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degree of

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BY

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1965

THE STATUS OF ELEMENTARY SCHOOL SCIENCE

AND HOW IT IS TAUGHT

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TO MY WIFE, WILLIE DOREATHA

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CHAPTER I

THE PROBLEM

The increasing importance of science in our nation and the world has created pressing educational demands. It has become essential for any citizen who wishes to be considered literate to have a basic understanding of the world in which he lives and works. Hypothetically speaking, therefore, it is a practical assumption that more attention than ever before needs to be given to the strengthening of science education at all levels. This would afford each student the opportunity to experience some of the excitement, beauty, and intellectual satisfaction found in scientific pursuits.

As a result of international emphasis, elementary school science is emerging as a distinct area of study and is being increasingly viewed as a necessary part of each child's general education. Evidence from such programs as those of the University of California Science Curriculum Improvement Study and the University of Illinois Elementary School science

Project indicates that children can be challenged by concepts and methods of learning more advanced than have, heretofore, been incorporated in science programs of the elementary school. These efforts and their acceptance demonstrate a growing interest among some educators relative to the need of both the teacher and the child for breadth and depth of experience in science as well as concern that learners develop the ability to use various methods of inquiry. Both the experience and the methods of inquiry help to improve the quality of the concepts learned by teachers and pupils alike.

There is joy to be found in the search for knowledge by the inquiry or discovery method; there is excitement in learning about the working of the physical universe and the biological world; there is intellectual power in the way an investigator in science asks questions and illicits answers to them. The primary task and fundamental purpose of elementary school science should be to awaken in each child a sense of this joy and excitement as well as to incite a desire to investigate and cultivate the intellectual powers of scientific exploration. Without such experience, one cannot expect children to develop adequately their rational powers.

> These powers involve the processes of recalling and imagining, classifying and generalizing, comparing and evaluating, analyzing and synthesizing, and deducing and inferring. These processes enable one to apply logic and the available evidence to his ideas, attitudes, and actions, and to pursue better whatever goals he may have.[1]

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[1]Educational Policies Commission, The Central Purpose

According to the Educational Policies Commission, a school which develops in its students the ability to think is itself a place where thought is respected and where the sympathetic values implicit in rationality are respected. It has an atmosphere conducive to thinking, and the pupils are rewarded by virtue of the fact that they make progress toward the goals the school values. Development of the rational powers of its pupils is characteristic of such a school Its goals are achieved because it aims directly at them.[2] A primary concern of all science teachers should be the achievement of the following goals as they work with children in the scientific areas: (1) building a world view that is consistent with modern scientific experiences; (2) gaining and understanding some skill in using the methods of inquiry; (3) developing the ability to explore new developments in science; (4) learning how to achieve and maintain optimum mental and physical health; and (5) preparing to make future contributions in science.[3]

The general goals of elementary education may be attained by a program that will help children achieve optimum intellectual, physical, social, cultural, and emotional

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<u>of American Education</u> (Washington, D. C.: National Educational Association, 1961), p. 5.

[2]Educational Policies Commission, <u>op</u>. <u>cit</u>., p. 16.

[3]Willard J. Jacobson and Harold E. Tannenbaum, <u>Modern Elementary School Science</u> (New York: Bureau of Publications, Teachers College, Columbia University, 1961), p. 11.

growth and development. Since science is basically the investigation and interpretation of phenomena which occur in our external and internal environment, experiences in science can contribute to all of these areas of growth and development.[4] Whether or not science education contributes to the achievement of these goals of elementary education depends upon the manner in which it is taught in the classroom. Two major questions, then, are of paramount importance. Do teachers gain the competence necessary to implement scientific instruction in a manner which will enable it to make its greatest contribution to the goals of elementary education? Are teachers in the elementary schools teaching science in such a way that it will contribute to the achievement of the overall goals of elementary education? Since it is normal for teachers to pattern their method of instruction after those whom they respected as teachers, the answer to the second question is contingent upon the answer to the first. If teachers study in a manner that enables them to discover the structure and function of science, they will, in turn, be in a position to teach science in an inquiry-centered fashion which will enable them to assist a child in developing his rational powers.

A study of the status of the elementary school science was needed in order to answer the foregoing questions. First of all, it was necessary to determine whether or not the

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[4]Jacobson and Tannenbaum, op. cit., p. 11.

science programs in college required for prospective elementary school science teachers were adequately preparing them to guide children in such a way that the central purposes of elementary school science education would be achieved. There was also a need for comparing the types of learning activities utilized in the elementary school science program with those activities which the teacher himself experienced at the college level. Only after these comparisons and/or contrasts were considered could any recommendations be made. Ostensibly, any recommendation would deal primarily with the pupil and teacher learning experiences in the science classes and how these experiences might be altered or supplemented in order for scientific study to make a maximum contribution to the general education of the child.

Statement of Problem

The specific purposes of this study are:

1. To investigate the recommendations and requirements in academic science courses for the prospective elementary school teachers in 153 selected colleges and universities representing all fifty states and the District of Columbia;

2. To determine to what extent elementary school teachers are utilizing the methods, objectives, concepts, and content emphasized in science experiences offered to them in college;

3. To determine the teaching methods used, course objectives, concepts developed, as well as the content stressed in science courses taken by prospective elementary school teachers;

4. To determine the current purposes of and content used in science education in thirty selected elementary schools in Oklahoma;

5. To determine the purposes of four separate series of textbooks published in the content area of elementary school science;

6. To determine how the purposes and learning activities of the recently developed programs in elementary school science differ from the established programs found in the elementary school classroom.

Limitations of the Study

One phase of this study was confined to responses to a questionnaire sent to 153 colleges and universities throughout the United States. These colleges and universities included a state university, a teacher education college, and a private college or university in each of the fifty states and the District of Columbia. Although the entire population from which this sample was drawn could have been studied, the manner in which the sample was selected and the size selected provided reliable data.

In order to make the results of this study applicable to the entire nation and thus be able to correlate closely the results from the teacher education survey to the results ascertained from actual classroom visitations, classrooms in all fifty states should have been visited. After studying the data from the teacher-education survey, it was found that the pattern under which elementary school teachers received their science education varried very little from college to college in the various states. This fact led the investigator to the conclusion that the teachers in Oklahoma are no different from teachers throughout the country. For this reason and because it was not considered feasible for this investigator to visit elementary school science classes throughout the entire nation, the visitations cited in this study are necessarily those made to Oklahoma schools. Sixty-six science classes in some thirty selected elementary schools were visited.

Procedure

Part I

The first step in this study involved an exhaustive survey of the literature relating to academic preparation of teachers of science in the elementary schools. The survey also included literature pertaining to the curriculum changes in elementary school science, current trends in methods of teaching science, the administrative role in elementary school science, and evaluative measures of elementary school science education.

A preliminary questionnaire based upon the literature findings was designed and sent to twenty colleges and universities with a request that suggestions and criticisms for its improvement be made in order that a questionnaire be formed which would accurately gather information on the types of science instruction offered at the college level. Of the twenty colleges and universities selected for evaluation of the questionnaire, seventeen professors responded.

Using the suggestions and criticisms found on the original instrument, the investigator developed a refined and improved final form of the questionnaire (see Appendix 1). The questionnaire was limited to three pages in length, and a self-addressed stamped envelope was enclosed for the convenience of those people completing and returning it. The institutions selected to receive the questionnaire included 153 colleges and universities in the United States. A state university, a teacher education institution, and a private college or university were selected from each state and the District of Columbia. The current edition of <u>World Book Encyclopedia</u> was used in making the selection of the institutions. The state university of each state was automatically selected, and the teacher education institutions and private colleges and universities were randomly selected from a list of accredited colleges and universities.

The questionnaires were directed to the Professor of

Science Education in each of the selected institutions. Of the more than 150 letters sent, there were some 125 usable responses received.

The data which the teacher education survey produced were carefully analyzed and tabulated. The responses given to each question were summarized in tabular form, and from these data another instrument was constructed. This latter instrument served as a basis for comparing the elementary school science programs in this state (Part II) and to find out whether or not the elementary school teachers were accomplishing the objectives of elementary school science which the college courses in science prepared them to achieve and as set forth in the teacher education survey.

Part II

This portion of the study involved visiting thirty elementary schools in Oklahoma for the prime purpose of observing the methods of teaching science in grades kindergarten through six. Interviews were held with thirty elementary school principals and sixty-four elementary school teachers during the school visits. An evaluation, which consisted of completing a twenty-six-item check list (see Appendix 2), was made during each classroom observation period. In addition to the college survey, the check list items were obtained from leading authorities in elementary school education.[5]

A letter from the dissertation advisor requesting the permission to visit the elementary classrooms during the science periods be granted to the investigator was mailed to the principals of each school prior to visitation. The schools used in this study varied in number of personnel from two to twenty-six teachers and in number of students from sixty-three to 750.

When the school visits were completed, questionnaires, interviews, and evaluation data were classified, analyzed, and tabulated, using simple totals and percentages for the appraisal of the status and teaching of science in the elementary schools. Data revealed that twenty-eight of the schools visited were using conventional elementary school science materials and two were using the new developments in elementary school science. The data collected from the schools using the conventional materials in elementary school science were compared with the data collected from the two schools using the newer developments in elementary school science for the purpose of determining which program was best achieving the goals and objectives of elementary school science education.

An analysis was also made of four series textbooks

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[5]"Evaluation Manual for the Improvement of Elementary Schools," revised edition (State Department of Education: The Oklahoma Curriculum Improvement Commission, 1958), pp. 42-43.

used in elementary school science programs and three of the newer developments in elementary school science. This analysis was made in an effort to determine the purposes, objectives, and content in the light of the current trends in elementary school science as well as to ascertain how these newer developments in elementary science differ from the conventional materials found in the elementary school classroom.

CHAPTER II

RELATED RESEARCH

The purposes of teaching science in the elementary school have their basis in the prevailing culture, in the nature of children, and in science itself. The needs and interests of children grow out of their culture and their nature as living human organisms. Science teaching should help children meet these personal and cultural needs.[6] Obviously, the very nature of the problem is extremely broad. Furthermore, the investigator felt a deep seated need to become more versed in this area. Consequently, the review of research is very comprehensive.

Meder stated that the rethinking of the purposes of science in childhood is bringing about a realization that science in the elementary school must be appropriate to children, their ideas of themselves, and their world; their interest in discovering facts for their own purposes; their natural application of critical thinking to their everyday

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[6] Rethinking Science Education (The Fifty-ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: The National Society for the Study of Education, 1960), pp. 335.

lives; and to their development of growth in resourceful and intelligent behavior. As it stresses the exploration of events in the environment and the development of explanations of events in the environment and the development of explanations of them, science utilizes the natural drives of children.[7]

In a review of the literature concerning the teaching of elementary school science, the investigator noted that a number of significant curriculum changes has been made in the science programs. The following paragraphs will list some of these changes.

Piltz conducted a study which indicates that the promising trends in elementary school science today are really a re-emphasis or a shifting focus on objectives and values commonly held over the past quarter century. He lists three main factors which underlie curriculum change.

1. Science knowledge is increasing. Facts have a way of changing in the light of new evidence, and modern science, the science of our time, has extended the store of knowledge in amazing ways.

2. Methods of science are being emphasized. Modern science is more than new knowledge. It is also a way of thinking and working. Modern science demands that students learn to identify problems and to seek their solution. This

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[7]Elsa Marie Meder, "Problem Solving for Today's Children," Science Education (April, 1952), 36:3, p. 131.

means gaining an understanding of basic principles, the habit of curiosity, the skill of observation, the attitude of questioning and exploring, the knowledge of experimentation, the ability to work out relationships, the patience to test and retest, the persistence to try again and again when efforts fail. Modern science teaching must be concerned with developing an inquiring mind and a respect for scholarship, for science is essentially a method of learning.

3. Modern equipment technology is revolutionary. Modern schools for modern science need to reflect in their design, furnishings, and facilities the changes taking place in equipment technology.[8]

Arthur M. Henry recently completed a study on the importance of science in the elementary school curriculum. An examination of this study discloses findings that indicate that if the child is to be prepared for a changing world, he must learn to think with regard to his ever-changing environment. Mental reproduction of old material is not so significant as ability to tackle materials and situations new to him. This cannot be accomplished by a pouring in of facts but rather by a program and activities which give the child freedom to probe and freedom to express himself. Whatever the role that science should play, the role that it <u>does</u> play

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[8]Albert Piltz, "Promising Trends for Effecting Needed Changes in Curriculum in Elementary Science," <u>Science Education</u>, Vol. 48 (February, 1964), pp. 7-12.

depends on the quality, background, and scientific insight of the teacher.[9]

According to Hopman, the curriculum of elementary science must be appraised for change within the context of an ubiquitous concern for education, government programs related to education, advances in science and technology, and inventive schemes and products. There will always be a need for reviewing and rethinking. Curriculum is dynamic and will continue to change. But change must have direction, and that direction of change must be based upon goals as educators view children and science within the context of a democratic society.[10]

If teachers fully recognize their personal involvement in curriculum change and if this involvement is dedicated to the achievement of worthy objectives, the direction any school system takes in effecting curriculum change in elementary science will be constructive and profitable to those most concerned--the children and youth whom we teach.[11]

It seemed clear to Hill that increasing knowledge in science, choosing an appropriate teaching-learning theory

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[9]Arthur M. Henry, "The Role of Elementary Science in the Curriculum of Elementary Schools," Science Education, Vol. 48 (February, 1964), p. 82.

[10]Anne B. Hopman, "Effecting Changes in the Elementary Curriculum of School Systems," Science Education, Vol. 48:1 (March, 1964), pp. 101-109.

[11]Ibid., p. 109.

upon which to operate, and considering teachers and learners as individuals are basic issues which post a host of problems to be solved by curriculum workers.[12]

Story has indicated that the aerospace adventure holds a prime fascination for the youthful mind and that such an enthusiasm is of the highest value in the light of present educational emphases.[13] Some authorities feel that we have been slow to recognize the unique potential of enthusiasm as an ideal force in the motivation of learning, particularly in the field of elementary science.[14]

The purpose of an investigation by Atkin was to assess children's reactions to the study of certain science topics deemed basic to modern astronomy. The major criterion in content selection was that all science content selected for the experimental classes was deemed highly significant by professional research astronomers. Atkin's findings are as follows:

1. Children demonstrated a high interest in astronomy.

2. The children were able to conceptualize many significant topics that were studied.

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[12] Katherine E. Hill, "Issues and Problems in Elementary Science in a Changing World," Science Education, Vol. 48:2 (March, 1963), pp. 109-113.

[13] M. L. Story, "Accent on Aerospace: New Motivation in Elementary Science," Science Education, Vol. 47:2 (March, 1963), pp. 200-201.

[14] Ibid., p. 200.

3. It appears that children can learn astronomy concepts deemed fundamental to the science even if these concepts are not perceived as being closely related to their personal and social needs.

4. Classroom teachers felt inadequate in handling the astronomy content identified in the project.

5. A discovery approach is feasible in teaching concepts of modern astronomy to elementary school children.[15]

It is recommended that the role of a discovery approach must be analyzed to assess its full potential as well as its limitations.[16]

Blackwood points out that science learning can be incorporated in the curriculum by teachers who take into full account certain well known characteristics of children and how they learn. Children tend to be investigators; they learn better when they have a part in planning the things to be studied and the methods to be used; they learn in many different ways; they learn through direct as well as through indirect methods. If science learnings are to be a part of the total elementary school program, there need to be many opportunities for teachers to acquire experiences and skills which, in turn, enable them to help children gain science

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[15]Myron J. Atkin, "Teaching Concepts of Modern Astronomy to Elementary Children," Science Education, Vol. 45:1 (February, 1961), pp. 54-58.

