A STUDY OF OPEN-MINDED AND CLOSED-MINDED PRE-SERVICE ELEMENTARY EDUCATION MAJORS BEING TRAINED IN CONTEMPORARY SCIENCE METHODS

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IN CONTEMPORARY

SCIENCE METHODS

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PREFACE

The purpose of this study was to compare open-minded and closed-minded pre-service elementary education majors enrolled in a science methods course. The areas of concern under investigation were (1) achievement in science, (2) attitudes toward the teaching of science, and (3) confidence in teaching science.

I am especially grateful for the encouragement and advice given by Dr. Kenneth E. Wiggins, Chairman of the Advisory Committee, and Dr. Jacob W. Blankenship. Special thanks are also due the other members of the advisory committee: Dr. Gene L. Post, Dr. Roy W. Jones, and Dr. L. Herbert Bruneau.

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CHAPTER I

INTRODUCTION

The past decade has been one of major revisions for science education. At no time in history has so much been attempted in the field of curriculum development as during that period of time between the Russian launching of Sputnik I and the present time. Recent curriculum revisions in science were first implemented at the high school level in the academic disciplines of physics, biology, and chemistry. Now that these programs seem to be operational, the emphasis is being shifted to the development of elementary science and junior high science programs that are similar in their rationale to those developed for the high schools.

In the elementary and seoondary science programs being developed currently there is the stress of teaching for the spirit of science. The Educational Policies Commission (of the National Education Association of the United States and the American Association of School Administrators) in Education and the Spirit of Science (1) says,

> . . . a general worldwide fostering of the spirit of science is wise . . . To communicate the spirit of science and to develop people's capacity to use its value should therefore be among the principal goals of education in our and every other country.

Current literature indicates that to accomplish the goals set by science curriculum planners will require that careful attention be given to both the utilization of scientific methods of inquiry

(2, 3, 4, 5, 6, 7, 8, 9, 10, 11) and the fostering of scientific attitudes (5, 6, 8, 9, 11, 12, 13, 14, 15, 16, 17).

It is apparent that the implementation of such major curriculum revisions in a short period of time may be difficult. Several factors contribute toward making the task a difficult one in the field of elementary school science. First, there is the fact that most of the training of the vast majority of elementary teachers has been traditional; therefore, they have no experience from which to pattern this particular style of teaching. Second, one must be aware that at the elementary level one may not find teachers who have strong backgrounds or interests in the fields of science. Third, there is an assumption, which may not be true, that any teacher would be capable of teaching science that has as its goals the development of scientific methods of inquiry coupled with the development of scientific attitudes. Certainly a fourth factor would be that at the elementary level teachers now feel the great burden of teaching, and may not desire the additional task of teaching science by methods which are unfamiliar to them.

The task of training thousands of teachers at the elementary level to teach science, as conceived by the curriculum planners of the new programs, will be one that can be expected to take time; and only time will determine if the difficulties, previously mentioned, will be of serious enough nature to drastically impede the progress of the new programs.

Significance of the Study

The Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1966 (18) which is compiled jointly by the Commission on Science Education, American Association for the Advancement of Science, and the Science Teaching Center of the University of Maryland, lists fifteen elementary science curriculum studies already being developed in the United States, plus many more merely in the initial phases of organization. With such national projects being undertaken one can also anticipate a change in science textbooks, the main-stay of most science teachers. The revisions now taking place put greater emphasis upon the performance of science as processes of inquiring, problem-solving, discovering, and experiencing of science. This tends to be in contrast to the more traditional approach in elementary science. Not only does one find scientific method being stressed, but there seems to be agreement among science educators (5, 8, 9, 11, 12, 13, 14, 15, 19) and scientists (4, 16, 17, 20, 21, 22, 23, 24) alike that one of the goals of science teaching should be the development of scientific attitudes. Recurring in the lists of attitudes that operate to the advantage of a scientist is the attitude of open-mindedness. The author would hasten to mention that to refer to open-mindedness as an attitude is debatable; however, as has been pointed out by Krathwohl, et al. (25), "Every classification scheme is an abstraction which arbitrarily makes divisions among phenomena solely for the convenience of the user . . . ." A more detailed discussion of open-mindedness can be found in the section on clarification of terms, and the selected review of literature.

If open-mindedness is of importance as an objective outcome in science education, it might then be important to know to what degree open-mindedness is possessed by elementary teachers. The degree to which it is possessed by an elementary teacher might conceivably be an influencing factor on the outcomes of the program of science being developed.

This study was undertaken to determine to what degree pre-service elementary education majors who were relatively open- or closed-minded gave promise of their ability to teach science. Most of the work on the measurement of scientific attitudes (including open-mindedness), strangely enough, seems to date back to the 1930's (26, 27, 28, 29). In view of this time lag a more recent instrument was used. The investigator chose to establish the criteria of open- and closed-mindedness by using the Dogmatism Scale, Form E, developed by Milton Rokeach (30), who would have preferred to call it the "Open-Closed Belief System Scale." This particular instrument has been used extensively to identify and study those who are open-minded and closed-minded. This may seem to be an inappropriate measuring scale, at first, since open-mindedness is frequently conceived as being in the affective domain and the instrument itself is a measure of cognitive behavior. Rokeach (30:399) states, however, "that, to our minds, analysis in terms of beliefs and systems of beliefs does not necessarily restrict us only to the study of cognitive behavior . . . our cognitive approach is as much concerned with affection as with cognition." Rokeach (30:400) goes on to say that, "the traditional distinction between what is cognitive and what is affective may be a convenient one but not a necessary one." The open and closed structure of a person's belief system, rather than the specific ideological content, is measured by the Dogmatism Scale. The instrument, therefore, emphasizes how a person believes rather than what he believes. A person who has an open belief system as measured by this instrument will subsequently be referred to as being open-minded; and one that has a closed belief system, as measured by the instrument, will be referred to as being closed-minded.

If this study should show that those who are relatively more open-minded demonstrate greater promise of being capable of teaching the new programs in science than those who are relatively more closed-minded, it would then seem desirable to implement other studies in the area of specific scientific attitudes to determine the relationships of these attitudes to the teaching of elementary science.

Statement of the Problem

The objective of this study was to compare open-minded and closed-minded pre-service elementary education majors enrolled in a science methods course. The groups were dichotomized on the basis of the Dogmatism Scale, Form E, (Appendix A), an instrument designed to measure the structure of openness and closedness of individual belief systems.

Specifically, the study attempted to determine the difference between the open-minded subjects and the closed-minded subjects on the basis of:

1. Achievement in science
2. Attitudes toward the teaching of elementary science
3. Confidence in the ability to teach elementary science.

Hypotheses

Open-minded elementary education majors do not differ significantly from closed-minded elementary education majors in their science achievement, their attitudes toward the teaching of elementary school science, or confidence in their ability to teach elementary school science.

To test the null hypotheses the following questions will be answered:

1. Are the scores on a science achievement test higher for open-minded elementary education majors than the scores of the test for closed-minded elementary education majors?
2. Do open-minded elementary education majors express a more favorable attitude toward contemporary methods of teaching science than do closed-minded elementary education majors? The determination of attitude is based on the criteria of peer, self, and instructor ratings plus the results of an instrument specifically designed for the purpose of measuring for attitudes toward the teaching of elementary school science.
3. Do open-minded elementary education majors express a greater confidence in their ability to use the methods found effective in the teaching of elementary science than do closed-minded elementary education majors? An analysis will be made of the pre-test results, post-test results, and change between pre- and post-test results in the areas of:

a. Experimentation

b. Discussion

c. Observation

d. Reading.

These factors will be used to determine if there are significant differences between those who are open-minded and those who are closed-minded.

4. Do open-minded elementary education majors have greater confidence in their ability to teach biological science than do closed-minded elementary education majors?

5. Do open-minded elementary education majors have greater confidence in their ability to teach physical science than do closed-minded elementary education majors?

Limitations of the Study

1. This study, as most in elementary education, does not include the males in the class since they comprised only about four per cent of the total sample. However, it would be interesting and valuable to have studies that include male elementary education majors provided samples exist that contain sufficient numbers of males.

2. The study was limited to the degree that the investigator and the investigative instruments used could accurately assess the hypotheses in question.

3. The students spend eight weeks in taking the elementary science methods course, and this limited amount of time might influence the degree to which the hypotheses under

question could be adequately tested.

4. Finally, the subjects of the study were those enrolled in the science methods course at Oklahoma State University during the fall of 1966. The assumption that they are representative of other elementary education majors enrolled previously and to be enrolled in the future might not be true; therefore, a limitation of the study could be the fact that the sample is not necessarily representative of the total population.

Clarification of Terms

Several terms are used frequently in the study, and a basic definition of these terms is essential to the understanding of the study. An elaboration of several of the major concepts can also be found in the selected review of the literature.

New Programs in Elementary Science refers to those programs in science presently being developed on a national level by scientists and educators to update the teaching of science. Examples of these programs include Science--A Process Approach being developed under the auspices of the American Association for the Advancement of Science, the Elementary Science Study or ESS being developed by Educational Services, Incorporated, and many more programs which are described in the Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1966 (18).

Achievement in Science will be a measure of the acquisition and retention of information in science from past training and experience.

Confidence in Science Teaching Ability refers to that confidence expressed by the subjects of the study in their ability to employ the methods of experimentation, observation, discussion, and reading in the teaching of elementary school science.

Attitudes Toward the Teaching of Science refers to a generalized acceptance or rejection of the methods advocated in the newer programs in elementary school science. Such attitude is determined on the basis of four criteria: peer-rating, self-rating, instructor-rating, and a scale designed to measure how, "an individual feels about elementary school science . . ." (31).

Open-mindedness and Closed-mindedness refer to the degree to which an individual's belief system is open or closed as measured by Rokeach's Dogmatism Scale (30). A basic characteristic that defines the degree of openness or closedness of the belief system is,

> the extent to which the person can receive, evaluate, and act on relevant information received from the outside on its own intrinsic merits, unencumbered by irrelevant factors in the situation arising from within the person or from the outside. (30:57)

The term "belief system", which is basic to this definition, "is conceived to represent all the beliefs, sets, expectancies, or hypotheses, conscious and unconscious, that a person at a given time accepts as true of the world he lives in" (30:33). A system is broken down into an organization of parts that may or may not be logically interrelated. It should be stated also that it is unlikely that the mind compartmentalizes its beliefs into such systems as religious, political, or scientific; therefore, a common structural bond is seen to underlie all beliefs and disbeliefs. It is the structure of how a person believes rather than the ideological content of what he believes that is measured by the Dogmatism Scale. To be open-minded in this study means that the individual has a low score on the Dogmatism Scale, and to be closed-minded means that the individual has a high score on the Dogmatism Scale.

Open and closed are seen to be at opposite ends of a continuum; therefore, to categorize an individual in all of his beliefs as open- or closed-minded would be to establish ideal types. Ideal types, as such, do not exist since the various beliefs of individuals fall somewhere along a continuum.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Introduction

The review of selected literature for this study will be presented in three parts. The subjects of the study were pre-service elementary education majors being trained in contemporary science methods; therefore, the first section of this review presents changes taking place in elementary school science. The second section discusses the importance of attitudes in science and the teaching of science. The final section reviews literature on open-mindedness and closed-mindedness and their relationships to success in the field of science and to success in teaching.

