that . . . books are something the contents of which have to be crammed into our heads. I think the opposite is closer to the truth. Books are there to keep the knowledge in while we use our heads for something better."[26]

It is not intended here to disparage in any way the important function of books and/or facts about science. Fully recognizing their contribution to the learner, the point being stressed concerns the manner in which books and factual information are used by teachers in science instruction. Being aware of the traditional goals of science instruction and recognizing the choice of approaches to

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[25]Phenix, Phil H. Realms of Meaning, New York: McGraw-Hill Book Co., 1964, p. 333.

[26]Szent-Györi, Albert, "Teaching and the Expanding Knowledge," Science, December, 1964, pp. 1278-9.

effect science teaching, the effort here is to select and support the approach which satisfies these previously stated goals and the newly selected goals in as productive a fashion as possible. The inquiry-discovery approach uses books and facts effectively by stressing certain science experiences and in doing so help the learners discover the information and skills which profit them the most.

There is no apparent reason that both inquiry skills and understanding of concepts cannot be learned by the discovery approach to elementary school science instruction. This conviction is expressed by Suchman when he states the following rationale for the new science approach:

> (a) Learning through inquiry transcends learning which is directed wholly by the teacher or the textbook; the autonomous inquirer assimilates his experience more independently. He is free to pursue knowledge and understanding in accordance with his cognitive need and his individual level and rate of assimilation.
> (b) Inquiry is highly motivated because children enjoy autonomous activity particularly when it produces conceptual growth.
> (c) Concepts that result from inquiry are likely to have greater significance to the child because they have come from his own acts of searching and data processing. They are formed by the learner himself; and for that reason would be more meaningful to him, and hence more stable and functional.[27]

The argument here has been that children learn better when they are involved, are interested, and are helped to realize the meaningfulness of their efforts.

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[27]Suchman, J. Richard, The Elementary School Training Program in Scientific Inquiry, Urbana, Illinois: University of Illinois, 1962.

This part of the review of research has pointed out the contributions to these principles being made by the new inquiry-discovery science teaching approach. Ausubel[28] uses a quote from Bruner in summing up this attitude. He reports,

> Hence it is highly defensible to utilize a certain proportion of classroom time in developing appreciation of and facility in the use of scientific methods of inquiry and of other empirical, inductive and deductive problem-solving procedures. There is no better way of developing effective skills in hypothesis making and testing, "desirable attitudes toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own . . . (and) attitudes about the ultimate orderliness of nature and a conviction that order can be discovered."[29]

THE ROLE OF QUESTIONS IN SCIENCE TEACHING

An often quoted but commonly violated admonishment to teachers is that "teaching is not telling" and "listening and memorizing are not learning." If this be true, then what is proper conduct of the teacher as he struggles to help youngsters learn? The review of research and literature in this section supports the notion that the skillful teacher is one who has a talent for asking good questions and can guide learners to thoughtful answers. While this facility is recognized as only one part of the teaching task, it is

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[28]Ausubel, David P. "Learning By Discovery," Educational Leadership, November, 1962, p. 116.

[29]Bruner, Jerome S. The Process of Education, Cambridge: Harvard University Press, 1960, p. 20.

viewed as a neglected part and one that the inquiry-discovery approach to science teaching is using to good advantage. One of the hypotheses of this study concerns whether the inquiry-discovery trained teachers are using questions more effectively than are the traditional science teachers.

Inquiry implies questions, but it also has generally been used to describe the behavior of the learner. An equally important responsibility for raising good questions, which tend to insure further inquiry, must be assumed by the teacher. The perceptive teacher will realize how limited or open the learning situation is because of the nature of his questions. Fish and Goldmark give some insight on this point when they tell of an approach related to inquiry into science teaching as described by Strasser.

> Mr. Strasser suggested that one way we may begin our own self-examination is to focus attention, at first, on the way we use questions in the instructional situation. The kinds of questions we use determine the kinds of operations the children will perform. The questions we use outline the kinds of thinking, observing, and other behaving responses of the learners for which we, their teachers, search. Therefore, through looking at the various kinds of questions we ask, we can begin to build a picture of our own teaching behavior. Do we ask only questions which demand recall and then convince ourselves we are giving children opportunities to engage in higher level thinking. Do we ask only those questions which call for our answers and then convince ourselves we are stimulating divergent, creative behaviors in the children of our class?[30]

Strasser is suggesting that teachers need to examine their question-asking techniques and goals to see if the

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[30]Fish, Alphoretta S. and Bernard Goldmark, "Inquiry Method: Three Interpretations," <u>The Science Teacher</u>, February, 1966, p. 13.

true inquiry spirit is being promoted or stifled. An important part of this discussion concerns the way a child's operations are determined by the kind of questions asked by his teacher. Instead of using the open, divergent question which allows the learner freedom to call on his own rational powers, the teacher often finds himself demanding from the learner behavior which too closely resembles mind-reading.

The very tone of the discussion is set by the nature of the questions being posed and the acceptance of the response by the teacher. Patterns of question-asking are soon perceived by children as they recognize the level of demand placed on the responses they give. Karplus chides teachers about their question-asking techniques with this description:

> Teachers usually ask a question, . . . to get an answer already formulated in their minds or to make a point of their own choosing. Teachers rarely ask a question because they are really curious to know what the pupils think or have observed.[31]

Even more critical of teachers' intentions with questions and the all too common violation of the worthy use of inquiry and questions is the following remark by Schaefer:

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[31]Karplus, Robert. "Science in the Elementary School," New Developments in Elementary School Science--A Conference. John W. Renner, Director, Frontiers of Science Foundation of Oklahoma, Inc. Oklahoma City, 1964, p. 10.

