AN INVESTIGATION OF THE EFFECTS OF SCIENCE TEACHING METHODS ON THE ATTITUDES OF ELEMENTARY EDUCATION MAJORS

Thesis for the Degree of Ph. .D

MICHIGAN STATE UNIVERSITY

HELENE B. BREWER

1973

This is to certify that the

thesis entitled

AN INVESTIGATION OF THE EFFECTS OF SCIENCE
TEACHING METHODS ON THE ATTITUDES OF
ELEMENTARY EDUCATION MAJORS

presented by

Helene B. Brewer

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Education

Judith E. Henderson

Major professor
Dr. Judith E. Henderson

Date June 5, 1973

O-7639

AN INVESTIGATION OF THE EFFECTS OF SCIENCE TEACHING METHODS ON THE ATTITUDES OF ELEMENTARY EDUCATION MAJORS

By

Helene B. Brewer

This study investigated the possibility of establishing within the framework of a university science department a Physical Science structured open classroom. In this classroom the teaching strategies of modeling and respondent learning were employed throughout a semester time span. The dependent variable of primary concern was the degree of positive attitude change, with no concomitant decrease in cognitive physical science learning, which occurred.

The subjects for this study were the randomly selected responses of all the students enrolled in two Physical Science courses specifically designed for the preparatory elementary school science teachers at Central Michigan University. The study was conducted during the regularly scheduled class time. The instruments used to gather the data in this study were three:

1. A Physical Science Aptitude Test (given at the beginning and end of each semester between the years 1970 to 1972).

2. A Lesson Plan Challenge

3. An Attitude Questionnaire

The results of the study indicated that:

1. It is possible to be innovative in teaching methodology within the framework of a university science department.

2. The departure from the traditional lecture method of instruction was not detrimental to the scholastic progress of the experimental group, but caused a significant increase in acquisition of knowledge.

3. Some change in attitude toward science and science teaching was in evidence.

AN INVESTIGATION OF THE EFFECTS OF SCIENCE TEACHING METHODS ON THE ATTITUDES OF ELEMENTARY EDUCATION MAJORS

By

Helene B. Brewer

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

College of Education

1973

DEDICATION

The writer wishes to dedicate this Dissertation to

C. Dorothy Schaefer

who could not wait

and

to my parents

Rufus and Marie Brewer

who have waited a long, long time for this event to occur.

ACKNOWLEDGEMENTS

The writer wishes to express her appreciation and thanks to the many persons who gave direction, counsel and aid in the accomplishment of this study. Whatever merit it may have is largely due to them.

A very particular debt of gratitude is acknowledged to both Dr. Judith E. Henderson and Dr. Henrietta L. Barnes. As mentors and advisors they have involved themselves in this dissertation from its inception to its completion. More than can be expressed is owed to their direction.

Special thanks are extended to Dr. Richard Stiggins of Michigan State University for his most constructive critiques and for his help in statistical methodology.

Grateful recognition is given to the students of Physical Science 351B at Central Michigan University who cheerfully cooperated as subjects for this investigation. Acknowledgement and gratitude are extended to Misses Harriet S. and Charleta Taylor of Mount Pleasant, Michigan for their encouragement and interest.

Gratitude is also expressed to Miss Marie Ann Bandl and to Mrs. Virginia M. Fisher.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

DESCRIPTION AND STATEMENT OF THE PROBLEM, THEORETICAL FRAMEWORK, PURPOSE AND OBJECTIVES

In the science world of the elementary school teacher new developments and new programs are being introduced at a most rapid rate. Since Sputnik (1956) and the bathyscaphe, Trieste (1960), the teaching of science in the schools has been the focus of much attention. The scientific explosion has created an exciting environment for science. Educators have become more concerned with their responsibility to prepare students to live and function in the environment of the atomic age. This concern is evidenced by the formation of the many nationally funded committees charged with the establishment and investigation of new curriculum projects. These projects are reported in the 1964 publication "Information Clearing House on New Curricula" from the University of Maryland and the National Science Foundation's booklet (1964) on course improvement programs supported by the Foundation. These sources along with Rosenbloom's (1964) Modern Viewpoints in Curriculum are cited by Lacy (1966) as being the most complete sources of information on new curricula.

Never before in the educational history of these times has the classroom teacher been asked to accept such radical changes in science teaching methods. The teacher has been asked to turn from the traditional rote learning, imitation, and repetition-of-facts presentation to methods that tend to promote critical thought, analysis, inquiry, discovery and/or creativity. These changes place considerable emphasis on the teaching of inquiry skills and manipulative skills rather than on just the acquisition of useful knowledge.

Concurrent with the required changes in science teaching on the elementary level the research points out that there is an increasing reluctance on the part of the elementary school teacher to teach science. Victor's (1961) study found that the chief factor in the reluctance of the elementary school teacher to teach science was an inadequate science background. Since that time, colleges and universities have increased their offerings of new programs and courses of science for the elementary teacher. However, little attention has been given to the development of programs designed to change dispositions and attitudes to be more favorable toward science. Newton and Watson's (1968) recent survey of science methods instructors indicated that the teacher trainers are of the opinion that only 13 percent of the essential attributes needed to teach science are affective qualities. Menzel, (1969) on the other hand, maintains that the teaching of science

requires a balance of both the affective and the cognitive qualities. Although it is acknowledged that prospective teachers acquire substantial science content and science methodology background, the ends to which those are to be applied are not clearly defined. That is, there is usually little attempt to help prospective teachers see ways in which to teach science content and methodology more effectively.

Science teachers seem to be concerned with the students' understanding, evaluation, analysis, and synthesis of scientific information. The student is required to experiment with concepts which too frequently stress convergent, rather than divergent problem solving. Broudy (1969) suggests that this procedure is simply the cognitive imputting of learning and labels this procedure as "didactic teaching." He further suggests that the stage is set for didactic teaching when the student has mastered sufficient expected material, his answers are reinforced to the point of boredom, or corrected and the accepted response is stored available for instant recall or use. But Menzel (1969) says that if this is science teaching and is so defined, this process leaves one with a sensation of emptiness. He also maintains that there is a place in science learning for attitude training. Menzel believes that such teaching is characterized by 'being critical, being intelligent, being uninhibited, and being friendly.' This kind of teaching requires the teacher to organize within the instructional theory a place for the development of dispositions and attitudes that involve the entire learning situation.

Current Elementary School Science Teacher Preparation

In the preparation of elementary school science teachers there exists a basic philosophical commitment that the general science education of the liberal arts student and the preparatory elementary school teacher have much in common. Gross and Mayo (1969) maintain that neither process--liberal arts curriculum or elementary teacher science preparation are designed to produce research scientists. These programs tend to focus on literacy in science and on understanding the nature of scientific activity. Gross and Mayo further claim that in both programs "an essential part is the presentation of science as an integral part of our total social, cultural, and intellectual make-up; and in both cases it seems advantageous to approach the teaching of science from the historical and philosophical viewpoint [p. 22.]"

Paul Brandwein (1965) notes the failure of these programs and offers an analysis of the teacher as a basis for teacher training. He states that the teacher brings to the classroom three different qualities; "substance, structure and style." He defines substance as the traditional subject matter including concepts and conceptual schemes, products, processes, certainties, his uncertainties and the failures of science. He analyzes structure as being related to the organization of the curriculum which should be built upon concepts in an interrelated manner. According to Brandwein, style includes the teachers, attitudes, their actions and mannerisms--in fact, what is done in the classroom and just how it is done.

In a structural sense as well as in substance, Brandwein's (1965) definition is too limited for this study. Physical Science should be a broad, interdisciplinary science program and should not be separated into discrete disciplines. Such a program should include the study of man's total interaction with his physical environment--man, plants, animals and elements--more of a natural science point of view. Gross and Mayo (1969) support the interdisciplinary position and state that "traditionally, education at all levels is separated into discrete disciplines, and the student seldom engages in formal study of the interrelationships between the various disciplines [p. 22.]" It should be noted, however that this was not always the case. Prior to the nineteen hundred's, classical mechanics provided the basis of investigation in physical science and scientists were trained in a general knowledge of what was then called 'Natural Philosophy'. With the work of Albert Einstein and others at the turn of the century, science and scientist branched into first two directions--relativity and quantum mechanics, then into more and more specialities.

While science is still usually taught as something separate and apart with little or nothing to do with real life, in some areas the reverse trend is beginning to emerge. It is the rare student who is able to discover the interrelationships between the various disciplines. Brandwein (1965) claims that the style of teaching for science programs should reflect the style of the scientist. The research scientist spends long hours and even years of study and diligent drill before he is able to understand the profound depths of his work. But this is not necessary for the elementary school science teacher.

It is true that the creator of an abstract science idea has as much of his talent and beliefs in his idea as any artist has in his art form. But the enjoyment of a beautiful piece of art or an excellent rendition of a work by Chopin or Bach or of one of Beethoven's sonatas or even a Charly Bird does not need a mastery of piano techniques or hours of violin lessons or practice. True, the expert will probably enjoy the music to a greater degree but even the side-walk musician with unskilled fingers and ears can enjoy and appreciate the beauty of a masterpiece.

To equate music and art to science enjoyment is not as far-fetched as it may at first seem to be. When the fear and awe of science is removed, the learner discovers that he really knows more about the environment of the world and the people in it than he thought. Just how the world functions can easily be shown and the beauty of the

environment and the wonder of scientific symmetry is revealed. Then even the unschooled non-scientist will be able to enjoy the universe.

Because the college professor has usually advanced beyond the threshold of his field, he is as reluctant as the modern painter or artist to spend much time and/or effort to explain his work to the novice, the philistine or to the non-interested observer. Like any artists, the creative scientist prefers that the work speak for itself. But most novices need a translation in order to appreciate science.

Teacher Training Institutions

In order to determine the nature of the physical science courses available to prospective elementary teachers, course descriptions of physical science offerings contained in 50 university catalogs were examined. Too seldom, it appeared, did institutions of higher learning involved in teacher education programs consider in their science content offerings the need to provide the opportunity for prospective teachers to become familiar with the use of manipulative science materials, or create for them a broad liberal science education by providing directed exposure to background reading in an attempt to instill a more positive attitude toward science teaching. At the present time, however, there appears to be a growing trend to provide

more relevant "science-for-teachers" experiences. Central Michigan and Michigan State Universities are two notable examples of this trend.

It appears necessary to establish in the teacher-training institutions an awareness of the need to assume the responsible role of teaching physical science with the goal in mind of enabling the prospective elementary school teacher to become familiar with and have the means by which to cope with a variety of approaches to teaching science to elementary school children. The average elementary school teacher is often afraid of science apparatus, hesitant about the use of demonstration equipment and therefore usually dislikes becoming involved with the unknown. Knowledge of science, in itself, does not infer the ability to teach science to elementary school children. There is a need to provide the prospective elementary school teacher with a science background specifically designed to meet these requirements.

Teaching elementary school science is a difficult task. It is suggested, therefore, that not only is the general science program, as taught in most liberal arts colleges inadequate for the specific need of the prospective elementary school teacher, but the purely cognitive, didactic approach to the problem of science teacher preparation reinforces the prospective teacher's fear and distaste for science instead of providing the tools of their profession. What is needed is a program of science,

coordinated with models of teaching methods, selectively designed and organized to provide relevant experiences for prospective teachers of children.

Teacher competencies are different for the teaching of new elementary school science programs than those needed to teach in the traditional way. Two basic areas in the training of elementary school teachers must be examined and re-evaluated. These competencies are the background science courses for prospective teachers and the nature of their professional training in learning theory. The major concepts should be taught in a way that provides experience and understanding of the processes of scientific inquiry.

If elementary school teachers are to be prepared to cope with the new and varied approaches to the teaching techniques of modern science curriculums, it is obvious that their college preparation would not be the same as the requirements and needs of the courses for science majors. The professional requirements and educational objectives for elementary school teachers have not the same goals as for those students who are preparing themselves for industry or for research in the adult world. It appears that the science needs of the elementary school teacher are similar to the needs of the liberal arts student, a wide and varied program, but the teachers' program is different in that it has definite goals. If it is expected of the elementary school teacher, that the

stress in their teaching is on the learning processes of knowledge, thinking, attitudes and skills, training with emphasis on observing, the formulation of hypotheses, number usage, measuring, and reaching of conclusions; then the model of how this teaching is to be done should be presented to them and learned by the teacher prior to the use of these techniques in their own classroom teaching situation. The meaning and importance of these techniques should be an intrinsic part of the prospective teacher's own college training. While it is of concern that these techniques be as universally applicable as possible, this writer is concerned with the application to the basic concepts of physical science.

The new styles of science teaching require a greater understanding of the learning processes as they relate to science learning. The prospective teacher should understand how children think, grow, and acquire meaning; the teacher needs to learn how to work with the individual child as well as how to work with groups of children. The work of Piaget (1958), Taba (1965) and other similar researchers have provided a broad base upon which to build this understanding.

In teaching the new science curriculums, teachers must be skilled in listening to children, alert to their learning difficulties and be able to aid the child in overcoming these difficulties so that the child can progress toward wisdom. Teachers do not have the time to learn nor have the inclination to learn these skills once they are in

the teaching situation unless they possess a positive attitude toward learning. Example and practice should be provided the prospective teachers before they attempt to create a conceptual learning situation in the classroom.

Several college curriculum groups are suggesting that separate science study programs are needed for prospective elementary school teachers but the colleges and universities have been very slow in recognizing this need and have been even slower in implementing such changes in their courses of study.

The classroom teacher plays many roles in the fulfillment of his teaching duties; the role of teacher, that of manager, disciplinarian, clerk, youth leader, counselor and model. Perhaps the most important of these roles is that of model. It is as model that the teacher transmits the attitudes, values and standards of the real world; the society and environment with which the student must cope. It would appear, therefore, that the teacher's attitude that is modeled toward learning, and toward science, is important.

If negative and prejudicial attitudes can be formulated by interaction with one's environment, then by changing this environment it should be possible to unlearn negative attitudes and replace them with positive and enthusiastic attitudes toward science and toward learning in general. The teacher who is most likely to model positive teaching-learning situations in the classroom and to reinforce similar attitudes toward learning on the part of the students is the enthusiastic and knowledgable teacher. Therefore, it would appear to be necessary that the training of the prospective elementary school teacher include the conscious reinforcement of positive and enthusiastic attitudes toward science learning.

Respondent Learning

There appears to be two teaching strategies needed to achieve these goals. One is found in respondent learning, the other in model learning. Henderson (1970) describes the teaching strategy of respondent learning as follows:

> Respondent learning is a change in behavior which results from the pairing of two stimuli. Initially the first stimulus elicits a particular behavior which the second stimulus does not elicit. Following a number of experiences in which the two stimuli occur together in time and space, the stimuli become so closely associated that the conditioned stimulus alone comes to elicit similar behavior to that of the originally elicited only by the unconditioned stimulus [p. 284].

Through the conscious pairing of powerful unconditioned stimuli such as relevance, concern and respect, variety, humor and the use of concrete manipulative objects with science concepts, it can be expected that positive associations will develop. Thus if such strategies are consciously built into the elementary school teachers' science courses it can be anticipated that the prospective teacher will develop a positive attitude toward science teaching.

The use of concrete manipulative materials within a science teacher preparation program is also supported by the work of Piaget (1958) who stresses that passive observation of the world, the situation, and unrelated events, is not enough for intelligence to develop, but that there must be an encounter, an engagement of the person with his environment, for learning to take place. His position on learning strongly stresses that when a person interacts with a part of the world in some way, this person does not just learn a small piece of information which is the result of the interaction, but he also learns how to interact with the world. When children interact they learn not only to solve the immediate problem, but they learn something about solving problems and about interaction with people and their environment. Respondent learning and the question of transferability as well as attitude formation is also supported by the notion that experience is an active process.