Changes Taking Place in Elementary School Science

During the greater part of the past decade there have been many nationally sponsored curriculum improvement studies in the fields of both elementary and secondary science. Traditionally, great stress has been placed on the content of science; however, curriculum studies tend to place a greater emphasis upon the processes of science, although as pointed out by Fischler (32) the two (content and process) should not, and, in fact, cannot be separated. This section of the related literature will review certain aspects of science curriculum revisions now underway.

The individuals that are responsible for the development of the new programs have come from the fields of science and education. An example to illustrate this point is found in the ESI Quarterly Report, Spring-Summer, 1966 (33):

> Educational Services Incorporated has sought by its method of operation to recruit innovative men and women and to give them the utmost freedom in conducting their research and to provide these educators of differing backgrounds and levels of education with the maximum opportunity to work together and to test their ideas and materials in the classroom. With its own core staff of scholars, scientists, teachers, and specialists in various teaching media, ESI provides the organization and support to make this partnership of educators effective.

An attempt is being made to develop programs which not only present the "what" of science, but also present the "how" and "why" of science. By utilizing the services of scientists those "whats", "hows", and "whys" might be more in tune with the nature of science. By using the services of educators the materials should be of such a nature that children can more effectively learn from the new materials.

What then are the discernible trends or changes that will be brought about by the science curriculum improvement studies? Ploutz (34) says that the following identifiable trends are evolving:

1. Concerning Organization. Science content is being organized into larger units, samples, chapters, and kits in order to reduce fragmentation of topics.

2. Concerning Individualization. Greater emphasis is continually being placed on individual involvement and participation.

3. Concerning Content Balance. Greater emphasis is being placed on earth, space, and physical sciences in contrast to earlier domination of plants, animals, human body, and related life science topics.

4. Concerning Scope and Sequence. Several contemporary experimental programs recognize the need for greater student participation in programs and do not identify or structure their units for specific grade-age levels.

5. Concerning Textbooks. The increased desire of school districts to plan their own programs, coupled with moderate gains in teacher ability and desire to teach science, has reduced complete dependency on the use of conventional science textbook series.

6. Concerning Equipment. The present emphasis on the use of equipment in the teaching of elementary school science assures the development of a wider choice of materials—games, puzzles, kits, records, tapes, and slides.

7. Concerning Nature of Content. The trend toward still greater sophistication of elementary science is evident.

8. Concerning the Emphasis on Measurement. Increasing importance is being attached to the development of skills in measuring. Students' experience with measurement lead to the construction of scale models, charts, and graphs and to the development of other methods of recording scientific data.

NSTA (35) has indicated that the trends in elementary school science found in a science facilities study are:

1. Planning of experience in science—Such planning includes both scope and sequence of science experiences. The content of the program has been broadened with much more emphasis being given to concepts in the physical and earth sciences.

2. More adequate instructional materials in science—This is especially true of printed material. Space is needed for housing and using these materials.

3. Problem-solving activities in science—The problem-solving approach, using both materials and equipment from the pupils' own environment and commercial scientific equipment is increasingly central to the elementary science program. No longer is the cluttered table in the science corner adequate for elementary school science teaching.

4. More effective teachers and better programs for preparing teachers for elementary school science—A deeper understanding of science for children also requires a greater competence in the use of science facilities.

5. Increased specialized personnel with competence in science—Resource teachers and supervisors for elementary science are increasingly being used, often as team teachers with the classroom teachers. The effective use of such resource persons depends, in part, upon the quality and arrangement of the facilities within the elementary school.

Johnson (7), of the U. S. Office of Education, asks the question, "In what directions are our science curricular changes heading?" He then goes on to say, "Let me put my vision of these changes (I will not call them trends) into a few bold statements." These statements are:

> Change from much subject matter to relatively less subject matter.
>
> Change from one problem-solving method to many relatively unstructured methods of inquiry.
>
> Change from use of a book in a series to the use of many books.
>
> Change from an emphasis on accumulating knowledge to an emphasis on how to find out and create knowledge.
>
> Change from facts and factual concepts as instructional goal in skills in inquiry as the teaching goals.
>
> Change from teacher-selected concepts as instructional goals to concepts as they may arise in the process of confirming or rejecting hypotheses.
>
> Change from reliance on qualitative observations to more and more stress on securing and recording quantitative observations.
>
> Change from science experiences as preparation for secondary school science to experiences for basic education of all students.
>
> Change from science as something to be learned from books to science as something that grows out of a series of experiments.
>
> Change from a science program based on topics to a science program based on a more fundamental frame of reference.
>
> Change from emphasis on technology to emphasis on science.

Change from science that must be developed from a limited understanding of mathematics to science that is built on mathematics.

In all of the programs of science being prepared, there is a shift from isolated factual content to a content centered around broad scientific concepts. Evidence that the content of science is still of great importance is apparent since considerable attention is being given to concepts which could be of great value in the teaching of science.

The conceptual schemes suggested by Brandwein (36) are: (1) Under ordinary conditions, matter can be changed but not annihilated or created; (2) Under ordinary conditions, energy can be changed or exchanged but not annihilated; (3) There is an interchange of materials and energy between living things and their environment; (4) The organism is a product of its heredity and environment; (5) The universe, and its component bodies are constantly changing; and (6) Living things have changed over the years.

Craig (37) suggests that the following be incorporated in the teaching of science: (1) The Universe is Very Large—Space; (2) The Earth is Very Old—Time; (3) The Universe is Constantly Changing—Change; (4) Life is Adapted to the Environment—Adaptation; (5) There Are Great Variations in the Universe—Variety; (6) The Interdependence of Living Things—Interrelationships; and (7) The Interaction of Forces—Equilibrium and Balance.

The conceptual schemes suggested by NSTA (10) might serve as bases around which a curriculum could be organized. The NSTA conceptual schemes are:

I. All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

II. Matter exists in the form of units which can be classified into hierarchies of organizational levels.

III. The behavior of matter in the universe can be described on a statistical basis.

IV. Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.

V. All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

VI. One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, and gaseous.

VII. All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

While there is not total agreement on which concepts should serve as a basis about which to build the curriculum, it is obvious that the concepts suggested are generally few in number, cut across the traditional subject matter lines, and have a greater depth of meaning since they tend to unify science. Trieger (38) says that in the newer science programs for both students and scientists, the big ideas are presented to serve the following functions:

a. to satisfy our drive for order and to make sense out of things;

b. to give a logical explanation of observation;

c. to unite a wide range of facts and reveal previously unknown or unseen connections;

d. to suggest new ideas for further explorations; and

e. to illustrate the power of scientific knowledge in changing our comprehension of ourselves, our world, and our destiny.

As one reviews the purposes of the new programs in science it is apparent that all of the studies place great importance on pupil involvement, and many go on to suggest that methods such as discovery, inquiry, or problem-solving can best accomplish the goals advocated by the curriculum planners. Morrison (39) in writing about the work of ESS indicates that pupil involvement is actually a mandate for this particular program.

> One mandate is imperative for our style of work: There must be personal involvement. The child must work with his own hands, mind and heart. It is not enough for him to watch the teacher demonstrate or stand in line to take a hurried glimpse of the reflection of his own eyelashes in the microscope eyepiece. It is not enough for him to watch the skillful classmates at work, not enough to follow the TV screen. He needs his own apparatus, simple, workable.

Another statement by the planners of the ESS approach indicates how strongly they feel that students need to be actively involved in the actual handling of their materials (40). Concepts, as such, are not presented at the beginning of a unit of study.

> The Elementary Science Study units differ widely, but they share a common approach to the teaching of science in elementary schools. Rather than beginning with a discussion of basic concepts of science, ESS puts physical materials into children's hands from the start and helps each child investigate through these materials the nature of the world around him. Children acquire a great deal of useful information, not by rote but through their own active participation. We feel that this process brings home even to very young students the essence of science—open inquiry combined with experimentation.

Hornig (6) sees a student participating in science in a manner quite similar to the methods employed by the science researcher.

> First, even at the elementary level, I think our emphasis will shift toward the inductive science the researcher knows, the effort to allow students to learn to observe for themselves the facts of nature and to reason from them, to set up experiments to aid their reasoning and to test their conclusions. I have always

> been struck by the dichotomy between the scientist, who sees science as an active, creative problem-solving activity, and the student, who has conventionally seen it as a dogmatic, tightly organized body of often unexciting fact.

Scott (41) in his article entitled "Science Is for the Senses" would have the child utilize his senses to the degree that they lend great support in the learning of science. He makes the following statement:

> To the greatest extent possible, all of the senses of the child must be involved if the flavor of science is to be known. There is no known way to obtain such involvement short of the child's direct participation. In designing a science program for the elementary school, the first and most important part of the equipment for any activity is the child himself.

Personal involvement in the learning of science is summed up by Blatt (3) in the following manner:

> If children are to become aware of the methods used by scientists, they must use these methods as the scientists do . . . allow students to become personally involved in trying to find possible answers by reading, experimenting, consulting with others, and by using their own intuitive powers. The responsibility for learning is on the student, which is the proper place for it since teachers cannot do the learning anyway. This is the problem-solving, or the "discovery" method which we talk about, but seldom implement in practice.

Blackwood (42) concurs that the teaching of science should be tailored after the methods of science, but that this does not mean that all chidren are expected to become scientists.

Carin and Sund (5) also believe that student involvement is of primary importance, and go on to point out that teachers should employ the experimental or discovery approach to science, and that they should emphasize inductive learning, problem-solving, and critical thinking.

One of the objectives of NSTA (35) is that learning in science in the elementary school should, "provide experience through which boys and girls can arrive at some of the concepts of science through observation, inquiry, problem-solving, and study of cause-and-effect relationships." This objective also involves student participation to a greater degree than has been true in traditional science programs.

The review of the literature pertaining to the new programs thus far has been concerned with the concepts of science to be taught, the pupil involvement in the learning of science, and the various methods to be utilized in the learning of science: discovering, inquiring, experimenting, and problem-solving. The idea of learning by way of the processes of science is perhaps one of the most innovative aspects of the curriculum revisions. Attention might well be focused now on what these processes of science are.

The Commission on Science Education of the AAAS in its program for K-6 Science—A Process Approach has as its main theme a group of processes which scientists utilize and that the developers of the program feel can be taught to children. In the primary grades the eight processes identified by AAAS (43) are:

Observing

Classifying

Measuring

Communicating

Inferring

Predicting

Recognizing Space/Time Relations

Recognizing Number Relations

At the fourth, fifth, and sixth grade levels integrated processes are used. They are:

Formulating Hypotheses

Making Operational Definitions

Controlling and Manipulating Variables

Experimenting

Interpreting Data

Formulating Models

Each of the AAAS lessons clearly indicates the process that is being emphasized. It is hoped by specifying the process being stressed that the teacher can more clearly understand and teach for the objectives of that particular lesson, and can also more adequately evaluate the students on the basis of that particular process.

A child should have ample opportunity to see the conceptual schemes suggested by NSTA (10) in "Major Items in the Process of Science"; these processes as stated by NSTA are:

I. Science proceeds on the assumption, based on centuries of experience, that the universe is not capricious.

II. Scientific knowledge is based on observation of samples of matter that are accessible to public investigation in contrast to purely private inspection.

III. Science proceeds in a piecemeal manner, even though it also aims at achieving a systematic and comprehensive understanding of various sectors or aspects of nature.

IV. Science is not, and will probably never be, a finished enterprise, and there remains very much more to be discovered about how things in the universe behave and how they are interrelated.

V. Measurement is an important feature of most branches of modern science because the formulation as well as the establishment of laws are facilitated through the development of quantitative distinctions.