> My observations and experience tell me that schools are ordinarily conceived as educational dispensaries--apothecary shops charged with the distribution of information and skills deemed beneficial to the social, vocational, and intellectual health of the immature. The primary business of a dispensary, of course, is to dispense--not to raise questions or to inquire into issues as to how drugs might be more efficiently administered and certainly not to assume any authority over what ingredients should be mixed. The "good" school is the dispensary which has the technical capacity to interpret and most exactly fill society's prescriptions for instruction.[32]

Decrying this misconception of the schools' real role, Schaefer elaborates on the need to make the school the center of inquiry, a place where good questions are treasured, not discouraged. The school should constantly face the child and the child face the teacher with the kinds of questions that demand more of the rational powers than simple recognition and recall. With this kind of inquiring spirit pervading the classroom atmosphere, there is hope that a more interesting, enthusiastic, intellectually rewarding classroom environment will evolve.

The psychological-intellectual atmosphere of the classroom is determined by the teacher in a number of ways. As the teacher-pupil interaction proceeds day by day and minute by minute, opportunity for discovery and inquiry is encouraged or stifled according to the action taken by the teacher. As the teacher conducts the class discussion, the

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[32] Schaefer, Robert J. The School as a Center of Inquiry, New York: Harper and Row, 1967, pp. 33-4.

structure for student involvement and student opportunity is determined. There may be discovery and inquiry, depending upon the way the teaching-learning situation is handled by the teacher. To a large degree, the deciding factor is the nature of the questions used. Miller comments,

> The questions the teacher asks or the assignments the teacher makes determine the quality of thinking required of pupils. If the assignment or question to the pupils (structuring, focus) is sufficiently open to permit some significant pupil choice in making a response, then drawing inference rather than mere remembering will be the most likely consequence. If the assignment or question is closed or narrow in its scope then recall will be required, but such inquiry-type mental processes as comparing, hypothesizing, evaluating, or generalizing will not.[33]

There is obviously quite a talent involved in designing good questions, as almost anyone who has tried to write a good examination will attest. When one remembers how difficult it is to write good test questions while removed from the classroom situation it helps to appreciate how disquieting it may become to accept the challenge of formulating good questions in the classroom discussion situation. Few teachers possess the skill to use the kinds of questions that both serve the situation and demand more than simple recall and recognition. This is one of the really important facilities that must be developed by the good inquiry-discovery teacher.

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[33]Miller, George L. "The Teacher and Inquiry," Educational Leadership, April, 1966, p. 552.

An important goal in the new projects in science is more extensive development of all the rational powers. Especially is this a concern of the SCIS project. An amplification of the effect questions may have on the contribution to development of the higher cognitive powers is given by Harris, who insists,

> The types of questions which teachers ask in discussion, in oral recitations, or on tests provide clues to the kind of learning that is being pursued in the classroom. Teachers who emphasize the superficial by asking questions which call only for recognition of memorized facts set a tone of expectations for pupils which tends to guide study and learning at the same level of superficiality. On the other hand, teachers who ask questions which require deeper levels of understanding set a tone for the same kind of study and learning.[34]

The art of questioning is the essence of discovery teaching. Thiele reveals this when discussing how to foster discovery with children, suggesting that, "Teachers guide pupils to discovery. By setting problems and clever questioning the teacher leads children to make their own discoveries. The skillful teacher questions more and tells less."[35]

Teachers who lack, or who fail to develop, this art of questioning contribute fuel to the criticism heaped upon the schools which accuses them of being closed systems of thought. The schools, according to these critics, maintain

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[34]Harris, Ben M. Supervisory Behavior in Education, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964, pp. 164-5.

[35]Thiele, C. L. "Fostering Discovery with Children," Arithmetic Teacher, February, 1954, p. 6.

curriculums steeped in problems to which predetermined answers are sought. Stereotyped processes are usually incorporated to find answers to these "fixed" questions instead of encouraging the child to draw his own conclusions from his own observations or experimentation. Compounded by dogmatic and dull textbooks, this kind of classroom situation is deadly to the learner and the teacher.[36]

This rather negative kind of learning situation will not automatically be resolved by the employment of different kinds of questions. The nature of the teacher's questioning techniques however, may be a reliable sign of the kind of instruction which takes place in his classroom. This may prove to be a worthy tool or approach to use in analyzing the teacher-learning situation.

Throughout this review of literature has been the idea that the new, inquiry-discovery approach to science teaching has much to offer the elementary school learner, other than just science content. Science taught by the discovery approach will equip the learner with skills he can use in all subjects and in his everyday life. Perceptively surveying the future of the new curricular projects, in 1960, Bruner pointed to some worthy goals for these endeavors. At that time, he stated,

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[36]Taba, Hilda. Curriculum Development--Theory and Practice, New York: Harcourt, Brace, and World, Inc., 1962, p. 153.

> Mastery of the fundamental ideas of a field involves not only the grasping of a general principle, but also the development of an attitude toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own. Just as a physicist has certain attitudes about the ultimate orderliness of nature and a conviction that order can be discovered, so a young physics student needs some working version of these attitudes if he is to organize his learning in such a way as to make what he learns useable and meaningful in his thinking. To instill such attitudes by teaching requires something more than the mere presentation of fundamental ideas. Just what it takes to bring off such teaching is something on which a great deal of research is needed, but it would seem that an important ingredient is a sense of excitement about discovery--discovery of regularities of previously unrecognized relations and similarities between ideas, with a resulting sense of self-confidence in one's abilities. Various people who have worked on curricula in science and mathematics have urged that it is possible to present the fundamental structure of a discipline in such a way as to preserve some of the existing sequences that lead a student to discover for himself.[37]

Seven years later finds these very things being stated as integral parts of the new inquiry-discovery approach to teaching science at the elementary school level.