[16]Ibid., p. 59.

learnings and skills.[17]

Scott recently found that in those elementary school classrooms where provision is made for science instruction, almost without exception, the program is prescribed by the children's science textbooks. Most of the science textbooks for young children offer some structure for the science program. Scott also suggests that a science program which would encourage questions, which would condition the learner to seek the answer for himself, which would promote reasoned guessing and the subjection of guesses to controlled tests, would foster inductive logic and discovery.[18]

Renner concluded in a recent study that there is a type of revolution going on in the field of science education. This revolution is of a different type but just as real as the one which prompted Thomas Paine to make the remark, "These are times that try men's souls." Revolution, whether it be political or educational, usually stems from a basic dissatisfaction with present conditions. The revolution's impetuc can come from within the organization which seeks to revolutionize itself. It can also come from an outside agency which uses the products of organization and is dissatisfied with them. The revolution in science education

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[17]Paul E. Blackwood, "How Can Science Learning Be Incorporated into the Elementary School Curriculum," Science Education, Vol. 40:3 (April, 1956), p. 211.

[18]Lloyd Scott, "An Experiment in Teaching Basic Science in the Elementary School," Science Education, Vol. 46:2 (March, 1962), p. 108.

got its impetus from the latter type of source, and that source was the scientific profession itself. A science course, to be a true scientific experience, must be not only talking science but also "doing" science. In other words, a science course must have a laboratory available where the student can have actual scientific experiences.[19]

Mallinson does not claim to offer an entirely new set of goals of instruction. It does appear, however, that there are some specific abilities which all students should acquire as a result of studying science.[20] Furthermore, it is suggested that these abilities can be stated in terms of "one-syllable" words so that all elementary teachers can understand the goals of elementary school science. If the list is accepted, it is hoped that it may assist the elementary teacher in developing a meaningful program of elementary science which has order and direction. The suggested list of goals, or "doings," of science follows:

1. The ability to observe the objects which exist and phenomena that take place in the child's environment and to report accurately what he observes.

2. The ability to compare objects and phenomena with respect to their likenesses and differences.

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[19]John W. Renner, "Why Change Science Teaching?" School Science and Mathematics, Vol. LXIV:5 (May, 1964), p. 415.

[20]Jacqueline Mallinson, "The Role of Elementary School in the Modern Curriculum," School Science and Mathematics, Vol. LX:7 (October, 1960), pp. 525-528.

3. The ability to rank information in terms of its relative importance.

4. The ability to determine whether or not there is enough information available to warrant making a conclusive or even a tentative answer.

5. The ability to determine what kind of information is still needed in order to formulate an answer to a question or locate data for a problem.

6. The ability to decide on the most efficient way to obtain the needed information to answer a question or problem.

7. The ability to carry out an experiment with the materials available, if it is decided that an experiment is the best way to obtain the answer or problem.[21]

The investigator has noted that more emphasis is being placed upon the different methods of teaching elementary school science on the college level as well as on the elementary school level. Greater emphasis is also being placed on the discovery or inquiry approach.

The purpose of an investigation by Neal was to ascertain specific procedures which aid children in developing the ability to use "the scientific method." The purpose of science education for children is to develop the abilities of the individual to solve the problems that confront him. To do this, he must have a scientific attitude, an understanding

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[21]Mallinson, op. cit., p. 529.

of the methods of scientific inquiry and a background of knowledge upon which to base his thinking.[22]

Science education, therefore, should, in the first six grades of a child's education, concern itself with helping an individual to live more effectively in his environment.[23]

The primary problems with which this study was concerned are:

1. To develop and select illustrative teaching techniques or procedures which may be used effectively by the teacher in grades one through six to promote growth in the ability to use the methods of scientific inquiry.

2. To determine the elements of problem solving which are specific objectives of education.

3. To evaluate the effectiveness of the teaching techniques or procedures through a study of children's responses.

4. To observe and describe the kinds of overt behavior which might justifiably be associated with the ability to use the methods of scientific inquiry.[24]

The following five methods of scientific inquiry were selected.

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[22]Louise A. Neal, "Techniques for Developing Methods of Scientific Inquiry in Children in Grades One Through Six," Science Education, Vol. 45:4 (October, 1961), p. 313.

[23]*Ibid.*, p. 315.

[24]Neal, *op. cit.*, p. 316.

1. Identifying and stating problems.
2. Selecting pertinent and adequate data.
3. Formulating and evaluating a hypothesis.
4. Generalizing and forming a conclusion.
5. Applying concepts or seeing relationships.

The study indicated that children's interests in science education were developed as a result of the direct approach of teaching methods of scientific inquiry.[25]

Neal reported in a later study that children can develop the ability to utilize methods of scientific inquiry through the use of a variety of techniques and guided experiences designed to achieve the important objectives of science education. Since there are many methods of inquiry, children should be taught to use many kinds of procedures appropriate for the development of critical thinking abilities.[26]

Suchman's views concerning inquiry training are somewhat different from those of Neal. Suchman stated that inquiry training is designed to supplement the ordinary science classroom activities. It gives the child a plan of operation that will help him to discover casual factors of physical change through his own initiative and control, and not to depend on the explanations and interpretations of teachers or other knowledgeable adults. Suchman concluded that for the

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[25]Neal, op. cit., p. 317.

[26]Louise A. Neal, "Methods of Scientific Inquiry," Science Teacher, Vol. 28:5 (September, 1962), pp. 53-55.

present, inquiry skills cannot be successfully taught to the age group as an isolated content-area. The major focus in elementary science education should remain the content rather than the method of science.[27]

Atkin and Karplus pointed out in a recent investigation that the discussion of the role of discovery in teaching has been identified. Many authors have stressed the great benefits to be derived if pupils discover concepts for themselves. According to Atkin and Karplus, in the development of a concept it is helpful for the student to distinguish the original concept, which can be called invention, from the subsequent verification or extension of the usefulness of the concepts, which can be called discovery. Undoubtedly, an invention is not complete and static, but it is the germ of a concept that is developed to a greater significance by the subsequent discoveries.[28]

The objective of the science program is to teach children to look at natural phenomena from the distinctive vantage point of modern science. If the children are not able to invent the modern concept, it is necessary for the teacher to introduce the modern scientific concepts.[29]

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[27]Richard J. Suchman, "Inquiry Training in the Elementary School," Science Teacher, Vol. 27:7 (November, 1960), p. 47.

[28]Myron J. Atkin and Robert Karplus, "Discovery or Invention," Science Teacher, Vol. 29:5 (September, 1962), p. 45.

[29]*Ibid.*, p. 47.

The pedogogical point to be stressed at this point is that this type of discovery teaching appears to be strongly motivating and rewarding. Yet, the teaching seems also to be extremely efficient, especially when compared with the pure lecture-laboratory approach. The pupils come to the point where they know they will discover something; therefore, they tend to develop a greater appreciation for the discovery method. Perhaps they did not invent the new concepts, but they did make discoveries.[30]

Menzel made a study similar to that of Atkin and Karplus in which he found that in very recent years the teaching of elementary science has taken on a new tenor. That tenor is the teaching of science through a discovery-type of learning. Here, methodology becomes a necessary part of the student's classroom experience. The role of the teacher, consequently, becomes increasingly more vital and this increased teacher importance must be emphasized if the new tenor is to be successful.[31]

Teaching by discovery removes the "yes-no," question-answer kind of science and in its place learning that can change behavior is substituted. Here, the method of learning "about concepts" is learned, knowledge is acquired, relationships become obvious, and the schoolroom becomes a pleasant

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[30]*Ibid*., p. 51.

[31]Wesley C. Menzel, "Teaching Elementary Science," *School Science and Mathematics*, LXIV:2 (1964), p. 146.

place to be.[32]

An examination of Lahte's report indicates that the teaching of science involves two factors--a body of knowledge and scientific methodology. Both are needed in the science program. The two aspects of science teaching are interrelated, however, and one aspect cannot be taught without the other. Scientific methodology involves discovery, for the experimental aspect and deductive inference and verification for the theoretical aspect. We must take a look at the curriculum we ask future elementary school teachers to study in terms of the type of questions which we, as college teachers, ask and the questions we expect the teachers we educate to ask.[33]

The problem-solving methodology was investigated by Nelson who stated that although the advocates of problem-solving methodology have long recommended inductive approaches to science learning, most elementary science textbooks still retain a preponderance of descriptive science, and much lip-service is offered to problem-solving.[34]

Measurements must be extremely accurate in the modern world. In the past, a yardstick often passed the test as a

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[32]Ibid., p. 147.

[33]Arnold M. Lahte, "Scientific Methodology," Science Education, 47:2 (March, 1963), pp. 147-162.

[34]Pearl A. Nelson, "Precision in Science and Arithmetic in Elementary Schools," School Science and Mathematics, LXII:9 (1962), p. 639.

precision instrument, but in this age dimensions of all kinds must be within a thousandth, yes even a millionth, of an inch. Things must fit together just right. Specifications must be followed accurately so that assembly lines can run smoothly.[35]

Once the relationship between measurement and scientific accuracy has been established, the elementary teacher should have no problem in accepting the interchangeability of the two subject areas. Accuracy is indeed one of the keystones to excellence in science whether at the industrial, professional, secondary, or elementary level.[36]

A second category of the elementary school science program which needs close examination is the type of science preparation that elementary school teachers receive in their college experiences. This investigator feels that the objectives for preparing elementary school teachers to teach science should place emphasis on the current trends in elementary school science education. The following paragraphs reveal some of the information uncovered in a survey of literature in this area.

The findings of a study by Michals indicate that objectives for preparing elementary teachers to teach science are best achieved when students who are actively participating

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[35] Ibid., p. 643.

[36] Ibid., p. 643.

in class activities on relevant topics are compared to lecture-demonstrations on the same topics.[37]

According to an investigation by Smith, it has become apparent from an analysis of view points of the teaching of elementary school science that this is a period of exciting growth and more profound study of the subject than had prevailed before in history. The emphasis on carefully planned and stated objectives, on development of fundamental concepts and on continuity in the program is typical of the encouraging trends in the field. Programs which were developed according to such recommendations would seldom be termed "crash programs." The need remains, however, for skilled teachers who can translate these insights and recommendations into widely and smoothly functional school practices.[38]

It was found that most of the courses taken by elementary teachers are those available for specialists in chemistry, physics, and biology. Furthermore, it was indicated that offerings for elementary teachers in geology and astronomy were seldom available. The findings showed strong sentiment on the part of teachers and administrators for the development of programs for training specialists for teaching

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[37]Bernard E. Michals, "The Preparation of Teachers to Teach Elementary School Science," Science Education, 47:2 (March, 1963), pp. 122-131.

[38]Eugene H. Smith, "An Analysis of Some Prominent Views on Teaching Elementary School Science," Science Education, 47:2 (March, 1963), pp. 183-193.

elementary science. All studies pointed out the need for in-service programs for helping elementary school teachers to do a better job of teaching science. Hence, it may be stated that much research needs to be undertaken to determine the optimal types of pre-service and in-service experience in science for elementary school teachers.[39]

It is obvious that a great deal more research needs to be undertaken in this field before any of the major problems can be solved. At the present time, a very small percentage of the investigations in the area of science education is devoted to the elementary school level.[40] It appears that future research studies should go one step further and investigate some of the techniques and methods that may best be applied to the solution of the major problems recognized by elementary science educators.[41]

Bryant found that institutions of higher learning use of three plans to fulfill their elementary requirements.

1. They specify the courses to be taken.

2. They specify certain science courses which are to be supplemented with elective courses.

3. They permit the students with the help of their advisor to elect science courses to meet the credit hour

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[39] Jacqueline Buck Mallinson, "Survey of Recent Research in Elementary School Science Education," <u>School Science and Mathematics</u>, LXIII:8 (November, 1958), p. 605.

[40] <u>Ibid</u>., p. 607.

[41] <u>Ibid</u>., p. 609.

requirements.[42]

It appears significant that the plan most widely used to fulfill science requirements is the one which specifies a group of required courses. Also evident is the fact that the extent to which the elementary school teacher is prepared in science depends, in part, on the institutions he attends. Perhaps in all too many instances he would be among the first to agree that the institution should standardize, at least to some degree, its requirements in elementary science education.[43]

The findings of a study by Uselton present a number of important implications concerning the preparation of elementary teachers in the area of science. It appears that the elementary teacher needs competencies in science that are different from those appropriate for scientists, technicians, and cultured persons in the American Social order.[44]

General education science programs should serve to correct misconceptions, prejudices, and superstitions, and to develop a scientific attitude that will enable a person to make sound judgments and distinguish between facts and

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[42]Paul P. Bryant, "Science Requirements for Elementary School Teachers in Colleges for Teacher Education," Science Education, 47:5 (December, 1963), pp. 475-482.

[43]*Ibid*., p. 481.

[44]Horace W. Uselton, *et al*., "Factors Related to Competence in Science of Prospective Elementary Teachers," Science Education, 47:5 (December, 1963), pp. 506-508.

unsupported claims and opinions. The cultured person should be able to appreciate the applications of science and technology as these affect his every day life. The elementary teacher needs a broader range of competencies than those mentioned in addition to a knowledge of the methods of teaching science concepts. A few hours of science credit earned in courses designed specifically for the person who majors in science fail to prepare the elementary school teacher in a proper manner.

It is generally assumed that the way in which teacher candidates have been taught has an important bearing on the way in which they teach. It is very important, therefore, that college personnel who have the responsibility of planning and supervising the program of study and preparation for prospective teachers be competent teachers themselves.[45]

According to a report by Viall, the study of science and mathematics in elementary programs is becoming more widely used and accepted. Quoting from a working draft is risky, but the guidelines as advocated by Viall and as they stand without text at the present time, include the following:

1. The preparation program for the elementary teacher should include a college-level study of the science and mathematics most appropriate as background for the elementary school program.

2. Science and mathematics courses should be taught

[45]Uselton, <u>op. cit</u>., p. 508.

in such a way that teachers understand the process of scientific and mathematical inquiry.

3. The elementary teacher should have breadth of preparation in science and mathematics with emphasis on interdisciplinary relationship.

4. The preparation of elementary teachers should include the study of curriculum and methods of teaching science and mathematics which are appropriate to the elementary school.

5. Observation of student teaching should provide opportunities to work with experienced elementary teachers who are competent in the subject area.

6. Programs for the preparation of elementary teachers should provide opportunities for pursuit of advanced upper-level study in a carefully planned program in science and mathematics.

7. A fifth year program should offer appropriate science and mathematics courses which might be applied toward a Master's degree.[46]

Every elementary teacher should have courses in the biological sciences and the physical and earth science that emphasize, in depth, fundamental concepts and principles. The material in these courses should be taught by members of the corresponding subject department, and it is essential

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[46]William P. Viall, "Studies of Teacher Education in Science," Science Teacher, 29:8 (December, 1962), pp. 12-17.

that the experimental aspects of science be stressed.[47]

A study by Dubins and Chamberlain revealed that more than one-half of the 733 schools studied require one year or less of science, and that about one-quarter apparently require a year of science with no laboratory work.[48]

Because of the growing interest on the part of educators and scientists in elementary school science, more research is being conducted in this area than ever before. Mallinson reviewed recent research in the field and stated that one may well be impressed by the increasing number of studies that are being produced. For many years the number conducted was few. For example, from 1929 to 1952 less than four such studies were published each year. However, during the school year 1952-53, seventeen were published, and during 1953-54, nineteen were published. It may thus be assumed that research in this area is increasing.[49]

The vast majority of studies published recently may be categorized in four problem areas, namely (1) the status of the elementary science, (2) the grade placement of science topics, (3) methods of enriching the curriculum, and (4) the

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[47]Viall, op. cit., p. 17.

[48]M. Ira Dubins and William D. Chamberlain, "The Amount of Science in the Preparation of Elementary School Teachers in the United States," School Science and Mathematics, LXIII:9 (December, 1963), pp. 755-762.

[49]Jacqueline B. Mallinson, "What Have Been Major Emphases in Research in Elementary Science During the Past Five Years?" Science Education, 40:3 (April, 1956), p. 206.

education of teachers.[50]

Mallinson also reported that research workers in science education would do well to review the literature before undertaking studies. In many cases they contribute data in areas in which the evidence is already conclusive. In turn, they by-pass areas in need of further study. Less research needs to be undertaken in areas where problems need to be identified, and more needs to be done to solve problems already evident.[51]

There seems to be an increasing interest in the evaluation of the training of teachers in elementary school science. In a study of recent research, Beuschlein stated that the following questions need urgent consideration.