The need for research related to the teaching of concepts specifically designed to foster appropriate attitudes associated with scientific concepts is particulary acute. Little change has been seen since Allport's (1935) statements describing attitudes as "mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related [p. 19]." This statement suggests that through planned experiences there are possibilities for creating

positive attitudes. The Taxonomy of Educational Objectives, Handbook II: Affective Domain (1964) attempts to analyze the process through which attitudes are acquired. It is said that attitudes first appear at the level of "willingness to respond" and become more deeply ingrained in the learner through the stages of "satisfaction in response," and "acceptance of a value." Krathwohl (1964) thus agrees with the findings of Piaget which support interaction for development of learning.

Science lessons and hence science programs present many opportunities for teachers to help students acquire or develop such attitudes as curiosity, rationality, judgement, suspended judgement, open-mindedness, critical thinking, objectivity, honesty, etc. It has been suggested that prospective teacher-training programs be built in such a way that reinforcement of these attitudes will also have value both in and outside the classroom expanding and including all areas of human experience (Gross and Mayo, 1969).

Model Learning

Henderson, et al. (1970) describe model learning as "behavioral change that occurs as a result of observation of both another person's behavior and its consequences to them [p. 295]." Through the conscious use of credible models and the consistent reinforcement of model behaviors that show both liking and approach behaviors toward science equipment, prospective teachers may interact more positively with science materials. Through the instructor's modeling of desirable behavior, further impetus may be given prospective teachers' interactions with science materials. Thus, students would be exposed to significant models from both instructor and peers which would encourage the use of science equipment. It is with this in mind that the use of a modeling strategy will be employed in this attempt to change or reinforce positive attitudes in the subjects of this study.

Purpose and Objectives

It shall be the purpose of this research to attempt to examine change in attitudes toward physical science of prospective elementary school science teachers after participation in a series of structured science classroom experiences. These experiences are ones purposely planned to provide positive attitude enforcement. They are designed specifically for future elementary school science teachers. With special attention to the teaching strategy of respondent learning and that of modeling, the treatment will include many interaction experiences with scientific apparatus designed for use in the elementary classroom.

This investigation shall provide data as to the amount of attitude change that can be expected with systematic situation planning. Each situation unit will employ a variety of stimuli designed especially toward positive conceptual reinforcement by presenting subject content under self-motivation and peer interaction. It is postulated that the evaluation of peer expectations as seen in educational objectives (and especially their taxonomies in the affective domain) require that attitudes or value orientations be considered in the total educational situation. It is hoped that empirical evidence can be ascertained that will support the suggestion that the individual teacher-student learns attitudes and values by assimilation of role expectancies. That these attitudes be learned, not as they have been formally presented as an educational objective, but, as they are perceived, adopted and reinforced by the peer group and indirectly as the peer group interacts with larger reference peer groups, it is felt that social environment fostering such learning is significant.

Focus of the Study

The particular object of this study is an investigation of how involvement in teaching situation role acting within a peer group will influence discernibly the attitudes of the members within the school classroom society.

Use of concrete experiences and teaching models with time allotted for ample discussion to analyze each learning situation should aid in influencing attitude change toward science and science teaching. One can conclude that it has long been accepted by the behavioral

scientists that there is an effective relationship between group behavior enforced by sanctions, and individual conformity, but little is known of the manner of the response to both individual and group forces. This apparent hiatus can seem anomalous were it not realized that there exist rather formidable obstacles to research in this area. The difficulty has been summarized by Muzafer Sherif (1964) who maintains that little progress will be made in understanding the relation between social interaction and individual attitude development until there are established "uniformities of behavior within a defined range of acceptance [p. 31]."

It is clear, therefore, that no single research effort will be able to overcome the difficulties inherent in a project involving model subjects with varied background and goals. Yet it is felt that a study, though limited in scope to representative prospective elementary school science teachers who are interacting within quite determined bounds, can produce valid and reliable insights into attitude development.

This assumption is drawn from the fact that education is an acculturation process. Directed teaching-learning model usage should provide data directed toward loss of fearful uncertainty of science teaching, improved understanding of conceptual knowledge and understanding and hopefully provide modeling as successful teaching behaviors which will be carried into future classroom settings.

Research Questions

It is the intent of this research to investigate the following questions:

1. Within the framework of a university science department, is it possible to provide a location for meaningful science experiences for the preparatory elementary school science teacher?

2. Will the departure from the lecture method of instruction, usually found in the university science department, be detrimental to the scholastic progress and growth of the preparatory elementary school science teacher?

3. Will the attitude of the prospective elementary school science teacher be changed, in either a positive or negative direction, as a result of such an experience?

4. Will the prospective elementary school science teacher when exposed to the teaching strategies of modeling and respondent learning demonstrate similar teaching strategies in their constructed lesson plan?

Description of the Procedure

This study will investigate the possibility of establishing within the framework of a university science department a Physical Science structured open classroom. In this classroom, the teaching strategies of modeling and respondent learning will be employed throughout a semester time span. The dependent variable of primary concern will be the degree of positive attitude change with no concomitant decrease in cognitive physical science learning which will occur. A physical science competency examination will be used to measure the cognitive learning. An attitude

questionnaire will determine the subjects' attitude change. A Lesson Plan Challenge will be used to ascertain the degree to which prospective teachers would utilize methodology similar to that which was modeled in their own lesson plans for a unit of study.

CHAPTER II

REVIEW OF THE LITERATURE

In the past two decades important changes in elementary school science education have been made. These have generally focused on the realm of instrumentation and teaching techniques. The deluge of teaching materials, tools and proposed methods of teaching science on the elementary school level is, in fact, overwhelming. For example, an abundance of educationally geared trade books, an avalanche of educationally oriented science films, and numerous innovative teaching methods. However, one finds that little attention has been paid to the personal attitudes of the student-teacher toward science.

Walsh (1951), for example, discusses his belief on what he terms are the 'proper' ways of employing films in education. Little change has been introduced which might be considered a departure from his method. Piltz (1961) provides a guide geared toward the standardization of equipment, materials and physical facilities which are a necessary and valued part of the curriculum improvement. Hedges' (1964) comprehensive studies of programmed instructional innovations in elementary science suggests how they

can be more effectively used in the classroom; and Fischer (1962) as well as Shoreman (1964), basing their proposals on experience, suggest a team-teaching model for elementary school science teaching. Since these publications, the literature has been filled with suggestions, guides and proposed teaching models of methods for teaching elementary school science.

Much work has also been done in the area of science curriculum evaluation, such as the work of Walbesser (1963), (1966) and that of Butts (1964). In the literature can be found various innovative teaching models of the inquiry or problem-solving approach methods for the elementary school science curriculum. Notable among these are the works of J. Richard Suchman (1966), (1967) and that of Fish and Saunders (1966). These and similar studies deal with observation and evaluation of elementary school science programs by viewing the behavioral changes of pupils. These studies of the evaluation of pupils in learning situations are prevalent but little information can be found relating to the evaluation of the attitudes of the elementary school teacher whose duty it is to teach this science.

In the literature there exists little evidence of research dealing with the degree of educational sophistication needed by the classroom teacher who undertakes the use of these suggested methods. Nor can be found uniform specific goals, behavioral objectives or definite purposes for the teaching of science in the elementary school curriculum. Usually it appears to be an effort toward the impartation of specific subject matter rather than the fostering of understanding of and appreciation for the wonders of science and its applications for use in one's environment.

The papers of Fish and Saunders (1966) describe teaching situations where the discovery methods, a different type of teaching, confront the classroom teacher. Teaching in or out of the classroom is a series of complex interactions. When one considers the infinite possibilities of strategies and responses involved in the educational process, it becomes clear that the classroom teacher needs to be made familiar with educational strategic planning in its broadest sense. Taba, Levine and Elzy (1964) propose the need to develop categories of the processes of thinking which can be applied to learning and teaching. They identify the four areas of learning as "knowledge, thinking, attitudes, and skills." However, they suggest that only the objective of "Knowledge" can be obtained through organized curriculum content. Professor Taba (1969) postulates that there need be a balance between content and teaching process. Her proposal is that instead of subject matter objectives in teaching, three major principles guide the teaching process. They are:

1. learning is a transactional process,
2. learning of cognitive skills is a developmental process, and

3. maturational learning arises both from enhanced experience with content and from development of cognitive processes.

In order to facilitate this learning, Professor Taba (1965) proposed two guides:

1. a detailed outline of the content topics, and
2. a similar outline of the intellectual skills and prerequisite techniques for learning and teaching these skills.

However, while acknowledging that attitudes are a part of the learning process, Taba makes no provision in her 'strategy for learning' for the acquisition of attitudes--positive or negative--by the prospective teacher or in the modeling of positive attitudes for the students. In this research, as in so many other sources of similar study, the acquisition of positive attitudes toward science teaching is disregarded.

Along with this attempt to increase objectivity and improve the accuracy of measurements of the effectiveness of the science teaching methodology in the classroom, educational experimentalists have striven to eliminate the 'personal factor' of teaching. The scientific approach to education, founded on experimentation, testing and observation, has led to the mechanization of teaching. The literature overflows with studies which are concerned with the cognitive and psychomotor domains of the learning process. The affective domain, being more difficult to evaluate, seems to have been avoided, overlooked or left to fend for itself. The need to pay attention to fostering

a more positive attitude or attraction toward science in the programs for elementary school science teacher preparation was pointed up in 1962 by Stollberg, but little reference can be found in the literature since that time. It would appear that most writers seem to assume that the proper attitude toward the teaching of science will be a by-product, an added bonus, to their advocated program.

Since most attitudes or prejudices are formed early in life, often in the home environment before there has been any formal school experience, and later in the schools, it is important that the science teacher be able to analyze the student's experience and relate it to an instructional strategy. Lacy (1966) puts forth the following principles which to him are basic to attitude formation in order to enable one to change or reinforce desired attitudes:

> Attitudes can be developed or changed at any age.
>
> Attitudes can be most successfully changed when a whole group is involved.
>
> Activity and direct experience within a group help to reinforce attitudinal change.
>
> Attitudes can be most successfully formed, reinforced, and changed when the individual is secure within himself and his environment.
>
> Respecting, liking, and trusting the individual attempting to bring about change is important in attitude development.
>
> Changes in attitude occur most readily when individuals can freely act upon their new beliefs.
>
> Wide and varied reading and experience in new areas of study help prepare for the formation of new attitudes.

> Mass media can be influential in bringing attitudinal change.
>
> Attitudes change more easily when the new has utility and answers a felt need of the individual [p. 34].

As a word Attitude can have a variety of meanings. It can tell of a behavior trait or explain a philosophy of life. The criteria for the definition used in this study is the most frequently quoted definition of the word attitude as stated by Gordon W. Allport (1935), it is:

> An attitude is a mental and neutral state of readiness organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects to which it is related [p. 20].

Allport (1966) based this definition on the criteria; an attitude must

1. have definitive orientation in the world of objects or values, and in this respect will be different from simple and conditioned reflexes;

2. not be an altogether automatic and routine type of conduct, but must be displayed in some tension even when latent; and

3. be rooted in experience, and therefore is not simply a social instinct [p. 19].

Sells and Trites (1960) suggest that such mental and neutral states cannot be observed directly in students. Their definition is

> An Attitude is a psychological construct or latent variable, inferred from observable responses to stimuli, which is assumed to mediate consistency and co-variation among these responses [p. 102].

Attitudes dictate modes of behavior toward or away from objects, (the teaching of elementary school science, as an example), situations or groups of objects or situations. Attitudes are not divorced from emotions and feelings and therefore vary in intensity and generality according to the environment over which they apply. Haney (1963) and others state that attitudes are learned and are difficult to distinguish from other attributes of personality.

Allport (1966) equates the term attitude with value and in so doing provides the need to further define and analyze the process by which attitudes are acquired and values formulated. A value as defined by Clyde Kluckholm (1952) is:

> . . . a conception, explicit or implicit, distinctive of an individual or characteristic of a group, of the desirable which includes the selection from available modes, means and ends of action [p. 395].

An analysis of Kluckholms' criteria for his definition has been summarized by Brumeld (1963) as,

> 1. . . . values are constructs involving both cognitive and cathetic factors; and
>
> 2. they are potentially but not always verbalized;
>
> 3. while primarily culture products they are uniquely expressible by each individual and each group;
>
> 4. because particular desires may be either devalued or valued, it is essential to make sure that values are equated rather with the desirable, defined according to the requirements of both personality and sociocultural systems of order, the need for respecting the interests of others and of the group as a whole . . ., and
>
> 5. selection among available alternative values are attachable to both the means and ends of action [p. 100].

Paramount in these definitions and summarizations is the fact that attitudes and values are constructs which can be inferred from verbal and behavioral expression. Therefore they can be acquired, observed and changed in the desired degree.

If one can then assume that attitudes are constructs, there must be a period of acquisition. Many research scientists assume this process to be an on-going process from birth. Others usually associate the process with the period of adolescence. Research studies by Jacob (1959), Lermann and Payne (1963), Katz (1968), and others extend the period of adolescence into the early 'twenties' while stressing the time of the middle 'teens' as being the most productive for attitude formation. Philip Jacob (1959) found little changes in the values of college students from that which they possessed in high school. However, Sanford (1962) states emphatically that values 'jelled' in college and that this provides a ". . . challenge to educators that is both direct and formidable [p. 22]." He further implies that the attitudes and values of students are still in the fluid state and need solidification. Because of the findings of Sanford (1962) and others, such as Symonds (1961) who found little measurable changes in the attitudes and values of a group of New Yorkers studied by him for over a period of thirteen years, ". . . what they are at thirteen, they in essence were at thirty [p. 196]" indicate that unless new associations or designed active intervention in the educative process of prospective elementary school science teachers is planned for, the prospective teacher will complete college to go forth to teach with the same attitude toward science as was acquired in elementary school. As it is considered as fact by most educators that teachers tend to teach as they have been taught, then it should follow that if a particular positive attitude toward science is desired, then this attitude must be present in the model and be reinforced in the science teacher preparation or training program.

The Affective Domain: Attitudes, How May They be Changed?

An accepted approach to the analysis of the process by which attitudes are acquired is found in the Taxonomy of Educational Objectives, Handbook II: Affective Domain (1964). An attitude is acquired when a 'willingness to respond' is shown and will become internalized in the person in the following stages:

1. a satisfaction in response,
2. an acceptance of a value,
3. a preference for a value,
4. a commitment, and finally
5. a conceptualization of the value.

It therefore becomes the task of the organizer (instructor) to follow these steps in order that new attitudes be considered by the student. In fostering attitudes, they must be planned for and not just assumed to be concomitants to cognitive outcomes.

Eight steps are suggested by Klausmeier (1961) to facilitate the learning of attitudes. Hanry (1964) interprets these steps in terms of the problems of science teaching in the following manner:

1. The attitude to be taught must be identified.

2. The meanings of the vocabulary used to describe attitudes or behaviors related to them must be clarified for the learner.

3. Informative experience about the attitude 'object' should be provided. In the case of scientific attitudes these 'objects' are usually the various situations that occur in the problem-solving process. Typical of these are:

   a. the sensing of the problem in a perplexing situation,

   b. clarifying and defining the problem,

   c. formulating the hypotheses,

   d. reasoning out the consequences of the hypotheses and the designing of the investigations,

   e. gathering of the data,

   f. treating and interpretation of this data,

   g. generalizing or drawing the conclusions, and

   h. communicating the results of the investigation to others. (Students need to be instructed in the performance of each of these steps and in their relationships to the various attitudes that characterize the scientifically minded person. It is hoped, . . . that pupils will exhibit these attitudes in appropriate situations outside the classroom as well as in it. To help them generalize these attitudes, teachers can point out the general nature of

the attitude object by showing similarities between scientific problem-solving procedures and the treatment of problematic situations in and about daily affairs).