This review of literature has defined the new inquiry-discovery approach, pointed out its strengths and contributions for the learner, stressed the importance of basic, essential science experiences, and considered the importance of effective questions. All of the information gathered has been for the purpose of emphasizing how much

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[37]Bruner, op. cit., p. 20.

the new science projects are doing to improve elementary education. The remainder of the paper will draw upon this information since the study is designed to determine whether teachers educated to use one of the new science projects are evidencing more of the characteristics of the new science instruction than are traditional science teachers.

CHAPTER III

INSTRUMENTATION AND TREATMENT OF DATA

The instruments chosen for use in the collection of data for this study were selected primarily for their value in making available the kind of information which would best determine the following: (a) whether SCIS-educated teachers were encouraging elementary school pupils to indulge in a significantly larger number of the new, inquiry-discovery type science experiences than were the traditional science teachers, and (b) whether SCIS-educated teachers were asking significantly more questions that demanded use of the higher cognitive powers than were the traditional science teachers.

TEACHER OBSERVATION INVENTORY--ESSENTIAL SCIENCE EXPERIENCES

After a thorough study of the Science Curriculum Improvement Study, its purposes, goals, and rationale for use, an instrument that would measure whether these intended directions were being successfully pursued did not appear to be available. A conference with the regional director of the SCIS project revealed that no such instrument had yet been devised by the project for evaluation purposes.

Because of the unique nature of the study, permission and encouragement were given to devise an instrument that would be useful, with observations, to determine how carefully the SCIS-educated teachers were following the instructions given by the project's mentors and materials.

Recognizing that direct observation of science lessons being taught was imminent, it seemed that the best way to determine whether the goals of the project were being pursued more diligently by SCIS-educated teachers than by teachers who were not educated in the project's methods would be to note the frequency of the pupils' involvement in the "essential science experiences."[1] These experiences are supported as major factors in the successful teaching of the SCIS project and have been shown as common experiences in most new inquiry-discovery science projects. These experiences are: observation, measurement, experimentation, interpretation of data, and prediction. A further explanation of these experiences follows.

1. Observation. Observations can be made in many other ways than visually. The pupil may resort to methods such as feeling, squeezing, poking and rubbing and be considered observing. Observation is generally considered the first action taken by the learner in acquiring a new understanding.

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[1]Renner and Ragan, op. cit., 1967.

2. Measurement. Measurement is similar to observation with the exception that measurement is quantitative and can be taken more than once in the same manner and receive approximately the same results.

3. Experimentation. The relationship between experimenting and observing can be summarized by saying that experimenting demands that observations and/or measurements be made, but observing and measuring do not demand that experiments be performed.

There must be a carefully defined situation which those participating in the operation understand and which they agree will not be further understood unless "something" is done (an experiment). Experimentation is really an attitude on the part of the experimenter; it is an attitude which leads the investigator to ask himself what he has to do in order to change the types of observations and/or measurements he can make.

4. Interpretation of Data. When the activity of data interpretation is viewed in its entirety, it can best be described as making sense out of what you have found.

Data are the information which is derived from an experiment or observation. In order for data to be interpreted they must be available for inspection. This fact tells us that the data must be arranged in such a way that there exists the possibility of their telling the interpreter a story.

5. Prediction. When predictions are made, they are made in order to foretell what will happen--an estimate of the events to take place and/or results to be achieved. An hypothesis is an assumption to allow the validity of a fact to be tested, and a prediction is the utilization of tested facts in order to foretell the future behavior of an individual, the results of an experiment, or the outcome of an event.

The foregoing categories were used by the observer to discern major teaching activities of each teacher noted during the observations of two thirty-five minute science lessons. Each time the teacher intentionally encouraged one or more pupils to indulge in one of the experiences a tally was made for that experience. When the observations were completed, a composite score for each of the categories was derived for each of the two groups of teachers. These composite scores were then computed to proportions for analysis purposes. The composite scores and proportions for the traditional teachers groups are shown in Table I. The composite scores and proportions for the SCIS-educated teachers group are shown in Table II.

Special attention should be directed to Table III, which shows the raw data numbers of frequencies of each of the essential science experiences categories for both groups of teachers. These raw data totals give a good description of the findings concerning how many of these important experiences were encouraged by both groups of teachers.

TABLE I

N'S AND PROPORTIONS FOR THE TEACHER OBSERVATION INVENTORY ESSENTIAL SCIENCE EXPERIENCES OF THE TRADITIONAL SCIENCE TEACHERS GROUP

Essential Science Experiences	Number	Proportion
Observation	344	.502
Measurement	11	.016
Experimentation	115	.153
Interpretation of Data	205	.299
Prediction	10	.014
Total	685	

TABLE II

N'S AND PROPORTIONS FOR THE TEACHER OBSERVATION INVENTORY ESSENTIAL SCIENCE EXPERIENCES OF THE SCIS-EDUCATED TEACHERS GROUP

Essential Science Experiences	Number	Proportion
Observation	683	.463
Measurement	82	.056
Experimentation	216	.147
Interpretation of Data	435	.295
Prediction	58	.039
Total	1,474	

TABLE III

FREQUENCIES FOR THE TEACHER OBSERVATION INVENTORY--
ESSENTIAL SCIENCE EXPERIENCES OF THE TRADITIONAL
AND THE SCIS-EDUCATED TEACHERS GROUPS

Essential Science Experiences	Traditional	SCIS-Educated
Observation	344	683
Measurement	11	82
Experimentation	115	216
Interpretation of Data	205	435
Prediction	10	58
Totals	685	1,474

TEACHER QUESTION INVENTORY

The developers of the "Teacher Question Inventory,"[2] McIntyre and Harris, have suggested that one of the revealing indicators of the kind of learning that is being structured in a classroom is the kinds of questions that the teacher asks. According to them, the matter of whether the teacher is getting the pupils involved in real thinking is important and should be considered in the evaluation of a teacher's instructional practices.