Carin and Sund (5) in speaking about the scientific method say, "Certain mental activities developed and usually used by individuals in scientific investigations constitute the prepared mind." They then go on to list the mental activities that scientists use as being:

Observation (including experimentation)

Analysis and synthesis

Imagination

Supposition and idealization

Inference (inductive and deductive)

Comparison (including analogy) at first glance

If one were to evaluate the students that come out of the new programs he should evaluate them on their ability to "do" science as suggested by Walbesser (44). This, in fact, is how Science—A Process Approach does evaluate its program. Kurtz (45), a college botany professor, also feels that this is the way to evaluate college botany students. In fact, he feels that the instructor should ask the question, "What do I want my students to be able to do after taking my course that they couldn't do before enrolling in it?" The performance of science processes then is seen as one of the hoped-for outcomes of a science course.

In summary, many science curriculum improvement revisions are underway and will in time produce significant changes in the teaching of science at the elementary level. The argument that content versus process in the new programs is "not real", is pointed out by Fischler (32). Much attention is being given to the selection of a few scientific concepts upon which to structure the programs. This type of content will, therefore, have greater depth of meaning and will produce less fragmentation of science. All of the programs place the student in the position of being actively involved in the processes of science. In most instances these processes are being identified for specific units or lessons. This type of science should be of greater value to the child, both now and in the future. These programs should prepare the future citizen to be more literate in an age of scientific and technological "explosions of knowledge."

Attitudes and the Teaching of Science

One of the goals of science teaching has been and continues to be the development of scientific attitudes. It might be argued that attitudes are difficult to identify; therefore, it is not only difficult to teach for specific attitudes, but perhaps even more difficult to determine accurately to what degree an individual attitude is possessed.

An attitude as defined by Green (46) is, " . . . a psychological construct, or latent variable, inferred from observable responses to stimuli, which is assumed to mediate consistency and covariation among these responses." Sells and Trites (47) in an explanation of attitude constructs say that, "When . . . choices are observed under stable environmental conditions, predictions of future responses under similar conditions may be accurate on the basis of the objectively observed behavior. . . ." In an article on the development of scientific attitudes Haney (14) says, "Attitudes regulate behavior that is directed toward or away from some object or situation or group of objects or situations . . . ."

With this general statement about attitudes as an introduction, the author will proceed to review the literature concerned with scientific attitudes, and more specifically, the attitude generally referred to as open-mindedness. A discussion of whether open-mindedness should be classified in the attitude category was presented in Chapter I. Rokeach (30) and Krathwohl, et al. (25) have pointed out the unity of the individual and expressed the opinion that classification schemes are arbitrary. At this point in the review of the literature, open-mindedness can only be reported as an attitude since this has been the position taken by the various authors.

Science educators stress that an outcome of learning sciences should be an awareness of scientific attitudes and the development of these attitudes by the students. Blough and Schwartz (12) in their elementary science methods textbook give a typical example of scientific attitudes. It should be noted that the first of these attitudes is "being open-minded." An individual with scientific attitudes is described by Blough and Schwartz (12) as follows:

> He is open-minded--willing to change his mind in the face of reliable evidence--and he respects another's point of view.
>
> He looks at a matter from many sides before he draws a conclusion. He does not jump to conclusions or decide on the basis of one observation; he deliberates and examines until he is sure.
>
> He goes to reliable sources for his evidence. He challenges sources to make sure that they are reliable.
>
> He is not superstitious; he realizes that nothing happens without some cause.
>
> He is curious. He is careful and accurate in his observations. He plans investigations carefully.

Carin and Sund (5), also writers of an elementary science methods textbook, make this statement:

> Most scientists cautiously guard against the human tendency to be opinionated, dogmatic, or pedantic. Through this humility and reluctance to be categorical or dogmatic, a second element of scientific attitudes is derived. All findings are tentative.

Though Carin and Sund do not mention open-mindedness, they do mention guarding against being dogmatic.

In one of the contemporary series of science books for grades K-6 Today's Basic Science, by Navara, Zafforoni, and Garone (9) one finds the philosophy which is also embodied in the new programs of science. The authors say:

> Throughout, the books emphasize process. The student is involved in the scientific method as he does experiments, makes observations, and solves problems. The problem-solving approach develops the student's inherent scientific attitude.

More specifically, teachers who use this particular series are instructed that they should, "Note the extent of open-mindedness as to the variety of other possibilities that might be proposed . . ." when they evaluate students. This evaluative criteria is found in The Molecule and the Biosphere (9), a sixth grade science textbook.

Helen Heffernan (15), Chief of the Bureau of Elementary Education, California Department of Education, asks the question, "Do our elementary schools really teach science?" She says to answer the question one must consider scientific attitudes. She then goes on to define scientific attitudes in the following manner:

> The scientific attitude is one of intellectual curiosity and wonderment, of eagerness to discover and accept reality, of open-mindedness and tolerance, of humility toward truth, of withholding judgment in the absence of evidence, and of considering all judgments and conclusions

> as tentative and subject to revision in the light of new or additional evidence.

Brandwein, Watson, and Blackwood (13) say, "Surely it is intelligent to suspend judgment, to be open-minded, to be honest and patient when one attempts to solve problems." They go on to say, "It is specious, then, to allot these attributes to the scientist alone when even casual thought will show them to be necessary to wise, gracious, and balanced living."

McCarthy (11) discusses three methods of teaching science, and indicates that regardless of the method or combination of methods chosen, one of the goals should be to, "Develop attitudes of open-mindedness, deliberation, and critical thinking."

The preceding paragraphs advocate that one of the objectives of science teaching should be the development of scientific attitudes. In the newer programs the opportunity to develop scientific attitudes in children appears to be greater than in the past. Leodas (8), an ESS staff member, in stating the rationale of the ESS approach to the teaching of elementary science says:

> The process of development was, and is, that of scientific research, in its approach to the problem, its spirit, and its methodology. The scientist realizes that accumulation of knowledge alone is insufficient, and that scientific attitudes and methods—the way the scientist works, thinks, and discovers—must also be conveyed.

Haney (14) says, "To be scientific means that one has such attitudes as curiosity, rationality, suspended judgment, open-mindedness, critical-mindedness, objectivity, honesty, and humility." Under the heading of "Acceptance of New Ideas" Haney (14) then goes on to discuss open-mindedness by saying:

> Open-mindedness is closely akin to suspended judgment . . . experiences that foster open-mindedness include those in which pupils are confronted by the need to revise a belief as the result of having acquired new information on the subject.
>
> The willingness to consider novel hypotheses and explanations and to attempt unorthodox procedures is a form of open-mindedness toward creative ideas . . . .

It is apparent from the literature that there is agreement among science educators that one of the outcomes of teaching science should be the fostering of scientific attitudes in students. There is less agreement about what these attitudes are, and this is probably due, in part, to the methods used for classifying these attitudes. As in all classification schemes some will be "splitters" and some will be "lumpers".

In Science Is a Scared Cow by Anthony Standen (48), the author in his typical style of debunking science says, "The scientists are convinced that they, as scientists, possess a number of very admirable human qualities, such as accuracy, observation, reasoning power, intellectual curiosity, tolerance and even humility." In remarking on a list that extols the virtues of the scientists, Mr. Standen goes on to say, " . . . who would go out of his way to deny such praise? And as advertising always convinces the sponsor even more than the public, the scientists become sold, and remain sold on the idea . . . ." Certainly, Standen does make one look at scientific methods and scientific attitudes more objectively than do most writers on the subject. He criticizes science educators for perpetuating the typical image of the scientist. It might be appropriate, therefore, to look at some examples from the literature on scientific attitudes that come from scientists, per se.

Roe (17), a psychologist, in a conclusion on a study of emminent scientists relates personality patterns to the creative process of science. She asks the question, "How do . . . personality characteristics relate to the creative process in science . . .?" Roe (17) then answers the question by saying:

> An open attitude toward experience makes possible accumulation of experience with relatively little compartmentalization; independence of perception, cognition, and behavior permit greater than average reordering of this accumulated experience. . . . The strong liking for turning disorder into order carries such individuals through the searching period which their tolerance for ambiguity permits them to enter. The strong egos, as noted, permit regression to prelogical forms of thought without serious fear of failure to get back to logical ones. Preoccupation with things and ideas rather than with people is obviously characteristic of natural scientists. . . . That a man chooses to become a scientist and succeeds means that he has the temperament and personality as well as the ability and opportunity to do so.

Roe points out that the creative scientist is deeply involved both emotionally and personally in his work, and gives the following example of how the personal factor might be avoided as an influence in his findings: "A scientist who is deeply committed to a hypothesis is well advised to have a neutral observer if the import of an observation is immediately apparent." A statement such as this indicates that at least in the field of science there is an attempt made by the scientist to avoid interacting with what he observes. In speaking about the creative scientist the author then goes on to say, "The scientist has more at stake than the artist, for data which may support or invalidate his hypothesis are in the public domain. . . ." This statement leads one to ask the question, "Is it the structure of science itself that requires men of science to practice typically conceived methods of science and to possess the attitudes that are consistent with the spirit of science?"

In an address made in Washington, D. C., on March 7, 1950, to the winners of the annual Westinghouse Science Talent Search, Oppenheimer (16) made the following statement:

> What are these lessons that the spirit of science teaches us for our practical affairs? Basic to them all is that there be no barriers to freedom of inquiry. Basic to them all is the ideal of open-mindedness with regard to new knowledge, new experience and new truth. Science is not based on authority. It owes its acceptance and its universality to an appeal to intelligible, communicable evidence that any interested man can evaluate.

In another article, Oppenheimer (22) points to the open-mindedness of science when he speaks about the "house" called science. He says of this "house", "One thing we find throughout the house: there are no locks; there are no shut doors; wherever we go there are the sights and usually the words of welcome. It is an open house, open to all comers."

In the concluding remarks in the book, The Making of a Scientist by Roe (23) the author says:

> You must be free, first free to observe and free to follow where your observations lead you, even if it means discarding some cherished beliefs. You must be patient. You must learn to wait until enough evidence is in. You must be willing to start all over again. Above all, you must be willing to see that you can be wrong, even if that means that your most cherished rival is right.

Spoehr's (24) description of a scientist tends to be in keeping with the above statement when he says, "It is true that scientists do not stand in awe of authority nor do they regard the established order within their domain as absolutely inviolable."

Bridgman (4) also takes a stand similar to that of Spoehr when he says, " . . . the scientist is the enemy of all authoritarianism."

In a study by Mead and Metraux (21) one finds that high school students hold an image of scientists similar to that held generally by both educators and scientists. On the positive side of the image of scientists high school students felt that scientists were "careful, patient, devoted, courageous, and open-minded."

The literature review, thus far, has dealt with the rationale of emerging science courses in which scientific methods of inquiry and scientific attitudes are stressed. Attention has been focused on scientific attitudes, with open-mindedness recurring in most lists of these attitudes. The elementary teacher, quite obviously, will be the most important factor to consider if science in the elementary school is to truly undergo a change, and the literature review will now deal with the role of the elementary teacher in the area of science.

In a study by Davis (27) teachers reported what they felt were characteristics of scientific attitudes, and it is on this basis that Davis operationally defines scientific attitudes. The characteristics as reported by Davis are:

1. Willingness to change opinion on the basis of evidence.
2. Search for the whole truth regardless of personal, religious or social prejudice.
3. Concept of cause and effect relationship.
4. Habit of basing judgment on fact.
5. Power or ability to distinguish between fact and theory.
6. Freedom from superstitious beliefs.