4. Desirable identifying figures for the learning process should be provided. These models, whether they be teachers, parents, peers, or historical figures, provide the learner with ready-made behaviors which he can use as his first attempts at the desired behavior.

5. Pleasant emotional experiences should accompany the learning of (relearning new) attitudes. Pupils need freedom to attempt their own patterns of exploration and sufficient time to pursue an investigation to the point where they experience the satisfaction that accompanies inquiry and discovery.

6. Appropriate contexts for practice and confirmation should be arranged. Learning experiences must be selected on the basis of knowledge, skills and attitudes to be learned. At times the central theme of a lesson might have to be a particular attitude with the other learnings playing secondary roles.

7. Group techniques should be used to facilitate understanding and acceptance. The varied activities possible in well-equipped science rooms permit students to learn as individuals on some occasions and as members of groups of varying sizes on others. Group decision-making that occurs in the planning and carrying out of investigations and the evaluation of results permits a sharing of emotional commitment which can enhance the learning of an attitude. (peer approval)

8. Deliberate cultivation of the desired attitude should also be encouraged. Pupils, (prospective elementary school science teachers) need to be aware of the behaviors that accompany an attitude and to practice them. Sometimes this requires the difficult task of breaking old habits or of improving poorly learned ones. The teacher must be able to provide guidance for this learning [p. 35].

One finds in the above interpretation the implication for the education of prospective teachers so that they will become models for their own school children. One cannot teach what one does not know. From this generalization, it is possible to conclude that teachers can not teach and pupils cannot learn attitudes that are not a part of their teacher's repertoiré.

The majority of prospective elementary school science teachers in teacher-training programs will still be in the period of adolescence. If this period does extend from the teens through the early twenties, the college student (age 18 - 22 years) is in the central growth period in the development of logical thinking as it is reflected in the formation of scientific notions. Even though the learner's past environment and experiences has equipped the prospective teacher with values and attitudes toward learning, these values or attitudes having been learned may need to be unlearned, changed, modified or reinforced.

Davis (1972) suggests that adolescence is the period to consider psychologically the process in which external interactions become cognitively (as opposed to reflectively) internalized. He stresses that "It is a thinking person . . . who judges and acts [p. 31]." Unless value development is equated in some manner to the process of learning, attitudes become wholely a product of environment. Therefore it would appear necessary to formulate hypotheses and attempt to discern the methodology by which attitudes/values relate or influence learning theory.

Jean Piaget (1958) has concerned himself in his investigations with the development of logical thinking as it is reflected in the formation of scientific notions. His learning theory depends upon a structure of rational intelligence which must be an on-going process of interaction with one's environment. However, Piaget (1958) recognized that experience alone is not sufficient, growth is dependent upon the ability to internalize experiences. These events lead to the formation of values or attitudes conditioned by the environment. Piaget's theory places much emphasis upon the role of activity in the development of intelligence. His work, The Growth of Logical Thinking, published in 1958 describes the educational process which is in accord with the findings of most behavioral theorists and it is for these reasons that this study accepts in part Piaget's approach to learning theory.

Whether one ascribes to the theory that the mind is a blank void which is filled as a person lives and experiences happenings, or to the theory that intelligence is the revealing of what the mind already knows and this knowledge is revealed in bits and pieces as one lives and experiences happenings, either could be though of as a passive process in which what one is exposed to and experiences produces intelligence. The Piagetian research reveals that intelligence is an active process which develops through the interaction between the individual and the world in which he finds himself. This position stresses that when a person interacts with a part of the world or environment in any way, his learning experience is not limited to just that one interaction, but he also learns how to interact, how to solve present and future problems and store knowledge for future use.

If the major Piagetian ideas can be summarized as follows: children have their own ways of looking at the world limited only by their experience with that world; these ways are unique to the process of maturing; these ways change with time and what is required to change and develop these ways are active interaction with world environment, then these notions place a grave responsibility on the science teacher. The public expects the teacher to interpret the facts and skills of science in a way that will be readily understood by his future learners.

The Teaching Strategies

In the preparation of elementary school science teachers there exists a basic philosophical commitment that the general science education of the liberal arts student and the preparation of elementary school teacher have much in common. Gross and Mayo (1969) maintain that neither process--liberal arts curriculum or elementary school teacher science preparation are designed to produce research scientists. These programs tend to focus on literacy in science and on understanding the nature of scientific activity, Gross and Mayo further claim that in both programs "an essential part is the preparation of science as an integral part of our total social, cultural and intellectual makeup; and in both cases it seems advantageous to approach the teaching of science from the historical and philosophical viewpoint [p. 23]."

It is suggested that the superior educational program would be one that draws upon experience and relates it to theory, which is then applied to a reevaluation of experience. The advantage of this approach to learning is that both theory and practical experience can be used to supplement each other. How this can be accomplished is shown schematically in the following diagram.

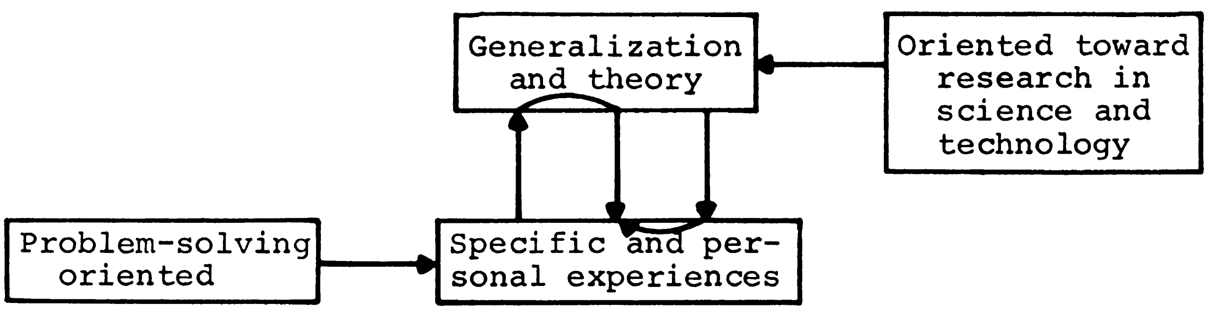


Figure 1.--Theory and experience in the learning process and their effects on the direction of learning.

Colville (1957) and Kersh (1962) researched this type of educational program and their findings indicate the inductive method of proceeding from experience to theory seem to be more efficient in transfer of learning.

Modeling and Peer Interaction

Henderson, et al. (1970) define "learning that occurs on a vicarious basis through observation of both another person's behavior and its consequences" as model learning. Identification and conformity are important aspects of the learning process. By imitating adult behavior children work out patterns of conformity that enable them to get along with adults and to grow up to become like adults. Unfortunately, identification is not a very selective process, for people are just as likely to copy the faults as well as the virtues. While there is little agreement in the literature as to how modeling aids the learning process, there is consensus that the acquisition of modeled responses does occur. Bandura (1969) takes the position that modeling is a unique type of learning which should be studied in its own right. Henderson (1972) interprets Bandura's theory as follows: "When a person observes a model's behavior, but otherwise performs no overt responses, he can acquire the modeled responses while they are occurring only in cognitive, representational forms (mental images). The 'learning' at this stage occurs purely on an observational or overt basis and cannot be said to have stimulated a behavioral change until the observer exhibits a behavior similar to that which was modeled [p. 295]." The manner in which the behavior is reinacted can be an example of positive or negative attitude change. The modeled stimuli seems to be stored until the learner has opportunity to model the stored behavior in an observable manner.

Professor Henderson (1972) further describes modeling as "behavioral change that occurs as a result of observation (direct or indirect) of both another person's behavior and its consequences [p. 295]." The conditions necessary for model learning to occur are:

1. A direct or indirect model must be in the immediate area,
2. A receiver must be able to perceive the model's behavior and its consequences, and
3. The receiver must reproduce the perceived behavior and experience similar consequences.

As model learning may occur both in and out of the classroom the stage for this type of learning must be set so that it may be experienced by the prospective elementary school science teacher before it becomes necessary for this teacher to create model learning situations in the classroom. Happenings must be experienced before they can be imitated and re-experienced. One of the strongest forces for model learning is peer interaction especially in the adolescent stage of development as was reported by Davis (1972).

The important factors which the teacher must know about in order to utilize the strong influence modeling can have in the learning process are:

1. the esteem with which the model is revered,
2. the readiness of the receiver to observe and assimilate and reproduce the behavior,
3. the proper use of incentives, and
4. occasion to practice and firmly cement the observed behavior.

Respondent Learning

As the purpose of this study is to ascertain the possibility of producing a change or reinforcement of positive attitudes toward the teaching of elementary school science teachers within a structured open classroom in a period of one semester, time-span of sixteen weeks, the teaching strategy of respondent learning will also be employed.

Since the beginning of the twentieth century, psychologists have been investigating the interaction between living organisms and their environment in order to find out how learning takes place. After much research, they have discovered that when one stimulus produces a certain reaction in an organism and when a second and irrelevant stimulus is introduced more or less simultaneously with the first stimulus, the second stimulus comes to elicit the same response without the aid or presence of the first stimulus.

The term 'classical conditioning' was the former name for this teaching strategy because of the experiments conducted over 50 years ago by I. P. Pavlov, the Russian physiologist, who is considered the first one to conduct countless conditioning experiments in his physiological laboratory in Russia. Since that time there has been similar research done in the laboratories in America, but much of the research has been concerned with eyelid reflex and psycho-galvanic responses (changes in the electrical conductivity and skin potential) and little of the research has had practical application to classroom learning.

Modern behavioral scientists have re-named 'classical conditioning,' choosing to refer to this type of learning as 'respondent learning.' The teaching strategies that attempt to influence respondent learning are referred to as respondent strategies. Respondent strategies are most powerful in affecting behavioral changes in the affective domain, i.e., primarily in the learning of attitudes, values and feelings. It seems to regulate motivation and the need to learn. To learn is the nature of being human. Walcott Beatty and Rodney Clark (1960) suggest that the individual is motivated to learn when he realizes that there is an imbalance or discrepancy between what he is or can do and what he should be or should do.

Anyone connected with schools can see that respondent learning is overlooked by teachers as a very good tool to use to overcome the almost universal negative attitude that has been acquired by many students toward school. Teachers have the obligation to teach positive constructive feelings and attitudes.

Teachers need to be made aware of and taught how to manipulate the necessary conditions for the occurrence of respondent learning. Henderson (1972) has analyzed the definition of respondent learning and has set forth the following five conditions:

1. An unconditioned stimulus--an event that automatically brings about a particular response.

2. An unconditioned response--a behavior automatically motivated by the presence of a particular event.

3. A conditioned stimulus--an event which acquires the power to bring a response by being associated with an unconditioned stimulus.

4. Pairing--the temporal association of two events. (stimuli)

5. A conditioned response--a learned response (change of behavior) which occurs as a result of an event which does not originally elicit a stimulus when paired with an unconditioned stimulus and continues to elicit that response in the absence of that unconditional stimulus.

In order to be able to manipulate these conditions the prospective elementary school science teacher has to learn how to plan for producing these conditions in the classroom. It becomes necessary therefore to provide experience in planning and in the implementation of these plans for respondent learning for the student teacher in a simulated classroom situation prior to exposure to actual classroom teacher.

Laboratory Manual

The members of the Educational Policies Commission of the National Educational Association and the American Association of School Administrators recommend that schools promote an understanding of the values on which science is based. It is suggested that a greater awareness of the spirit of science would lead educators to assign to it a large and more explicit place among the many goals of education.

After a review of the impact of science and technology on our lives today (1966), the commission cited seven values which it believed underlie science:

1. Longing to know and to understand.
2. Questioning of all things.
3. Search for data and their meanings.
4. Demand for verification.
5. Respect for logic.
6. Consideration of premises.
7. Consideration of consequences [p. 15].

While these values are not stated in the way most traditional values are stated, a closer examination of their meaning points up no conflict with traditional values. The commission further stated that "insofar as an individual learns to live by the spirit of science, he shares in the liberation of mankind's intelligence and achieves an invigorating sense of participation in the spirit of the modern world. To communicate the spirit of science . . . should therefore be among the principal goals of education [p. 17]."

However, the Commission gives no indication as to how its recommendations might be implemented. They do seem to suggest that the attitude of the teacher must be changed so that the teacher will consider himself a guide to the intellectual growth rather than the source of knowledge and authority. In science lessons, for example, the students need not memorize the names of consellations they never see. Instead, would it not be better, that they learn the location of a few star guideposts and to observe the way these seem to move through the heavens?

If it is possible to change the mechanism and the atmosphere (attitude) of our schools to a direction that invites learning based on the ideals of science or rational thought, it would seem that an organizational scheme which would allow for greater opportunities for individual work might achieve the goal. Such a scheme would need to provide the student with freedom for which he might accept responsibility. In such a system suitable for instruction based on the ideals of science, however, many things would have to be different--the role of the teacher, the physical plant, the curricular material, and the daily life of the student.

In the intent to try to implement the recommendations of the Commission, it was deemed necessary to start with the preparation of the elementary school science teacher in physical science. Should the research and the experiment prove to be successful it could then be expanded to include other areas.

From observation it would appear that like the ghost of Hamlet's father, most scientific concepts seem to elude most elementary school teachers. In the routine college laboratory, these teacher/students seem to traverse the required experiments in a cook-book fashion, step by step, without viewing the entire experience as an entity. They seem to have but one end in view, that of just completing the assignment hoping that the result of their efforts will be a conclusion which is satisfactory to the instructor without much thought of the relevancy to the whole scientific picture: the environment and scientific life within the experiment.

With this in mind, a search of the available college physical science laboratory experimental manuals, two of which are worthy of note: Chaplin *et al*. (1965), *Laboratory Manual for College Physical Science*, published by W. C. Brown Company, Dubuque, Iowa for Morehead State College at Morehead, Kentucky and McSpadden's *Laboratory Manual and Problems for College Physical Science*, (1965) published by Kendall/Hunt Publishing Company also of Dubuque, Iowa was made. Both of these manuals are well designed for the liberal arts student but emphasize skills and concepts that are not relevant for the elementary school science teacher. However, it should be noted that McSpadden's revised edition, available in 1972, comes much closer to satisfying the needs of the prospective elementary school science teacher. The other manuals which existed at the time that this research was begun are excellent manuals designed for the student destined for the research laboratory. All of them involve mathematics far in excess of the needs or skills of the elementary school teacher. A few other manuals were so designed as to offer no challenge to the minds of the prospective teacher. Some manuals are designed for a full year sequence and others were terminal in nature with little or had no carry-over features for the elementary school classroom. Thus no manual was found at the beginning of this research that was thought suitable for the elementary school science teacher program which would have open-ended experiences with carry-over features for the elementary school classroom.

CHAPTER III

PROCEDURE AND METHODOLOGY

This project was designed to examine the influence of a unit of instruction on the responses of prospective elementary school science teacher/students when they are placed in learning situations designed to elicit positive attitudes toward the teaching of elementary school science.

This study is an attempt to research the effects (within the structured open-classroom framework) of the teaching strategies, namely, modeling, peer interaction and respondent learning, on the attitudes toward science teaching of prospective elementary school science teachers. In the course of this experience these students had the opportunity to express their opinions, purposes, feelings, beliefs, hunches, goals and interest (in short, their attitudes) toward science teaching in the elementary grades.