Developed as an evaluative guide, the question inventory also has value as a tool to determine the skill in questioning that causes pupils to develop deeper levels

[2]Harris, Ben M. and Kenneth E. McIntyre, Teacher Question Inventory, Austin: University of Texas, 1964.

of understanding. The six cognitive types of questions were adapted from Bloom's[3] Taxonomy of Educational Objectives and follow a hierarcial order from the simplest "recognition" type question to the most difficult "synthesis" type question.

Thirty-five minutes of each science lesson observed were recorded and the same day of the observation, to assure accurate recollection of the nature of the lesson, the tape recordings were replayed and all of the questions asked by the teacher were transcribed. A careful analysis of each question was then made by the observer and assigned to one of the six categories on the observation inventory.

The six types of questions are listed and defined below, with examples. These represent various types of cognition which such questions stimulate.

1. Recognition. This type of question presents the pupil with cues that require only the recognition of the correct option from two or more choices. Examples: "Is it easier to walk or slide on a scooter?" "Is the wool or the cotten warmer?" "Is the bean hollow or solid?"

2. Recall. This type of question asks the pupil to recall one or more simple facts, drawing from his past experience. In this case there are no choices given.

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[3]Benjamin S. Bloom (ed.), Taxonomy of Educational Objectives: Handbook I - Cognitive Domain (New York: David McKay Company, Inc., 1956).

Examples: "How many turns does the moon make before it goes all around the earth?" "What are sound waves called that we can't hear?" "What are two minerals in their natural state?"

3. Demonstration of Skill. This type of question requires the application or use of knowledge in the performance of a skill, as in arithmetic, reading, science or foreign language. Examples: "What does that sentence mean?" (reading for comprehension) "How many fourths should we borrow from the six?" (basic arithmetic processes.) "What is your estimate for books on the shelf?" (measurement skill in science) "What is the English translation of that sentence?" (foreign language skill).

4. Comprehension. This type of question requires the pupil to produce evidence that he understands a point. Examples: "Can you see an example of an abrasive in this room?" "What are the cells of the root like?" "Can you explain what a heart valve is?"

In the following two categories, it is assumed that the student has never been confronted with the question before; consequently he cannot answer the question merely by recalling something he has previously learned.

5. Analysis. This type of question requires the pupil to explain the relationship between elements in a totality. It involves the analysis of a complex phenomenom. Examples: "Why did the lighted candle go out when we placed

it in the closed container?" "What is different about these containers and the four containers we used before?" "Why did the first chick out show less strength?"

6. Synthesis. This type of question calls upon the student to combine or reorganize specifics so as to develop a new structure or generalization. Examples: "What would have happened if the experiment had been organized in this other way?" "How could you find out which of these two sets of jars have the most liquid in them?"

These six types of questions were used to fulfill the teacher question inventory part of this study. Almost all of the questions asked by the teachers during the science lessons were applicable to one of the six categories described above.

TREATMENT OF THE DATA

Upon completion of the observations, the composite scores under each question category were compiled for each group of teachers. These raw scores were computed to proportions and are reported in Table IV for the traditional science teachers group and in Table V for the SCIS-educated teachers group.

The two observation instruments that have been described above made up the total effort by the observer to define the activities that took place in the science lessons taught by both groups of teachers. It appears that the

TABLE IV

N'S AND PROPORTIONS FOR THE TEACHER QUESTION INVENTORY OF THE TRADITIONAL SCIENCE TEACHERS GROUP

Types of Questions	Number	Proportion
Recognition	174	.182
Recall	405	.424
Demonstration of Skill	79	.083
Comprehension	198	.207
Analysis	87	.091
Synthesis	12	.012
Total	955	

TABLE V

N'S AND PROPORTIONS FOR THE TEACHER QUESTION INVENTORY OF THE SCIS-EDUCATED SCIENCE GROUP

Types of Questions	Number	Proportion
Recognition	121	.085
Recall	241	.169
Demonstration of Skill	355	.249
Comprehension	237	.166
Analysis	289	.203
Synthesis	183	.128
Total	1,426	

data collected through the use of these two instruments are adequate to show whether the SCIS-educated teachers are teaching science in a manner significantly more complementary to one of the "new" science projects' goals than are the traditional science teachers.

The normal standardized deviate z score was the technique used for the analysis of data since the data represent observed frequencies and such a score was derived for each pair of categories. Table VI contains the resultant z statistics that were derived by an analysis of the per cent proportions of the essential science experiences. Since the level of confidence for z was set at the 0.05 level, a value of 1.96 or greater was required for significance.

TABLE VI

PROPORTIONS AND Z SCORES FOR THE TEACHER OBSERVATION INVENTORY-ESSENTIAL SCIENCE EXPERIENCES CATEGORIES OF THE TRADITIONAL AND SCIS-EDUCATED TEACHERS GROUPS

	Traditional	SCIS-Educated		
Questions	Proportion	Proportion	Difference in Prop.	z
Observation	.502	.463	.039	1.659
Measurement	.016	.056	.040	4.261*
Experimentation	.153	.147	.006	.360
Interpretation of Data	.299	.295	.004	.189
Prediction	.014	.039	.025	3.096*

*Significant at 0.05 level

A z score for comparison of proportions, of 1.659 was obtained from the category of observation. This fell below the established level of significance and was interpreted to show no statistical difference. It is important to take note of the total number of observation experiences tallied for each group of teachers. The SCIS-educated teachers group encouraged 683 such experiences, or 1.99 times as many as the traditional science teachers' total of 344.

For the category of measurement a z score of 4.261 was obtained and could be considered significant since it was a higher value than that established for the 0.05 level. This difference was in favor of the SCIS-educated teachers group and is further explained by the total frequencies for each group. The SCIS-group had 82 tallies, or 7.45 times as many of these experiences as the traditional group's 11 frequencies.