1. What steps can be taken to provide an adequate content background for all teachers of elementary science?

2. How can we develop and evaluate growth in understanding of science principles and ability to do critical thinking?

3. What can be done to help teachers become adept in using problem solving techniques with elementary pupils?

4. By what means can we more readily incorporate pertinent research findings into actual practice?

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[50]<u>Ibid</u>.

[51]George G. Mallinson and Jacqueline V. Buck, "Some Implications and Practical Applications of Recent Research in Science Education," <u>School Science and Mathematics</u>, LVI:5 (May, 1956), pp. 365-69.

5. How can we step-up research in elementary school science and increase its scope and significance?[52]

Another area that warrants a great deal of consideration in elementary science research is the role of the administrator. In order for students and teachers to benefit from the many changes that are occurring in elementary school science programs, the chief administrators must be made aware of the importance of these changes and how they may influence their school programs.

Eiss found that rapid changes in elementary science have developed from increased public attention to science education and from the impetus given the science program as a result of the National Defense Education Act. As a result of the increased interest in education, the role of the administrator is changing, particularly in the areas of science education. The role of the administrator has moved away from a position of guardian of school standards toward a more dynamic role of leader and director of a flexible, on-going program. The administrator is a middleman in several ways; he is the central figure between the Board of Education and the school, between the parents and teachers, and between the school and the general public. In this position, he must be all things to all people. He must be cognizant of all the

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[52] Muriel Beuschlein, "Implications of the Findings of Recent Research in Elementary Science Education," <u>School Science and Mathematics</u>, LVIII:8 (November, 1958), pp. 610-12.

recent trends in education and be prepared to sponsor or oppose their implementation in his school system. He must know when to encourage a teacher to try new ideas and theories and when to suggest caution in proceeding along new paths. The honest, responsible administrator will face his role as middleman, make his decisions with the help of all the resources at his disposal, and move toward a better and more worthwhile program. In his hands he holds the key which can open the door to improvement of science education or lock it against any change.[53]

Continuous research in all aspects of elementary science education is necessary if the value of current trends and practices is to be properly and validly evaluated. The evaluation evidence collected by Scott during the first two years of experimentation by the University of California Elementary School Science Project provides a basis for the following conclusions.

1. There are no unqualified, automatic successes in the preparation of fully effective instructional materials in elementary school science. All materials must be subjected to an intensive and continuing program of testing and revision.

2. The methods of basic science can be used in the

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[53]Albert J. Eiss, "The Role of the Administrator in Elementary School Science," Science Education, 46:2 (1962), pp. 170-71.

elementary school, and the science program for young children is demonstrably improved by their use.

3. The learning experiences in science which have been outlined by the University of California Elementary School Project have been met with interest and enthusiasm by children, teachers, and parents alike.

4. Elementary school science materials which merely present experience for children are usually quite insufficient; teachers must also be given considerable help with the content and methods of basic science.

5. The preparation of excellent instructional materials demands more insight, more imagination, and more energy than is generally supposed.

6. Research scientists can make valuable and probably indispensable contributions to the development of an improved elementary school science program.[54]

In the opinion of Mayor, it seems reasonable to assume that elementary science is here to stay. Even though it is the most recent addition to the elementary curriculum, its value is generally accepted. Assuming that its role is accepted, the issue with elementary science rests largely on the improvement of the program. Mayor feels that there are four major problems that as yet remain unsolved. They are listed as follows:

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[54]Lloyd Scott, "The University of California Elementary School Science Project. A Two Year Report," Science Education, 46:2 (March, 1962), pp. 105-113.

1. Lack of direction.

2. Lack of order.

3. Lack of continuity.

4. Lack of adequately trained teachers.[55]

Summary

In this chapter the literature concerning the current purposes and trends in elementary school science education has been surveyed. With very few exceptions, authorities in the field agree that the following list contains the major purposes for the teachings of elementary school science.

1. To aid in the development of intellectual, social, and emotional maturity in children.

2. To aid in the development of critical thinking.

3. To develop an awareness of the nature of the environment.

4. To develop an understanding of man's capabilities of controlling his environment.

5. To guide and stimulate the search for answers to the "why, when, where, how, and the what-of-it" in the milieu of our scientific environment.

6. To develop and strengthen science concepts as a basis for further growth.

7. To provide an atmosphere conducive to the

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[55]John R. Mayro, "The AAAS Feasibility Study of Science in Elementary and Junior High School," School Science and Mathematics, LXI:4 (April, 1961), p. 251.

development and maintenance of scientific attitudes.

8. To teach the application of the scientific methods to the solution of problems which are amenable to scientific analysis.

Modern trends in elementary school science education indicate that there is

1. Greater emphasis on inductive development of concepts and principles through the discovery or problem-solving approach in science teaching and less emphasis on memorization of facts.

2. A shift away from teacher demonstration as a prime method of teaching and toward pupil experimentation.

3. A movement toward more pupil-teacher planned experiments and away from simple manipulation directed by detailed instructions.

4. A movement toward science for all students and away from science for only the college-bound students.

5. Increased use of audio-visual instructional materials by small groups or by individuals.

6. Increasing provision for flexibility in design and construction of science facilities.

CHAPTER III

A SURVEY OF THE EDUCATION OF ELEMENTARY TEACHERS IN SCIENCE

This chapter deals with the status of the education of elementary school teachers in science in 125 (of 153 contacted) colleges and universities representing the fifty states and the District of Columbia. The major concern of this survey was to determine the types of experiences in science that prospective elementary school teachers received during their college education. All of the institutions participating in this study require that elementary school teachers study science and the courses offered cover all fields of science.

All of the 125 colleges and universities responding did not answer each of the questions on the questionnaire; therefore, the data in the tables and elsewhere in this study represent the number of responses given to each question. The data collected, however, do establish the types of experiences which the prospective elementary school teacher receives in science.

Teacher Preparation in Science

Table 1 shows that fourteen different science courses in forty-seven colleges and universities are especially designed for elementary school teachers. These courses cover practically all fields of science. The survey showed that greater emphasis is placed upon the biological and physical science offerings with lesser emphasis being placed upon the earth sciences (geology). The range in the number of credit hours taken by students was greatest in the biological sciences. A limited number of institutions offered courses in special areas such as aerospace, astronomy, nutrition, health, and physical geography. This writer feels that these are excellent courses, but they should be taken after the students have had ample foundation courses in the biological sciences and the physical sciences. It was pointed out by several of the respondents that these special courses were offered because of particular staff member interest in the particular science areas. Only one institution offered botany and zoology which were designed for elementary school teachers, and this was in a leading private university.

The course offerings in science by the three types of institutions used in this study were very similar. The investigator feels that since these courses are designed for elementary school teachers, there is probably no attempt to produce in these courses specialists in science. Rather, these course offerings present a broad spectrum of science to

TABLE 1

SCIENCE COURSES ESPECIALLY DESIGNED FOR ELEMENTARY SCHOOL TEACHERS AS INDICATED BY 47 INSTITUTIONS

Courses Offered	Teacher Education		State Universities		Private Colleges and Universities	
	12 Responding		20 Responding		15 Responding	
	A*	Range in Cr. Hrs.	B*	Range in Cr. Hrs.	C*	Range in Cr. Hrs.
Aerospace Workshop	1	0-4				
Astronomy	1	2-4	1			
Biological Science	11	2-12	10	4-8	4	4-12
Botany					1	3-6
Chemistry	5	4-8	2	3-8	2	3-6
General Science	1	0-3	0			
Geology	2	2-6	2	3-8	3	3-8
Natural History			2	2-4		
Natural Science			2	2-6		
Nutrition and Health					1	0-3
Physical Geography			1	0-3	2	
Physical Science	8	3-6	8	3-8	3	3-6
Physics	3	3-6	3	3-6	4	3-6
Zoology					1	0-4

*A, B, and C columns represent the number of schools offering courses.

the student in order that an integrated comprehension and broad background might be developed in the subject. It was indicated by the majority of the respondents that elementary school teachers were required to fulfill their science requirements from the biological and physical sciences and that the average credit requirement was eight to twelve hours of science. The writer feels that getting a broad scope of science is essential in order that the students might have the opportunity to discover the fundamental concepts of science which are essential for the elementary school child to understand.

The offering of courses especially designed for elementary school teachers is not an established trend. Table 2 represents the responses of forty-eight institutions which require prospective elementary school teachers to take requirements in science from the regular science curriculum. Twelve different science courses were listed by these institutions; courses in the biological and physical sciences were in the majority of the offerings and earth sciences were not listed at all. Specialized courses from the regular curriculum such as zoology, botany, chemistry, and physics were offered more by the state universities than by the teacher education institutions or the private colleges and universities. The range in course offerings as well as the range in credit hours required or recommended by the three types of institutions used in this study was very similar.

TABLE 2

SCIENCE COURSES TAKEN FROM THE REGULAR SCIENCE CURRICULUM BY PROSPECTIVE ELEMENTARY SCHOOL TEACHERS AS INDICATED BY 48 INSTITUTIONS

Courses Offered	Teacher Education		State Universities		Private Colleges and Universities	
	15 Responding		19 Responding		13 Responding	
	A*	Range in Cr. Hrs.	B*	Range in Cr. Hrs.	C*	Range in Cr. Hrs.
Biological Science	8	3-8	13	3-8	10	3-4
Zoology	1	0-8	5	3-8	1	0-4
Botany	1	0-3	5	3-8	1	0-4
General Science	1	0-6	1	0-3		
Physical Science	5	3-6	11	3-9	5	3-6
Chemistry	4	3-6	6	3-4	2	3-6
Physics	2	3-4	6	3-4	4	3-4
Astronomy			2	0-3	1	0-3
Geography	1	0-3	2	3-6	1	0-3
Meteorology			2	0-3		
Oceongraphy			1	0-3		
Physiology					1	0-3

*Columns A, B, and C represent the number of schools offering courses.

It was pointed out by several respondents that a student could satisfy his science requirements by taking all of his science in one area. The writer feels that this situation should not exist in any of the institutions of higher learning because it is necessary for the prospective elementary school teacher to receive a broad scope of science in order to fulfill the goals of elementary school science which were enumerated in Chapter I.

Offerings in astronomy, meteorology, oceanography, and physiology were limited. These courses were offered because of geographical locations of certain institutions and special interest of particular staff members in the specific science area. As was indicated earlier, courses of this type are good, but foundation courses in the general areas should supercede such specialized areas for the elementary education major. This writer feels that such specialized courses are of little value to the elementary school teacher because of the advanced nature in which subject matter of this type is presented.

Methods of Teaching Science

Since teachers tend to teach as they have been taught, the types of teaching methods used in the science courses taken by prospective elementary school teachers is considered to be very significant. These methods govern, for the most part, the future performances of elementary school teachers.

Table 3 represents the responses of seventy-seven institutions indicating the types of teaching methods utilized in the science courses taken by prospective elementary school teachers. The lecture-laboratory, lecture-demonstration, and discussion methods were most commonly used. Twelve of the institutions indicated that they used the discovery or inquiry method of teaching, and several made a notation that they plan to use the discovery approach in the near future. The methods used by the three types of institutions surveyed in this study were similar.

Eleven of the institutions indicated that they use the pure lecture method; however, several respondents pointed out that this was an inadequate method for teaching science. Because of extremely large classes, inadequate science facilities, and insufficient staffing, this was the only feasible method for them to use. The writer feels that this certainly defeats the goals of elementary school science. First of all, very little learning takes place when this method is used, and secondly, this method cannot be used effectively at the elementary school level.

The lecture-laboratory method was the most widely used method in this survey. This combination method is good at the college level if the laboratory offers students an opportunity to experience discovery. It is noted, however, that the private colleges and universities did not emphasize the lecture-laboratory method as much as the teacher-education

TABLE 3

METHODS USED IN THE SCIENCE COURSES TAKEN BY PROSPECTIVE ELEMENTARY SCHOOL TEACHERS AS INDICATED BY 77 INSTITUTIONS

Methods Used	Teacher Education	State Universities	Private Colleges and Universities	Totals
	26 Responding	30 Responding	21 Responding	
	A*	B*	C*	
1. Lecture Only	3	4	4	11
2. Lecture Laboratory	9	10	4	23
3. Discovery	3	6	3	12
4. Lecture-Demonstration	6	7	2	15
5. Discussion				
6. Combination of 2, 3, and 5	4	4	4	12
7. Field Trips	1			1
8. Films and Slides	1		1	2
9. Combination of 2 and 8	4	8	7	19

TABLE 3--Continued

Methods Used	Teacher Education	State Universities	Private Colleges and Universities	Totals
	26 Responding	30 Responding	21 Responding	
	A*	B*	C*	
10. Closed Circuit T.V.	1			1
11. Combination of 2, 4, and 5	1	10	2	13
12. Team Teaching	1			1
13. Programmed In-Instruction	1			1
14. Individual Projects	1			1
15. Group Projects	1			1

*A, B, and C represent the number of institutions utilizing the methods.

institutions or the state universities.

Although the lecture-demonstration method is used by fifteen of the institutions, the writer feels that this is an inadequate teaching method when other methods (e.g., experimentation in the laboratory) are not used also. It is understandable, however, that extremely large classes and lack of space and facilities make it necessary to employ the lecture-demonstration method.

The combination of discovery, lecture-laboratory, and discussion methods is used by twelve institutions. The investigator feels that this combination offers the best means for preparing those persons who will soon be concerned with children achieving the goals of elementary school science education. This combination affords the potential teacher opportunities to practice doing the things he will need to do in the elementary school classroom. It should be noted that twenty-four of the institutions utilized the discovery method to some extent. This offers evidence of the concern for discovery and that concern should be observed in the elementary school classroom.

Closed circuit T. V., team teaching, programmed instruction, individual projects, and group projects are used to a limited extent.

Since methodology is of great importance not only on the college level but also on the elementary school level, the writer feels that all teachers of science should have the experiences available in a methods of teaching science course. Ninety-one of the schools that participated in this investigation indicated that they offered a methods of teaching course for elementary school teachers. Table 4 consists of a seven-item check list by which the science education professor evaluated the course in methods of teaching science offered at their particular institution. Ninety-one institutions responded to this question, the largest response given to any of the questions on the questionnaire. Table 4 also shows that eighty-two of the ninety-one institutions emphasize the discovery method. Analysis reveals that the discovery method is more popular in methods courses than in the science courses since only twenty-four institutions indicated that discovery was used in the teaching of science. The type of ratings given to all of the questions in the check list would indicate the following: (1) prospective elementary school teachers are provided with opportunities to experience discovery; (2) they learn the importance of science in the elementary school; (3) they become familiar with the newer developments in elementary school science; (4) they become familiar with the contributions that science makes to the overall educational growth of the child; (5) they have had opportunities to relate science concepts, inquiry processes, observations, and experimentation; and (6) they are familiar with laboratory procedure and planning. Since one tends to teach as he is taught, it would be expected, according to

TABLE 4

EVALUATION OF THE METHODS OF TEACHING SCIENCE COURSES OFFERED FOR PROSPECTIVE ELEMENTARY SCHOOL TEACHERS AS INDICATED BY 91 INSTITUTIONS

	Very Much			Some			Little			None		
Questions	TE	SU	P	TE	SU	P	TE	SU	P	TE	SU	P*
1. Is the inquiry or discovery teaching method emphasized?	12	24	12	10	8	8	3	2	3		5	4
2. Are opportunities provided for students to experience discovery?	9	18	7	12	12	12	4	5	5		4	3
3. Is the importance of science in elementary school education emphasized?	13	27	15	6	5	5	4	3		2	4	7
4. Are the new developments in elementary school science analyzed and compared?	8	10	8	11	13	5		7	6	6	9	8
5. Are the contributions that science makes to the overall educational growth of the child emphasized?	12	16	10	4	11	9	7	5	3	2	7	5

TABLE 4--Continued

Questions	Very Much TE	Very Much SU	Very Much P	Some TE	Some SU	Some P	Little TE	Little SU	Little P	None TE	None SU	None P*
6. Does work in the laboratory provide opportunities for students to relate science concepts, inquiry processes, observation, and experimentation?	14	20	8	7	7	10	4	5	3		7	6
7. Is the importance of laboratory procedure and planning stressed?	12	24	6	8	7	13	5	4	4	2	4	4

*TE--Teacher Education Institutions; SU--State Universities; P--Private Colleges and Universities. The number in the columns represents the number of institutions in each of the evaluation levels for each question.

these findings, that these types of experiences would be reflected in the elementary school classroom. The investigator has found contradictions to these claims by observing some sixty-six science class periods in thirty elementary schools in Oklahoma (see Chapters IV and V).