This chapter will describe the procedures and methodology used to carry out this research. The description is divided into the following sections: the plan of the study, the subjects, the setting, the instructional procedures, instructional materials, evaluation and tests.

The Plan of the Study

The research covered a one semester (16 weeks) time span and four separate groups of students were studied.

Since the available teaching facility was limited to 30 stations, the size of the sample under study was also restricted to this available space. Therefore, a decision was made to extend the study of the attitude changes over four successive groups of students of Physical Science 351B from the four semesters between the years 1970 to 1972.

The use of the 'special' physical science groups and the PSNS Project Physical Science groups enrolled over the same four semesters were paired, semester group to semester group, and were considered the research and control groups. The PSNS groups, who were also preparing to teach elementary school science, but were enrolled on another track, served as the control group and provided a basis for comparison when considering the research questions. The control group received no special treatment and/or reinforcement of positive attitudes toward science teaching, i.e., the control group was taught in the traditional lecture/demonstration method. These 'telling' lectures are the strategy used in most university science courses. The PSNS textbook serves as the laboratory manual for the control group sessions.

Subjects

As has been stated before, the subjects for the project were regularly enrolled students in the 'special' Physical Science 351B (a required course for all students enrolled in the elementary science curriculum program) as the experimental group, and the PSNS Approach to science teaching, the Physical Science 351A students as the control group. These students were also enrolled during the four semester periods between the years 1970 to 1972.

From the total number of students enrolled in the Physical Science courses specifically designed for the preparatory elementary school teachers, namely: Physical Science 351A (the control group) and the Physical Science 351B (the experimental group for this study) during the years 1970 to 1972, fifty samples were randomly selected from each group for analysis and study. The fifty students of the experimental gropu not only provided the before and after testing data but provided a source of additional evidence for attitude change as the students progressed through the semesters. Only two of the subjects had previous teaching experience. None of the subjects had previously considered their personal attitudes toward science teaching in the grades, although when questioned, 81 percent admitted to having a 'fear' of science because the subject 'science' was considered very difficult.

All but two of the subjects in both the experimental and control group were female, single and between the ages of 18 and 22 years.

The Setting

A classroom-laboratory facility in which to structure the learning experiences and the laboratory exercises had to be found. With the assistance and permission of the Chairman of the Department of Physics--Physical Science--Room 204 was set aside for the exclusive use of the 'special' Physical Science 351B prospective elementary school science teacher/students. This room has 30 working areas.

This Room 204 has large wall cupboards. In these cupboards were gathered and stored many types of tools and equipment and teaching aids, which could provide learning experiences for the prospective elementary school science teachers.

Similarly, at the same time, Room 206, an adjacent room to the experimental facility Room 204 in Brooks Hall, was designated for the exclusive use of the PSNS Project Approach to teaching elementary science. These sections were taught by another professor from the Physical Science Department. Room 206 has exactly the same dimensions of Room 204. It also has similar cupboards for the storing of equipment. Its seating capacity is also for 30 students and the working facilities are similar to Room 204.

The structured open classroom (structured only because the facilities and equipment are confined to the aspects of physical science) provided opportunity to study or experiment with science equipment at will. While Room 204 was monitored, enrollees in Physical Science 351B had access to the room and cupboards at will.

Instructional Procedures

Different instructional procedures were followed within the two groups under study. These procedures will be described briefly for each group with differences highlighted.

The PSNS Project Approach to Teaching: The Control Group

The Physical Science 351A control group met twice each week of the semester for two successive class periods, a total of about four hours each week. The PSNS textbook was used as the source of information as well as for instructions for the investigation of the materials set out for each student before each class meeting. The materials are usually prepared by a student assistant and arranged at each station before class convenes.

The experimental work is usually divided into four categories. Chair-arm experiments, which require very little equipment and can be performed by students during the course of a lecture at their own seats. Take-home experiments which require no supervision and take only a minimum of equipment, but take more time or require additional facilities such as running water. The laboratory experiments and the demonstration experiments designed for laboratory facilities require more extensive equipment.

The demonstration experiments are performed by only one person with only one set of equipment for the class. The laboratory experiments are performed by the students usually working in pairs. The chair-arm experiments were performed on the arm of the chairs during a lecture period. The needed materials were usually passed out to the students in plastic bags as they entered the classroom or during the class period.

The take-home experiments are supposed to be sufficiently simple that the students can perform them at home. Any required materials are distributed in plastic bags as the students leave the classroom. Instructions as to what to do during the experiment at home are clearly given in the textbook but little or no indication as to what to expect from the experiment is available to the student. The results obtained from these experiments are to be discussed and compared at a subsequent class meeting if possible.

An on-going lecture/laboratory notebook was to be kept by each student in which all happenings occurring in the PSNS project class meetings, the routine followed for each experiment, and the results of the experiments were to be recorded. These notebooks were to be periodically collected, graded by the instructor, and then returned to the student.

The PSNS project is built around one main stem: solid matter. Most of the experiments are based upon crystals and the formation of crystals. The project follows a modified 'discovery' method; the asking of questions, the use of scientific 'modelmaking' and hypothesizing, but little or no opportunity is provided for self investigation or self interest experiments. There is a minimum of individual positive feedback. The assignments tightly follow the textbook and the lectures are not necessarily coordinated with the experiments. The students who, for the most part, are prospective elementary school teachers, receive little direct instruction in how to teach the content to elementary school children.

The students are assigned partners at the beginning of the semester and except for the chair-arm and take-home experiments keep their partner throughout the term. This limits peer interaction and discussion to some degree. The achievement of the student is graded generally on the completion of the laboratory notebook and final examination.

The Physical Science 351B 'Special' Section: The Experimental Group

The Physical Science 351B experimental group also met twice each week for two successive class periods, a

total of about four hours a week. The length of the semester is sixteen weeks. A variety of textbooks designed for the prospective elementary school science teacher were made available for use by the students. These books were usually entitled in some form of "Teaching Science to Elementary School Children." After a week of examination of these textbooks, the students were required to purchase one of them as a reference text.

As has been stated before, the cupboards in Room 204, had been stocked with as many tools, experimental equipment and supplies and teaching aids as was possible to provide the opportunity for study investigation, or use by the students. Five complete sets of teacher editions of science texts for K - 6 elementary grades from the various elementary school science textbook publishers are also available for comparison and study. These textbooks could be used in the laboratory or checked out for use for three day periods.

At the beginning of the semester, the students were given a suggested list of projects to work on during the semester. It was suggested that the student examine the grade school textbooks of the grade level of their choice and build their own curriculum for that grade. From one section of their curriculum, it was suggested that they choose one unit and enlarge this unit into a working plan. Then from this unit they could choose one concept and construct a mini-science-lesson plan which would

include a science demonstration or class involvement exercise. This mini-science-lesson or another one could be taught to their classmates who in turn would simulate the suggested grade level pupils.

Students also had the option of starting a library card catalogue of science books for self use and for their future grade school pupils. To get started with this project it was suggested that at least ten books in each section be reviewed. It was further suggested that 3 by 5 cards be used for this purpose.

At the beginning of the semester, general discussion of grade school teaching and possible problems that could arise with possible solutions are at first considered. Teaching strategies are discussed. Attitudes toward teaching, toward science and children in general are considered.

Role playing as various grade school children was suggested. Then after a few mini-lesson modeling exercises in which there is cooperative interaction between the instructor and those students who have already student-taught, it is suggested that the other prospective elementary school science teachers in the class teach their own prepared mini-science-lesson. Again the other students are asked to play two roles, that of grade school children of the selected grade level stated by the student-teacher and that of the role of supervisor-teacher and grade and comment on the performance.

Another project is the laboratory manual which is given to the students of the experimental group as a suggested guide for the investigation of the science equipment in the cupboards. Using the guide, the students are encouraged to investigate the various objects in the cupboards and either work by themselves, with a self-chosen partner or in a group with the equipment. Because of the variety of tasks, the freedom of choice, the cooperative interaction and the concern and respect for each other, the freedom from competition permits good natured cooperative interaction. The study of the science curriculum, the designing of the unit plan and the mini-science-lesson and the science demonstration are self paced. The absence of pressure permits the students to work at their own rate and spend time in the laboratory at will.

The procedures used in the experimental group all support the use of the strategies of peer-modeling and respondent learning which were geared toward the development of positive attitudes toward science teaching.

In this project, grades were generally based on peer evaluation of the mini-science-lesson which were taught, self-evaluation of science growth and instructor-graded curriculum, unit and lesson plans.

The experimental groups were subjected to modeling examples at intervals as suggested by Bandura (1969). Besides instructor demonstrations of teaching examples, there was involvement with peer group demonstrations, suggestions and constructive criticism. Active elementary school teachers were invited to attend the class when mini-lessons were scheduled to offer suggestions, give examples and serve as models.

It was further suggested that the students teach other mini-demonstrations or short lessons patterned after the examples of teaching strategies they observed. Time for discussion was always permitted. Then the students were further exposed to a direct or indirect model within a known environment. First acting as an observer of the model behavior and the resulting consequences, then attempts to exhibit similar behavior to that which had been observed or modeled, were tried by consenting students. These procedures were designed to reinforce a positive attitude toward science teaching.

Support for this approach can be found in the suggestions contained in the concluding remarks of Thompson's (1967) "Quest for Prescriptive Values in Our Educational Programs" in Learning Research and School Subjects. ". . . the learning of values and their related logic is a distinctly social phenomenon which can most profitably be studied in the social situation in which the learner relates to highly significant others, . . . his peers [p. 225]." Dr. Thompson further suggests that such studies be in as naturalistic a setting as possible and that the studies be involved with teachers, and selected peers of the learner and extend over longer periods of time. It is for this reason that these activities were extended over the entire semester unit of time.

Instructional Materials

Instructional materials consisted of a variety of concrete, manipulative objects which could be used to demonstrate those physical science concepts under study during the term. Concepts generally were those most likely to be taught in an elementary school science program. These objects ranged from pins, baloons, and compasses to hard-boiled eggs and radioactive isotopes. For a more elaborate description of the materials, the reader is referred to Appendix D.

Besides the standard equipment in Room 204, other instructional materials for laboratory work were supplied upon demand of the student. While the instructional program consisted of two, two-hour sessions a week, the facilities in Room 204 were open to the members of the group whenever they wished to spend time there.

Because no commercially produced physical science laboratory manual seemed to fit the requirements of the 'special' physical science group, a laboratory manual was devised to serve as a suggested guide for those students who had no background in science. The students were not restricted to the use of just this manual and these sets of experiments. Should the student want to try other experiments, whenever possible, arrangements were made to supply them with the use of the needed equipment.

The experiments in the laboratory manual began with the usual measurements of known objects using both the English and metric systems. Two experiments were required of all students because it was felt that they were examples of group dynamics. These experiments were the construction of a diode radio and the making of a camera, the loading, exposure and developing of a sheet of film and the printing of the resulting negative. Anyone wishing a copy of the laboratory manual used in this research may have a copy upon request of the writer.

Evaluation

Both the experimental and the control groups were asked to take identical tests at the beginning and at the end of the semesters. The battery of tests provide for:

1. An assessment of Physical Science knowledge,
2. A lesson play challenge, and
3. The evaluation of the student's attitude toward science, and science teaching.

All groups were instructed to do their best, but told that the scores would not be used in computing their course evaluation.

Tests

Differences in physical science knowledge acquisition were evaluated on the basis of a pre- and post-Physical

Science Aptitude Test administered at the beginning and end of each semester. This test was given to both the control and the experimental groups. The Test was a part of the Engineering and Physical Science Aptitude Test which was prepared under the direction of Bruce V. Moore, C. J. Lapp, and Charles H. Griffin of Pennsylvania State University and has been published by the Psychological Corporation. The total test is comprised of 145 items. The Physical Science sub-test contained 45 items. The Split-half reliability of the total test equaled .90, (.84 > or < .96). The physical science part of the aptitude test was equal to 31 percent of the total test. According to the Spearman Brown Prophecy Formula for correcting reliability for the test length, the following formula was used:

$$r_{tt} = \frac{nr_{nn}}{1 + (n - 1)\ r_{nn}}$$

$$r_{tt} = \frac{.31\ (.90)}{1 + (.31 - 1)\ .90} = \frac{.279}{} = .738$$

This reliability for the groups of students tested was believed to be adequate.

The items of the physical science comprehension test consisted of true or false statements about general science information. A typical true statement was "Evaporation produces a cooling effect." A typical false statement was "A siphon will work in a vacuum." All of the statements were designed to determine knowledge of the physical science principle involved in the process about which the statement was made.

As the majority of the students enrolled in Physical Science 351 were preparatory elementary school teachers, the Lesson Plan Challenge was used to assess the subjects' performance skill. Subjects were asked to respond to the following assignment:

> You have the responsibility of teaching a Unit on Centrifugal force to a fifth grade class. Prepare a lesson plan for helping them learn the concept of Centrifugal force.

The responses to this challenge were rated on each of seven major points. The challenge was scored by five individuals and the writer. The five raters were not associated with the Physical Science Department but were university instructors or former teachers. A critique for evaluating the lesson plan was developed (Appendix A) and all scorers independently rated each response of the two randomly selected group. The total possible score was 17 points. These points were awarded in the following manner:

> Zero points if subject did not attempt challenge or it was found that not one of the attributes were present in the response.

Then one point was given for each of the following attributes found to be present in the lesson plan:

1. General Objectives were stated.

2. General Objectives were written as behavioral objectives.

3. Specific strategies were stated. If yes, one additional point was given if the strategy was stated as a

    a. Lecture-response,

    b. Problem solving,

    c. Teacher modeling or demonstration, and

    d. Peer interaction. (Total possible points--5)

4. Manipulative materials were suggested. If yes, additional points were given if

    a. the materials were specified,

    b. the materials were easily available,

    c. the materials suggested were inexpensive, and

    d. the materials were appropriate to the task. (Total possible points--5)

5. Provision for the learner to manipulate the materials were suggested.

6. Some kind of evaluation of the learning outcomes was mentioned,

    a. a pre-test,

    b. a post-test, or

    c. both a pre-test and a post-test.

7. Learners were expected to discover principle of centrifugal force.

While the battery of tests were given during class time to all students, only 50 tests selected at random from all the responses were analyzed from the control group and 50 test responses were also selected at random from the experimental group and used as the data upon which this research is founded.

The subjects' attitudes toward science teaching were also measured on a five-item questionnaire. (Appendix A.) The items consisted of statements concerning the perceived acceptability of science teaching and the subject's perception of his own ability and desire to incorporate science into his own classroom teaching. The subjects rated the statements on a one to five point scale ranging from strongly agree to strongly disagree.

The subjects' attitude toward science was also measured by determining the amount of time he would allocate to science in his own teaching schedule (Appendix A). The subjects were asked to respond to the following hypothetical situation:

> Imagine that the elementary teacher you have just replaced in a classroom leaves you the following time schedule of subjects that he taught. Record in the second column the tentative time schedule you would recommend based on your values at this time. (You may recommend adjustments or adopt the existing schedule.)

While the responses to this evaluation of attitudes were gathered from all students, agaon only the randomly selected responses were tabulated.

It was anticipated that the data gathered would reflect the pre-instruction, post-instruction, cognitive performance and attitude status of all participating students.

The reader should realize that only answers to the following questions were sought in this research:

1. Within the framework of a university science department, is it possible to provide a location for meaningful science experiences for the preparatory elementary school science teacher?

2. Will the departure from the lecture method of instruction, usually found in the university science department, be detrimental to the scholastic progress and growth of the preparatory elementary school science teacher?