A z score of .360 was obtained for the category of experimentation and was considered too low to show a statistical difference. An examination of the total number of frequencies for each group shows the SCIS group with 216 tallies, or 1.88 times as many experimentation experiences as the traditional group's total of 115.

The category of interpretation of data obtained a z score of .189 which was less than enough to show a statistical difference. The SCIS-educated teachers group had tallied 435 experiences in this category which was 2.12 times as many as the 205 such experiences encouraged by the traditional science teachers group.

In the last category, prediction, a z score of 3.096 was obtained. This value was considered significant showing the SCIS-educated teachers group with the larger proportion. In tallied frequencies, the SCIS group had 58, or 5.8 times as many of these experiences as the 10 tallied for the traditional group.

Although a z score was not computed for the total number of observed experiences for all five categories, the totals and a comparison are given here. The total number of essential science experiences observed for the traditional science teachers was 685 while the total number of the same experiences observed for the SCIS-educated teachers was 1,474. This is a difference of 2.15 times in favor of the SCIS-educated teachers group.

The same procedure for finding the per cent proportions and resulting z scores of essential science experiences was used for the questions categories. The results of this analysis of data are shown in Table VII. The level of confidence was set at the 0.05 level, requiring a value of 1.96 or greater for significance.

For the category of recognition type questions, a z score of 7.041 was obtained, which showed that a statistically significant higher proportion of these kinds

TABLE VII

PROPORTIONS AND Z SCORES FOR THE TEACHER QUESTION INVENTORY CATEGORIES OF THE TRADITIONAL AND THE SCIS-EDUCATED TEACHERS GROUPS

	Traditional	SCIS-Educated		
Questions	Proportion	Proportion	Difference in Prop.	z
Recognition	.182	.085	.097	7.041*
Recall	.424	.169	.255	7.144*
Demonstration of Skill	.083	.249	.166	10.283*
Comprehension	.207	.166	.041	2.538*
Analysis	.091	.203	.112	7.345*
Synthesis	.012	.128	.116	10.117*

*Significant at 0.05 level

of questions were asked by the traditional science teachers group. This type question demands only recognition of the correct option from two or more choices when presented to the learner.

Upon comparing proportions in the recall-type question category, a z score of 7.144 was derived, again showing a significantly larger proportion of this type question being asked by the traditional science teachers group. Recall type questions demand only a simple recall of facts from previous experience.

In the category of demonstration of skill a z score of 10.283 was obtained. This score would indicate a significant difference of this kind of question and that the SCIS-educated teachers group had asked significantly more in proportion. Application or use of knowledge in the performance of a skill best defines this type of question.

For the category of comprehension a z score of 2.538 was obtained, again showing a statistically significant difference between the groups, this time favoring the traditional teachers group. This type of question requires the pupil to produce evidence that he understands a point.

The analysis category obtained a z score of 7.345, which was significant at the 0.05 level and favored the SCIS-educated teachers. This type of question involves analysis of more complex phenomenon or the explanation of relationships existing between elements in a totality.

The final questions' category, synthesis, obtained a z score of 10.117 and was significant in favor of the SCIS-educated teachers group.

It is interesting to note the total number of questions asked by the teachers in each of the groups of teachers. The teachers who had been educated to use the new, inquiry-discovery approach to teaching science used 1,426 questions, or 1.49 times as many as the total of 955 used by the traditional science teachers.

CHAPTER IV

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

SUMMARY

The purpose of this research study was twofold. First, the study was designed to determine whether or not there was a significant difference in the number of "essential science experiences" encouraged by teachers who had received education in the SCIS, inquiry-discovery approach and teachers who were educated primarily in the traditional, textbook-centered, expository approach to science teaching at the elementary school level. The second purpose of the study was to determine whether or not there was a significant difference in the number of questions asked by the SCIS-educated teachers which required more analytical thinking than the questions asked by the traditional science teachers at the elementary school level.

Essentially, the study was developed to attempt to discover whether teachers who had received instruction in one of the new science projects were really teaching in the manner they had been instructed to teach in order to fulfill the expectations of the project. The possibility was considered that the goals of the new science projects might be being met reasonably well by teachers using the textbook and the traditional expository approach.

Observations of science lessons taught by several teachers who used the two different approaches were used to determine whether differences in teaching practices were significant. By observing and using the same two observation instruments designed to categorize certain teaching acts, data were gathered that were statistically treated to determine whether differences existed.

The observations involved thirty classes of elementary children, ranging from grade one to grade six. Fifteen of these classes were taught by teachers who had been educated to use the SCIS methods and materials for science instruction at the elementary school level. These classes were randomly selected from all of the teachers educated in the SCIS approach in the Norman city school system. Fifteen classes were taught by teachers who had not received instruction in materials from the SCIS or any other of the "new" science projects. These teachers were taking their science curriculum from the science textbook, were using a strongly expository approach, and were selected by choosing teachers who were teaching at the same grade level, with similar teaching experience, and within the same building as the teachers chosen for the SCIS group. They, too, were located in the Norman city schools, represented all grade levels, and were selected by the school system's director of elementary education.

The two observations of each class were made exactly one week apart at the same time of day. The observer recorded data on one of the observation instruments during thirty-five minutes of the observation period and used a small portable tape recorder to gather further information from the lesson during that thirty-five minute period. The questions from the tape recording were transcribed the same day of the observation. The questions were then analyzed and assigned to the proper category on the Teacher Question Inventory.[1]

The raw data were converted to proportions and statistically analyzed, using the z ratio for difference between correlated proportions, to determine whether any differences in the observed data existed. The level of significance was established a priori at the 0.05 level; a z value of 1.96, therefore, was necessary to establish a significant difference.