Objectives of the Science Courses Taken By Prospective Elementary School Teachers

Table 5 contains forty objectives and purposes of the science courses taken by prospective elementary school teachers as indicated by fifty-two institutions. These objectives cover the entire range of the field of science. The majority of these objectives are non-factually centered and are consistent with the current trends in elementary school science. It was noted, however, that twenty-six of the institutions indicated that one of the major objectives of the science courses taken by prospective elementary school teachers was to help the student grow in the knowledge of the content of science. The seven other most outstanding objectives were Numbers 4, 15, 17, 19, 20, 23, and 24. If the students achieve these objectives, they would utilize their rational powers, thus achieving the central purpose of America education.

The objectives submitted indicate that students are encouraged to think; thus, this encouragement should carry over to the elementary school science classroom. However, statistics in Chapter IV will give evidence that, to a large

TABLE 5

OBJECTIVES OF THE SCIENCE COURSES TAKEN BY PROSPECTIVE ELEMENTARY SCHOOL TEACHERS AS INDICATED BY 52 INSTITUTIONS

Objectives	TE	SU	P*	Totals
1. To give an overview of science with special emphasis upon basic principles used in the elementary school.	1	2	4	7
2. To give opportunity for student demonstration and experimentation.		1	2	3
3. To survey fundamental laws which govern plant and animal growth.		2	1	3
4. To understand methods, materials, and techniques related to teaching science in elementary schools.	7	2	2	11
5. To emphasize the fundamental principles and skills in natural science and their relations to the activities of the elementary school grades.	4	1	4	9
6. To better prepare elementary candidates for teaching natural and physical sciences and health.	1	1	1	3
7. To develop an appreciation and enthusiastic interest in the world in which we live and the laws that govern it.	1	4	2	7
8. To study the child's environment by means of an quaintance with insects, reptiles, birds, and plants.		3	1	4

TABLE 5--Continued

Objectives	TE	SU	P*	Totals
9. To develop a unit of work from one area of natural science appropriate to elementary instruction.	2	3	1	6
10. To develop ability in problem solving, critical thinking, and reflective thinking.	2	3	2	7
11. To develop the ability to maintain and use the scientific attitude of the mind.		2	1	3
12. To develop insight into the interrelationship and interdependence among living things and the physical world.	2	3	4	9
13. To develop understanding, attitudes and habits conducive to good personal and community health and safety.	2	3	3	8
14. To assist in the development of a wide range of interests and hobbies.			2	2
15. To develop cultural understanding of the physical and biological sciences and the nature of the discipline that produced them.	8	2	1	12
16. To familiarize teachers with methods and materials available in the form of literature, resource units, films, etc.		3	1	4
17. To teach the basic concepts needed to teach present-day and future elementary school science.	3	7		10

TABLE 5--Continued

Objectives	TE	SU	P*	Totals
18. To develop a better understanding of the real meaning of science which includes the discoveries and the methods of investigation.	4	5		9
19. To discover and learn many concepts and generalizations that children can use in solving problems in their environment, applying them in various activities such as experimenting, constructing, discussing, and observing.	4	4	2	10
20. To realize the importance of developing interest, skills, appreciations and attitudes in children through science teaching.	6	5	1	12
21. To learn appropriate methods and techniques for teaching science to children through discussion, planning, observing, constructing equipment, reading, working in small groups, working alone, taking trips, and using other audio-visual media such as T. V.	1	3	2	6
22. To learn and understand many concepts and generalizations that describe the universal science principles of Time, Space, Adaptation, Interrelationships, Variety, and Energy.	1	3	2	6

TABLE 5--Continued

Objectives	TE	SU	P*	Totals
23. To grow in the ability to solve problems through analyzing the process in dealing with problems significant to children: a. Discovering and defining problems b. Gathering ideas through discussion and reading c. Making decisions from action planning d. Carrying out decisions e. Keeping records f. Drawing conclusions g. Identifying the science concepts pertinent to the problem h. Evaluating the procedures used i. Increasing faith in one's ability to solve numerous problems.	2	8		10
24. To develop a stronger disposition and ability to use scientific attitudes of inquiry and identify ways to help children: a. Willingness to consider evidence effectively b. Willingness to search for cause and effect relationships c. Demand for more evidence before making decisions d. Questioning the accuracy of sources of information e. Questioning the opinion of those who are not qualified in the field in which opinions are given f. Rejection of superstitions, prejudices, astrology, fortune telling as scientific explanations g. Changing one's ideas as a result of new evidence h. Realization that scientists are continuously finding better explanations	3	6	1	10

TABLE 5--Continued

Objective	TE	SU	P*	Totals
25. To read, examine, and evaluate elementary science textbooks, children's science information books, and local and state guides for elementary science teaching.	5	1	1	7
26. To realize how interest and pleasures from explorations that are satisfying to an individual's curiosity.		4		4
27. To understand the usefulness of scientific knowledge and scientific ways of thinking for the welfare of people.	1	1		2
28. To develop an understanding of how community resources and contacts with immediate environment may serve as a laboratory for scientific experiences.		4		4
29. To recognize the values of demonstration and experimentation as aids to learning and to habit formation.	6	1		7
30. To recognize the value of quantification and apply it when it is appropriate in order to make certain kinds of science experiences more meaningful to children.		3		3
31. To develop an appreciation of the scientific method and its limitations.	3	4		7
32. To develop an appreciation of the nature of scientific laws and theories and their limitations.	4	3		7

TABLE 5--Continued

Objectives	TE	SU	P*	Totals
33. To develop an understanding of facts, fundamental laws and principles that explain natural phenomena, the operation of mechanical appliances and technological processes on a level of a non-science student.	5	3	1	9
34. To understand the properties and changes of matter, earth processes and history, nature of the universe, and application of energy.	1	2		3
35. To grow in knowledge of the content of elementary school science.	15	6	5	26
36. To master the fundamental principles of chemistry, physics, molecular biology, geology, astronomy, and meteorology.	1		1	2
37. To gain an understanding and appreciation of the biochemical, cellular integrated approach to living organisms.	1			1
38. To develop an appreciation of the developmental and sequential nature of science in the elementary school.		3		3
39. To acquaint teachers with the latest research and techniques in science teaching.		2		2

TABLE 5--Continued

Objectives	TE	SU	P*	Totals
40. To acquire a working philosophy of the teaching of science as being more than the teaching of subject matter.		1		1

*TE--Teacher education institutions; SU--State Universities; P--Private colleges and universities. Number in columns represents the number of institutions utilizing the objectives listed.

extent, these objectives are not being accomplished in the elementary school science classes.

Major Concepts of Science Future Teachers Are Expected to Learn from Their Science Experiences

Understanding concepts of science is more important than memorizing numerous unrelated scientific facts. Table 6 indicates the types of science concepts students are expected to learn from their science experiences in college. Based upon the limited responses to these concept questions, no definite trend was established for the types of concepts in science that students were expected to learn. The data in Table 6 does show that twelve of the seventeen concepts given were in the area of physical science, and the teacher education institutions showed a greater emphasis in concepts than the state universities and private colleges and universities. By achieving the objectives listed in Table 5, the concepts in Table 6 would be understood by the students.

TABLE 6

MAJOR CONCEPTS THAT SCIENCE FUTURE TEACHERS ARE EXPECTED TO LEARN FROM SCIENCE EXPERIENCES AS INDICATED BY 46 INSTITUTIONS

Concepts	15 TE* Responding	17 SU* Responding	14 P* Responding	Totals
1. Concepts that describe the major patterns of the universe; space, time, change, interrelationships, adaptation.	5	2		7
2. Forms of energy and balance, matter, and change.	6	3		9
3. Atomic structure of matter and conservation laws.	1	2	1	4
4. Investigation, correlation and interrelationships between principles running through all the sciences.	5	1	1	7
5. Reproduction-life cycles, growth, and development.	3	1	2	6
6. Air pressure, light, heat magnatism, electricity, water, sound, simple machines.	5	2	1	8
7. Evolution.	2		1	3
8. Changing surface of the earth.	2		1	3

TABLE 6--Continued

Concepts	15 TE* Responding	17 SU* Responding	14 P* Responding	Totals
9. Ptolemy's and Copernicus' systems.			1	1
10. Kinetic molecular theory.	2			2
11. Electromagnetic spectrum.	1			1
12. Order and logic of science.	3	2	1	6
13. Fundamentally, all living organisms operate similarly by biochemical control systems, regulate internal environment, and assist in maintaining homoeostasis.	1			1
14. The gene-pool.	1			1
15. The prime movers and their relations to a dynamic system.	1			1
16. The concepts of accuracy, precision, validity, reliability, as applied to scientific instruments and situations.	1			1
17. The concept of statistical theory in elementary science.	1			1

*TE--Teacher education institutions; SU--State Universities; P--Private colleges and universities.

This chapter has dealt with what colleges and universities say they are accomplishing in elementary school science education. The following chapter will deal with what is actually being accomplished in science by the elementary school teachers. Based upon the findings in this teacher education survey, there was no common agreement for programs in science for elementary school teachers.

CHAPTER IV

TEACHING MATERIALS AND THEIR IMPLEMENTATION

In this chapter an analysis was made of the types of teaching materials used in the elementary school classrooms of Oklahoma. The objectives and content of these materials were surveyed and compared with objectives given by the elementary school teachers who participated in this study. Both the conventional and "newer"* materials in elementary school science were analyzed.

There are, in the main, about ten major science text series commonly used in elementary schools. There is a book for each grade level from kindergarten through sixth grade in each textbook series; however, some texts combine the kindergarten and first grade materials. Each book in the text series consists of a variety of subject matter which is often organized into units of some breadth and which often deals with topics such as earth, plants and animals, electricity, machines, etc.[56] The newer methods also consist of materials

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*See Chapter I.

[56]Albert Piltz, "Review of Science Textbooks Currently Used in Elementary Schools," <u>School Science and Mathematics</u>, LXI:5 (May, 1961), p. 368.

for grades kindergarten through sixth grade and cover a variety of subject matter which is organized in units. Since both types of materials are being used in the schools surveyed in this study, an analysis of them was significant for this investigation.

To receive the data for this portion of Chapter IV, four elementary school science text series were analyzed.

Man's concept of the universe is expanding so greatly and his understanding of scientific principles increasing so rapidly that the science taught to now practicing teachers may no longer be considered appropriate. Truth does not change, but man's ideas concerning truth do change. The concept of change is important for children to learn. The earth changes, living things change, and human life changes. These are scientific concepts that teachers need to develop in the child as he grows. That scientists change their minds in the fact of new evidence is a basic scientific attitude which should be taught.[57]

The Science Handbook section of Singer Science Series begins with a statement of purposes of elementary school science: (1) to satisfy interest and stimulate curiosity; (2) to provide a basis for wide class participation; (3) to correct common misconceptions; (4) to enable and prepare children to meet emergencies effectively; (5) to understand

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[57]Teacher's Guide: Science for You, Singer Science Series, Grade One, 2nd edition (Syracuse, New York: The Singer Company, 1962), p. 1.

the environment; (6) to understand natural happenings; (7) for appreciation; (8) to develop scientific attitudes; (9) to acquire accurate concepts to broaden interests.[58]

There are seven content areas that serve as an organizational framework for the Singer Science Series. They are plants, animals, the human body, the earth, the universe, matter, and energy. An example of the type and manner in which material is presented in the Singer Series is given below.

> Does Air Have Weight?
>
> You weigh things with scales. Can air be put on a scale? Is there a way to discover if air has weight? You can answer this question if you do the following experiment.
>
> You will need
>
> 1. A yardstick
> 2. A nail
> 3. Two carpet tacks
> 4. Two large balloons
> 5. A piece of board
> 6. A hammer
>
> What you do
>
> 1. Make a hole through the yardstick at the 18 inch mark.
> 2. Put the nail through the hole and drive the nail into the end of the board. Lay the board on a desk or table as shown in the picture.
> 3. Put two carpet tacks part-way into the yardstick at inch and 35 inch marks.
> 4. Hang a balloon on each tack.
> 5. The yardstick should balance. If it does not, add a little piece of paper or small rubber bands to the light end

[58] Ibid., pp. 1-4.

until it goes down and is balanced.

6. Blow into one of the balloons until it is as large as it can get without breaking.

What you have learned

The balloon containing air is heavier than the empty balloon.[59]

Based upon the stated purposes, the content, and the structure of the Singer Series, one would expect students to receive worthwhile experiences in science. The books as constructed, however, do not achieve their purposes. After carefully analyzing the purposes, content, and treatment of the content, the writer has made the following conclusions: (1) students do not formulate problems; they are given to them; (2) the answers are given; therefore, the student's interest and curiosity are not stimulated; (3) the experiments provide a basis for wide class participation, but do not provide the student with the opportunity to reason; all of this is done for him; (4) the experiences do not prepare students to meet emergencies because there are no opportunities for them to develop their rational powers. En esse, this series gives the student the problems, tells him what he needs and what he should do in order to solve the problem, and finally tells him what he has learned. This is not the way to learn science.

The authors and editors of the Scott, Foresman Basic Science program give three basic objectives of elementary

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[59] Singer Science Series, op. cit., p. 144.

science. First, the science program must stimulate and guide children in a constantly growing understanding of the forces, phenomena, processes, materials, and living things that make up a large part of the world in which they live. Secondly, a course in science must present information in a logical, understandable, and efficient manner. To be really effective, however, it must also foster the abilities necessary for scientific thinking through problem solving; for example, the ability to see likenesses and differences, the ability to make inferences, the ability to see relationships, the ability to classify, the ability to generalize, and the ability to understand and use the language of science, both written and oral, should all be developed in pupils. Thirdly, as children advance and progress through the first and second objectives, new attitudes must be established. A child who has developed such attitudes reacts towards his environment in distinct ways--ways totally different from those of a child who has no understanding of scientific values.

The series below represents the characteristics of a child who has an understanding of scientific values.

> He has an inquiring mind; he wants to know the "what," the "how," and the "why," of things.
>
> He plans before he acts.
>
> He is careful and accurate in what he does.
>
> He distinguishes between fact and opinion.

He holds his conclusions subject to revision in the light of new evidence and revises those conclusions if the evidence warrants it.

He is as unprejudiced and impersonal as possible.

He is free from superstitution, relying instead on the universality of cause and effect.

He is tolerant of new ideas and suggestions.

He respects and relies upon judgment of experts.

He appreciates the value of both the content and the method of science.[60]

The following information from the Scott, Foresman Series demonstrates that the material as presented in the book does not achieve its objectives.

Problem:

Do seeds need soil in order to germinate?

Materials:

Seeds, pan of soil, jar of stones, water.

Procedure:

1. Put seeds in the pan of soil.
2. Put seeds in the jar of stone.
3. Put water in the jar of stones until it covers part of the seeds.
4. Water the seeds in the pan of soil.
5. Observe to see if the seeds sprout.

Concept:

Seeds do not need soil in order to germinate.

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[60]Basic Science Handbook K-3 (Dallas: Scott, Foreman and Company, 1961), p. 12.