The attitudes listed in the study by Davis tend to be consistent with the objectives of teaching science in the elementary school as reported in a study by the U. S. Office of Education (42). The two objectives rated highest in this survey were:

1. Help children develop their curiosity and ask what, how, and why questions.

2. Help children learn (how) to think critically.

In an investigation of 117 elementary teachers, Victor (49) concludes:

> . . . an inadequate science background is definitely a factor in the reluctance of elementary teachers to teach science . . . other factors seem for the most part to have developed either as logical consequences of an inadequate science background or as substitutes for an understandable reluctance to admit to an inadequate preparation in science.

The new curriculum revisions in elementary science are in agreement with the following statements which tend to characterize good science teaching. Keislar (50) takes the position that:

> The best teacher is the one who works himself out of a job the fastest. We need to do a better job, therefore, in teaching students to read efficiently, to use library materials, to plan and carry out an investigation, or to use effective problem-solving strategies.

Mead and Metraux (21) say, "Where science teaching is successful, the teacher has created a situation in which his or her personality sinks into the background . . . ."

Roe's (17) study of scientists gives the following implications for education:

> The discovery that it is possible to find things out for oneself is not a natural part of growing up for every child of our culture. It can be seen clearly in these life histories that for many of these men it was chance, —the chance, usually, of getting in a class in school where this type of activity was encouraged.

Klausmeier (51) advocates that, "Deliberate cultivation of the desired attitudes should be encouraged. Pupils need to be aware of the behaviors that accompany an attitude and to practice them." Brandwein, et al. (13) say, "A teacher who is not open-minded, who is bigoted and prejudiced, who is not honest, judicious, and patient in his dealings with his students and the problem in class, cannot with propriety 'teach' these attitudes or help make them active attributes." This provocative statement, quite naturally, causes one to ask if all teachers can be considered as potentially capable of handling the newer approaches to science, which place great stress upon scientific attitudes.

Open-Mindedness and Closed-Mindedness

Brandwein, et al. (13) have suggested, as have others less directly, that certain teachers may have difficulty when it comes to teaching the new programs in science which place a great deal of emphasis upon scientific methods and scientific attitudes. A summary of the previous section of the review of literature will reveal that there are several attributes that are associated with success in science that are also relevant to the Dogmatism Scale used in this study. The following expressions seem to be relevant and bear repeating: scientists are open-minded (9, 11, 12, 13, 14, 15, 16, 21), and tolerant (15, 17). They "guard against being dogmatic" (5), are "not in awe of authority" (24), are enemies "of all authoritarianism" (4), and "must be free . . . if it means discarding some cherished belief" (23); and science "is not based on authority." (16)

Since open-mindedness is traditionally considered an attribute of scientists, the author chose to test the hypotheses that pre-service elementary teachers who are relatively more open-minded (as measured by Rokeach) also show greater promise as teachers of elementary science. Attention will now be focused on the work of Rokeach and others in the area of open-mindedness. As has been stated previously, the Dogmatism Scale, devised by Rokeach, is a measure of the degree to which a person's belief system is open or closed. Rokeach (30:399) points out that as one analyzes cognitive behavior he works with affective states at the same time.

> . . . analysis in terms of beliefs and systems of beliefs does not restrict us only to the study of cognitive behavior. We assume that every affective state also has its representation as a cognitive state in the form of some belief or some structural relation among beliefs within a system. With respect to the enjoyment of music, for example, we all build up through past experience a set of beliefs or expectancies about what constitutes "good" and "bad" music. It is in terms of such expectancies, which are more often implicit than explicit, that we enjoy a particular composition. Thus, a person who is exposed to a particular piece of classical music or jazz may enjoy it, even though it may be totally unfamiliar to him, because it is congruent with an already existing set of beliefs he has built up over time. Depending on the extent to which he is prepared to entertain new systems, he may or may not enjoy Schonberg, or other music perceived as incompatible with his own beliefs about what constitutes good music. . . . In all cases, enjoyment or its opposite is the affective counterpart of a belief organization and can be thought of as being in one-to-one relation (isomorphic) with it. Thus, our cognitive approach is as much concerned with affection as with cognition.

The paragraph presented above is used as an example in the <u>Taxonomy of Educational Objectives, Handbook II: Affective Domain</u> (25) to emphasize "the fundamental unity of the organism." The authors state further that, "Every classification scheme is an abstraction which arbitrarily makes divisions among phenomena solely for the convenience of the user . . . . "

The four factors of compartmentalization, analysis, synthesis, and rigidity have been studied as they relate to open- and closed-mindedness. The relationship of these four factors to ability in the field of science will now be presented.

In Roe's (23) studies of the lives of scientists the relationship of compartmentalization to the creative process is discussed. The author says:

> If past experiences have brought about a compartmentalization of the storage areas so that some portions are partially or wholly inaccessible, obviously the scientist is limited in his search. Compartmentalization of particular areas may result from personal experiences of a sort that lead to neurotic structures . . . the more areas of experience there are accessible to conscious and preconscious thought, the better are the prospects for creativity.

Rokeach (30:36) refers to compartmentalization as isolation and states that, "the degree to which there is isolation within the belief system . . . that is, the less intercommunication between individual beliefs—the more is the formation of new systems retarded." (30:398)

Roe (17) concludes in her article, which emphasizes the negative influence of compartmentalization, that, "An open attitude toward experience makes possible accumulation of experience with relatively little compartmentalization; independence of perception, cognition, and behavior permit greater than average reordering of this accumulated experience . . . . "

Compartmentalization has been found to be related to open-mindedness, and to this could be added analysis and synthesis. As suggested by Carin and Sund (5) the abilities to analyze and synthesize are vital attributes if one is to utilize scientific methods.

Rokeach's studies of analysis and synthesis of open and closed subjects did not seem to show that the subjects differed in their ability to perceive analytically (30:264), but that they did differ on perceptual synthesis (30:267). Or to put it another way, open-minded subjects seem to take less time than closed-minded subjects as they proceed from problem to problem on an embedded figures test.

Rokeach (30:213) also found, " . . . that subjects with relatively closed-systems . . . take longer to solve the Doodlebug Problem than do subjects with relatively open systems. This is clearly due to differences in the ability to synthesize, and not to analyze . . . closed persons have greater difficulty in remembering the beliefs to be integrated. Greater difficulty in recall, in turn, seems to be related to an unwillingness to play along." Rokeach (30:289) points out that there are definite differences in those who are open and closed in problem-solving, remembering and perceiving, and also in emotional experiences.

In a study of efficient use of scientific methods Solomon (52) found that those who were non-rigid differed significantly in their ability to utilize scientific methods from those who were rigid. Rokeach (30:193) says that this is in general keeping with his findings, and also points out the importance of the ability to analyze and synthesize for those in the field of science. Rokeach suggests, "that rigidity and dogmatism in the personality, and the ability to analyze and the ability to synthesize tend to go hand in hand."

The remainder of the studies presented in the review are not related specifically to compartmentalization, analysis, synthesis, and rigidity, but in each of the studies Rokeach's Dogmatism Scale has been used.

Kemp's (53) work shows that open-minded individuals were more successful than closed-minded individuals when it came to critical thinking. Critical thinking is another attribute normally associated with success in the field of science.

Blankenship and Hoy (54) found that, " . . . on the average, open-minded biology teachers were more ambitious, resourceful, self-reliant, progressive, and assertive; conversely, closed-minded biology teachers were more conventional, less enthusiastic, retiring, conservative, and methodical and rigid."

Johnson's (55) study shows that, "There was a significant relationship between the degree of open- and closed-mindedness of student teachers and their expressed attitudes toward teaching and teacher-pupil relationships." However, Johnson did not find the Dogmatism Scale to be a useful predictor of success in student teaching if supervisors and cooperating teachers' ratings were used as the criterion of success.

Hudspeth (56) found that faculty who were open-minded in their belief system were more favorable in their attitudes toward educational media.

In summary, Rokeach's Dogmatism Scale has been used in a great number of studies. These studies deal with such topics as compartmentalization, analysis, synthesis, rigidity, critical thinking, and teaching success. Finally, the review of literature did not reveal a study similar to the one proposed by this investigator.

CHAPTER III

DESIGN AND METHODOLOGY

Description of the Sample

The subjects in this study were 50 senior female elementary education majors enrolled in Education 4K2, Science for the Elementary School, during the fall of 1966 at Oklahoma State University. The males were not included in the study since they composed only about four per cent of the total sample. All had maintained an overall grade point average of at least 2.3 on a 4. scale. The number of science courses taken during college was generally 11 or 12 semester hours. Most of the students had at least one course in each of the following: biology, geology, and geography. Nine had at least one course in college level chemistry, and eight had at least one course in college level physics. Most had six semester hours of mathematics. None of the subjects had previous teaching experience in the public schools. Most of the subjects were preparing to do their student teaching during the second half of the semester.

Description of Course of Study

Science for the Elementary School is a course required of all elementary education majors at Oklahoma State University. The course, which the investigator taught, utilized many of the ideas and materials that are found in current curriculum studies. Most schools are placing greater stress upon the teaching of science at the elementary level. However, Eiss (57) and Victor (49, 58) point out a characteristic reluctance of elementary teachers to teach science. Many factors contribute to this reluctance, and certainly this hesitancy might be expected with the newer experience-centered science programs. Even at the high school level teachers have expressed feelings of reluctance toward the BSCS programs. Cornelius (59) says, "One drawback in the use of BSCS materials was lack of laboratory oriented teacher preparation . . . . Naturally discouragement and frustration resulted." The ESCP apparently sees this lack of laboratory oriented preparation as threatening also. In an article by Stephenson (60) the conclusion is reached, "That to protect the large investment in time, energy, and money that the ESCP will represent, a massive, nationwide teacher preparation program must be mounted without delay."

The feeling of inadequacy in the ability to teach science expressed by a group of pre-service elementary majors working at Lowell State College (61) was apparently overcome by the use of the ESS materials. This is in general agreement with the findings of Oshima (62) who found that pre-service teachers in Science for the Elementary Schools who had been taught by the laboratory approach showed significantly greater confidence in their ability to teach science than those taught by the demonstration method.

If elementary science should take a laboratory approach with a great deal of pupil involvement, as suggested by today's curriculum planners, then those who will teach it need the experience of doing this type of laboratory work. If elementary pupils are to learn from doing laboratory work, then their more mature teachers should certainly be able to learn from this type of experience. And, if they can learn from these pre-service experiences, they should be able to continue to do so, with confidence, as they learn with their students in actual classroom situations. Obviously there is a limit to the number of college science courses students can take; however, the methods used in teaching this course of study might aid the teacher to continue the learning of science in her own classroom by a more scientific method.

To be more specific, during the course of study, Science for the Elementary School, the instructor used many of the materials found in the sample kit provided by ESS. This kit contained the following units: "Growing Seeds", "Small Things", "Behavior of Mealworms", "Gases and Airs", and "Kitchen Physics". Nichols (63) in discussing the units being developed by ESS says:

> Each ESS unit has its own special history and character. There are, however, certain general features that apply to all. Each has been the product of close collaboration among scientists and elementary classroom teachers. Each is based on investigations that can be pursued by the children themselves. Each has involved children in its early development and has been tested in a large number of classrooms.
>
> Bringing science into the elementary school requires that much more of the physical world be brought in for the child to observe, manipulate and test. We have devoted much time to finding equipment and living things that can lead to rich and manageable experimentation by children but that are cheap and familiar as possible. Drinking straws, dixie cups, paper clips, blotters—these are basic equipment for elementary science. But so are balances, syringe pumps, microscopes, battery holders, petri dishes, and mealworms.