3. Will the attitude of the prospective elementary school science teacher be changed, either in a positive or negative direction, as a result of such an experience?

4. Will the prospective elementary school science teacher when exposed to the teaching strategies of modeling and respondent learning demonstrate similar teaching strategies in their constructed lesson plans?

Summary

The procedures used in the experimental groups were specifically designed to provide for optimal respondent and model learning. Respondent learning was provided for through the pairing of physical science with (1) freedom of choice, (2) freedom to explore, (3) time to play and manipulate science equipment, (4) anxiety-reduced evaluation (both peer and instructor), and peer interaction. Model learning was provided for through demonstrations by the professor, visiting teacher, and other students. The professor systematically controlled the consequences to the models so as to reinforce positive science approach behaviors. In this way, the possibility of the influence of negative models was controlled.

CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

The object of this study was to assess the attitudes of prospective elementary school teachers toward science teaching and, though extended exposure to a structured open classroom of science equipment and the opportunity to experiment at will, to determine if there would be a positive attitude change, while suffering no loss of cognitive growth in physical science.

The data are from a series of pre- and post-physical science knowledge tests, a lesson plan challenge and an attitude questionnaire given to regularly enrolled students in Physical Science Sections 351A and 351B during the semesters between the years 1970 to 1972.

The universe for the study was all the physical science students enrolled in these sections in the Physical Science Department at Central Michigan University, Mount Pleasant, Michigan, during the semesters between the years 1970 to 1972.

The sample was a randomly selected 100 student responses: 50 responses from the students enrolled over the four semester period in Physical Science 351A, the control group, and 50 responses from the students enrolled in Physical Science 351B over the same time period. The Physical Science 351B group was the experimental group. The sample was selected from all the students enrolled over the stated two-year time span, (four semesters) in these two courses.

The presentation will attempt to answer the proposed questions of the study as put forth in Chapter I, page 18 of this study. The questions will be responded to in numerical order with an interpretation of the data collected.

Question one of the study is answered by the fact that the study took place. In essence, an affirmative answer to the question:

> Within the framework of a university science department, is it possible to provide a location for meaningful science experiences for the preparatory elementary school science teacher?

was obtained as evidenced by the fact that such a course was established.

The answer to the second question of the study:

> Will the departure from the lecture method of instruction, usually found in the university science department, be detrimental to the scholastic progress and growth of the preparatory elementary school science teacher?

was determined by a pre- and post-test of physical science knowledge administered to all the students enrolled in Physical Science 351A and 351B.

The instrument employed as a measure of scholastic status in science was the science portion of the *Engineering and Physical Science Aptitude Test* (Moore, Lapp, and Griffin, 1943). As reported in Chapter III, page , the overall test reliability estimate computed by means of a split-half method and reported in the test manual was .9.

The sub-test used here consisted of 45 true/false items which was approximately one-third of the total test length. This reliability estimate, therefore, corrected for the shorter length by means of the Spearman Brown Prophesy formula was .74. This was considered to be an acceptability high level for the group decisions to be made on the basis of the data.

It is apparent from the data reported in Table IV-1 that both groups performed at about the same level at the time of the pretest. However, performance level of the experimental group appears to exceed that of the control group at the time of the posttest. In order to examine these apparent differences, individual difference scores were computed for participants in each group and typical change per group (Post minus Pre) were compared statistically, using a Z or normal distribution test statistic:

$$Z = \frac{\overline{X}_e - \overline{X}_c}{\sqrt{\frac{s_e^2}{n_e} = \frac{s_c^2}{n_c}}}$$

TABLE IV-1.--Comparison of Experimental and Control Groups on Cognitive Variable.

	Pretest	Posttest	Difference	
	$\bar{X}$	$\bar{X}$	$\bar{X}$	S.D.
Experimental	26.3	29.1	2.80	2.58
Control	25.1	26.3	1.24	2.74

The resulting value of Z is 7.5835 which exceeds the critical value of Z at alpha = .05. It must therefore be concluded that the experimental treatment (351B) produces a larger increment in learning about science then does the control (351A). The answer to the second question is therefore that not only is there no detriment in scholastic status due to the departure from tradition, but in fact there is an improvement in performance.

These results appear to indicate that there is some defensible grounds for advocating the structured open classroom approach with special emphasis upon strategies designed to change attitudes toward science.

Question three:

> Will the attitude of the prospective elementary school science teacher be changed, either in a positive or negative direction, as a result of such an experience?

was answered by means of an attitude questionnaire. As has been stated elsewhere in the study, research by several writers indicate the average elementary school teacher does not like science or science teaching.

Therefore, it was assumed for the sake of the study that the subjects did not like science, felt uncomfortable with the idea of teaching science and were afraid of the science equipment.

The attitude questionnaire was administered at the end of each semester to each of the groups. The data is reported as a comparison between the control and the experimental groups. Individual items of the attitude questionnaire will be reported separately through graphic representation. In none of the five items were statistical comparisons carried out, due to the high degree of similarity between response distributions. The results are presented on the five items in their entirety before any conclusions are made.

The first item of the attitude questionnaire read as follows:

> I think I understand science well enough to teach it in the classroom.

A rating of (1) would indicate little understanding while a rating of (5) will indicate complete understanding.

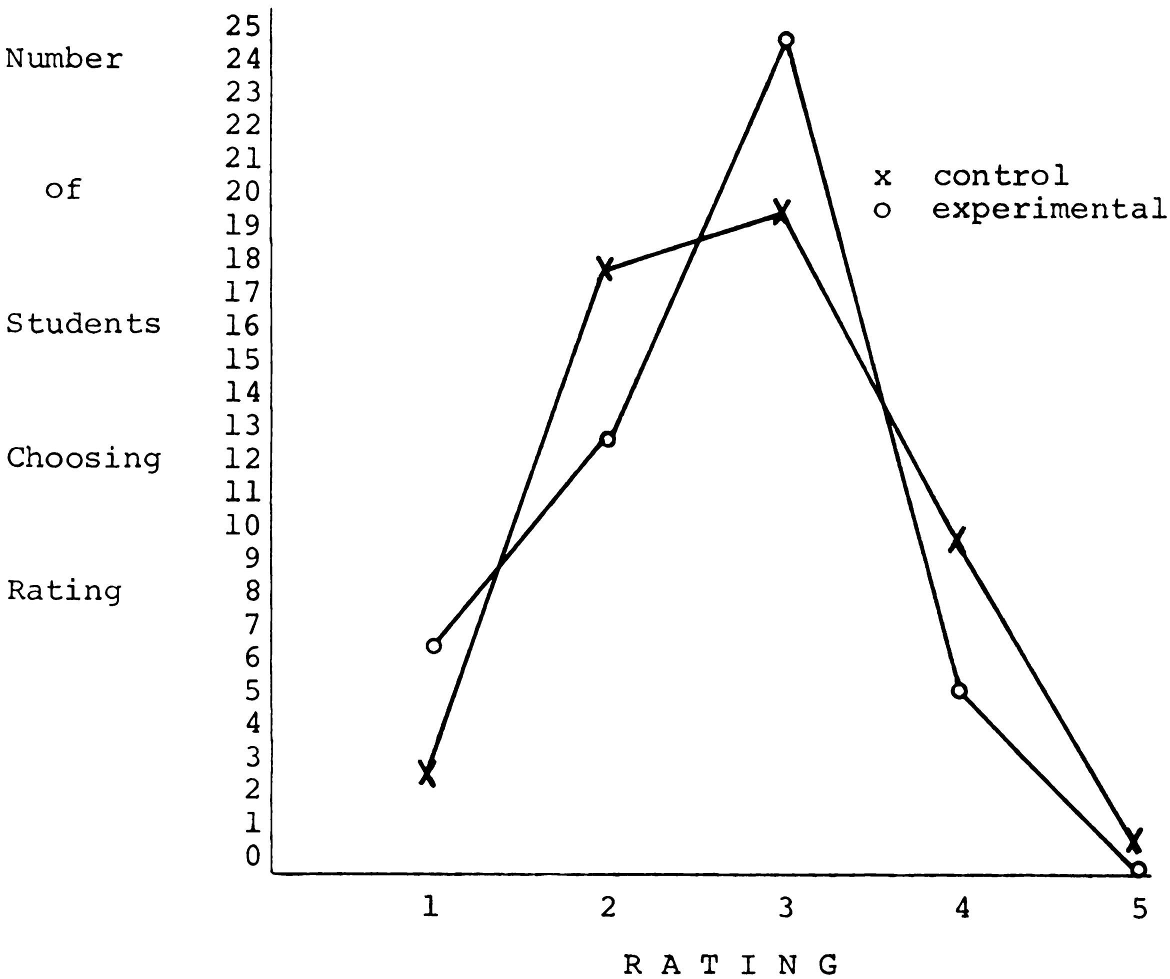


Figure 2.--Frequency distribution of responses to attitude questionnaire, item #1.

The second item of the attitude questionnaire read as follows:

Studying science can be very enjoyable.

A rating of (1) would indicate strong disagreement, while a rating of (5) would indicate strong agreement.

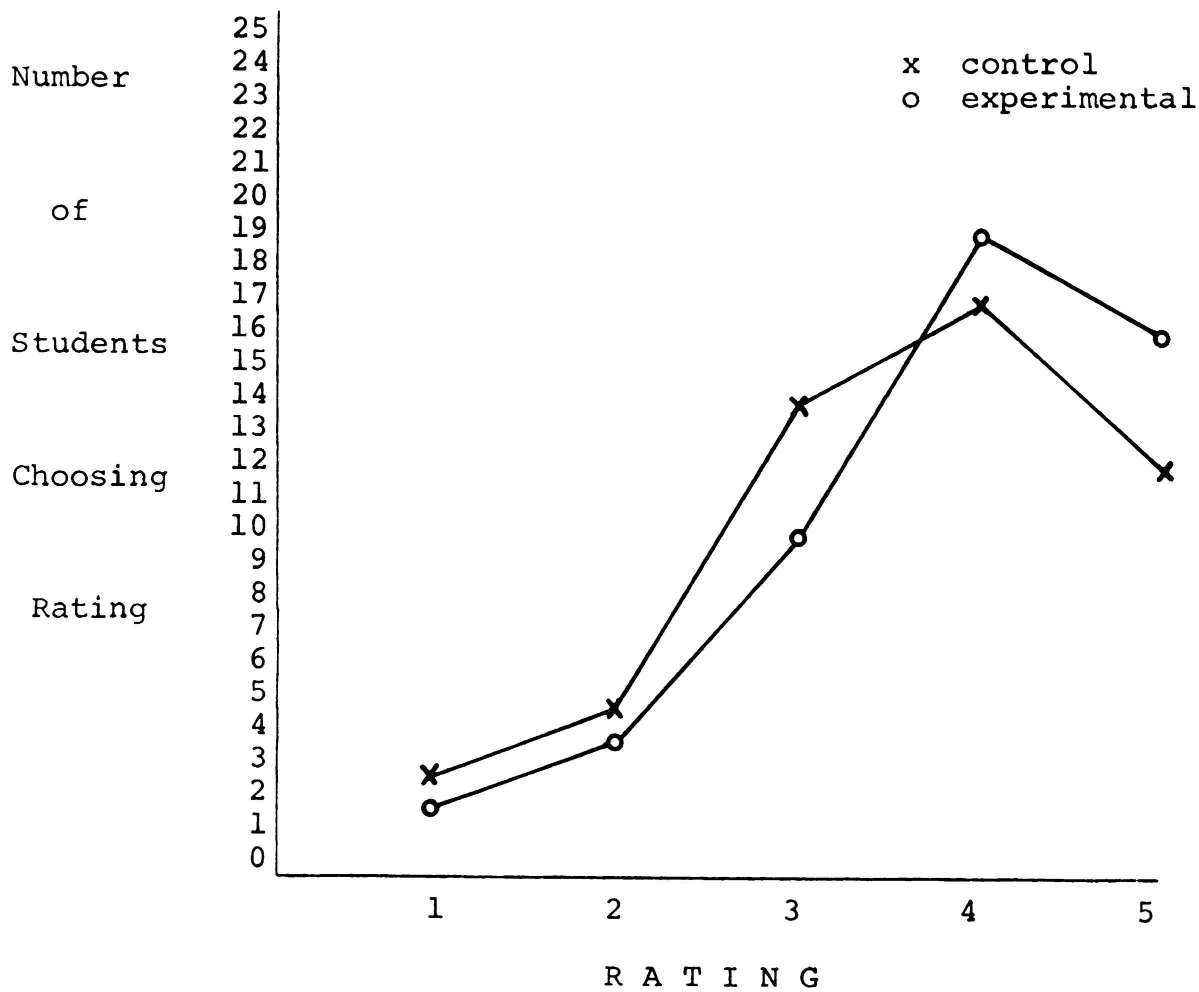


Figure 3.--Frequency distribution of responses to attitude questionnaire, item #2.

The third item of the attitude questionnaire read as follows:

> I think all elementary teachers should teach science every day if possible.

A rating of (1) would indicate that teachers definitely should teach science every day and a rating of (5) would indicate they definitely should not teach science every day.

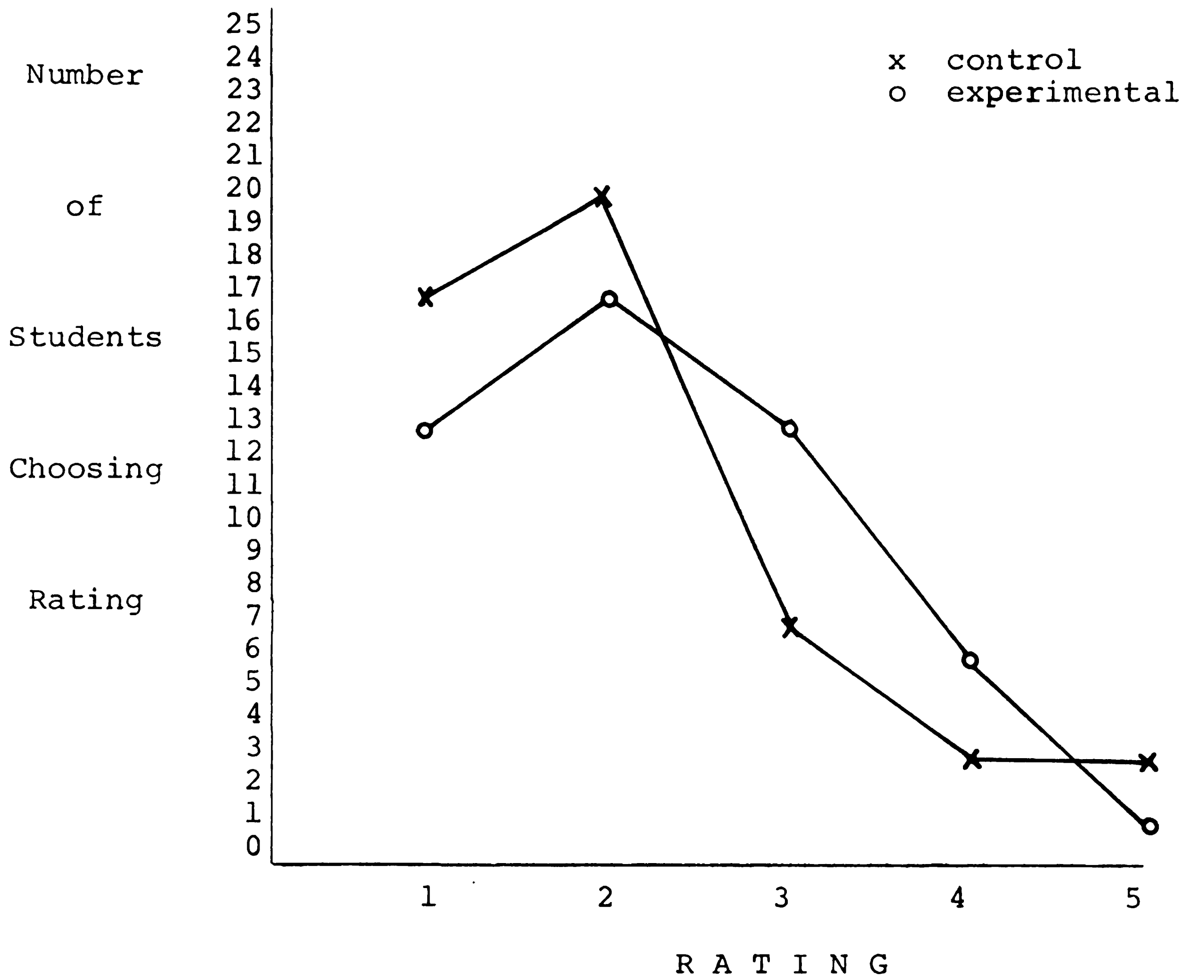


Figure 4.--Frequency distribution of responses to attitude questionnaire, item #3.