The collection of data resulting from the observations and the findings from the analysis of the data were interpreted to give the following significant information:

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[1]Harris, Ben M. and Kenneth E. McIntyre, Teacher Question Inventory, Austin: University of Texas, 1964.

1. The essential science experience categories of measurement and prediction show significantly higher proportions of experiences for the SCIS-educated teachers group.

2. For every category of the essential science experiences inventory, a much larger number of frequencies was recorded in favor of the SCIS educated teachers. Respectively, the differences were: observation - 1.99 times; measurement --7.45 times; experimentation - 1.88 times; interpretation of data --2.12 times; and prediction --5.80 times.

3. The total number of the essential science experiences provided for children by the SCIS-educated teachers was 1,474, or 2.15 times as many as the 685 frequencies for the traditional science teachers.

4. The questions considered lower level by Harris and McIntyre,[2] recognition and recall, were recorded a significantly larger proportion of times for the traditional science teachers group than for the SCIS-educated teachers.

5. The questions considered higher level by Harris and McIntyre,[3] analysis and synthesis, were recorded a significantly larger proportion of times for the SCIS-educated teachers group than for the traditional teachers group.

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[2] Ibid.

[3] Ibid.

6. The demonstration of skill type of question was recorded a significantly higher proportion of times in favor of the SCIS-educated teachers.

7. The comprehension type of question was recorded a significantly higher proportion of times in favor of the traditional teachers group.

8. The total number of questions asked by teachers educated in SCIS methods and materials was 1,416, or 1.49 times as many questions as the 955 asked by the traditional teachers group.

CONCLUSIONS

In view of the foregoing data the following conclusions were drawn.

1. Since two of the essential science experiences were found to show statistically significant differences in favor of the SCIS-educated teachers and none were significant in favor of the traditional science teachers, the null hypothesis of no significant difference in essential science experiences between the two groups was rejected.

2. Since the two categories of questions which represent the lowest level of thinking were statistically significant in favor of the traditional teachers group and the two categories of questions which represent the highest level of thinking were significant in favor of the SCIS-educated teachers, it was concluded that the null hypothesis

of no significant difference between the two groups was rejected.

3. The SCIS-educated teachers encouraged pupils to become involved in over twice as many of the essential science experiences as did the traditional science teachers. Since these experiences are considered an important part of the "new" science projects, the SCIS-educated teachers are successfully exposing children to far more experiences that complement the new, inquiry-discovery approach to elementary school science teaching than are the traditionally educated teachers.

4. Because of the hierarchial nature of the scale of questions, from lowest level to highest level, the use of the bottom two types of questions and the top two types of questions for comparison purposes is interesting. The questions which demand the least of the higher cognitive powers, recognition and recall, were used to a highly-significant degree more by the traditional science teachers than by the SCIS-educated teachers. The questions which demand the most of the higher cognitive powers, analysis and synthesis, were used to a highly-significant degree more by the SCIS-educated teachers than the traditional teachers group. This comparison presents rather strong evidence concerning the nature of the questioning techniques of teachers who depend heavily on the textbook and telling and those teachers who are using the inquiry-discovery

approach which minimizes the use of the textbook and leads children to investigate. The teachers using the inquiry-discovery approach apparently are encouraging use of the learners' higher cognitive powers because of the nature of the questions asked in this classroom. This supports the hope that the new science projects will help the learner more fully develop his rational powers beyond simple recall and recognition.

5. The SCIS-educated teachers used significantly more demonstration of skill type questions. This suggests that these teachers are probably treating science more like a skill subject than as a content subject. In Chapter II a reference was made concerning the need to make science more like a skill subject so that it will serve the learner in the future, much like reading and mathematics do. The traditional approach to science teaching has been a content approach, a fact that is born out by the findings of this study.

6. Not only are the SCIS-educated teachers asking more questions of the higher cognitive type, they are asking more questions in general. This should be expected since the SCIS project is an inquiry-discovery approach and demands that thoughtful questions be asked in greater numbers. These SCIS-educated teachers were asking forty-nine per cent more questions than were asked by the traditional science teachers.

RECOMMENDATIONS

All of the teachers who are expected to teach elementary school science should be educated in the inquiry-discovery approach. With the skills gained from this instruction and with a reasonable supply of materials, teachers who have previously taken their science instruction from the textbook can provide children with a great many worthwhile experiences in science. The traditional science textbook should not be used since its very nature is antithetical to the new inquiry-discovery approach.

Teachers need to receive instruction in techniques of skillful questioning. The success or failure of the inquiry-discovery approach to any subject rests upon the kinds of questions generated by the teacher.[4] Teachers must learn to recognize questions that demand different levels of cognition and make greater use of those that demand use of the higher cognitive powers. The teacher must encourage his students to use higher level questions as well, and be willing to discuss the more difficult questions with the students.

An occasional, self-imposed tape recording of a full science lesson would be extremely revealing to the teacher who is aware of the goals of inquiry-discovery teaching. It would be especially helpful to replay the tape with

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[4]Miller, George L., "The Teacher and Inquiry," Educational Leadership, April, 1966, p. 552.

certain pre-determined goals in mind which complement the inquiry-discovery approach. As the teacher hears himself in action, he can learn how well he is fulfilling the goals he has set. This occasional self-analysis would be very helpful in guiding the teacher toward instructional practices better than those he is employing.

Teachers need to be made aware of well qualified educational objectives and how these objectives can be skillfully met through their teaching acts. An example would be to familiarize teachers with Bloom's Taxonomy of Educational Objectives[5] and show them how they can more equitably give a fair share of time to lower and higher level activities. An instrument like the Teacher Question Inventory[6] would be excellent to use with the tape recording to help the teacher see how much emphasis he is placing on different types of questions.