Many more experiences in addition to those found in ESS were used; they were centered about such things as pendulums, levers, pulleys, magnetism and electricity. The time factor was a problem; consequently, only a class period or slightly longer was spent in using each of the various materials. After the introductory session a discussion followed on how the experiences might be expanded for various grade levels, experience backgrounds, the scientific processes utilized, and the desired outcomes of the experience.

Instrumentation and Collection of Data

A description of the data gathering instruments, and how these instruments were administered in the study will now be presented. Attention is first focused on how open-mindedness and closed-mindedness were determined. Following the section on open- and closed-mindedness the instruments used to test for achievement in science, attitudes toward the teaching of elementary school science, and confidence in the ability to teach elementary school science are covered.

Open-Mindedness and Closed-Mindedness

Rokeach's Dogmatism Scale, Form E, was selected to measure the degree of open-mindedness and closed-mindedness in this study. The Dogmatism Scale is a general measure of the degree to which a person's "total mind is an open mind or a closed one." (30:397) Those who score extremely high on this scale are seen to differ consistently from those who score extremely low in the formation of new belief systems, whether or not the systems are conceptual, perceptual, or esthetic in nature. The essence of the differences between those who are open and closed is found to be in the ability to analyze and synthesize. Those who are more open are found to have greater ability to synthesize. A basic characteristic that defines how open or closed a person's belief system is

> . . . the extent to which the person can receive, evaluate, and act on relevant information received from the outside on its own intrinsic merits, unencumbered by irrelevant internal pressures that interfere with the realistic reception of information are unrelated habits, beliefs, and perceptual cues, irrational ego motives, power needs, the need for self-aggrandizement, the need to allay anxiety, and so forth. (30:57)
>
> The more open one's belief system, the more should evaluation and acting on information proceed independently on its own merits, in accord with the inner structural requirements of the situation. Also, the more open the belief system, the more should the person be governed in his actions by internal self-actualizing forces and the less irrational inner forces. (30:58)

Several revisions went into the development of Form E of the Dogmatism Scale. The reliability ranges for the scale vary from .68 to .93. Rokeach defends this reliability on the basis that the scale contains quite a strange collection of items that cover a lot of territory. Validity of the scale was established by using the "Method of Known Groups".

The instrument was administered to the subjects during the first week of school. A copy of the Dogmatism Scale is found in Appendix A. Of the 60 items that comprise the instrument only 40 are specifically a part of Rokeach's Dogmatism Scale, Form E. The additional items were added at the suggestion of Rokeach. The subjects were instructed to respond by placing values ranging from +3 to -3 in front of each item. A +3 meant the respondent agreed very much with the statement. At the other end of the continuum a -3 meant that the respondent disagreed very much with the statement. In scoring the instrument a +4 was added to each value assigned by the respondent. Therefore, the lowest possible score would be 40 and the highest possible score would be 280.

Achievement in Science

The Read General Science Test, Forms AM and BM (64), was the instrument used in this study to obtain a general measure of the subjects acquisition and retention of scientific content. The test which is normally used for secondary school students is sufficiently difficult and general to be usable with college level students who are not trained specifically in the sciences. In constructing the test the Forty-sixth Yearbook of the National Society for the Study of Education, eleven widely used textbooks and representative state curricula guides were used.

Form AM has a mean validity index for the test items of .42 and Form BM has a .43 mean validity index for the test items. The corrected split-half reliability coefficient was .88 and the standard error of measure was 4.6 standard score points. Read (64) says of the test:

> Comparison of the distribution of scores of the two forms for the group tested indicated that the two forms are almost directly comparable at all points along the scale, even in terms of raw scores. Thus, any differences found between results of administration of the two forms are accurate reflections of changes that have taken place from one administration to the other, within the limits of the reliability of the test, and are not consequences of any systematic differences between the forms.

The Read General Science Test was taken by the students during the second class meeting of Education 4K2 during the fall of 1966.

Attitudes Toward the Teaching of Elementary School Science

The determination of attitudes toward the teaching of elementary school science was an algebraic sum of the signs (+, –, 0) on four different ratings.

The first of these ratings was the Instructor's Rating. Each of the subjects was assigned a subjective rating of positive (+), negative (–), or indeterminate (0) on the basis of her performance in the class. A (+) rating indicated a favorable attitude, a (–) rating indicated an unfavorable attitude, and a (0) rating indicated an indeterminate attitude toward the methods of teaching science presented in the course, Science for the Elementary School. The rating was given at the end of the course, but prior to the scoring of any of the other evaluative instruments of the study.

The second instrument was on Peer Rating and Self Rating of the attitudes toward the teaching of elementary science. The technique, devised by Webb (65) refers to the procedure as SPM or "Self-Plus-Minus". The method is described in the following manner:

> . . . the individual was given a roster of the individuals within his group. He was asked to go through this roster and compare himself with every other man in the group. If he considered himself superior on a particular trait to a given man, he assigned a plus by that name. His self-rating rank within the group then could be given by simply counting the number of pluses which he assigned to the members of his group and subtracting from the total N. If, for example, he had given 15 pluses in a group of 24 men, he considered himself to be superior to 15 men in that group and 8 men to be inferior to him, and his rank on that particular trait from his point of view was 9 in the group (24 – 15 = 9).

A roster of students in Education 4K2, Science for the Elementary School, was passed out on the last day of class. The instructions (which are in keeping with the technique developed by Webb) read in part:

> If you consider yourself more favorable toward the teaching of elementary school science using the methods you have studied in Education 4K2 than a given individual, assign yourself a plus (+) by that name. If, in contrast, you consider yourself less favorable toward the teaching of elementary school science using the methods you have studied in 4K2 than a given individual, assign yourself a minus (-) by that name. (NOTE: You are rating your attitude as compared with the other individuals rather than rating their attitude toward the program.) (See Appendix B)

The results obtained from the SPM procedure give both a Self Rating and Peer Rating. This then gives two more of the measures for a favorable attitude toward the teaching of elementary school science.

To receive a (+) or favorable on the Peer Rating required that the individual's rating fall in the top quartile. If the rating placed the subjects in the lower quartile a (-) or unfavorable rating was recorded. Those ratings falling between the upper and lower quartile were recorded as indeterminate or (0) and were no longer considered in this study.

The same technique of SPM was used to arrive at a Self Rating of (+) favorable, (-) unfavorable, or (0) indeterminate. Webb (65) found that this method of estimating Peer Rating and Self Rating, "yields highly reliable measures within sessions for both group ratings and self ratings."

The Peer and Self Rating were done during the last class meeting of Education 4K2.

The fourth attitude rating was obtained by administering an instrument developed by Dutton and Stephens (31). (See Appendix C) In developing this attitude scale 200 prospective elementary education majors wrote short statements of their feelings about science. These statements were then edited and the final form of the instrument contains 20 items that have low Q values. The 20 statements include an equal number of favorable and unfavorable attitudes. Scale values on the twenty items run from 1 through 11. The reliability for the instrument was found to be 0.93. Dutton and Stephens (31) define "attitude" for the purpose of their study as, "how an individual feels about elementary school science . . . . A distinction needs to be made between this type of attitude and the term scientific attitude or scientifically minded persons . . . . "

The instrument may be used as the developers say to:

> . . . study the general pattern of responses for an individual or for a class. Individual scale items show like or dislike for some particular aspect of elementary school science. By placing the scale values in front of items checked by each student and totaling the points, an average for the entire scale can be secured.

An individual who has a score in the upper quartile is rated as having a (+) favorable attitude, an individual in the lower quartile is rated as having an (-) unfavorable attitude, and all scores falling between the upper and lower quartile are (0) indeterminate.

The instrument was administered during the last week of the course.

In summary, four ratings are used to determine a subject's attitude toward the teaching of elementary school science. An algebraic sum of the four ratings--Instructor's Rating, Peer Rating, Self Rating, and Dutton and Stepehen's (11) Science Attitude Scale--was used to establish the criteria of (+) favorable attitude, (-) unfavorable attitude, and (0) indeterminate attitude.

Confidence Scale

The instrument used to measure feelings of confidence toward the teaching of elementary school science was developed by Evans and Frazier (66) under a grant from the United States Office of Education. (See Appendix D) Eighty-four teachers in the graduate school at the Ohio State University reacted to various drafts of the instrument, and various statistical procedures were applied before the final draft was utilized in the study. In a description of the confidence scale, entitled "How Do I Feel About Teaching Science?" the authors say:

> The instrument as finally revised is composed of eight science-learning situations, conceived of as representative of possible situations arising in an elementary school classroom. Four of the situations are related to content in the biological science, and four are related to the content and materials associated with the physical sciences.
>
> Under each teaching situation, five learning activities are described, each of which falls into one of these four categories: experimentation, observation, discussion and reading. A total of 40 items is found under the eight learning situations, with their number being equally divided between biological science and physical science.

The measurement for feelings of confidence toward the teaching of elementary school science employed the pre-test/post-test method of obtaining data.

Analytic Procedure

Several instruments have been employed to test the hypotheses proposed in Chapter I of this study. The various statistical tests used in this study utilize nonparametric techniques, which is in keeping with other studies that deal with data from the behavioral sciences. Siegel (67) suggests that the reasons for the suitability of nonparametric tests are that they do not assume that a sample is drawn from a normally distributed population, that scores need not have exact numerical value, and that these techniques are computationally simple. The level of significance was set at .05 in all of the hypotheses tested. Another way of stating this is to say that if a difference between two groups does exist, the probability of such a chance happening is five times, or less, in a hundred.

The first step consisted of establishing two groups of subjects; one group designated as open-minded in its belief system, and the other designated as closed-minded in its belief system. Open-mindedness and closed-mindedness were determined by administering the Dogmatism Scale. The group was arbitrarily divided into two equal categories, open-minded and closed-minded. This was determined by placing a subject in the open-minded group if her score fell within the lower quartile for the entire sample, and in the closed-minded group if her score fell within the upper quartile for the entire sample. This technique of dichotomizing the scores from the Dogmatism Scale is in keeping with other studies that have used this particular instrument.

The Mann-Whitney U Test, described by Siegel (67) on pages 116-127, was utilized to test for difference between open- and closed-minded subjects on pre-test and post-test scores taken from tests on achievement in science and confidence in ability to teach elementary science. The Mann-Whitney U is described by Siegel as one of the most powerful of the nonparametric tests.

The Fisher exact probability test, described by Siegel (67) on pages 96-104, was used to test for differences in attitudes toward the teaching of elementary school science held by those who are open-minded and those who are closed-minded.

Finally, the Wilcoxon matched-pairs signed-ranks test, described by Siegel (67) on pages 75-83, was used to test if those who are open-minded and those who are closed-minded had a significant change between their pre-test and post-test scores on the confidence in teaching science test.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

As stated in the previous chapter several nonparametric statistical techniques were used to test the hypotheses under consideration in this study. The level of confidence was set at .05, and two-tailed tests determine if differences are significant. If differences are found at the predetermined level of significance, the alternate of the null hypotheses is analyzed to determine if the predicted directions of the hypotheses are significant. In each of the following sections, the methods of analysis with accompanying tables present the results of this study.