The fourth item of the attitude questionnaire read as follows:

> Studying science made me more excited about becoming a teacher.

A rating of (1) would indicate the student was strongly excited and a rating of (5) would indicate that he was strongly not excited about becoming a teacher.

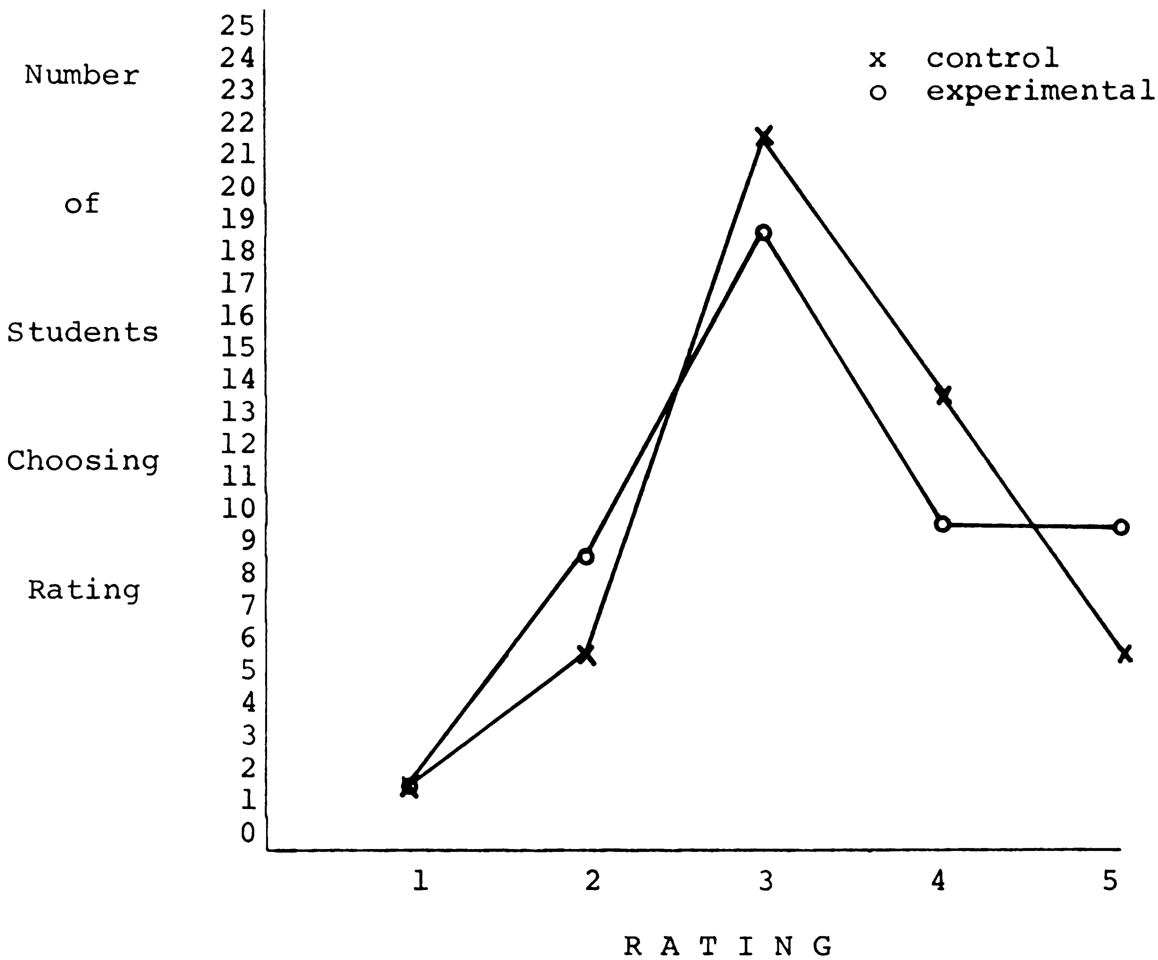


Figure 5.--Frequency distribution of responses to attitude questionnaire, item #4.

The fifth item of the attitude questionnaire read as follows:

> Studying science has helped me see some ways I could actually make a difference in a classroom.

A rating of (1) would indicate a strong agreement, a rating of (5) would indicate a strong disagreement with the statement.

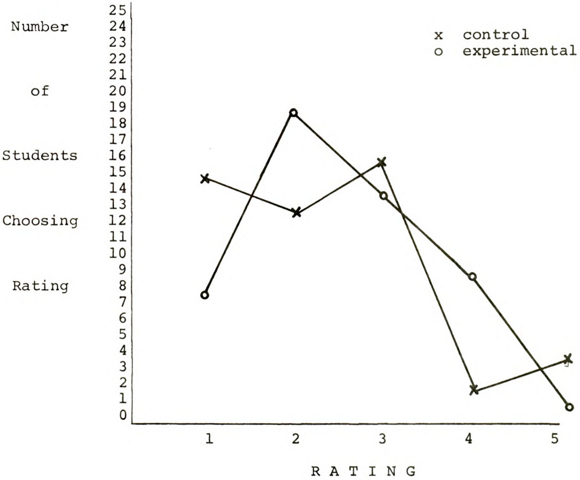


Figure 6.--Frequency distribution of responses to attitude questionnaire, item #5.

As has been observed from the fore-going graphs, the graphic representation of the groups reveals that the responses are apparently identical and therefore no statistical test was carried out. The reason for not carrying out a rigorous statistical examination of the items was that there would be no meaningful large differences even in the presence of statistical significance.

However, typical responses of all subjects to each item may be of interest to the reader. They lead to the following conclusions:

1. The two groups agree that they have only average understanding of science to teach it in the classroom.

2. The two groups indicate that studying science can be very enjoyable.

3. The two groups are in favor of teachers teaching science every day in the classroom, if possible.

4. The two groups indicate that studying science helped them become more excited about becoming a teacher.

5. The two groups indicate that studying science has helped them see some ways to actually make a difference in a classroom.

The sixth item of the attitude questionnaire posed a different type of question. This item stated:

> Imagine that the elementary teacher you have just replaced in a classroom leaves you the following time schedule of subjects that he taught. Record in the second column the tentative time schedule you would recommend based on your values at this time. (You may recommend adjustments or adopt the existing schedule.)

The time changes designated for science teaching are reported in two ways. The total students increasing time for science, the total students suggesting a decrease in science time and those students who were satisfied with the existing schedule.

TABLE IV-2.--Proportion of Comparison Groups Advocating Changes in the Existing Schedule.

Time	Increase	Decrease	Remain
Experimental	76 %	4 %	20 %
Control	68 %	6 %	26 %

The proportion reported in Table IV-2 reflect some apparent difference between groups. This was explored further by comparing the groups with respect to the amount of time allocation changes.

As reported in Table IV-3, the experimental group allocated 12.6 additional minutes to science while the control typically allocated a lesser amount.

TABLE IV-3.--Time Allocation to Science; Attitude Questionnaire, Item #6.

	$\bar{X}$	S.D.
Experimental Group	12.6	10.1
Control Group	10.4	10.2

These mean changes were compared by means of a Z test statistic:

$$Z = \frac{\overline{X}_e - \overline{X}_c}{\sqrt{\frac{S_e^2}{n_e} + \frac{S_c^2}{n_c}}}$$

The resulting value of Z was 1.1. This failed to exceed the critical of Z at alpha = .05. It must therefore be concluded that the groups did not differ significantly on the change in time allocated to science.

The third instrument designed to measure differences between the two groups was the Lesson Plan Challenge. It was impossible to differentiate between the two groups on the basis of the Lesson Plan Challenge because of the failure of the control group to respond to the task. On the variables of interest within the lesson plan there cannot be a differentiation between the two groups as the control group failed to complete the assignment. This failure to complete the assignment by the control group might be a reflection of a lack of motivation within the group which could be explored at a later time in order to really differentiate between groups.

The number of students completing the task in the control group was 14 out of 50 or 28 percent. The number from the experimental group that completed the assignment was 46 out of 50 students or 96 percent.

Even though it is impossible to differentiate between the two groups on this variable, it might be of interest to look at the elements of the experimental group's lesson plans.

From the responses of the experimental group to the lesson plan challenge, it would appear that it would have been very interesting to have been able to compare the two groups on this variable and perhaps someone in the future might want to do this. It was not possible to do so at this time because of the failure of the control to complete the task.

The inter-rater reliability of the ratings of the lesson plan using six raters was computed as suggested by Robert Ebel and found to be .866 or 86.5 percent. This would have been significant if the writer had been able to differentiate between the groups on this variable, it is not really of interest at this time, but might be of interest to the person who might want to use this procedure at some future time.

CRITIQUE FOR EVALUATING THE LESSON PLAN OF THE EXPERIMENTAL GROUP

The proportion out of 46 including the attribute **in the lesson plan.**

	Proportion
1. General objectives stated	21.7%
2. Objectives written as behavioral objectives .	8.8%
3. Specific strategies stated	85.0%*
4. The strategy was	
Lecture-response	43.7%
Problem solving	4.3%
Teacher modeling or demonstration . . .	47.8%*
Peer interaction	13.0%
5. Manipulating materials suggested	55.5%*
Materials specified	41.4%*
Materials easily available	39.2%*
Materials appropriate to the task . . .	36.5%*
Materials considered expensive	2.1%*
6. Provision for learner to manipulate materials	36.5%*
7. Mention of evaluation of learning outcome . .	47.8%*
Kind--pre- or post test	31.2%*
8. Discovery principle employed	17.3%

*Aspect of lesson plan development advocated or emphasized in experimental instruction.

CHAPTER V

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

On the basis of the data of this study as presented in Chapter IV, and within the stated limits of generalization, the questions under investigation will now be discussed.

Question One

> Within the framework of a university science department, is it possible to provide a location for meaningful science experiences for the preparatory elementary school science teacher?

The fact that this study was possible, reflects an affirmative answer to question one. The author was able to depart from the traditional approach of science instruction and change routine procedures within the classroom. While sample limitations restrict generalization, it would appear that it is possible to be innovative in curriculum structure within the framework of a university.

That the instruction was meaningful for the preparatory elementary school science teacher was evidenced by their responses to the remaining questions of this study.

Question Two

> Will the departure from the lecture method of instruction usually found in the university science department, be detrimental to the scholastic progress and growth of the preparatory elementary school science teacher?

The data collected to investigate question two indicates to a statistically acceptable degree of probability that the answer to question two was negative. The departure from the traditional conception of science teaching which was provided for the prospective elementary school science teachers under study in this investigation did not appear to be detrimental to their scholastic progress. It was shown from the scholastic measure used in the study, that the subjects of both groups were apparently at about the same level of development at the instigation of the procedure, however, as is indicated by the data reported in Table IV-1, page 66, the performance level of the experimental group exceeded that of the control group at the end of the procedure. Apparently when the group is exposed to a combination of modeling, peer interaction, freedom of choice, and many activities designed to produce respondent learning, the gain in conceptual knowledge is significant.

Question Three

> Will the attitude of the prospective elementary school science teacher be changed either in a positive or negative direction as a result of such an experience?

Based on numerous prior studies of elementary teachers' attitudes toward science, it was assumed for this study that the subjects initially did not particularly like science. Fifty studies beginning with Victor (1961) point to this conclusion. It was also noted that the students, on the whole, were taking the course because it was required; this data was obtained from the information given by the students the first week of the semesters. Additional written and oral comments during the first week also pointed out that the students generally had negative attitudes toward science teaching.

The attitude questionnaire which was administered at the end of the procedure indicate a large degree of similarity between the experimental and control groups; therefore, only the experimental group responses were reported in Chapter IV. Because the graphical data was so similar, no statistical comparisons were made of the responses of the two groups. However, the graphs did indicate that the majority of the students in the two groups agreed that:

1. They have only average understanding of science and science teaching.
2. They find studying science can be enjoyable.
3. They are in favor of teachers teaching science in the classroom as often as possible.
4. They indicate that the study of science is helpful and did increase their interest in becoming a teacher.

5. They also indicated that studying science was helpful in showing them ways to make a difference in the classroom.

The time allotment challenge of the attitude questionnaire as was reported in Table IV-3 indicated that the experimental group did think more time should be spent on science oriented experiences in the classroom. From a statistical analysis, the groups did not differ significantly. However, the writer would like to note that it is of interest that the majority of the subjects of both the control and experimental groups indicated a desire to increase the amount of time they would allot to science teaching. Perhaps this is an indication that all of the students recognized the need to relate to the environment through science.

While there were no statistically significant differences on the attitude measure that was used in this study, informal observations of the experimental group did indicate positive attitude change. For example, students in this group could be found in the laboratory at all hours. Classes which were to terminate at 10:00 frequently continued past midnight. While the projects were not required, all but one of the students of this group did twice as many projects as was suggested. Many students would arrive one-half to one hour early for the class. Many students indicated a desire to pursue concepts which extended beyond the scope of this course.

Whenever possible this was arranged. Finally, out of a current class of 30 students, some 20 students are known to have pre-enrolled in the next science course to be taught using similar procedures.

This researcher also became aware of the fact that the hesitancy and apprehension with which the students approached the science laboratory equipment gradually appeared to diminish for some and disappear for others. Thus, to the extent that one considers "approach" responses an indicator of positive affect (Krathwohl and Bloom, 1964) one can hope that attitudes actually did change in a positive direction, but that the written measures were not sufficiently sophisticated to so indicate. These observations suggest that the attitude measure which was used did not adequately sample the changes in attitude which appear to have been experienced by many of the subjects in the study.

Question Four

> Will the prospective elementary school science teacher when exposed to the teaching strategies of modeling and respondent learning demonstrate similar teaching strategies in their constructed lesson plan?

On the basis of the data gathered, the question can only be considered partially answered. Due to the fact that only 28 percent of the control group attempted the challenge of the lesson plan, it was not possible to differentiate between the two groups. However, there were items of interest within the lesson plan which were rated using the Critique for Evaluating the Lesson Plan, which pointed up some interesting additional facts. As has been reported on page 77 of this study, the proportions of the items stressed by the experimental group in their lesson plan indicated that the teaching strategies of modeling and respondent learning can be thought to be important. For example, the teaching by demonstration (modeling) was indicated by 47 percent of the experimental group.

It should also be of interest that in 55.5 percent of the cases, the experimental group indicated that they would employ manipulative materials in their teaching procedures. In specifying the materials, they would use materials which were easily available and appropriate to the assigned task. The materials that were considered were not expensive and there were provisions for their pupils to get involved and manipulate the materials.