The development of inquiry skills in the scientific process should be a major goal of elementary school science instruction. Provision for the five essential science experiences discussed in this paper is a promising way to assure the development of such skills. Teachers should be instructed in the methods of teaching the five essential

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[5]Benjamin S. Bloom (ed.), Taxonomy of Educational Objectives: Handbook I - Cognitive Domain (New York: David McKay Company, Inc., 1956).

[6]Harris and McIntyre, op. cit.

science experiences, which are: observation, measurement, experimentation, interpretation of data, and prediction.

It would be helpful for teachers who have been taught to use the inquiry-discovery approach to elementary school science instruction to have opportunities for periodic in-service education of a refresher and/or evaluation nature. This instruction should encourage sharing of experiences as well as a general up-dating of practices and activities.

The teachers who were not educated in the inquiry-discovery approach, but who are using new textbooks that promote use of inquiry and discovery in science instruction should have adequate in-service education. This instruction should acquaint the teachers with inquiry-discovery teaching in general, introduce them to useful materials, and show the teachers how to effectively use the approach and materials. In-service education should not conclude until each teacher feels adequately prepared to make good use of the inquiry-discovery approach and its materials and is exemplifying satisfactory progress with its use.

SUGGESTIONS FOR FURTHER RESEARCH

Basically the same study done here needs to be done as a "before and after" study. Current curriculum developments suggest a strong trend toward more inquiry and discovery in elementary school science instruction. Teachers who have not been instructed in this approach in their pre-service teacher education will be confronted with new textbooks which purport to contain the discovery approach. Since in-service training has been used to acquaint teachers with modern mathematics, it is likely that in-service training will be used to familiarize teachers with the inquiry-discovery approach to science teaching. A study conducted to determine whether significant changes in the approach to science teaching used by the traditionally educated teachers has occurred after in-service training would be interesting and should prove enlightening to the in-service training personnel. Observations and data collection would be made before and after the in-service education. Results should provide information that would strengthen further in-service instruction in the inquiry-discovery approach.

A before and after study could be designed to determine whether teachers who were only recently educated in the inquiry-discovery approach to science teaching were using questions that demand higher cognitive powers in the teaching of another content-centered subject such as social studies, health, or language. An examination of the types of questions asked in these other subjects could be made before instruction in the "new" science, and then again after the "new" science instruction. This comparison would allow the determination to be made as to whether or not a significantly greater number of higher level questions were being asked in the other content-centered subjects after the special instruction in science. The results of that research should reveal whether teachers are transferring to other disciplines any of the higher level questioning techniques encouraged by the inquiry-discovery approach to science teaching as supported by the findings in this study.

A content analysis study of the newer elementary school science texts could be designed to determine whether elementary science is being treated as a skill subject or a content subject. Findings should reveal whether newer "discovery" accentuated texts are still placing heavy emphasis upon factual recall and if they really are encouraging and providing for the development of the discovery and inquiry skills.

The final suggestion is that a study should be done to determine whether the evaluation methods and devices used by the new inquiry-discovery science projects are really evaluating the learner's progress in developing inquiry and discovery skills. Care should be taken to note the objectives and goals stated for the projects. The study should be designed to show whether the evaluation procedures practiced by the teachers are effectively determining how well these goals and objectives are being met. A part of that study could be designed to compare the evaluation techniques practiced by teachers using the traditional approach and teachers using the inquiry-discovery approach to determine whether a significant difference exists between the two groups of teachers. The results of that study should reveal whether teachers instructed in the inquiry-discovery approach are enhancing their teaching with evaluation techniques that complement the goals of that approach.

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APPENDIX A

TEACHER QUESTION INVENTORY*

Teacher______________________________________ Grade________

Time____________to____________ Date________________________

TABULATION WORKSHEET

Question Types	Tallies	Total	Percent
<u>Recognition</u> (Which of these? Was it this way or that? etc.)			
<u>Recall</u> (Why? What? When? etc.)			
<u>Demonstration of Skill</u> (What is the English translation? etc.)			
<u>Comprehension</u> (Can you give me an example? What do you mean?			
<u>Analysis</u> (Why did it happen? How are they similar? etc.)			
<u>Synthesis</u> (What general principle can you see in this? etc.)			
TOTAL--ALL TYPES			

(Adapted from the Teacher Question Inventory by Kenneth E. McIntyre and Ben M. Harris, Austin: University of Texas Press.

TEACHER OBSERVATION INVENTORY

The purpose of this inventory is to note the number of times the teacher under observation intentionally encourages one or more of the pupils to indulge in the "essential science experiences" listed below. A check mark will be made in the appropriate category each time such an experience is detected by the observer. Each of these experiences is explained in more detail elsewhere.

Experiences	Tallies	Total	Percent
Observation	____________________	_____	______
Measurement	____________________	_____	______
Experimentation	____________________	_____	______
Interpretation of Data	____________________	_____	______
Prediction	____________________	_____	______
TOTAL--ALL TYPES		_____	______

School: Code #______

Teacher: Code #______

Date: ________________

Lesson Time: __________

Tape: Code #______

APPENDIX B

THE UNIVERSITY OF TEXAS
College of Education
Austin 78712

January 9, 1967

Mr. John Wilson, Special Instructor
College of Education
The University of Oklahoma
Norman, Oklahoma 73069

Dear Mr. Wilson:

Thank you for your letter of December 17 requesting permission to use the Teacher Question Inventory and Pupil Response Inventory as instruments to collect data for your doctoral dissertation. I appreciate your interest in these materials. You have my permission to use these materials.

Sincerely yours,

Ben M. Harris,
Associate Professor

BMH/cwe

NORMAN PUBLIC SCHOOLS
Norman, Oklahoma
December 21, 1966

Mr. John H. Wilson
College of Education
University of Oklahoma
Norman, Oklahoma

Dear Mr. Wilson:

This is to assure you that our system will be pleased to be of whatever assistance we can with your study related to the teaching of "inquiry-discovery methods of Science". Also, we would be most interested in seeing the results of your study when it is completed.