Open-Mindedness and Closed-Mindedness

Open-mindedness and closed-mindedness refer to the structure of the belief system, and the instrument used to gather the data of this study was the Dogmatism Scale, Form E, developed by Rokeach.

Table I presents all of the scores obtained by the subjects in this study. The range of all the scores is 105 to 200 with a mean score of 141.3. The subjects were diohotomized into two equal groups. Those persons whose scores fell into the quartile having the lowest scores (105 to 125) are referred to as the open-minded group and those persons whose scores fell into the quartile having the highest scores

(156-200) are referred to as being closed-minded. Obviously, such terms as open- and closed-minded are relative. The mean of the open-minded group is 117.1 and the mean of the closed-minded group is 168.1. All those subjects whose scores did not fall into either the top or the bottom quartile are not considered further in this study.

TABLE I

DOGMATISM SCORES

Open-Minded						Closed-Minded	
First Quartile		Second Quartile		Third Quartile		Fourth Quartile	
Student	Score	Student	Score	Student	Score	Student	Score
1	105	14	126	26	140	38	156
2	106	15	126	27	141	39	157
3	106	16	127	28	143	40	158
4	110	17	129	29	144	41	159
5	117	18	129	30	146	42	160
6	118	19	133	31	148	43	166
7	120	20	134	32	148	44	166
8	121	21	135	33	148	45	168
9	122	22	138	34	150	46	169
10	123	23	138	35	150	47	174
11	124	24	139	36	154	48	175
12	125	25	139	37	155	49	177
13	125					50	200

Achievement in Science

Table II presents the scores obtained by subjects on the Read General Science Test. The data were analyzed by the Mann-Whitney U Test to determine if there were significant differences in science achievement between those who were open- and closed-minded. A U of 65.5 was calculated. The table value required to reject the null hypotheses is 41 when $n_1 = 12$ and $n_2 = 13$; therefore, the hypothesis is tenable. However, it might be pointed out that the mean of the open-minded group was slightly higher ($\bar{X} = 53$) than the mean of the closed-minded group ($\bar{X} = 50$).

TABLE II

ACHIEVEMENT SCORES

Open-Minded		Closed-Minded	
Student	Achievement Score	Student	Achievement Score
1	59	38	34
2	45	39	48
3	49	40	52
4	48	41	54
5	60	42	56
6	50	43	46
7	63	44	58
8	62	45	*
9	46	46	63
10	52	47	56
11	47	48	52
12	55	49	40
13	53	50	41

*No Score

Attitudes Toward Teaching of Elementary Science

Table III presents the four ratings on attitudes toward the teaching of elementary school science. The results of the subjective rating by the instructor consist of 8 (+) favorable, 2 (-) unfavorable, and 3 (0) indeterminate for the open-minded group, whereas the closed-minded group consists of 7 (+) favorable and 6 (-) unfavorable.

It should be repeated, for clarity, that on the next three ratings (Self, Peer, and Dutton) a (+) favorable rating required that a

TABLE III

ATTITUDE RATINGS

Open-Minded Subjects						Closed-Minded Subjects					
Student	Instructor	Self	Peer	Dutton	Sum of Signs	Student	Instructor	Self	Peer	Dutton	Sum of Signs
1	+	0	0	0	+	38	−	−	0	−	−
2	+	+	−	0	+	39	−	0	0	0	−
3	+	0	−	+	+	40	+	0	+	−	+
4	0	0	−	0	−	41	−	+	0	−	−
5	−	+	0	+	+	42	+	0	−	0	0
6	+	+	+	0	+	43	+	−	0	−	−
7	+	0	0	0	+	44	+	0	0	+	+
8	+	+	+	0	+	45	+	−	0	+	+
9	+	+	0	−	+	46	+	+	0	0	+
10	0	0	0	+	+	47	+	0	0	−	0
11	+	−	+	+	+	48	−	−	−	−	−
12	−	+	0	0	0	49	−	0	0	+	0
13	0	0	+	−	0	50	−	−	−	+	−

subject be in the upper quartile, an (-) unfavorable rating required that she be in the lower quartile, and an (0) indeterminate meant that her rating fell in the middle one-half of the ratings.

Using Webb's (65) technique for Self and Peer Rating the results show that on the Self-Rating there are 6 (+) favorable, 1 (-) unfavorable, and 6 (0) indeterminate for the open-minded group, while in the closed-minded group there are 2 (+) favorable, 5 (-) unfavorable, and 6 (0) indeterminate. The Peer Rating results show that for the open-minded group 4 were (+) favorable, 3 were (-) unfavorable, and 6 (0) indeterminate; but the closed-minded group had only 1 (+) favorable with 3 (-) unfavorable, and 9 (0) indeterminate.

The Dutton Scale is a numerical scale which shows that for the open-minded group there are 4 (+) favorable, 2 (-) unfavorable, and 7 (0) indeterminate. On the Dutton Scale the closed-minded group also had 4 (+) favorable, but it had 6 (-) unfavorable, and 3 (0) indeterminate ratings.

An algebraic sum of the signs (+, -, 0) on the four ratings reveals that in the open-minded group 10 are (+) favorable, 1 is (-) unfavorable, and 2 are (0) indeterminate, while the closed-minded group has only 4 (+) favorable, but 6 (-) unfavorable, and 3 (0) indeterminate. Due to the rather small N of the study, the investigator was forced to use the Fisher exact probability test (67) to statistically analyze the data. The Fisher method of hypothesis testing employs a two-by-two contingency table, and due to this fact, if an individual's final rating was (0) indeterminate, it was not used in this analysis. In the final analysis, then, for the open-minded group there are 10 (+) favorable toward the teaching of elementary science, and 1 shows an (-) unfavorable attitude; however, there are only 4 (+) favorable with 6 (-) unfavorable toward the teaching of elementary science in the closed-minded group. The results given by the use of the Fisher exact probability test reveal that the differences between the open- and closed-minded groups are significant beyond the .05 level. Therefore, the null hypothesis is rejected, and in fact, the differences are significant beyond the .025 level for a one-tailed test.

While the cumulative results of all four ratings seemed to be the best indication of the attitudes held by the students, any one of the four individual ratings gives the same direction, if not the same magnitude of difference.

Confidence in Science Teaching

This section of the study reports data obtained on the confidence scale devised by Evans and Frazier (66). The instrument, entitled, "How Do I Feel About Teaching Science?" has questions that deal with four methods employed in the teaching of science. These methods are experimentation, discussion, observation, and reading. The instrument has 40 items, 10 items for each of the previously mentioned methods employed in the teaching of science. One-half, or 20, of the items come from the biological sciences, and one-half come from the physical sciences.

Tables IV through IX give the pre-test and post-test results on the confidence instrument for both open- and closed-minded individuals. Mann-Whitney U tests were performed on the pre-test scores of the open- and closed-minded groups to ascertain significant differences.

TABLE IV

CONFIDENCE SCORES - EXPERIMENTATION

Open-Minded			Closed-Minded		
Student	Pre	Post	Student	Pre	Post
1	34	34	38	34	35
2	37	48	39	34	44
3	41	40	40	26	35
4	*	42	41	34	37
5	33	36	42	*	35
6	33	38	43	30	36
7	29	44	44	45	47
8	36	41	45	37	46
9	32	49	46	33	45
10	36	42	47	36	42
11	37	44	48	32	34
12	30	42	49	35	37
13	33	39	50	37	45

*No Score

TABLE V

CONFIDENCE SCORES - DISCUSSION

Open-Minded			Closed-Minded		
Student	Pre	Post	Student	Pre	Post
1	42	40	38	30	34
2	45	49	39	33	46
3	41	41	40	36	41
4	*	50	41	41	36
5	43	43	42	*	28
6	38	42	43	37	40
7	33	45	44	45	47
8	46	46	45	38	47
9	36	41	46	35	48
10	40	47	47	41	41
11	35	42	48	30	47
12	36	46	49	39	40
13	42	43	50	43	48

*No Score

TABLE VI

CONFIDENCE SCORES - OBSERVATION

Open-Minded			Closed-Minded		
Student	Pre	Post	Student	Pre	Post
1	34	42	38	39	36
2	41	49	39	42	47
3	45	45	40	35	39
4	*	46	41	41	36
5	39	42	42	*	36
6	37	43	43	38	42
7	37	43	44	44	48
8	43	48	45	47	46
9	38	43	46	38	48
10	41	42	47	37	46
11	30	45	48	40	41
12	38	44	49	36	39
13	42	45	50	39	46

*No Score

TABLE VII

CONFIDENCE SCORES - READING

Open-Minded			Closed-Minded		
Student	Pre	Post	Student	Pre	Post
1	44	50	38	40	36
2	47	50	39	47	49
3	50	49	40	48	49
4	*	41	41	46	40
5	39	40	42	*	39
6	42	48	43	37	49
7	24	40	44	50	50
8	46	49	45	42	48
9	43	47	46	36	50
10	35	43	47	34	43
11	20	31	48	39	47
12	34	48	49	38	41
13	39	41	50	44	50

*No Score

TABLE VIII

CONFIDENCE SCORES - BIOLOGICAL SCIENCES

Open-Minded			Closed-Minded		
Student	Pre	Post	Student	Pre	Post
1	87	90	38	84	77
2	88	98	39	84	99
3	89	94	40	77	82
4	*	92	41	88	74
5	79	83	42	*	78
6	76	92	43	78	84
7	75	89	44	95	99
8	89	94	45	88	98
9	74	89	46	74	98
10	85	91	47	74	89
11	65	83	48	77	89
12	86	98	49	79	82
13	82	85	50	84	95

*No Score

TABLE IX

CONFIDENCE SCORES - PHYSICAL SCIENCES

Open-Minded			Closed-Minded		
Student	Pre	Post	Student	Pre	Post
1	67	76	38	59	64
2	82	98	39	72	87
3	88	81	40	68	82
4	*	87	41	74	75
5	75	78	42	*	60
6	74	80	43	64	83
7	48	83	44	89	93
8	82	90	45	76	89
9	75	92	46	68	93
10	67	83	47	74	83
11	57	79	48	64	80
12	52	82	49	69	75
13	74	83	50	79	94

*No Score

For each of the categories under test the accompanying calculated U is now reported:

Experimentation	U = 69.0
Discussion	U = 51.5
Observation	U = 66.0
Reading	U = 61.0
Biological sciences	U = 68.5
Physical sciences	U = 71.0

To reject the null hypotheses when $n_1 = 12$, $n_2 = 12$ requires that U = 37; therefore, none of the differences were significant at the .05 level on pre-test scores.

The calculated Mann-Whitney U values of post-test scores are:

Experimentation	U = 70.5
Discussion	U = 67.5
Observation	U = 53.8
Reading	U = 76.0
Biological sciences	U = 71.0
Physical sciences	U = 79.5

The table value of U for the previous data with $n_1 = 13$, $n_2 = 13$ is 45. Again, it is impossible to reject the null hypotheses at the .05 level.

The Wilcoxon matched-pairs signed-ranks test was used to test if significant differences existed between the pre-test results and the post-test results for both the open- and closed-minded groups on the various aspects of the confidence scale. The results obtained for the open-minded group reveal that the differences between pre-test and post-test results on confidence in experimentation, discussion, observation, and reading plus the biological and physical sciences are significant at or beyond the .005 level for one-tailed tests. For the closed-minded group the results are similar, but the levels of significance are not as great. The results show the following levels of significance to be: experimentation and physical sciences at or beyond the .005 level, reading and biological sciences .025, and discussion and reading .01.