Another point of interest however might be the relatively high number of student/teachers who indicated that they would employ the traditional lecture-response strategy (43.7%). This points up the possibility that teachers tend to teach as they have been taught.

An additional factor which might be considered is that more and more students choose the 'special' Physical Science 351B as an elective following its removal from the required list.

From these responses, the writer is encouraged to try to bring manipulative equipment into a lower division course in an effort to excite or encourage a chain reaction. Hopefully, more and more students will experience pleasant sensations about science and science learning. If this takes place, perhaps the students will continue to seek more cognitive knowledge of their environment.

In the process of analyzing the data in reference to the study's stated purpose several areas for further research suggest themselves.

The conclusions from the data point up the need to weigh further the manner in which affective educational objectives are measured for science programs for elementary school teachers. Unless some heed is paid by the university science departments to provide special measures for attitude improvement, science education programs will continue to ignore the specific needs of the prospective elementary school science teacher. Science is a socializing process and unless positive values or attitudes are assimilated, they will remain abstractions.

It is suggested that further study should be done to see if in fact the traditional university classroom approach works against the purpose of teachers allowing elementary school children freedom to explore their "natural" environment. Further study is indicated as to whether the informal unstructured social environment of the open classroom sustains this process of education.

Though Piaget's theory of cognitive development was emphasized in the study to stress involvement with activities between the peer groups and some use of manipulative equipment was employed by the prospective elementary school science teachers, it might be hypothesized that just one semester is not a long enough time to change a lifetime of ingrained attitudes. It is suggested therefore that further research be directed at examination of time as a variable in attitude change.

Observations made by this researcher suggested that the process of attitude change is possible, but more time and more prolonged experience with science materials and constructive models may be needed. What is suggested are science courses which would combine science content and science teaching methods into meaningful experiences which also emphasize science process as well as science product.

The writer sees the possibility as the result of this study of the need to seek the many answers to how attitude change is brought about through more flexible interaction within the school social and academic climates.

The writer does recognize a number of variables which confound the findings of this research. Chief among these variables is the fact that while this writer taught all the classes of the experimental groups, there were a variety of instructors for the control group. Another factor that remains an uncontrolled variable was the fact that this project was an evolving process and each new semester brought new students with new problems. While the basic format of the procedure remained the same, there were needs within the various groups which had to be met. However, the method of selection, randomizing across semesters, helped to decrease the potentially biasing effects of these factors. The writer personally found the instructional modification and evaluation activities described herein to be both helpful and exciting. Perhaps the most powerful lesson learned was that much work in relation to creating positive teacher attitudes toward science and science teaching yet remains to be done.

BIBLIOGRAPHY

BIBLIOGRAPHY

Allport, Gordon W. "Attitudes in the History of Social Psychology." In Attitudes: Selected Readings. Edited by Marie Jahoda and Neal Warren. Baltimore: Penguin Books, 1966.

Bandura, A. and Walter, R. H. Social Learning and Personality Development. New York: Holt, Rinehart and Winston, 1963.

Beatty, Walcott, and Clark, Rodney. "A Learning Theory for Teachers." Unpublished paper. San Francisco State College, 1960, 253-293.

Brandwein, Paul F. Substance, Structure and Style in the Teaching of Science. New York City: Harcourt, Brace and World, Inc., 1965.

Broudy, H. S. "Can We Define Good Teaching?" The Teachers College Record, 70:583-592 (April, 1969).

Brumeld, Theodore. "The Meeting of Educational and Anthropological Theory." In Education and Culture: Anthropological Approaches. Edited by George D. Spindler. New York: Holt, Rinehart and Winston, 1963.

Butts, David P. "The Evaluation of Problem Solving in Science." Journal of Research in Science Teaching, 2:116-122, No. 2 (1964).

Chaplin, James R. et al. Laboratory Manual for College Physical Science. Dubuque, Iowa: W. C. Brown Company, 1965.

Colville, W. J. "Personality Assessment of Candidates to Seminaries: A Study of Clinical and Psychometric Methods and Their Effectiveness." In The Research Planning Workshop. Edited by S. W. Cook. New York: Religious Education Association, 1962.

Davis, Martin. "The Social Climate of the American Roman Catholic High School Seminary with Special Reference to the Generation of Group Value Orientation." Unpublished Doctoral Dissertation, The University of the Pacific, Stockton, California, 1972.

Ebel, Robert L. "Estimation of the Reliability of Ratings." Psychometrika (1951), 16, 407-424.

Fischer, Abraham S. "The Use of Team-Teaching in the Elementary School." School Science and Mathematics. 62:281-287 (March, 1962).

Fish, Alphoretta S., and Saunders, T. Frank. "Inquiry in the Elementary School Science Curriculum." School Science and Mathematics. 66:13-22 (January, 1966).

Gross, Phyllis and Mayo, Dwight E. "Preparing the Elementary Teacher for Science: A New Direction." Science and Children. 6:21-23 (March, 1969).

Henderson, Judith E. and Prawat, Richard S. Individual and the School, Handbook - Education 200. East Lansing; Michigan State University, 1970.

Haney, Richard E. "The Development of Scientific Attitudes." The Science Teacher. 31:33-35, No. 8 (December, 1964).

Hedges, William D. "Teaching Science by Programming." Science and Children. 2:20-23 (October, 1964).

Jacob, Philip E. Changing Values in College: An Exploratory Study of Impact of College Teaching. New York: Harper, 1959.

__________. "Does Higher Education Influence Student Values?" In Spotlight on the College Student. Washington: American Council on Education, 1959.

Katz, Joseph. "Four Years of Growth, Conflict, and Compliance." In No Time for Youth: Growth and Constraint in College Students. Edited by Joseph Katz and Associates. San Francisco: Jossey-Bass, 1968.

Kersh, J. E. "The Motivating Effect of Learning by Directed Discovery." Journal of Educational Psychology. 53:65-71 (1962).

Klausmeier, H. J. Learning and Human Abilities: Educational Psychology. New York: Harper and Row, Publishers, 1961.

Kluckholm, Clyde. "Values and Value Orientations in the Theory of Action: An Exploration in Definition and Classification." In Toward a General Theory of Action. Edited by Talcott Parsons and Edward T. Shils. Cambridge, Mass.: Harvard University Press, 1951.

Krathwohl, David, et al. Taxonomy of Educational Objectives, Handbook II: Affective Domain. New York: David McKay Company, Inc., 1964.

Lacy, Archie L. Guide to Science Teaching. Belmont, California: Wadsworth Publishing Company, 1966.

Lehmann, Irvin J., and Payne, Isabelle K. "An Exploration of Attitude and Value Changes of College Freshman." Personnel and Guidance Journal, 41:403-408 (January, 1963).

McSpadden, Clyde. Laboratory Manual the Problems for College Physical Science. Dubuque, Iowa: Kendall/Hunt Publishing Company, 1965.

Menzel, E. W. "Science Teaching and Sensitivity Training." The Science Teacher. 36:17-19 (November, 1969).

Moore, Bruce V., Lapp, C. J., and Griffin, Charles H. The Engineering and Physical Science Aptitude Test. The Psychological Corporation, 1943.

National Education Association. "Education and the Spirit of Science, 1966." Section 4, pp. 15-27, Educational Policies Commission, Washington, D.C., 1966.

National Science Foundation. "Science Course Improvement Projects." Bulletin: 62-38. Washington, D.C., October, 1962.

Newton, D. E. and Watson, F. G. The Research on Science Education Survey. The Status of Teacher Education Programs in the Sciences, 1965-1967. Harvard Graduate School of Education, Cambridge, Massachusetts, 1968.

Piaget, Jean and Inhelder, Bahrbel. The Growth of Logical Thinking: From Childhood to Adolescence. Translated by Anne Parsons and Stanley Milgram. New York: Basic Books, Inc., 1958.

Piltz, Albert. "Equipment, Material, and Facility Requirements for a Good Science Learning Activity." In Piltz, Albert, Science, Equipment and Materials for Elementary Schools. Washington: U. S. Department of Health, Education and Welfare, Office of Education, OE-29029, Bulletin #28, pp. 7-19, 1961.

Rosenbloom, Paul C., ed. Modern Viewpoints in Curriculum. National Conference on Curriculum Experimentation. New York: McGraw-Hill Book Company, 1964.

Sanford, Nevitt. "The Challenge to Educators." In Spotlight on the College Student. Washington: American Council on Education, 1962.

Sells, Saul and Trites, David. "Attitudes." In Encyclopedia of Educational Research. Edited by Chester Harris. New York: The Macmillan Company, 1960.

Sherif, Muzafer, ed. Reference Groups: Exploration into Conformity and Deviation of Adolescents. New York: Harper and Row, 1964.

Shoresman, Peter B. "Teaming up for Science Instruction." Science and Children. 1:17-19 (April, 1964).

Stollberg, Robert. "The Education of Elementary School Teachers in Science." In The Task Before Us. The Association for the Education of Teachers in Science, 1962.

Suchman, J. Richard. Idea Book--Inquiry Development Program in Physical Science. Science Research Associates, Inc., Chicago, 1966.

Symonds, Percival M. From Adolescent to Adult. New York: Columbia University Press, 1961.

Taba, Hilda. "Strategy for Learning." Science and Children. 3:21-24 (September, 1965).

__________. Levine, S., and Elzey, F. F. Thinking in Elementary School Children. Cooperative Research Project No. 1574. U. S. Office of Education, Washington, D.C., 1964.

Thompson, George G. "Quest for Prescriptive Values in Our Educational Programs." Learning Research and School Subjects. Edited by Robert M. Gagne and William J. Gephart. Itasca, Illinois: F. E. Peacock Publishers, Inc., 1968.

Victor, Edward. "Why are Elementary School Teachers Reluctant to Teach Science." The Science Teacher. 28:17-19 (November, 1961).

Walbesser, Henry H. "Science Curriculum Evaluation: Observations on a Position." The Science Teacher. 33:34-39 (February, 1966).

________. "Curriculum Evaluation by Means of Behavioral Objectives." Journal of Research in Science. 1:296-307 (1963).

Additional References

Brooks, B. L. and Bransford, L. A. "Modification of Teachers' Attitudes Toward Exceptional Children." Exceptional Children, 38:259-60 (November, 1971).

Frieder, B. "Motivator: Least Developed of Teacher Roles Prime: Prescription Instruction Motivation and Evaluation." Ed. Tech. 10:28-36 (February, 1970).

Kennedy, T. G. and Humphrey, R. A. "Effect of the System Approach on Changing Preservice Teacher Attitudes Toward Selected Instructional Design Factors." Journal of Educational Research. 64:365-9 (April, 1971).

Laganda, J. F. "GT Report: Summary of What Happens to the Attitudes of Beginning Teachers." Gr. Teacher. 88:8+ (September, 1970).

Meeker, D. L. "Measuring Attitude and Value Changes in Selected Humaities and Human Relation Programs." J. Res. Mus. Ed. 19:467-73 (Winter, 1971).

Stone, A. A. "Emphasis Changed in Teaching." School and Community. 56:28 (February, 1970).

Whitehead, J. L., Jr. "Effects of Authority-Based Assertion on Attitude and Credibility." Speech Mon. 38: 259-60 (November, 1971).

Williams, F. E. "Assessing Pupil-Teacher Behaviors Related to a Cognitive-Affective Teaching Model." J. Res. and Develop. Educ. 4:14-22 (Spring, 1971).

APPENDIX A

INSTRUMENTS OF MEASURE

PHYSICAL SCIENCE COMPREHENSION

(Time 10 minutes)

Directions: Examine each statement below and decide whether it is true or false. If the statement is true, fill in the space under T on the answer sheet. If the statement is false, fill in the space under F.

		T	F
SAMPLES: X.	Iron is a metal.	x	
Y.	Water is a solid.		x

Iron is a metal; so the space under T has been filled in on the answer sheet for Sample X. Water is all liquid, not a solid. Therefore, the space under F has been filled in for Sample Y.

T	F		
		1.	All gases are lighter than air.
		2.	A molecule can be seen.
		3.	Wave motion is found in practically every field of physical science.
		4.	A gas completely fills any closed vessel that contains it.
		5.	Hydrogen is inflammable.
		6.	One magnetic pole of the earth is at the north geographic pole.
		7.	The velocities of falling bodies vary directly on their weights.
		8.	An opaque substance obstructs the passage of light.
		9.	The total amount of energy in the universe is constantly changing.
		10.	A vacuum is a good conductor of heat.
		11.	If all forces were eliminated from a moving body it would gradually come to rest.
		12.	A bimetal strip can be used to actuate a thermostat.
		13.	Increasing the pressure lowers the boiling point of water.
		14.	The boiling point of water depends upon the atmospheric pressure.
		15.	A thick tumbler is less likely to break when hot water is poured into it than a thin one.
		16.	Meteorites become luminous as they near the earth chiefly because they are more clearly visible.

T	F		
		17.	Pure water can be cooled below 0°C without freezing.
		18.	A thermometer measures the quantity of heat in a substance.
		19.	A kilogram is equal to 10,000 grams.
		20.	Mercury freezes at about -40°F.
		21.	The water in a modern steam locomotive boils at 100°C.
		22.	A newly formed cumulus cloud is part of an ascending air column.
		23.	A barometer is used to measure temperature.
		24.	Bakelite is a good conductor of electricity.
		25.	Evaporation produces a cooling effect.
		26.	A boat will sink deeper into the water as it passes from a river into the ocean.
		27.	Sound may be transmitted through a vacuum.
		28.	Air is a poor conductor of electricity.
		29.	A centimeter is 1/10 of a meter.
		30.	The bubbles emerging from a diver's suit become smaller as they approach the surface.
		31.	Cream has less density than skim milk.
		32.	Sliding friction is always greater than starting friction.
		33.	As a body is raised above the surface of the earth the force of gravity pulling it downward becomes smaller.
		34.	The temperature of the human body is about 37°C.
		35.	Light travels 100,000 miles per second.
		36.	Air under pressure liquidifies at -140°C.
		37.	The voltage of a group of cells in parallel is the same as the voltage of one cell.
		38.	A non-compensated pendulum of a clock should be lengthened in cold temperatures.
		39.	If thunder follows lightning at an interval of 10 seconds, the flash must have been 10 miles away.
		40.	Pumping more helium into a fully expanded balloon would decrease its lifting power.
		41.	A siphon will work in a vacuum.
		42.	All known gases have been changed into liquids.
		43.	Rolling friction is usually greater than sliding friction.
		44.	Bodies weigh more at the pole than they do at the equator.
		45.	Moist air is lighter per unit of volume than dry air.

YOUR ATTITUDE MEASURE

Name_______________ Section_______ Class: F.S.J.S., Curr.:
Teaching____________________
Other______________________

* * * * * * * * * * * *

SCIENCE:
Please answer each question by circling the number that best shows your attitude.

* * * * * * * * * * * *

1. I think I understand science well enough to teach it in the classroom.

Little Understanding — Complete Understanding

1 2 3 4 5

2. Studying Science can be very enjoyable.

Strongly Agree — Strongly Disagree

1 2 3 4 5

3. I think all elementary teachers should teach science every day if possible.

Definitely Should — Definitely Should Not

1 2 3 4 5

4. Studying science made me more excited about becoming a teacher.

Strongly Excited — Strongly Not Excited

1 2 3 4 5

5. Studying science has helped me see some ways I could actually make a difference in a classroom.

Strongly Agree — Strongly Disagree

1 2 3 4 5

6. Imagine that the elementary teacher you have just replaced in a classroom leaves you the following time schedule of subjects that he/she taught. Record in the second column the tentative time schedule you would recommend based on your values at this time. (You may recommend adjustments or adopt the existing schedule.)