Pupil Observation:

1. Seeds began to grow in the pan of soil.
2. Seeds began to grow in the jar of rocks.[61]

When material is presented in this manner, it would appear that the authors are of the opinion that all the scientific knowledge a student needs to learn is contained in the books. The material as presented takes away the opportunity for students to develop or explore their own ideas. The child is not given the opportunity to formulate problems; they are stated for him. He is not allowed to decide what materials are necessary in order to test the problem; they are listed for him. He does not have to choose the correct procedure needed to solve his problem; it is outlined for him. Illustrations are given to aid the student in solving the already stated problem, and finally the concepts are stated; therefore, the student needs only to memorize the facts given. Activities of this sort certainly fail to develop in children the ability to make inferences, see relationships, classify, generalize, or to understand the written and oral use of the language of science.

The authors of the D. C. Heath Science Series state their ideas of a good elementary school science program.

> 1. A good science program is strongly structured. It provides a framework of

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[61] Science Is Learning (Dallas: Scott, Foresman and Company, 1961), pp. 110-111.

concepts rather than a surface of isolated facts.

2. A good science program contains a balanced selection of concepts from each area of science. It develops these concepts in a spiral progression throughout the grades.

3. A good science program is geared to the children's developmental needs, physical, mental, and emotional.

4. A good science program is strongly related to the total school program. Many of the science topics are cross-connected with other curricular areas, especially social studies, health, and mathematics.

5. A good science program carries its responsibility to the future. It provides the scientific literacy and rational attitudes that are essential for responsible citizenship in the scientific age.

6. A good science program provides a framework of concepts, built up through experiences on which to build future learnings. A life time would not be long enough to follow up every lead in science that a single group of children may present or to keep up with current developments. But when we organize our program on the basis of fundamental concepts, we change science into a tool subject, so to speak. Each concept becomes a probe, an examining tool with which to dissect new facts, to discover their essence, and relate them to what we already know.[62]

Each new subject in the series is introduced through a familiar experience. Many of the illustrations show schoolroom activities in order to encourage children to regard the classroom as a science laboratory and to begin with a familiar

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[62]Teacher's Guide: Science for Work and Play, Grade One, D. C. Heath Science Series (Boston: D. C. Heath and Company, 1961), p. 4.

setting. Various regional environments are shown, and these permit the teacher to begin with a discussion of the region most familiar to the children.[63]

It should be noted that an understanding of many of the basic scientific concepts is developed in Science for Work and Play: the use of wheels in daily living; the science reasons for some rules of safety; the characteristics of various types of weather; broad classification of plants and animals; a beginning exploration of the water cycle; the cycle of the seasons; how machines help to do work quickly and efficiently; the miracle of growth; and the basic needs of living things.[64]

It was stated that in the D. C. Heath Series each subject is introduced through familiar experiences. Structuring a textbook in this fashion assumes that all environments are alike. Introducing such experiences in the role of the teacher; she is the one that is familiar with the environmental conditions of her students.

The characteristics of a good elementary science program as stated in the D. C. Heath Series are in keeping with the current trends in elementary school science, but the manner in which the material is presented is not representative of the current trends. An example from one of the books in the series will demonstrate this point.

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[63]Ibid., p. 18.

[64]D. C. Heath and Company, op. cit., p. 18.

How Are Sounds Different?

> When you listen to a radio or phonograph record, you hear many kinds of sounds. There may be the sounds of people's voices, or musical instruments or any of a great number of other sounds. All the sounds are vibrations and they all come from the same place--from the vibrating "speaker" in the radio or phonograph. Yet, sounds are very, very different. You would never mistake a drum for a flute, or a tuba for a piccalo. How are sounds different, and what makes them so?
>
> Here is a simple experiment that will tell you about one difference--the difference in pitch.
>
> Rub your fingernail lightly across the cloth cover of an old book. Listen to the swishy sound. The sound bumps up and down over each thread of the cloth.
>
> Do it several times, moving your fingernail slowly, then faster and still faster. How does the sound change? What do you do to make a higher pitched squeaky sound? How do you make a low-pitched deeper sound?
>
> Now you know the faster movements produce more vibrations each second, and the sound is more shrill on higher pitches.[65]

Navarra and Zafforoni, authors of the Harper and Row Science Series, Today's Basic Science, point out that these books were written based on the theory that pupils learn science in the way that the scientist himself acquires knowledge. The pupil, like the scientist, observes and experiments. He reads, discovers, and exchanges ideas with others.[66]

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[65]Science for Work and Play, D. C. Heath Science Series Grade 6 (Boston: D. C. Heath Company, 1961), pp. 4-5.

[66]John G. Navarra and Joseph Zafforoni, Teacher's Edition Today's Basic Science (New York: Harper and Row, 1963), pp. vi-vii.

The purposes of the Harper and Row Science Series are given below.

> 1. To contribute to development in procedure, content, and problem solving;
>
> 2. To guide the pupil through observations and experiments;
>
> 3. To set forth the following procedures: (a) observation, (b) experimentation, (c) discussion, (d) recording data, and (e) reading;
>
> 4. To introduce the child to a specific and rewarding analysis of what "doing an experiment" means;
>
> 5. To give the child problems to solve and to guide him through the specific methods in finding the answers to his particular problems;
>
> 6. To develop many features and procedures by which problems may be attacked and solved;
>
> 7. To acquaint the child with the role of "facts" in the solution of problems.[67]

The nine content areas that serve as an organizational framework for Today's Basic Science are air, weather, aviation, time, space, earth, matter, energy, and life. The types of experiences that pupils get from the use of the above texts are in contradiction with the theory upon which the books are based; that is, pupils learn science in the way that the scientist himself acquires knowledge. The example below from the above book illustrates the writer's point of view.

Light for Plants

> Most plants need light.
> Light helps plants make food.
> Plants need light to grow.

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[67]Navarra and Zafforoni, op. cit., p. vii.

Experiment:

Plant some grass seeds in two pots of soil.
Place one pot in a dark room.
Place the other pot in the light.
Water each pot of soil once a day.
Observe each pot as the grass begins to grow.
What do you find?

Now do this:
Place the pot of yellow grass in the light.
Observe it for a few days.
What is happening?
The yellow grass is turning green.

Plants do need light.[68]

This type of experimentation does not permit the pupil to learn science the way scientists acquire knowledge. The scientist does these things through experimentation and observation. No one tells the scientist the answers to his problems. This he must find out for himself. Here all the answers are given. The investigator contends that the types of experience presented here do not foster discovery.

Table 7 illustrates a similarity of broad topics which embrases all areas of science knowledge as appearing in four of the publications which are utilized by teachers as resources for their teaching of science in the elementary school.

This table clearly indicates that there is very little difference in these four series of textbooks. The emphasis on content is quite similar.

TABLE 7

SIMILARITY OF SCIENCE TOPICS IN RESOURCE MATERIALS

Science Fields	D. C. Heath	Singer Science	Scott, Foresman	Harper and Row
Biological Science	Plants and Animals	Plants and Animals	Man's Control of Living Things	Living Things
	The Human Body	The Human Body	Structure, Life Processes and Interrelationship of Living Things	
	Safety and Health			
	Conservation			
Earth-Space Science	The Earth	The Earth	Earth and Its Relations	Our Earth and Sky
	Weather and Climate			Around the Year
	The Solar System and Space	The Universe	Man's Control of Physical Environment	
Physical Science	Chemical Change	Matter and Energy		Magnets and Electricity
	Electricity and Magnetism			Wheels
	Machines			Sounds
	Energy and Physical Change			Light and Color
	Science and Industry			

Objectives of Science Units or Lessons Given by Teachers Using the Conventional Materials in Elementary School Science

Twenty-eight of the schools that participated in this study used the conventional materials in elementary school science. Fifty-four elementary school teachers listed the objectives and purposes of their respective science programs; these are shown in Table 8. It must be noted that the objectives given by these teachers were purely content-centered, whereas the objectives listed in the books that they used were concept or experience-centered. Obviously, the teachers had developed objectives which were not consistent with the author-stated objectives of the books they were using. If, however, the books were content-centered, it would then follow that in order for the teachers to use these books, the author-stated objectives would have to be restated in a factual manner. This was the situation as is evidenced by the objectives that were given. The teachers wanted to have their pupils achieve the objectives that were given for the materials analyzed in this chapter, but the materials they were using made this difficult if not impossible. The teachers' wishes could have been fulfilled if they had been using the newer approach to teaching elementary school science which will be reviewed later in this chapter.

TABLE 8

OBJECTIVES OF SCIENCE UNITS OR LESSONS GIVEN BY TEACHERS USING CONVENTIONAL ELEMENTARY SCHOOL SCIENCE MATERIALS

Kindergarten

To discover chemical and physical changes by aiding the teacher in baking a cake.

First Grade

To aid the children in realizing the importance of water for maintaining life.

To help children understand how animals get their food and the different kinds of food eaten by different animals.

To help children understand how frogs develop.

To help children understand, through experimentation, those factors which are responsible for rain.

Second Grade

To demonstrate the concept of space.

To help children understand the uses of magnets in the home and industry.

To develop an understanding of the differences between living and non-living things.

To develop an appreciation of light and color.

Third Grade

To understand the similarities and differences between light and sound.

To demonstrate the functions and uses of different kinds of magnets.

To help pupils understand how magnetism and electricity can be converted into other forms of energy.

TABLE 8--Continued

To help children gain a better understanding of machines and how they are so helpful and important to us.

To identify the various rocks of the earth and where they are found.

Fourth Grade

To develop a concept of the solar system on the basis of its components and their relative sizes and spacing in a tremendous volume of space.

To help students understand simple machines and their uses.

To give the students a basic understanding of friction.

To help students find out what electricity is and how it differs from other forms of energy.

To help children realize that plants are living things that need water and food to grow and develop.

To acquaint students with the helpful and harmful activities of insects.

To develop an understanding of living and non-living things.

To allow students to gain an understanding of the growth and development of trees.

To provide experiences that will help pupils develop an appreciation for the importance of electricity and magnetism.

To give the children an understanding of the world of molecules.

To acquaint the children with the similarities and differences in the growth and development of plants and animals.

To give the students an understanding and an appreciation of X-rays.

Fifth Grade

To discover how much food value a seed has through experimentation.

To become more aware of the causes of weather conditions.

TABLE 8--Continued

To give the students a better understanding of the world of molecules.

To help children classify the seven basic foods and correlate these with the functions of the digestive system.

To develop an understanding of the energy and size of the sun.

To help children to realize that plants are the basis of life.

To aid the pupils in finding out what factors are responsible for the different types of weather and how man is able to give weather predictions.

To give the pupils an understanding of the physical properties of nature.

To aid the children in understanding the importance of the properties of the atmosphere.

To help the pupils understand the differences between chemical and physical changes.

To explore the theory that energy and mass are interchangeable.

To demonstrate three things that produce electricity.

To understand principles of a hot air furnace.

Sixth Grade

To obtain a better understanding of tree growth and development.

To give the students an understanding and appreciation of different fuels and their uses.

To develop concepts concerning the changes of earth sediments.

To understand how plants are able to make their own food and supply food for animals.

To correlate weather and climate.

To help pupils gain an understanding of the basic concepts concerning electricity and magnetism.

To familiarize pupils with the many uses of magnets.

TABLE 8--Continued

To allow students to discover through experimenting that electricity and magnetism are forms of energy.
To help the pupils understand the concepts involved in flying a plane.
To understand the interrelationship of plants and animals in a balanced aquarium.
To understand the causes of erosion.

The Purposes of Three New Developments in Elementary School Science

The need for the re-education of both teachers and administrators in order that they might understand better the nature of good science programs has been brought into sharp focus by scholars in science and education. They point to the necessity of providing teachers with modern, up-to-date knowledge, preparing them to teach science "as science," and giving them modern information concerning child growth and development. Teaching experience alone is insufficient preparation for the new programs of elementary school science.[69]

With cooperation and interdisciplinary assistance of many scholars, effective and essential methods have been developed and should be used by educators if they hope to provide acceptable science experiences. Organized research by groups in colleges and universities is resulting in findings that can change both content and methods in teaching. An

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[69] New Developments in Elementary School Science (Washington, D. C.: National Science Teachers Association, 1963), p. 51.

important direction of change is toward providing pupils the opportunity to delve into sufficient problems, to invent, create, explore, and investigate science. Schools that concentrate on learning of this kind will probably educate children to become more effective members of tomorrow's society.[70]

This portion of the chapter will deal with three of the new approaches to elementary school science and how they are used in the elementary school classroom. The importance of student participation in experiments is fundamental to all three studies.

University of Illinois Elementary Science Study

The University of Illinois Elementary School Science Study was begun in 1960 with support from the National Science Foundation and was developed under the direction of Stanley P. Wyatt and J. Myron Atkin at the University of Illinois. The study is preparing materials for grades 5 through 7.

The Illinois Science Project seeks a new approach to content by providing children with an understanding of how scientists work to obtain answers to problems in astronomy, rather than providing solely a collection of discrete facts.[71]

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[70] Ibid., p. 51.

[71] Astronomy-Charting the Universe-Teacher's Guide, Third Edition, Elementary School Science Project (Urbana: University of Illinois, 1961), Introduction.

Four of the six books are presently available in published form. Three have been analyzed and they are _Charting the Universe_, _The Universe in Motion_, and _Gravitation_.

Charting the Universe

This unit covers such topics as measurement, distances in the solar system and beyond, the size and shape of the earth, and the universe square law as a tool for finding very great distances. The major purposes and objectives of _Charting the Universe_ are listed below.

> To introduce the use of clues in estimating sizes and distances of objects.
>
> To show how astronomers used clues to establish the spherical shape of the earth.
>
> To develop a background of mathematical and geometrical concepts used in indirect measurements.
>
> To use the ideas developed in preceding chapters to measure the size of the earth and the distance to the moon.
>
> To establish the size of the moon from an understanding of angular diameter (how large an object appears).
>
> To explain how a scale model of the solar system can be constructed to determine the sizes of planetary orbits.
>
> To tell how astronomers can measure the distances to the stars by observing apparent changes in the star's position and by measuring their apparent brightness.
>
> To present a picture of the structure of the universe and the objects which compose

> it--satelites, planets, stars, and galaxies beyond our own.[72]

The Universe in Motion

The Universe in Motion guides students in learning about time and motion. Students observe and measure the motion of the moon, sun, stars, and planets and study theories which explain this motion. The students are introduced to geocentric and heliocentric perspectives.

In The Universe in Motion, children encounter a new dimension-time. With the passing of time, celestial objects are constantly moving; i.e., their positions are changing from moment to moment. The Universe in Motion will help children develop skill in observing motions of the sun, moon, and planets. Children will share the experiences of a few scientists who search for reasonable models to explain observed motions in the solar system and the distant stars.[73]

Listed below are the main objectives of The Universe in Motion.

> To help develop an awareness of apparent motions of the sun, moon, and stars in their daily tracks across the sky. Children are expected to measure some of these motions and plot the tracks of the sun and moon from day to day.
>
> To provide children with the opportunity

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[72] Astronomy-Charting the Universe, op. cit., Introduction.

[73] Astronomy-The Universe in Motion-Teacher's Guide, Second Edition, Elementary School Science Project (Urbana: The University of Illinois, 1962), Introduction.

to use sky maps and to encourage star-gazing throughout the year.

To focus children's attention on the periodic motions of the sun, moon, and planets against the fixed stellar background. The apparent backward motions of the planets are introduced as a set of puzzling phenomena which have been observed for many centuries.

To search for a reasonable model to explain the puzzling observations of astronomy. Several models of the solar system are proposed, and each is tested in relation to the observational evidence.

To trace Kepler's works as he searched for a reasonable model of the solar system in motion. Kepler's laws are discovered and applied to illustrate how the speeds, distance, and orbital periods of planets can be determined with a high degree of precision.

To explore motions on the grandest scale. Children will learn that astronomers measure motions of our sun, nearby stars, and distant galaxies. They will learn that Kepler's laws are applicable to celestial objects other than planets. They will develop a sense of the patterns of motion throughout the universe.[74]

Gravitation

The work on Gravitation deals with such concepts as velocity, acceleration, mass, and force. This unit stresses the science of motion, the universal law of gravitation, and how gravitational forces affect the movement of celestial objects.