The Mann-Whitney U test was used to determine if the differences between pre-test and post-test results of open-minded and closed-minded subjects were significant. This seemed to be a logical analysis to make since those who are open-minded had shown a greater gain between their pre-test and post-test than those who are closed-minded. However, none of the calculated U values were small enough to reject the null hypotheses that changes in confidence of open- and closed-minded subjects are different.

Summary of Findings

The two groups under investigation in this study were established by using Rokeach's Dogmatism Scale. If a subject's score fell in the lower quartile of all the scores, she was placed in the open-minded group; if, however, a subject's score fell in the upper quartile, she was considered a member of the closed-minded group.

The general null hypothesis stated that open- and closed-minded groups would not differ in three areas. These three areas, which were subjected to empirical tests, are achievement in science, attitudes toward the teaching of elementary school science, and confidence in one's ability to teach elementary school science.

No significant differences were found in the area of achievement in science between those who are open-minded and those who are closed-minded. However, the mean of the open-minded group exceeds that of the closed-minded group.

The attitudes toward the teaching of elementary school science of open-minded and closed-minded subjects differ at the .025 level of confidence. The cumulative results of four different ratings were used to test for differences; however, each of the ratings indicated that the attitudes held by the open-minded group were more favorable than those held by the closed-minded group.

The data from the confidence scale indicates no significant differences between open- and closed-minded individuals on either pre-test or post-test scores. Both the open- and closed-minded groups were found to make changes in their confidence based on the pre-test and post-test results. Since the open-minded group did show a greater gain in confidence it was decided to determine if the changes that had occurred in confidence for open- and closed-minded groups were significantly different. However, this was not the case and the null hypothesis could not be rejected in any of the cases when concerned with difference between the open- and closed-minded groups on confidence in the teaching of elementary school science.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

General Summary

This investigation was implemented to determine if a given group of open-minded pre-service elementary education majors gave greater promise of being capable of teaching science than a given group of closed-minded pre-service elementary education majors.

Rokeach's Dogmatism Scale, Form E, was administered to the students in Education 4K2, Science for the Elementary School, and it was on the basis of this instrument that the open- and closed-minded groups were established.

The investigator of this study also taught the course, which lasted for eight weeks and was taken just prior to the student teaching experience. The course was taught so that the student teachers were actively involved in experiences found in many of the emerging elementary science programs.

The areas of concern in this study were achievement in science, attitudes toward the teaching of elementary school science, and confidence in ability to teach elementary school science. The data were submitted to nonparametric tests to determine if significant differences existed between those who are closed-minded. The results of the data interpretation are found in the next section.

Conclusions and Implications

The data of this study were analyzed to determine if there were significant differences between open-minded and closed-minded subjects on (1) achievement in science, (2) attitudes toward the teaching of elementary school science, and (3) confidence in the ability to teach elementary school science.

Regarding achievement in science, it is concluded that there are no significant differences between open-minded and closed-minded subjects. However, the open-minded group had a slightly higher mean on the achievement instrument than the closed-minded group.

The attitudes held toward the teaching of elementary school science for the open-minded group were significantly more favorable than the attitudes of the closed-minded group. If attitudes of teachers are important, the open-minded group might be expected to do a better job of teaching science by the approaches now being advocated in many of the national curriculum revisions.

No significant differences were found to exist between the open-minded and closed-minded groups on pre-test and post-test scores of confidence in the teaching of science. In fact, both the open- and closed-minded groups showed significant improvement between their pre-test and post-test scores on the confidence instrument. This resultant increase in confidence for both groups is gratifying because most elementary teachers are expected to teach science in a self-contained classroom.

Finally, as Glass (68) stated in a recent article, one of the goals of studying science is to, "recognize its spirit and to learn its methods." It must be remembered, however, that most of the teachers in the elementary schools are products of a method of science teaching that is referred to by Schwab (69) as a "rhetoric of conclusions." Can those who have been educated by more traditional methods be expected to teach the processes of science? Can they help students develop attitudes that are consistent with the spirit of science? Or are there those who can more effectively accomplish this task because of the structure of their particular belief system?

Recommendations

It is the opinion of the investigator that the following five statements should be given consideration by those who are involved in the teaching of elementary science methods courses.

1. The methods course was taught in such a way that the students had opportunities to work with the approaches being developed in many of the newer elementary science programs. Students (both open- and closed-minded) made significant changes in confidence between their pre-test and post-test scores; consequently, it is recommended that this approach to the teaching of Education 4K2, Science for the Elementary School, be continued with a modification. It might be advisable to modify the course to use only one of the approaches, such as AAAS, ESS, ISCS, or for that matter one of the newer textbook series, since the rationales of many of the newer programs are similar.
2. The students in this study did not have an opportunity to teach a practice lesson in science, and many felt that this

would have been a very beneficial experience. It might be desirable to have each student prepare a unit of study for a specific grade level, and present a lesson from this to her peers prior to the student teaching experience. The time factor is very limiting, and to implement this additional experience would require a different type of class schedule than the one now in existence.

3. Many of the student teachers were rather dubious about teaching science by the methods employed in this study. It would seem advantageous to continue to have either first-hand or vicarious observational experiences of successful teaching sessions that employ the methods of the newer programs in science. For example during this study, the media employed to furnish these observational experiences were some 8mm films of elementary students being taught science in a traditional setting by the newer methods.

4. The results of this investigation indicated that the attitudes toward the teaching of elementary science for open-minded pre-service elementary education majors were significantly more favorable than the attitudes of closed-minded pre-service elementary education majors. A follow-up study should be implemented to determine if open-minded in-service elementary teachers express a more favorable attitude toward the teaching of science. The population to be sampled could possibly be composed of subjects who had been tested with the Dogmatism Scale prior to graduation at the baccalaureate level. In fact, the names of the subjects of this investigation and

their permanent addresses have been obtained; however, to get a N of adequate size for in-service testing it would probably require at least a year or two of teaching science by methods similar to those advocated in this investigation. Other in-service groups of elementary teachers could also serve as a population from which to draw the sample.

5. The past decade has been one of curriculum innovation; the next should be one of implementation of these programs. Curriculum developers need to be aware of the training and characteristics of students and teachers alike if the desired objectives of the newer science teaching approaches are to be successful.

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APPENDIX A

DOGMATISM SCALE

The following statements represent what the general public thinks and feels about a number of important social and personal questions. The best answer to each statement is your <u>personal opinion</u>. There are many different and opposing points of view; you may find yourself agreeing strongly with some of the statements, disagreeing just as strongly with others, and perhaps uncertain about others; whether you agree or disagree with any statement, you can be sure that many people feel the same as you do.

Mark each statement in the left margin according to how much you agree or disagree with it. Please mark every one. Write +1, +2, +3, or -1, -2, -3, depending how you feel in each case.

+1 I agree a little.	-1 I disagree a little.
+2 I agree on the whole.	-2 I disagree on the whole.
+3 I agree very much.	-3 I disagree very much.

_____ 1.* The United States and Russia have just about nothing in common.

_____ 2.* Once I get wound up in a heated discussion, I just can't stop.

_____ 3. Most people are failures and it is the system which is responsible for this.

_____ 4.* In times like these, a person must be pretty selfish if he considers primarily his own happiness.

_____ 5. It is by returning to our glorious and forgotten past that real social progress can be achieved.

_____ 6.* The highest form of government is a democracy, and the highest form of democracy is a government run by those who are most intelligent.

_____ 7.* Fundamentally, the world we live in is a pretty lonesome place.

_____ 8.* There is so much to be done and so little time to do it in.

_____ 9. While the use of force is wrong by and large, it is sometimes the only way possible to advance a noble ideal.

_____ 10.* In a discussion I often find it necessary to repeat myself several times to make sure I am being understood.

_____ 11.* A man who does not believe in some great cause has not really lived.

_____ 12. If I had to choose between happiness and greatness, I'd choose greatness.

_____ 13. It is only natural for a person to have a guilty conscious.

_____ 14. There is nothing new under the sun.

_____ 15.* In this complicated world of ours the only way we can know what's going on is to rely on leaders and experts who can be trusted.

_____ 16. Young people should not have too easy access to books which are likely to confuse them.

_____ 17. Communism and Catholicism have nothing in common.

_____ 18.* Most people just don't give a "damn" for others.

_____ 19.* It is only when a person devotes himself to an ideal or cause that life becomes meaningful.

_____ 20.* It is better to be a dead hero than a live coward.

_____ 21.* In the long run, the best way to live is to pick friends and associates whose tastes and beliefs are the same as one's own.

_____ 22.* The worst crime a person could commit is to attack publicly the people who believe in the same thing he does.

_____ 23.* I'd like it if I could find someone who could tell me how to solve my personal problems.

_____ 24.* In the history of mankind there have probably been just a handful of really great thinkers.

_____ 25. My hardest battles are with myself.

_____ 26.* When it comes to differences of opinion in religion, we must be careful not to compromise with those who believe differently from the way we do.

_____ 27.* A person who thinks primarily of his own happiness is beneath contempt.

_____ 28.* The present is all too often full of unhappiness. It is only the future that counts.

_____ 29.* Even though freedom of speech for all groups is a worthwhile goal, it is unfortunately necessary to restrict the freedom of certain political groups.

_____ 30.* My blood boils whenever a person stubbornly refuses to admit that he is wrong.

_____ 31.* If a man is to accomplish his mission in life, it is sometimes necessary to gamble "all or nothing at all."

_____ 32. In a heated discussion people have a way of bringing up irrelevant issues rather than sticking to the main issues.

_____ 33.* Man on his own is a helpless and miserable creature.

_____ 34.* The main thing in life is for a person to want to do something important.

_____ 35. There is no use in wasting your money on newspapers which you know in advance are just plain propaganda.

_____ 36.* Most people just don't know what's good for them.

_____ 37. There are certain "isms" which are really the same even though those who believe in these "isms" try to tell you they are different.

_____ 38.* It is only natural for a person to be rather fearful of the future.

_____ 39.* In a heated discussion I generally become so absorbed in what I am going to say that I forget to listen to what others are saying.

_____ 40.* Of all the different philosophies which exist in this world, there is probably only one which is correct.

_____ 41. At times I think that I'm no good at all.

_____ 42. I'm sure I'm being talked about.

_____ 43.* There are a number of people I have come to hate because of the things they stand for.

_____ 44.* Unfortunately, a good many people with whom I have discussed important social and moral problems don't really understand what's going on.

_____ 45. It is sometimes necessary to resort to force to advance an ideal one strongly believes in.

_____ 46.* A person who gets enthusiastic about too many causes is likely to be a pretty "wishy-washy" sort of person.

_____ 47.* It is often desirable to reserve judgment about what's going on until one has had a chance to hear the opinions of those one respects.

_____ 48.* To compromise with our political opponents is dangerous because it usually leads to the betrayal of our own side.

_____ 49. It's all too true that people just won't practice what they preach.

_____ 50.* If given the chance, I'd do something of great benefit to the world.

_____ 51.* In times like these it is often necessary to be more on guard against ideas put out by people or groups in one's own camp than those in the opposing camps.

_____ 52. I have often felt that strangers were looking at me critically.

_____ 53.* There are two kinds of people in this world: (1) those who are for the truth, or (2) those who are against the truth.