Existing schedule		Recommended schedule	
Reading	90 min.	Reading	____ min.
Mathematics	50 min.	Mathematics	____ min.
Social Studies	40 min.	Social Studies	____ min.
Science	30 min.	Science	____ min.
Language Arts	30 min.	Language Arts	____ min.
Art/Phy. Ed./Music	30 min.	Art/Phy. Ed./Music	____ min.

7. Comments: ____

____

____

Critique for Evaluating Lesson Plan

Check only if attribute is present in lesson plan.

	Yes	No
Was general objectives stated?	____	____
Were they written as behavioral objective(s)?	____	____
Are specific strategies stated? If yes, was it to be	____	____
Lecture-response	____	____
Problem solving	____	____
Teacher modeling or demonstration	____	____
Peer interaction	____	____
Was use of manipulating materials suggested?	____	____
Are materials specified?	____	____
Are materials easily available?	____	____
Are materials appropriate to task?	____	____
Could the materials be considered expensive?	____	____
Was there a provision for learners to manipulate materials?	____	____
Was evaluation of learning outcomes mentioned?	____	____
Pre-test?	____	____
Post-test?	____	____
Were learners expected to "discover principle of centrifugal force?"	____	____
Length of comment. Pages		
1/4	____	____
1/2	____	____
3/4	____	____
full	____	____
1 1/2	____	____
2	____	____
Total score	____	

APPENDIX B

SAMPLE LABORATORY EXPERIMENT

SAMPLE LABORATORY EXPERIMENT

Experiment No. 10
Pin-Hole Camera

Name______________________
Date______________________
Lab Partners______________

Purpose:

--to make and use a pin-hole camera.

Apparatus:

--heavy-weight black posterboard, black tape, scissors, ruller, pencil, razor blade, straight pin, 100 watt bulb, 12" reflector, light fixture, something to photograph, masking tape, clock, 120 size Tri-x black and white film, Kodak Tri-Chem Pack, 3 8oz. containers (preferably of different shapes), clothespin.

Theory:

--Any small hole will act as a lens and produce a visible, inverted image on a screen. This is due to the fact that light rays always travel in straight lines through a hole and falls on the film at the inside back of the camera. This acts as a screen upon which a real, inverted image is formed. The smaller the hole is, the sharper the image will be and, conversely, the larger the hole, the "fuzzier" the image. Obviously, a smaller hole necessitates a longer exposure. The hole made by a regular sewing pin in a good compromise between sharpness and exposure time.

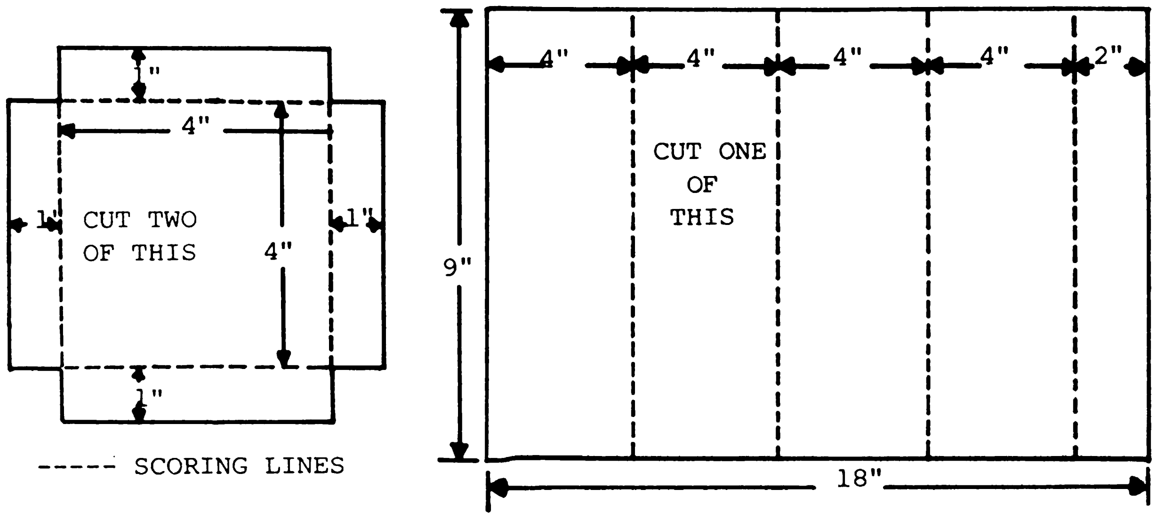
Procedure:

I. Construction of the Camera

--cut out of heavy black posterboard, the three main camera parts (front end, back end and body), using the pattern below. Score the main body piece at slightly less than the 4" indicated, to allow for the thickness of the cardboard.

--bend the end piece flaps on the scored lines, and tape the corners with black tape, to make two end caps.

--bend the body tube on the scored lines to form a rectangular cylinder. Fasten the end flap with a long strip of black tape.



--slip one end cap over one end of the cylinder and tape it securely in place with strips of tape around the joint.

--place the front end cap over the remaining end. Do not tape it. This end must remain removable to insert and remove the film. On the outside of the front end cap, draw two diagonal lines from the four corners. They will intersect at the middle of the cap. Carefully make one clean pinhole at this point, keeping the needle perpendicular to the cap surface--do not angle it.

--secure the cap on the camera with rubber bands.

--your camera is not finished. Write your name on the back cap.

II. Loading the Camera

--take the camera into an absolutely dark room. A closet at night is often useful for a darkroom--especially if you keep the camera and film under a coat on your lap while you work.

--unroll the film and cut off a piece about 3" long. The film comes as a strip 2½" wide and about 30" long. It is rolled like a jellyroll with a strip of paper of the same width but several inches longer.

--stick one small piece of masking tape on each corner of the film piece, and then press it to the inside back of the camera--opposite the pin-hole location.

--reroll the film in the paper and tape it securely, so that the rest of it may be used at another time.

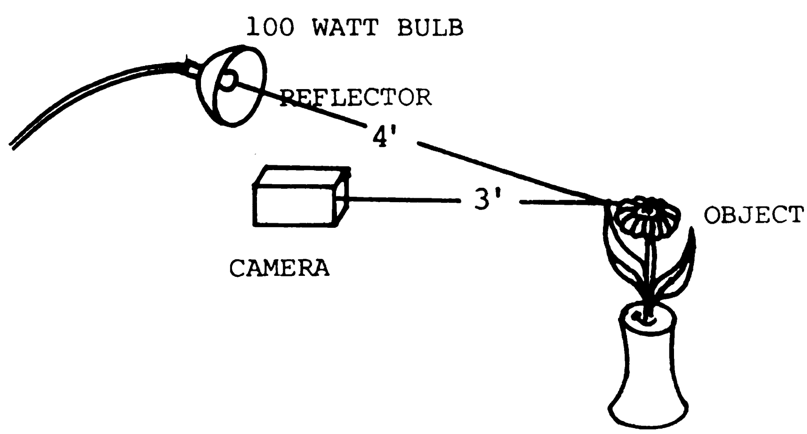
--replace the front cap and secure it with rubber bands.

--hold the box with the pin-hole against you. You can now leave the darkroom or turn on a light.

III. Exposing the film

--keep the pin-hole covered until you are ready to make the exposure.

--place the camera, light and object to be photographed as shown below:



Naturally, other distances and light sources may be used, but the exposure will have to be determined by trial and error for each new set-up. This particular combination has been found to work well for tri-x film and a 30 minute exposure.

--when everything is in place, uncover the pin-hole and leave the set-up undistrubed for 30 minutes.

--after the time has elapsed, cover the pin-hole and take the camera into the darkroom again.

IV. Developing the Film

--prepare the chemicals for development as follows, using the Tri-Chem Pack: mix each pack in the box with 8 ounces of water at about 70°F. This doubles the usual concentration of the developing solution. It is best to mix each of the three solutions in a container of a different shape, so that they can be identified in the dark.

--darken the room completely. Remove the front cap from the camera and take out the film. Fasten a spring-type clothes pin to a corner of the film so that it can be easily handled in the solutions. Place it first in the developer. Keep it completely immersed for 3 minutes (not 2 minutes as recommended in the chemical instructions). Keep the film moving slightly while it is in the chemicals.

--after 3 minutes, take it out of the developer and put it in the stop bath. Leave it there for about 30 seconds to a minute. Then immerse it in the fixing solution. After the film has been in the fixing solution for about 3 minutes, the room light may be turned on. Leave the film in the fixer for a total of about 6 minutes. It should then be washed in running water for about 15 minutes. After rinsing the film should be hung up to dry.

--the dry negative may be printed.

APPENDIX C

LIST OF LABORATORY EQUIPMENT

LIST OF LABORATORY EQUIPMENT

Instruments, Apparatus and Materials for a Class of 30 Students

Quantity	Description
15	Balances, Triple Beam
1 pkg/24	Steel Ball 2"
6	Battery, 6-volt
6	Bulb, neon
6	Bulb, unfrosted 25 watt
8	Bunsen Burners (natural gas)
6	Overflow Cans
8	Conductivity Apparatus
3 doz.	Diffraction Grating
6	Hot-Plates, electric
6	Magnifying glass
6	Microscope, zoom, 100 - 500
8	Milliammeters, 0 - 150 MA
15	Mirror
6	Mortar #1
6	Pestle #1
1	Overhead Projector (Apollo #6)
4 pkg/2	Penlights
8	Ringstand set
6	Ripple Tank Apparatus
3 doz.	Rulers, 6" plastic
8	Solar cells
36	Thermometers, uncalibrated
15	Thermometers, -20° to 110° C
15	Thermometers, -30° to 250° F
16	Thermos Bottle
1	Timer, recording
1	Large Wall Clock with second hand
12 oz.	Wire, copper #18
2 pkg.	Wire, gauze 4x4 pkg./6
16 oz.	Wire, iron #18
8x1 oz.	Wire, Nichrome
1 doz.	Litmus Paper, Blue
1 doz.	Litmus Paper, Red
3 doz.	Balloons
3 doz.	Candies
1 box	Common pins
3 box/12	Plugs, academy
36	Sockets
15	Hall's Carriage
1	Chart, Metric system

Quantity	Description
1 pkg.	Cheesecloth
30	Friction pad, cotton
30	Friction pad, silk
30	Friction pad, wool
1	Cloud chamber, w/power supply, radium source and instructions
15	Earphones, double headset
15	Electroscope, metal case
15	Electrolysis apparatus, Brownlee
1	Geiger tube
6	Power Supply
6	Amplifier - Oscillator
6	Loudspeaker
1 pkg./12	Diffraction grating
6	Spectrum tube power supply
3 doz.	Aluminum strips
3 doz.	Copper strips
3 doz.	Zinc strips
3 doz.	Carbon strips
15	Pulley, single
15	Pulley, double tandum
15	Pulley, triple tandum
4 x 5lb.	Sand
1	Scale, bathroom, English
9 pkg./25	Socket, battery lamp (25)
6	Spectrum Tube - hydrogen
6	Spectrum Tube - neon
6	Spectrum Tube - Helium
6	Spectrum Tube - Argon
15	Super Slinky
1	Wall Chart - Electromagnitic
36	Lead Sinkers 125 gm.
30	Meter sticks
1	Assorted nails
3 pkg./100	Filter Paper - 125 cm
3 pkg.	Carbon paper
3 pkg.	Graph Paper
3 pkg.	Plastic Bags - 1 qt.
2 box	Pins
3 doz.	Protractors, Metal
1 box	Rubber Bands
1 doz.	Sandpaper #0
1 lb.	Rubber Stoppers, 1 - hole #6
2 lbs.	Rubber Stoppers, 2 - hole #7
1 pkg./500	Straws, drinking
Pkg. 5 rolls	Adding Machine Tape
4 rolls	Masking tape 3/4" x 60 yd.
8	Test tube stands
30	Test tube holders
3 spools	Heavy Thread
6	Tongs

Quantity	Description
1 box	Toothpicks
5 x 10 ft.	Dialysis Tubing, 5/8"
1 x 50 ft.	Rubber Tubing, 1/4"
1 lb.	Wire annunciator
3 lb.	Wire, copper #28
6	Surface Tension Unit
1	Metronome
6	Plastic Storage Trays
10 ft.	Grooved Track
16	Spring Balance, 250 gm.
16	Friction Blocks
3	Acceleration Apparatus
12 oz.	Calcium Carbonate Chips (Boiling chips)
1 pkg./1 oz.	Cotton, Absorbent
1 pkg.	Matches, safety
2 doz.	Carbon Rods
1 pkg./500	Wood splints
4	pH Paper (Hydrion 1 - 14) Dispenser
6	Bowl, 1-gal. Battery Jar 6x8
3 pkg./12	Beakers, Pyrex brand 150-ml.
3 pkg./12	Beakers, Pyrex brand 250-ml.
36	Dish, evaporating #1
3 pkg./12	Flask, Erlenmeyer 250-ml.
3 pkg./12	Funnels, 75 - mm
3 pkg./12	Funnels, long stem, 75 - mm
3 doz.	Bottles, gas-collecting, 250 - ml
8	Glass plates
3 doz.	Glass plates 2½ x 2½
8	Cylinder, Graduate, 50 -ml.
6	Cylinder, Graduate, 1000 - ml.
3 doz.	Jar, 16 oz.
3 doz.	Jar, 32 oz.
1 doz.	Jar, 64 oz.
3 doz.	Pipets, dropping
6 doz.	Microscope Slides (3 gr)
1 pkg./12	Petri Dish, Pyrex, 10x100
3 doz.	Stirring Rods, 15 cm.
1 gross	Test tubes, 20 x 150
6 lb.	Glass Tubing, 6 mm
1 doz.	Watch glass, 90 mm
3 doz.	Candles
6	Calorimeters, black
6	Calorimeters, shiny
4 pkg./2	Penlight Batteries
2 pkg.	Corrugated Driers 12 x 18 (100)
1 roll	Cellophane, Green
1 roll	Cellophane, Blue
1 roll	Cellophane, Red
1 roll	Cellophane, Yellow
8	Friction Pads, wool

Quantity	Description
30	Safety goggles
	Paper towels
30	Lab. Aprons, 27 x 36 in.
8	Gooseneck lamps
8	Bulbs, 60 watt
125 g.	Bean seeds (Kentucky Wonder)
15 pr.	Scissors
1 qt.	Alcohol, ethyl
1 lb.	Ammonium Chloride
1 lb.	Ammonium hydroxide
1 lb.	Calcium Carbonate
1 lb.	Calcium Chloride, anhyd.
1 lb.	Copper sulfate
1 gal.	Formaldehyde
6 lb.	Acid, hydrochloric
1 oz.	Magnesium metal ribbon
1 lb.	Magnesium sulfate
1 oz.	Mercuric oxide, N.F.
1 lb.	Nickel sulfate, labg.
2 pt.	Phenolphthalein Solution
1 lb.	Phenyl salicylate
1 lb.	Potassium sulfate
1 lb.	Sodium carbonate, labg.
1 lb.	Sulfur, flowers
9 lb.	Acid, sulfuric
1 lb.	Urea, USP.
4 oz.	Sodium peroxide
1	Aquarium Set - 10 gal.
6	File, Triangular, 5 in.
1	Barograph
1	Hygrometer
1	Barometer, aneroid
1	Barometer, mercury
1	Sling psychrometer
15	Electroscope, aluminum leaf
15	Friction rod, rubber
15	Friction rod, glass
8	lens sets
15	magnet sets
15	compass, magnetic
	Crystal molds

Other tools such as hammers, soldering irons, pliers, screwdrivers, etc.