The purposes of this unit are listed in the following

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[74] *Ibid*.

paragraphs.

> To describe the world of motion that surrounds us.
>
> To lead the pupils to an understanding of Galileo's work on inertia. Activities demonstrate the influence of friction on moving objects and students experiment with the effect of an object's mass on its motion.
>
> To stress the fact that force is necessary to keep an object moving in a curved path.
>
> To relate concepts to balanced and net forces encountered and discussed. Newton's Second Law of Motion is involved as the student, through the activities, sees how force, mass, and acceleration are related.
>
> To allow children to observe and measure acceleration produced by the earth's gravity. Children come to the understanding that gravity is a constant force which accelerates all objects at the same rate toward the center of the earth.
>
> To extend the concept of acceleration and to include a change of direction as well. Students learn to use the arrow representation called a vector diagram to show what happens when a force changes the motion of an object.[75]
>
> To lead pupils to compare the acceleration of objects at the surface of the earth with the acceleration of the moon, 240,000 miles away. A mathematical relationship between distance and acceleration is developed and shown to work for planets as well as the moon. Students are expected finally to see a relationship between pairs of forces; gravitational attraction is a mutual affair.

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[75]Astronomy-Gravitation-Teacher's Guide, Third Edition, Elementary School Science Project (Urbana: University of Illinois, 1962), pp. 1-40.

> To examine the conditions which produce orbits of differing shapes. They consider the effects of the earth's gravitation on an object's motion and speculate about weight in the earth's interior.
>
> To help students learn how planetary motion would be affected if gravitation were turned off in the solar system. They learn how a planet's mass may be determined through observation of the satellite's orbital motion.
>
> To learn how the law of gravitation may be used to compare the masses of stars.[76]

The material in these four books differs from the conventional science content for elementary schools in that it places great weight on a few fundamental concepts of astronomy rather than a large number of isolated facts.

<u>Science Curriculum Improvement Study</u>

The Science Curriculum Improvement Study (SCIS) was developed under the direction of Robert Karplus at the University of California. So far, the SCIS has produced materials for grades kindergarten through three. The Study is carrying out experiments to develop a concept of science instruction for elementary school children that is based on the nature and structure of science and the learning processes of children and to develop materials for such instruction. The rationale of the Study emphasizes the teaching of a conceptual framework--the scientific point of view--within

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[76] *Gravitation*, *op. cit.*, pp. 50-104.

which children can perceive and interpret scientific phenomena in a meaningful way and organize their inferences into generalizations of lasting value. The immediate aims of the SCIS are to investigate aspects of basic science that can be understood by elementary-school pupils, concepts that are most useful in guiding the intellectual development of pupils, effective teaching plans for these topics, and means of preparing elementary-school teachers to teach such a science program. It is the judgment of Karplus and his associates that experimentation in developing a new science curriculum for the elementary school should bring university scientists into classrooms to teach the materials they have developed. Also, in their opinion, there must be continuing study of what pupils are learning from the new materials, of the programming of learning experiences, and of the preparation of teachers.[77]

The four units which have been developed thus far are Material Objects, Interaction and Systems, Variation and Measurement, and Relativity of Position and Motion.

Material Objects

The overall objective of the teaching program outlined in Material Objects is to make the children able to recognize what in their environment makes up material objects. The

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[77] Current Curriculum Studies in Academic Subjects, prepared by Dorothy M. Fraser (Washington, D. C.: National Education Association, 1962), pp. 22-23.

objects themselves are to be distinguished from their properties (shape, color, texture, size, etc.), from the influence or effect they have on one another, from the patterns in which they may be arranged and from the expectations they arouse.[78]

Other objectives of the teaching program include developing habits of careful observation, developing the ability to discriminate fine differences and to recognize broad similarities among objects, developing a vocabulary that is useful in describing objects, and developing various ways in which observations and experiences can be recorded. Their approach to the teaching is based on giving the children many objects and specimens of substances to observe and manipulate.[79]

Interactions and Systems

In this book the ways in which objects affect other objects are explored. Listed below are the primary purposes of the unit.

> To help children learn to recognize regular patterns of behavior.
>
> To identify the material objects that are present and seem to be connected with the happenings.
>
> To recognize that changes are taking

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[78] Material Objects-Teacher's Manual, Trial edition, Science Curriculum Improvement Study (Berkeley: University of California, 1963), p. 2.

[79] Ibid., p. 3.

> place during the period of observation--changes in shape, position, color, temperature or other changes in appearance.
>
> To determine which object or objects were instrumental in causing the change.[80]

Attention is then focused on the causes of changes, or the interaction among the objects. The concept system is introduced after a number of experiences with interacting objects have been had.[81]

Variation and Measurement

The unit on Variation and Measurement represents a substantial departure from traditional science teaching. First of all, there is a concern with such fundamental concepts as variation within populations, arbitrary and individual units of measurement, and conservation of volume. Second, there is unusually heavy emphasis on experimentation and observation in the classroom. Third, the individual lessons are planned to commence threads of thought and inquiry. Students have opportunities to make qualitative and quantitative observations and measurements.[82]

As with the other units prepared by the Science

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[80] Interaction and Systems-Teacher's Guide, Trial edition, Science Curriculum Improvement Study (Berkeley: University of California, 1963), pp. 3-4.

[81] Ibid., p. 4.

[82] Variation and Measurement-Teacher's Manual, Trial edition, Science Curriculum Improvement Study (Berkeley: University of California, 1964), Preface.

Curriculum Improvement Study, the objective of Variation and Measurement is to give the children a start in looking at objects and at groups of objects in a more analytical way. In the activities of the unit, children will have the opportunity to apply and reinforce their understanding of properties. At the same time they will have opportunities to make qualitative and quantitative observations of measurements.[83]

Relativity of Position and Motion

This unit also represents a substantial departure from traditional science teaching. First of all, there is a concern with such fundamental concepts as relativity and configuration. Second, there is unusually heavy emphasis on experimentation and observation in the classroom. Third, the individual lessons are planned to commence threads of thought and inquiry not to conclude and summarize understandings.

The objectives of this unit are listed below.

> To lead pupils to become aware of the relativity of their simple observations to position and motion.
>
> To wonder whether there might be ways of determining the "real" motion of objects.
>
> To encourage pupils to develop and test ideas for making such determinations.
>
> To enable them to understand better the full meaning of the Theory of Relativity at a later time.

[83] Variation and Measurement, op. cit., p. 5.

To allow pupils to re-examine the motion of change for change is not so easy to recognize as it may appear to be.

To help children deal with such situations by encouraging them to think about an artificial observer called Mr. O.

To encourage children to separate the objects in the system under study from everything else.

To teach children how to analyze changes more objectively.

To give the pupils opportunities for describing the behavior of moving and stationary objects.

To develop the concept of geometrical arrangement of objects.

To understand the symmetry of systems.

To point out the use of coordinates to locate points relative to a reference frame.

To encourage children to report their observations frankly.[84]

This unit as well as the others in the development of the Science Curriculum Improvement Study provides for many kinds of activities--teacher demonstration, pupil experiments, readings, interpreting illustrations, solving problems, discussions, etc.[85] Much of the work is designed to lead the children to examine critically any impressions they have and to make the learning experiences fun for them and the teacher.

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[84] Relativity of Position and Motion, trial edition, Science Curriculum Improvement Study (Berkeley: University of California, 1964), pp. 1-8.

[85] Ibid., p. 9.

Teachers should remember that the emphasis in the study is upon (a) an analytical approach by the child, (b) reporting by the child of observations he ascribes to Mr. _O_, (c) verbalization by the pupil when he is ready, (d) patience with the experiments, the children, and themselves. Teachers should keep a record of particularly good and particularly inept contributions in _a_ and _c_ to help improve this teaching program, and also make a note of experiences which are either especially rewarding or especially frustrating.[86]

The overall objective of SCIS is the advancement of scientific literacy. The program is based on certain ideas as to the nature of the learning process. The creative work of science is based on an interplay of observation and interpretation that shape one another and lead to improved understanding of natural phenomena. Observation and interpretation must be related in a similar way in the science program, in the children and later in the adults if they are to share in the understanding of natural phenomena. Letting the children observe without suggesting interpretations is not adequate; similarly, it is unsatisfactory to force interpretations on children without an adequate observational background.[87]

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[86] _Relativity of Position and Motion_, _op. cit._, p. 13.

[87] Robert Karplus, _Science in the Elementary School_, an address, A Conference on the New Developments in Elementary School Science, Oklahoma City, Oklahoma, sponsored by The Frontiers of Science Foundation (Feb. 27, 1964), pp. 12-13.

<u>AAAS Commission on Science Education</u>

This study was developed by a committee of the American Association for the Advancement of Science (AAAS). In its early deliberations, guided by recommendations of the conferences held in the summer of 1962, it was decided that the Commission could contribute to the improvement of science in the elementary school by development of an experimental program for science in grades Kindergarten through sixth which would have as a primary objective the teaching of the processes of science. The development of this sequence has been the major effort of the Commission to date.

There was consensus among the committee participants that science instruction in the elementary and junion high schools should deal in an organized way with science as a whole, rather than with the separate scientific disciplines. They also agreed that there should be a planned, cummulative program from the kindergarten through the junior high school. Science teaching at these levels should emphasize the discovery approach, it was agreed, to enable pupils to learn methods of observations and interpretations of data at the time they learn content.[88] Course materials have been developed as a series of teacher guides under the title <u>Science-A Process Approach</u>.

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[88]<u>Current Curriculum Studies in Academic Subjects</u>, prepared by Dorothy M. Fraser (Washington, D. C.: National Education Association, 1962), p. 25.

The philosophy underlying the new program is quite different from the conventional elementary programs. Here the assumption is made that science is much more than an encyclopedic collection of facts and that children in the primary grades will derive much benefit from experiences which will enable them to acquire the use of certain processes which are essential for the learning of science.[89] In these grades the processes listed below are separately labeled threads in the sequence.

Recognizing Space/Time Relations

Recognizing Number Relations

Observing

Classifying

Measuring

Communicating

Inferring

Predicting

In the intermediate grades the children should acquire the use of more complex and integrated process abilities which are an extension and an elaboration of the process skills developed in the primary grades. The following are the kinds of integrated scientific processes stressed in the intermediate grades.

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[89] Science-A Process Approach, Commentary for Teachers, Commission on Science Education (Washington, D. C.: American Association for the Advancement of Science, 1964), p. 18.

Formulating Hypotheses

Making Operational Definitions

Controlling and Manipulating Variables

Experimenting

Formulating Models

Interpreting Data[90]

> The task analysis charts provide a hierarchy of behavioral tasks for the processes listed. Each process hierarchy of learning sets identifies the dependence that exists among behaviors making up that process. The studies of Gagne have shown that the attainment of each of the "subordinate" objectives by the learner is an event which makes a highly dependable prediction of the next highest related performance in the hierarchy. If the learner attains the objectives subordinate to a higher objective, his probability of learning the latter has been shown to be very high; if he does not acquire the behavior associated with one or more of the subordinate objectives, his probability of learning the higher one drops to zero. From this point of view, the entire experiment can be characterized by such a collection of sequences, one building upon another, until the terminal performances are achieved.[91]

In the Process Approach the child is made aware of some of the processes which will help him develop or clarify many important concepts relating to the world around him. Many of these ideas are profound, but the child, even on the elementary level, can be helped to understand even profound ideas if he can be made to feel that he lives in a world of wonder that is exciting to explore. The child enjoys using his mind when ideas are presented to him in a good learning

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[90] Science-A Process Approach, op. cit., p. 31.

[91] Ibid., p. 32.

sequence and when a desire to learn has been created in him.[92]

Careful analysis of the objectives and content found in the newer developments in elementary school science showed that the objectives are process-centered and are consistent with the structure of the content. The objectives and content are presented in a manner that will develop the pupil's rational powers, thus achieving the central purpose of American education.

Objectives of Science Units or Lessons Given by Teachers Using the Newer Developments in Elementary School Science

Two of the elementary schools used in this study utilized the newer developments in elementary school science. In fact, there were only two schools using these newer developments in Oklahoma.

Since the objectives contained in the material were consistent with the content and since the objectives given by the teachers using these materials were in agreement with the content, the superiority of the newer approach over the conventional can best be demonstrated by the objectives given by these teachers and the implementation of these objectives.

Table 9 represents the objectives and purposes of units or lessons as stated by the teachers using the newer materials. The example below illustrates how the

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[92] Science-A Process Approach, op. cit., p. 28.

discovery-approach requires students to think critically.

Objective: To allow children to discover fundamental properties of solution.

Implementation: The basic materials are provided for the students; not all of them are provided because as he progresses with the experiment, he will discover the need for others. There is a general class discussion concerning the problem. Through observation, experimentation, collection, and analysis of data, hypothesizing, and generalizing, the students, guided by the teacher, discover the properties of some familiar solutions which lead to the formulation of scientific concepts of solutions. This is the discovery approach. This is how scientists acquire knowledge. Based on the conventional approach, implementation would provide the students with a list of all the materials needed for this experiment. The properties of solutions would be given. The procedure for carrying out the experiment would be outlined in detail, and the expected results and concepts would be stated. This just is not the way to learn science.

Based upon the analysis of materials used to teach elementary school science and activities observed in the schools using these materials, the investigator has concluded that the discovery approach, as demonstrated by the newer developments in elementary school science, is far superior to the conventional materials in elementary school science which are factually-centered.

TABLE 9

PURPOSES OF SCIENCE UNITS OR LESSONS GIVEN BY TEACHERS USING THE NEW DEVELOPMENTS IN ELEMENTARY SCHOOL SCIENCE

Kindergarten

To learn to identify objects by sight, color, odor, and weight.

To help children discover or have an awareness of gases.

First Grade

To allow pupils to discover similarities and differences in metals and to become aware of the properties of different metals.

To understand the concepts of systems of allowing the pupils to experiment with the three basic colors--red, blue, and yellow--plus water.

Second Grade

To learn to observe and group objects according to their properties such as texture, size, and color.

To help students identify objects and the properties of objects apart from other abstractions.

Third Grade

To give the pupils an understanding of moving as a change in position.

To acquaint the students with the many different kinds of minerals and allow them to group the minerals according to their properties.

Fourth Grade

To understand variation in measurement by constructing and explaining a histogram.

Fifth Grade

To allow children to discover fundamental properties of solutions.

TABLE 9--Continued

To observe that a change occurs in making a solution.

Sixth Grade

To invent concepts of temperature; to learn the value and use of thermometers; and to understand variation in measurement.

Chapter V shows in more detail the total picture of the status of elementary school science in Oklahoma.

Summary

The conventional material in elementary school science is fact-centered. The objectives of these materials, however, are process-centered, which means that the material as presented in the books does not achieve the objectives. The objectives given by the teachers using these materials are strictly content-centered. This demonstrates the fact that in order to use these materials the objectives must be consistent with the manner in which the content is presented. Since the majority of the experiments in these books is of the "cookbook" type, it is only natural for teachers to develop content-centered objectives. The objectives stressed in the teacher-education survey were mostly process-centered; therefore, the elementary school teachers of science are neither accomplishing the objectives stressed by colleges and universities nor the author-stated objectives emphasized in the materials they are using or colleges are not achieving their purposes. They say process, but are teaching content.

In the conventional materials, all of the facts which the student is expected to learn are given. All the student has to do is to follow the text to the letter and memorize the facts. This is not the way to learn science. The materials and the way they are presented offer no opportunity for the student to develop his rational powers.

The newer developments in elementary school science are process-centered, and the content is presented in such a manner that the objectives can be readily achieved. The objectives given by the teachers using these materials were also process-centered and were in agreement with the objectives stressed in the material they were using. The newer materials offer the students an opportunity to develop their rational powers, thus enabling them to achieve the central purpose of American education. These materials offer the student experiences which require him to observe, experiment, hypothesize, generalize, collect data, analyze, form concepts and conclusions. This opportunity is not provided in the conventional material.