_____ 54.* A group which tolerates too much differences of opinion among its own members cannot exist for long.

_____ 55. I sometimes have a tendency to be too critical of the ideas of others.

_____ 56. To compromise with our political opponents is to be guilty of appeasement.

_____ 57.* While I don't like to admit this even to myself, my secret ambition is to become a great man, like Einstein, or Beethoven, or Shakespeare.

_____ 58.* Most of the ideas which get printed nowadays aren't worth the paper they are printed on.

_____ 59. Even though I have a lot of faith in the intelligence and wisdom of the common man I must say that the masses behave stupidly at times.

_____ 60.* It is only natural that a person would have a much better acquaintance with ideas he believes in than with ideas he opposes.

*Denotes the original 40 statements of the Rokeach Dogmatism Scale

APPENDIX B

SELF-RATING AND PEER-RATING INSTRUMENT

DIRECTIONS

Attached is a roster of the individuals who have participated in Education 4K2. We would like for you to go through this roster and compare yourself with every other person whose name is listed with regard to your attitude toward the teaching of elementary school science.

Please proceed as follows:

(1) Find your own name on the roster. (If your name does not appear on the roster, please raise your hand.)

(2) Draw a line around your own name.

(3) Begin with the first name on the roster and proceed with the comparisons as indicated below:

If you consider yourself more favorable toward the teaching of elementary school science using the methods you have studied in 4K2 than a given individual, assign yourself a plus (+) by that name. If, in contrast, you consider yourself less favorable toward the teaching of elementary school science using the methods you have studied in 4K2 than a given individual, assign yourself a minus (-) by that name. (NOTE: You are rating your attitude as compared with the other individuals rather than rating their attitude toward the program.)

REMEMBER: You are to compare yourself with every other individual whose name is on the roster.

Example:

__+__ Jane Doe (I consider myself more favorable toward the teaching of elementary school science using the methods studied in 4K2, so I give myself a "+" by Jane Doe's name.)

__-__ Mary Smith (I consider myself less favorable toward the teaching of elementary school science using the methods studied in 4K2, so I give myself a "-" by Mary Smith's name.)

APPENDIX C

ATTITUDES TOWARD ELEMENTARY SCHOOL SCIENCE

ATTITUDES TOWARD ELEMENTARY SCHOOL SCIENCE

Leaders in science education stress the importance of concepts, generalizations, scientific methods, and attitudes. While progress has been made in most of these areas, much more work must be directed toward the development of positive attitudes toward science. The term "attitude" used in this questionnaire refers to how an individual feels about elementary school science - an emotionalized feeling for or against science. (A distinction needs to be made between this type of attitude and the term scientific attitude or scientifically minded person who possesses an open mind, looks at a problem from many sides, and seeks reliable sources for his evidence.)

This questionnaire is designed to measure how you feel about elementary school science. Most of these statements were obtained by asking 200 prospective elementary school teachers to write short statements of their feelings about science. Please indicate your feelings by circling the number which indicates the degree with which you agree or disagree with each statement. Remember that these statements were made by students like yourself and you should interpret them from the point of view of a prospective elementary school teacher and your own feelings and experiences.

EXAMPLE: Democrats are interesting people.

AGREE----1----2----3----4----(5)----6----7----8----9----DISAGREE

Note that 5 is circled, indicating neither strong disagreement nor strong agreement.

COMPLETE THE FOLLOWING STATEMENTS IN A SIMILAR MANNER:

1. "Field trips to such places as botanical gardens or observatories make science an interesting subject."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

2. "Science is unrelated to life experiences."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

3. "I wish I had been given more science instruction in elementary school."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

4. "I never could see anything through a microscope."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

5. "It is very helpful to know the basic facts about animal life."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

6. "Science seems to be 'over my head.'"

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

7. "Possibilities for student participation make science an interesting subject."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

8. "The study of science doesn't bore me, but I would never pursue it independently."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

9. "It is fascinating to study live specimens in the classroom."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

10. "I am always interested in learning more about science."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

11. "I just hate mice, worms, bugs, and any other small crawling things."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

12. "Science education is a 'must' at this time."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

13. "Scientists are people who invent something to improve everyday living."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

14. "Science learnings are often the basis of a good hobby."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

15. "Science is very important in this scientific age in which we live."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

16. "A lizard is an interesting and attractive classroom pet."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

17. "Science is interesting, but not as important as other subjects."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

18. "Science is boring."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

19. "I like to do science experiments."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

20. "Elementary school science should be taught to groups of children with approximately the same I.Q."

AGREE——1——2——3——4——5——6——7——8——9——DISAGREE

APPENDIX D

HOW DO I FEEL ABOUT TEACHING SCIENCE?

HOW DO I FEEL ABOUT TEACHING SCIENCE?

It seems to be generally agreed that most prospective elementary school teachers feel less confident about the teaching of science than they do about teaching the "three R's." Part of this may be the result of the less adequate preparation of the teacher in science; part may come from the feeling of the teacher himself that he is inadequately prepared to teach science.

This questionnaire is designed to measure how confident you may feel in various situations involving several aspects of elementary science teaching. Please indicate your feelings with respect to the situations on the following pages by circling the appropriate number before each item on the answer sheet. For example, if you feel "very confident" about a certain situation, circle the number 5; if you feel "moderately confident" circle the number 4; and so on, utilizing the code shown below:

(5) Very confident
(4) Moderately confident
(3) Uncertain
(2) Moderately unconfident
(1) Very unconfident

SITUATION A

Your class is doing a unit on "Animals." The children ask the question, "How are plants and animals alike?" Below are some possible activities which you and the class may do. How confident would you feel about each?

1. Have children observe pets and plants at home to see how they are similar in basic needs.

2. Take the class on a field trip to notice the variations in plants and animals.

3. Do experiments to see if both plants and animals need water, food, etc.

4. Discuss with the class some of the similarities and differences between plants and animals.

5. Provide reference lists of children's books on plants and animals.

SITUATION B

A fourth-grade teacher is just a little afraid to do experimentation with her class. One day she attempted to demonstrate the presence of carbon dioxide in the breath. She had one of the pupils blow air through a straw which was immersed in a glass of lime water. The carbon dioxide in the pupil's breath should have made the calcium precipitate out and turn the water a milky color. However, much to the class's delight, the lime water stayed clear and the calcium did not precipitate. Below are some possible activities which could be undertaken. How confident would you feel about each?

6. Do the experiment over again using a new solution of lime water.

7. Discuss suggestions from the class to determine what was the reason for the failure in the experiment.

8. Try another experiment which will show the same body process as the one which failed.

9. Discuss some other related experiments which attempt to show the same results as the one which failed.

10. Encourage reading by children to discover possible reasons for failure in the experiment, provide reference materials for them to use.

SITUATION C

Your class is working on a unit study in "How do plants grow?" Below are some possible activities which may be carried out by the children and the teacher. How confident would you feel about each?

11. Read in books about plants and how they grow.

12. Observe a plant in a box or container to record growth changes.

13. Do experiments to show how a plant seed germinates.

14. Provide a list of references of children's books.

15. Have a sharing discussion about plants that children have in their homes.

SITUATION D

Your fourth grade class is studying a unit on weather. The question is raised, "How does the weather man know it's going to rain?" In looking at these possible activities, how confident would you feel about each?

16. Construct and use a model barometer or other equipment used by the weather man.

17. Use science kit to conduct experiments to determine causes of precipitation, condensation, etc.

18. Encourage children to read in reference material to find information about weather (books, magazines, weather reports, etc.)

19. Help the children design and follow through with a daily weather chart.

20. Form a committee to investigate the question further and provide a list of resource materials for committee use.

SITUATION E

Your class is doing a unit study in "How simple machines help us." Below are some possible activities which may be carried out by the children and the teacher. How confident would you feel about each?

21. Observe the ways that simple machines are used in the school or community and record results of observations.

22. Provide a list of children's books on the uses of simple machines.

23. Discuss with the class the basic principles behind the workings of a pulley and some of its practical uses.

24. Have a sharing and discussion period about children's toys which resemble simple machines.

25. Discuss some of the uses of similar simple machines such as the lever, inclinded plane, ball bearing, etc.

SITUATION F

While on a field trip, the school bus passes through an area where corn is planted. It has been a rainy year, and some of the corn fields are flooded in spots, and the corn is dying. The children, discussing the trip the next day, raise the question, "We have always been told that water is needed for plant life; why is the corn dying? It has plenty of water." In terms of the activities, how confident would you feel about each?

26. Discuss some experiments which the class may do to determine some of the requirements of plant life, and some conditions which may harm plants.

27. Do experiments with different kinds of plants (corn, watercress, wheat, bean, etc.) to show that each of them have slightly or greatly different environmental requirements for ideal growth.

28. Form a committee for further investigation of the problem; provide appropriate reference materials for them to use.

29. Have children observe plants in their homes and gardens to determine effects of the environment on the plants.

30. Make an observational chart of some local plants which live in the water, others which live on dry land. Observe local plants and record results.

SITUATION G

Your classroom is doing a unit study on the solar system. Below are some possible teacher-pupil activities. How confident would you feel about each?

31. Plan a trip to a nearby observatory or planetarium.

32. Find information about the solar system in materials other than the text which would be at an appropriate reading level for the children.

33. Design an observation chart of the visible planets. Observe the visible planets and keep a record of their positions in the night sky.

34. Construct a model of the solar system using balls, marbles, or beads to show the approximate relative sizes of the sun and the planets.

35. Have a class discussion on the importance of the sun.

SITUATION H

Your classroom is working on a unit study of "Electricity and what it can do." Below are some possible activities which may be carried out by the children and the teacher. How confident would you feel about each?

36. Construct a model electric motor from inexpensive materials.

37. Do experiments to show how a light bulb works.

38. Dismantel old or broken appliances to observe and learn more about how they work.

39. Provide a list of references of children's books on the uses of electricity.

40. Discuss some of the ways electricity is used in the school.

Name________________________________

ANSWER SHEET: HOW DO I FEEL ABOUT TEACHING SCIENCE?

SITUATION A

	Very Confident		to	Very Unconfident	
(1)	5	4	3	2	1
(2)	5	4	3	2	1
(3)	5	4	3	2	1
(4)	5	4	3	2	1
(5)	5	4	3	2	1

SITUATION B

(6)	5	4	3	2	1
(7)	5	4	3	2	1
(8)	5	4	3	2	1
(9)	5	4	3	2	1
(10)	5	4	3	2	1

SITUATION C

(11)	5	4	3	2	1
(12)	5	4	3	2	1
(13)	5	4	3	2	1
(14)	5	4	3	2	1
(15)	5	4	3	2	1

SITUATION D

(16)	5	4	3	2	1
(17)	5	4	3	2	1
(18)	5	4	3	2	1
(19)	5	4	3	2	1
(20)	5	4	3	2	1

SITUATION E

	Very Confident		to	Very Unconfident	
(21)	5	4	3	2	1
(22)	5	4	3	2	1
(23)	5	4	3	2	1
(24)	5	4	3	2	1
(25)	5	4	3	2	1

SITUATION F

(26)	5	4	3	2	1
(27)	5	4	3	2	1
(28)	5	4	3	2	1
(29)	5	4	3	2	1
(30)	5	4	3	2	1

SITUATION G

(31)	5	4	3	2	1
(32)	5	4	3	2	1
(33)	5	4	3	2	1
(34)	5	4	3	2	1
(35)	5	4	3	2	1

SITUATION H

(36)	5	4	3	2	1
(37)	5	4	3	2	1
(38)	5	4	3	2	1
(39)	5	4	3	2	1
(40)	5	4	3	2	1

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