Sincerely yours,

Lester M. Reed
Superintendent

LMR/mfa

APPENDIX C

ESSENTIAL SCIENCE EXPERIENCES INVENTORY
TRADITIONAL SCIENCE TEACHERS GROUP

Teacher	Observation	Measurement	Experimentation
1	19	1	0
	10	0	6
2	6	0	2
	6	0	1
3	6	0	3
	3	0	3
4	10	0	0
	7	0	2
5	3	0	0
	4	0	0
6	5	0	1
	8	0	0
7	5	0	5
	12	0	11
8	7	0	3
	6	0	2
9	24	3	9
	12	6	16
10	16	0	0
	9	0	0
11	1	0	2
	8	0	3
12	23	0	19
	35	0	22
13	11	0	0
	15	0	0
14	35	1	5
	1	0	0
15	12	0	0
	25	0	0

ESSENTIAL SCIENCE EXPERIENCES INVENTORY
TRADITIONAL SCIENCE TEACHERS GROUP

Teacher	Interpretation of Data	Prediction
1	8	0
	7	0
2	2	0
	1	0
3	5	0
	8	0
4	3	0
	6	0
5	2	0
	6	4
6	0	0
	3	0
7	2	0
	1	0
8	6	0
	7	4
9	13	0
	3	0
10	2	0
	6	0
11	9	0
	9	0
12	23	0
	4	0
13	5	0
	18	0
14	22	2
	14	0
15	3	0
	7	0

ESSENTIAL SCIENCE EXPERIENCES INVENTORY
SCIS-EDUCATED TEACHERS GROUP

Teacher	Observation	Measurement	Experimentation
1	41	0	0
	40	0	10
2	34	5	0
	29	0	0
3	73	1	0
	39	2	6
4	18	0	17
	12	0	6
5	27	0	0
	21	0	0
6	5	0	20
	20	0	15
7	31	0	30
	17	0	2
8	30	0	16
	20	5	0
9	13	15	5
	3	43	0
10	30	0	12
	32	0	12
11	24	0	12
	35	0	28
12	19	0	7
	0	0	0
13	15	0	4
	30	0	0
14	18	7	7
	5	4	0
15	0	0	7
	2	0	0

ESSENTIAL SCIENCE EXPERIENCES INVENTORY
SCIS-EDUCATED TEACHERS GROUP

Teacher	Interpretation of Data	Prediction
1	11	0
	20	2
2	8	0
	16	0
3	0	0
	7	0
4	19	0
	10	0
5	20	0
	28	0
6	30	0
	0	0
7	12	2
	9	0
8	0	0
	5	0
9	13	1
	8	2
10	21	0
	36	6
11	24	0
	31	23
12	22	0
	11	3
13	8	0
	14	0
14	7	3
	7	6
15	14	5
	24	5

TEACHER QUESTION INVENTORY
TRADITIONAL SCIENCE TEACHERS GROUP

Teacher	Recognition	Recall	Demonstration of Skill
1	1	12	0
	5	18	0
2	25	13	1
	4	12	0
3	5	13	0
	2	26	0
4	20	1	0
	22	0	10
5	0	0	0
	2	15	0
6	5	24	2
	2	12	0
7	3	8	0
	0	9	0
8	4	22	0
	6	11	0
9	3	18	0
	0	7	9
10	13	18	0
	2	6	2
11	0	5	8
	0	6	0
12	12	53	44
	6	14	0
13	10	11	0
	10	33	0
14	1	2	3
	2	19	0
15	7	14	0
	2	3	0

TEACHER QUESTION INVENTORY
TRADITIONAL SCIENCE TEACHERS GROUP

Teacher	Comprehension	Analysis	Synthesis
1	6	6	0
	8	1	0
2	8	0	0
	7	3	0
3	2	2	0
	3	0	0
4	3	0	0
	1	1	0
5	0	0	0
	7	6	0
6	0	0	0
	0	0	4
7	1	2	0
	2	6	0
8	12	3	2
	9	7	0
9	0	17	4
	8	4	0
10	1	0	0
	2	0	0
11	0	2	0
	19	0	0
12	21	0	0
	47	3	0
13	0	4	0
	11	5	0
14	1	2	2
	7	4	0
15	5	2	0
	7	7	0

TEACHER QUESTION INVENTORY
SCIS-EDUCATED TEACHERS GROUP

Teacher	Recognition	Recall	Demonstration of Skill
1	7	31	9
	14	6	1
2	12	12	14
	0	2	21
3	10	39	6
	14	35	2
4	8	1	20
	8	2	1
5	7	4	11
	0	5	52
6	3	18	10
	0	0	13
7	1	3	0
	0	6	0
8	2	1	35
	0	7	19
9	7	2	67
	1	2	0
10	0	2	3
	1	10	0
11	0	12	0
	0	2	0
12	0	7	0
	4	6	0
13	12	5	4
	0	2	37
14	6	10	13
	3	0	17
15	1	5	0
	0	4	0

TEACHER QUESTION INVENTORY
SCIS-EDUCATED TEACHERS GROUP

Teacher	Comprehension	Analysis	Synthesis
1	3	6	0
	10	31	11
2	12	13	0
	0	8	0
3	2	0	0
	0	7	0
4	6	4	3
	12	14	0
5	25	3	0
	17	3	0
6	3	1	33
	0	0	0
7	0	25	2
	8	22	9
8	20	0	0
	4	7	0
9	0	14	0
	0	10	0
10	0	13	33
	0	14	15
11	24	18	12
	14	21	25
12	0	16	8
	10	11	5
13	3	4	0
	0	4	0
14	30	4	4
	7	0	5
15	13	5	2
	14	11	16