CHAPTER V

OBSERVATION OF SCHOOLS AND CLASSROOM PROCEDURE USING "CONVENTIONAL" AND "NEW MATERIALS"

The investigator visited thirty elementary schools in Oklahoma and observed sixty-six classroom lessons in science for this portion of the research. The purpose of the research was to determine the status of elementary school science in this state and to compare these findings with the teacher-education survey discussed in Chapter II. The elementary schools used in this study ranged in number of personnel from two to twenty-six teachers and from sixty-three to 750 in number of students. The schools were located in small, medium, and large districts.

Interviews with Thirty Principals

Interviews were held with the principal of each school in order to gain information concerning the structure of the science program and to get a general view of the entire school program.

The schools varied in their physical plants from very modern and up-to-date science facilities to very antiquated with no science facilities. Over-crowded classrooms were noted in ten of the schools visited. Practically all of the classes were self-contained. Twenty-nine of the principals were teaching principals, and four of these taught science. Only sixteen of the sixty-four teachers had specialized in science, and they were teaching in thirteen of the thirty schools used in the survey.

All of the principals indicated that science experiences were an integral part of the total elementary school program. Seventeen of the principals stated that very little science was being taught in grades one through three, but added that emphasis was placed in that area in grades four through six.

Only ten of the thirty principals pointed out that the elementary school science programs were an integral part of the science program for kindergarten through twelfth grade. This lack of coordination that exists between many of the elementary and secondary schools is, to a large extent, responsible for schools failing to provide the types of experiences in science that meet the needs and interests of the children. The investigator saw a dire need for a well-coordinated program in science for grades kindergarten through twelve. The administrative role is of vital importance in coordinating such a program. Eight of the ten principals who indicated that lack of coordination existed in their schools expressed a desire and a need to plan their science programs with the secondary schools.

Consultant help in science was available to teachers in eleven schools surveyed in the study. One school received assistance from a college professor trained in science; six received help from a central office; four consulted high school science teachers. Ten of the eleven schools indicated that the amount of help received from consultants was extremely limited. In reality, competent consultants are needed in every school. Qualified consultants could do a great deal to bring about the needed coordination between the elementary and high school science programs.

In-service science education programs were in operation in sixteen of the schools. Without exception, the principals agreed that an in-service program should be well-organized, well established, and well staffed by competent people who understand the needs of the teachers, the students, and the community. The two schools using the new developments in elementary school science had an in-service program that was designed to acquaint their teachers with these newer developments. The principal of one of the schools had attended a seminar in New Developments in Elementary School Science; therefore, she served as the leader of their in-service program. The program was conducted for one semester prior to its introduction in the classroom. Although all of the teachers in the school had received the same type of basic education in school as had other teachers in this study, the investigator observed that the teachers from this school had little difficulty in using the discovery approach to teaching. The second school using the newer developments also had an in-service program. In this instance, however, the school had employed a staff member who was well-trained in this area, and she served as both a leader in the in-service program and as a consultant. The major concern here is to point out that the use of the newer developments can be achieved through in-service programs, seminars, and/or qualified consultants.

Teaching units were used in twenty-three of the thirty schools visited. These units followed the adopted materials rather closely in most of the schools.

Interviews with Elementary School Teachers

Interviews were held with sixty-four elementary school teachers for the purpose of obtaining the following information:

1. Grade taught
2. College or university attended
3. Courses taken in science and methods of teaching science
4. Purpose of the present unit or lesson
5. Content being taught
6. Teaching methods used

Of the sixty-four teachers interviewed, forty-nine were females and fifteen were males. These teachers received their education as indicated in the table below.

TABLE 10

TEACHER EDUCATION

Type of Institution	Number Attending
State Universities	14
Private College or University	8
Teacher Education Institutions	42
Total	64

Only nine of the sixty-four teachers had taken a course in science especially designed for elementary school teachers, and everyone of these nine stated that the course was taken after they had completed their first degree. This clearly indicates that the types of experiences in science that the teachers had during their college training did not meet their needs. Furthermore, it shows that teachers find the discovery method of teaching better meets the needs and interest of the children than does the conventional method.

Five of these teachers are teaching in the schools using the conventional science books, but in their particular classes, emphasis is being placed upon the discovery approach. The other four teachers are teaching in the two schools using the new developments in elementary school science.

Only thirty-nine of the sixty-four teachers had taken a course in the methods of teaching science. This writer considers this a definite weakness on the part of the teacher as well as the teacher-education program. Methodology is highly important and all elementary school teachers should be required to take such a course in the methods of teaching science.

The summation of Tables 11, 12, and 13 indicates that the majority of the sixty-four elementary school teachers in this study took their science requirements in one or more of the following eight areas: biological science (general), chemistry, zoology, botany, geography, physics, geology, and physical science (general). The other courses were taken mainly because of special interest in a particular area. The data clearly show that, on an average, these teachers have taken more courses in science than was required or recommended in the teacher education survey. This can be explained by virtue of the fact that the majority of these teachers have taken additional courses in science since they were graduated from college. The teachers who had taken additional courses in science pointed out that after teaching science at the elementary school level, they felt the need for additional training. They thought that the college training they received was not sufficient to enable them to teach science as it should be taught. The basic reason for this, according to them, was that they were unable to use their college experiences in science in their classrooms. This throws doubt on

TABLE 11

COURSES TAKEN IN SCIENCE BY 14 ELEMENTARY SCHOOL TEACHERS WHO ATTENDED STATE UNIVERSITIES

Courses	No. Taking Course	Range in Credit Hours	Average in Credit Hours
Astronomy	4	2-5	4
Botany	5	3-9	5
Biological Science (Biology)	4	8-67	21
Chemistry	4	4-23	12
General Science	0		
Geology	10	3-8	6
Geography	7	3-9	5
Meteorology	1	0-4	4
Natural History	1	0-4	4
Natural Science	0		
Oceonography	0		
Physical Science	3	3-6	4
Physics	5	4-65	17
Zoology	3	4-14	9
Workshop in Elementary School Science	2	4-8	6
Seminar	2	0-2	2

TABLE 12

COURSES TAKEN IN SCIENCE BY 8 ELEMENTARY SCHOOL TEACHERS WHO ATTENDED PRIVATE COLLEGES OR UNIVERSITIES

Courses	No. Taking Course	Range in Credit Hours	Average in Credit Hours
Astronomy	0		
Biological Science (Biology)	7	3-20	8
Botany	2	4-18	11
Chemistry	4	3-16	11
General Science	1	0-9	9
Geology	2	3-4	3
Geography	3	6-13	9
Meteorology	0		
Natural History	0		
Natural Science	0		
Oceonography	0		
Physical Science	4	3-6	4
Physics	0		
Zoology	5	3-8	8
Workshop in Elementary School Science	1	0-6	6

TABLE 13

COURSES TAKEN IN SCIENCE BY 42 ELEMENTARY SCHOOL TEACHERS WHO ATTENDED TEACHER EDUCATION INSTITUTIONS

Courses	No. Taking Course	Range in Credit Hours	Average in Credit Hours
Astronomy	0		
Biological Science (Biology)	28	2-32	5
Botany	22	1-8	4
Chemistry	29	3-21	6
General Science	8	2-18	5
Geology	11	2-12	4
Geography	16	2-8	3
Meteorology	0		
Natural History	8	2-12	5
Natural Science	4	3-8	5
Oceonography	0		
Physical Science	16	2-6	3
Physics	19	2-8	3
Zoology	22	2-33	7
Workshop in Elementary School Science	2	4-8	6
Seminar	2	0-2	2

the college statements that they are teaching process. The taking of additional courses in science, however, did not solve their problems.

As was mentioned before, the teachers in the two schools using the new developments in elementary school science made use of the in-service education programs, seminars, and consultants to become acquainted with these new developments. From the types of activities observed in these classrooms, the problem of teaching elementary school science has been solved for them. The investigator has concluded that it is not the addition of more courses in science that is needed, but rather a complete familiarity with the new approach to teaching science--the discovery or inquiry method.

The content being taught by the sixty-four teachers fell into four broad areas. Below is a summation of the areas and the number of class periods observed in these areas.

Content Area	Number of Class Periods
Biological Science	20
Physical Science	31
Earth-Space Science	10
Meteorology	5
Total	66

The above data show that physical science activities are in the majority. Student interest is high in this area.

The data in Table 14 indicate a variety of teaching methods used by the elementary school teachers. The types of methods being used are consistent with the types the colleges and universities used in this study say they are stressing. Exceptions to this include discussion, individual projects, group projects, and reading. These were used widely by the elementary school teachers in this survey. The latter were not stressed in the teacher education survey.

TABLE 14

TEACHING METHODS USED BY 64 ELEMENTARY SCHOOL SCIENCE TEACHERS IN OKLAHOMA

Methods	Number of Teachers Using Method	Percent of Teachers Using Method
Lecture	20	30
Laboratory	27	41.4
Demonstration	33	50.7
Discovery or Inquiry	12	18
Field trips, films, filmstrips, models, and specimen	32	49.2
Educational T. V.	6	8
Team Teaching	0	0
Programmed Learning	0	0
Discussion	64	100
Individual Projects	29	44.6
Group Projects	28	43.7
Reading	37	56.8
Science Records	3	4.6

The discovery or inquiry method was used extensively by only two schools in the state of Oklahoma. The use of discovery was observed, to a limited extent, in several of the schools using the conventional elementary school science materials.

It should be noted that in all classes the students were encouraged to participate in discussions. This affords the students opportunities to express their own ideas concerning the content of the lesson or phenomenon they may have observed outside the classroom. This was one of the most rewarding experiences of the investigator because the students demonstrated that they have a natural tendency to discover. This was evidenced by the types of questions that arose during the discussion periods. Pupils wanted to know the "how" and "why" of things, not as indicated in the books but by methods or techniques of their own. This gave substantial proof that the newer developments will meet this challenge of students.

Demonstrations were given by a large number of teachers, especially where facilities and space were limited. A number of teachers allowed the students to give demonstrations either as groups or individuals. This allowed the student to gain some science experiences, even under crowded conditions. Regardless of the condition of the classroom, group activity proved to offer an excellent opportunity for the students to learn science.

Educational T. V. as presented in the elementary grades consisted of lectures and demonstrations. These sessions were followed by a class discussion with the teacher. An introduction was made before the program. The students showed very little interest in the science programs on T. V. This investigator attributed this to the fact that the lecturer did not follow materials and/or that little time was alloted for the students to experiment. Most teachers would provide a better program in science without the aid of the television science programs.

Table 15 lists the twenty-six items that were used to evaluate sixty-six classroom activities in elementary school science. The numbers in parentheses represent the evaluation of the science classes observed in the two schools using the new developments in elementary school science. It is evident, according to the data obtained for each item in the check list, that the new developments in elementary school science are superior to the conventional materials. It also shows that teachers who have been trained to teach the conventional materials and have utilized these materials for years can master the new method of teaching science with little difficulty. The data indicate that reform in elementary school science is needed in the state of Oklahoma, and further analysis of the data indicates that a possible solution could be found in utilizing the new developments in elementary school science. The teachers and students in the two schools using these newer programs have found them to be most rewarding. It appears that the newer developments train the students to use their rational powers; thus, they are achieving the central purpose of American education.

TABLE 15

OBSERVATION FINDINGS OF 66 ELEMENTARY SCHOOL SCIENCE CLASSROOM ACTIVITIES IN 30 ELEMENTARY SCHOOLS

The column headings and their meanings are listed below.

N--No opportunity to observe
M--Missing and needed
1--Exists to a limited extent
2--Exists to a considerable degree
3--Exists extensively

Check List	Evaluation				
	N	M	1	2	3
1. The inquiry or discovery teaching method is used.		41	11	2	(12)*
2. Opportunities are provided for pupils to experience discovery.		32	17	5	(12)
3. The new developments in elementary school science are used.		54			(12)
4. The teacher is familiar with the new developments in elementary school science.		31	21	1	1 (12)
5. Appropriate facilities for the program being used are made available for children to study science.		17	20	16	1 (12)
6. A variety of science textbooks and reference materials is available to provide for diffeences in reading abilities and science backgrounds of pupils.		15	22	12	5 (12)

TABLE 15--Continued

Check List	Evaluation				
	N	M	1	2	3
7. In terms of the program being used, opportunities are provided for sufficient variations in experience and materials to meet individual differences, needs and interests.		11	27	10	6 (12)
8. Children are given an opportunity to develop the ability to solve problems by applying appropriate processes to problems at their level.		15	21	14	4 (12)
9. In terms of the program used, appropriate classroom use is made of both human and material resources of the community.		5	20	16	13 (12)
10. Opportunities are provided for appropriate mutual effort between pupils and teachers for exploring, selecting, and planning science activities.		9	23	16	6 (12)
11. Opportunities are provided for participation and problem solving by individuals or groups.		6	28	(2) 18	2 (10)
12. Children show an interest in science.			8	(2) 27	19 (10)
13. Children's interests and concern in science are considered by the teacher and used in developing understandings in science.		4	15	(2) 22	13 (10)

TABLE 15--Continued

Check List	Evaluation N	M	1	2	3
14. Actual science experiences for the children are considered to be paramount.		8	18	(2) 21	7 (10)
15. Pupils are free to explore and use the resources of the classroom.		13	19	(2) 18	4 (10)
16. Children have many opportunities to handle the equipment, apparatus, and materials of science.		13	27	(2) 10	4 (10)
17. Pupils exhibit a growing awareness and appreciation of natural laws, and scientific principles and their application to daily living.		11	28	(2) 12	3 (10)
18. Students learn to think by defining problems, gathering evidence, stating hypotheses, and verifying their findings and generalizations.		14	26	(2) 9	4 (10)
19. In terms of the science program, students show evidence of growing in knowledge of the content of elementary school science.		4	18	(2) 25	7 (10)
20. Students show evidence of memorizing facts.		(8)**	(4) 12	11	31
21. Science concepts are understood rather than verbalized.		6	37	(3) 12	(9)
22. The classroom teacher is informed, resourceful, and enthusiastic.			16	(3) 21	17 (9)

TABLE 15--Continued

Check List	N	M	1	2	3
23. Sufficient time allotments are made for science study.		17	20	13	4 (12)
24. The science experiences that the children have contribute to the goals of the overall program.		5	19	26	4 (12)
25. Classroom activities show promise for developing the highest quality of which the children are capable.		5	29	14	6 (12)
26. Learning activities provide for the development of both the products and the processes of science.		8	31	(2) 9	6 (10)

*The numbers in parentheses represent the evaluation of the science classes in the two schools using the new developments in elementary school science.

**Missing but not needed.

CHAPTER VI

CONCLUSIONS, RECOMMENDATIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

Conclusions

Based on the data collected from ninety-five colleges and universities, no definite trends were established for programs in science for elementary school teachers. Forty-seven of these institutions offered courses especially designed for elementary school teachers and forty-eight require that the students take their requirements in science from the regular science curriculum.

It was concluded that the majority of the institutions agreed that from eight to twelve hours in science should constitute the credit requirement. The study showed that the sixty-four elementary school teachers in Oklahoma used in this study had, on an average, more credit hours in science than is required or recommended by the institutions mentioned above.

The lecture-laboratory, lecture-demonstration, and discussion teaching methods were mainly used in the courses in science taken by elementary school teachers. These same methods were used by the elementary school teachers in this study. It was noted in the elementary school, however, that heavy emphasis was placed on individual projects, group projects, and reading, which were used in place of the laboratory. The discovery or inquiry method of teaching was used to a limited extent both by the college professors in all institutions surveyed and by the elementary school teachers using the conventional and content science materials. Discovery was used extensively by the teachers in the two elementary schools using the new developments in elementary school science.

The investigator was told that heavy emphasis was placed on the discovery approach in the Methods of Teaching Science Courses. Evidence of this, however, was not noticed in twenty-eight of the elementary schools visited in this study.

The objectives of the science courses offered by the colleges and universities for elementary school teachers were, for the most part, process-centered. The objectives of elementary school science given by the elementary school teachers were strictly factual-centered.

The conventional series of elementary school science textbooks analyzed in this study contained process-centered objectives, but the structure of the books was factual-centered; therefore, the objectives of these books could not be achieved.

The objectives of the new developments in elementary school science were process-centered, and the material, as presented, achieved its objectives. The goals of the new developments in elementary school science were centered upon the development of an understanding of the nature of science, its modes of inquiry, and its conceptual inventions, the understanding of natural phenomena, and the place of science in the activities of man. The achievement of these goals would result in a student who is literate in science and one who is capable of a citizen's participation in a science orientated society. The major concern of the new developments in elementary school science is developing rational powers.

The majority of the elementary school teachers were enthusiastic, but insufficient time allotments for science instruction, inadequate facilities, lack of space, and a need to be informed of the current trends in elementary school science made it impossible for classroom activities to develop the highest quality of learning in science of which children are capable.

The majority of the elementary school teachers were not familiar with the new development in elementary school science.

Appropriate facilities, textbooks, and references were not available for the majority of schools surveyed in this study.

Human and material resources of the community were widely used.

The majority of the elementary school children showed evidence of memorizing facts; therefore, they failed to understand many of the basic science concepts. This situation was not noted in the schools using the new developments in elementary school science. The majority of these students had memorized less scientific facts and understood far more basic science concepts.

Based upon the findings in this study, it is concluded that drastic, but constructive, changes in elementary school science education and teacher education are in order. This constructive change can be found by utilizing the new developments in elementary school science. The conventional materials need to be completely revised, if not excluded.

Recommendations

Based upon the conclusions drawn from this study, the following recommendations are made.

1. Colleges and universities offering programs in science for elementary school teachers should offer courses in biological, physical, and earth science which are process-centered. This would give the elementary school teacher the type of experiences necessary to teach elementary school science to allow children to derive maximum value from it.

2. Administrative personnel in elementary schools

should give thoughtful consideration to the new developments in elementary school science--examine, compare, and investigate from every possible point of view--because they have been proven to be superior to the conventional materials in elementary school science in that they develop rational powers.

3. Well-organized in-service education programs in elementary school science and competent consultants should be made available for all elementary school science teachers. They have been found to be effective in acquainting teachers with the new developments in elementary school science and their uses.

4. A well-coordinated science program should be formulated for grades kindergarten through twelve. This would better meet the needs and interests of children.

Suggestions for Future Research

This investigator feels that an evaluative instrument for the newer developments in elementary school science should be constructed. Such an instrument should adequately determine the scientific knowledge gained by children in grades one through six from these programs in order to evaluate thoroughly these "newer" developments as compared with the conventional science materials.

Research should be conducted to develop college courses in science which are process-centered.

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APPENDIX 1

QUESTIONNAIRE USED FOR TEACHER EDUCATION SURVEY

Please complete the following questions and return to

W. D. Moorehead
532 Constitution Apt. 9
Norman, Oklahoma

I. Does your institution offer courses in science especially designed for elementary school teachers?

Yes_____ No_____

If the answer is "Yes," please complete the following table.

Science Dept. in which course is given	Course title	Pre-requisites	Cr. hrs.	Textbook Used
1.				
2.				
3.				
4.				
5.				

II. If the answer to question number one was "no," please list those courses in science from the regular science curriculum which are required of elementary school teachers.

1.

2.

3.

4.

5.

III. Please indicate the teaching methods used in the courses in science taken by elementary school teachers.

IV. Please complete the following with reference to the science courses offered for elementary school teachers.

A. Major objectives of each course.

B. Major concepts of science students are expected to learn.

C. Principle units of study in each course.

V. Please indicate the degree to which the following are emphasized in the courses in the Methods of Teaching Science offered for elementary school teachers. Use the following scale: Very much--3; Some--2; Little--1; None--0.

1. Is the inquiry or discovery teaching method emphasized? ______

2. Are opportunities provided for students to experience discovery? ______

3. Is the importance of science in elementary school education emphasized? ______

4. Are the new developments in elementary school science analyzed and compared? (Example, Science Curriculum Improvement Studies, University of California) ______

5. Are the contributions that science makes to the overall educational growth of the child emphasized? ______

6. Does work in the laboratory provide opportunities for students to relate science concepts, inquiry processes, observations, and experimentation? ______

7. Is the importance of laboratory planning and procedure stressed? ______

VI. If the curriculum in science for elementary school teachers has undergone changes in recent years, please list those factors which were responsible for bringing about these changes.

APPENDIX 2

AN EVALUATION OF THE STATUS OF ELEMENTARY SCHOOL SCIENCE AND HOW IT IS TAUGHT IN THE ELEMENTARY SCHOOLS OF OKLAHOMA

I. Interview with principal:

1. Principal____

2. School____

3. Location____

4. Number of teachers_______ Number of students______

5. Number of teachers who specialized in science______

6. Science is offered in the following grades:

   Kindergarten________
   First Grade_________
   Second Grade________
   Third Grade_________
   Fourth Grade________
   Fifth Grade_________
   Sixth Grade_________

7. Science experiences are an integral part of the total elementary school program. Yes____ No____

8. Elementary school science is an integral part of the total elementary and secondary school science program. Yes____ No____

9. Consultant help in science is available to the teachers. Yes____ No____

   If yes please state source.__________________________

10. In-service education programs are developed to help teachers become more competent in science teaching.
Yes____ No____

11. Teaching units are used.
Yes____ No____

If "yes," what areas of science are covered?

II. Interview with science teacher:

1. Sex: Male____ Female____ Grade taught__________

2. School Attended________________________________

3. Courses taken in science:

Courses	Credit Hours
1. Astronomy	
2. Biological Science (Biology)	
3. Botany	
4. Chemistry	
5. General Science	
6. Geology	
7. Geography	
8. Meteorology	
9. Natural History	
10. Natural Science	
11. Oceonography	
12. Physical Science	
13. Physics	
14. Science for Elementary School Teachers	
15. Zoology	
16. Other	

4. Were the courses taken especially designed for prospective elementary school teachers?
Yes____ No____

5. What is the purpose of the present unit?

6. Content being presently taught.

7. Teaching methods used:

   a. Lecture only____________

   b. Lecture-laboratory________

   c. Lecture-demonstration_____

   d. Discovery or inquiry______

   e. Field trips, films, filmstrips, models and specimens utilized________

   f. Closed circuit T V________

   g. Team Teaching____________

   h. Programmed Teaching_______

   i. Discussion________________

   j. Individual projects_______

   k. Group projects____________

   l. Combinations of the above ____________________

   m. Other____

III. Observations of classroom activities

The column headings and their meanings are:

N--No opportunity to observe
M--Missing and Needed
1--Exists to a limited extent
2--Exists to a considerable degree
3--Exists extensively

Check List	Evaluation N	M	1	2	3
1. The inquiry or discovery teaching method is used.					
2. Opportunities are provided for pupils to experience discovery.					
3. The new developments in elementary school science are used.					
4. The teacher is familiar with the new developments in elementary school science.					
5. Appropriate facilities for the program being used are made available for children to study science.					
6. A variety of science textbooks and reference materials is available to provide for differences in reading abilities and science backgrounds of pupils.					
7. In terms of the program being used opportunities are provided for sufficient variations in experience and materials to meet individual differences, needs and interests.					
8. Children are given an opportunity to develop the ability to solve problems by applying appropriate processes to problems at their level.					
9. In terms of the program used appropriate classroom use is made of both human and material resources of the community.					
10. Opportunities are provided for appropriate mutual effort between pupils and teachers for exploring, selecting, and planning science activities.					
11. Opportunities are provided for participation and problem solving by individuals or groups.					
12. Children show an interest in science.					

Check List	Evaluation N	M	1	2	3
13. Children's interests and concern in science are considered by the teacher and used in developing understandings in science.					
14. Actual science experiences for the children are considered to be paramount.					
15. Pupils are free to explore and use the resources of the classroom.					
16. Children have many opportunities to handle the equipment, apparatus, and materials of science.					
17. Pupils exhibit a growing awareness and appreciation of natural laws, and scientific principles and their application to daily living.					
18. Students learn to think by defining problems, gathering evidence, stating hypotheses, and verifying their findings and generalizations.					
19. In terms of the science program students show evidence of growing in knowledge of the content of elementary school science.					
20. Students show evidence of memorizing facts.					
21. Science concepts are understood rather than verbalized.					
22. The classroom teacher is informed, resourceful, and enthusiastic.					
23. Sufficient time allotments are made for science study.					
24. The science experiences that the children have contribute to the goals of the overall science program.					
25. Classroom activities show promise for developing the highest quality of learning in science of which the children are capable.					
26. Learning activities provide for the development of both the products and the processes of science					

Comments:

APPENDIX 3

LETTER ACCOMPANYING QUESTIONNAIRE FOR

TEACHER EDUCATION SURVEY

532 Constitution Apt. 9
Norman, Oklahoma
December 2, 1964

Dear Professor:

One of the phases of a research project in which I am currently engaged is gathering data concerning the courses in science and the methods of teaching science taken by elementary education majors in selected colleges and universities in the United States. The information obtained from the questionnaires will be used to prepare my doctoral dissertation which is in the general area of elementary school science. This study is being done under the direction of Dr. John W. Renner, Associate Professor of Education and Chairman of Science, University Schools, University of Oklahoma.

Would you please complete and return the enclosed questionnaire?

A self-addressed, stamped envelope is enclosed for your convenience.

Thank you for your assistance.

Sincerely yours,

W. D. Moorehead

APPENDIX 4

FOLLOW-UP LETTER TO COLLEGES AND UNIVERSITIES

532 Constitution Apt. 9
Norman, Oklahoma
January 14, 1965

Dear Professor:

Recently you received a questionnaire requesting information about the courses in science and methods of teaching science studied by future elementary school teachers. Over 60 per cent of the institutions requested to participate in this research have replied.

I am eager to have your institution represented in this study. Won't you please complete and return the enclosed questionnaire?

Sincerely,

W. D. Moorehead

APPENDIX 5

LETTER OF TRANSMITTAL TO ELEMENTARY SCHOOL PRINCIPALS IN OKLAHOMA

As part of his work in fulfilling the requirements for the doctorate in science education at the University of Oklahoma, Mr. William D. Moorehead is engaged in a research project to determine the status of elementary school science and how it is taught in the elementary schools of Oklahoma.

In order for him to obtain valid data, it is necessary that Mr. Moorehead visit a number of elementary classrooms during the science period. Would you please return the enclosed postcard indicating whether or not you would be willing to have Mr. Moorehead visit your school. If you can assist us, please indicate the hours of the day science is taught in the classes in your school.

Thank you for your consideration.

Sincerely,

John W. Renner
Associate Professor
of Education and
Chairman of Sciences
University Schools

APPENDIX 6

FOLLOW-UP LETTER TO ELEMENTARY SCHOOL PRINCIPALS

Recently you received a letter indicating that Mr. William D. Moorehead is engaged in a research project to determine the status of elementary school science and how it is taught in the elementary school of Oklahoma.

We are eager to have your school represented in this study. Would you please return the postcard sent to you and indicate whether or not you would be willing to have Mr. Moorehead visit your school during the science class periods.

Thank you for your consideration.

Sincerely,

John W. Renner
Associate Professor
of Education and
Chairman of Sciences
University Schools

APPENDIX 7

DEFINITION OF TERMS

For the purpose of this study, terms are defined as follows:

Ability--The power to respond and to produce in certain situations. It is developed with training and experience and is broader than a skill.

Achievement--The mastery or output of a student in information or skills.

Action Research--Research by a school's faculty, usually to evaluate and objectify curriculum practices in their own setting.

Activities--The less formally organized portions of the curriculum, during or after school hours, usually not carrying academic credit.

Activity-Centered Unit--A unit having a minimum of teacher directed recitation, but featuring pupil activities of oral, written, and group nature.

Aims--The thinking ahead on what teachers and other educational planners wish to accomplish with themselves and their students.

Applied Science--Scientific procedures and knowledges put to use in coping with man's environment, needs, and wants.

Appreciation--A feeling, awareness, or judgment concerning the value or significance of an event, experience, or object.

Assumption--Accepting as correct without proof, a fact, theory, principle, or idea, as part of the circumstances in a given situation that is being tested or proved.

Attitude--A mind set or readiness to react to given situations in certain ways.

Basic Science--Scientific knowledge and data that must be understood and at hand in order to achieve some other desired scientific or technical goal.

Concept--A generalization growing out of recognition of a common element in a number of facts and experiences. A concept attaches meaning to learning.

Control--In an experimental situation, a factor or group which is left unchanged as a standard for comparison with a similar factor or group (called experimental) that is acted upon or treated in some way with a variable.

Creativity--The demonstration of insight and ingenuity that departs from the accepted routine.

Critical Thinking--An approach to thought characterized by caution in drawing conclusions, based upon accurate and adequate evidence.

Deductive Method--Learning based on deductive logic. It applies general laws, either discovered by induction or assumed, to the explanation of specific events.

Democratic Leadership--Leader encourages the group to select its own working partners, discuss its policies, and reach its own decisions.

Demonstration Methods of Teaching--A showing of a process or experiment, using materials or equipment by the teacher or a small group of students, to the group.

Empirical Data--Information acquired on the basis of what has been seen and experienced, sometimes on an unstructured trial and error basis.

Evaluation--A broad attempt to make sound judgment on many aspects of an educational situation, besides those that can be measured by standard tests.

Fact--A thing known to be true or to have happened.

Functional Curriculum--A curriculum aimed at usefulness in meeting life adjustment problems, in contrast to subject curriculum.

General Education--Kinds of behavior and understandings that all persons, despite their differences, need to learn to live effectively in a democratic society.

Generalization--The process of organizing a group of specific facts or information into a form that is non-specific yet applicable to a number of specific situations.

Hypothesis--A tentative conclusion or supposition.

The basis for testing a particular procedure, either by experiment or observation.

Inductive Method--Gathering of evidence, weighing of probabilities, and discarding irrelevant details in arriving at general rules according to which events occur; and the testing of hypotheses by devising suitable experiments.

Integration--(In Curriculum)--A general term, used loosely in a variety of situations. It refers to a drawing together in meaningful association the various segments of the curriculum, cutting across and often largely erasing subject lines.

Knowledge--The ability, after learning, to recall or recognize facts, objects, and places, and to establish relationships, such as date with event, and symbols with meaning.

Laboratory Technique--A learning situation in which students work individually or in small groups, using a variety of equipment and materials, for the essential purpose of understanding principles, gaining experimental evidence, solving problems and acquiring manipulative skills.

Motivation--The stimulation of activity towards a goal when previously there was little or no such behavior. Intrinsic motivation grows out of interest with the activity itself. Extrinsic grows out of outside stimulation, like marks, awards, competition, etc.

Objectivity--A point of view in which facts are weighed, and truths sought, with as much freedom as possible from opinion, emotion, and prejudice.

Pragmatic--Thinking and learning that tests results on the basis of its function in actual practice.

Principle--A generalization based upon a broad conceptualization or on several concepts.

Problem-Solving--An approach to learning, based on recognizing, analyzing, and resolving situations realistic to the experience of the learner.

Reasoning--The process of drawing conclusions or inferences from facts or other conclusions that have already been established or proved to be true.

Reflective Thinking--Active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends.

Science--A series of conceptual schemes necessarily including facts, principles, and descriptions of natural surroundings, arising out of observation and experiment, and giving rise to further observation and experiment.

Scientific Method--There is no one scientific method, but it includes any attack upon problems or barriers to knowledge that ingenuity suggests. Scientific method comprises all the operations, procedures, devices, and types of processes, by which scientists arrive at the conceptual schemes of science.

Understanding--A generalization of experience that is used as a guide to future experience. It is an outgrowth of experience, not memorization.

Values--The rules of conduct by which people shape their behavior and from which they derive their hopes.

Variables--A factor or quality that may exist in different amounts.