ABSTRACT

A QUASI-EXPERIMENTAL STUDY OF THE EFFECTS OF TWO MODES OF INSTRUCTION ON THE ATTITUDES OF PRESERVICE ELEMENTARY TEACHERS IN THE AREA OF SCIENCE TEACHING

By

Edward Maynard Liddle

Purpose

It was the purpose of this study to assess and compare the effects of two modes of small group instruction in an elementary science methods course upon the attitudes held by preservice elementary teachers related to science and the teaching of science. This focus on attitudes is based in the need for elementary teachers to exhibit positive attitudes toward science and the teaching of science, particularly student and activity centered strategies of instruction.

Procedures

Eighty junior and senior level elementary and special education majors enrolled in the course, Teaching Science in the Elementary School, 325f, at Michigan State University during the fall term of 1970 were the subjects

involved in this study. These students were also enrolled in small group sections of the course, from which forty students in each of two groups were randomly selected.

The science methods course consisted of nine lecture sessions, regularly assigned outside reading and ten small group sessions. All subjects had the same kinds of learning experiences available outside of the small group sessions. The different treatments utilized in this study were implemented in these small group sessions. One treatment was designated as auto-instructional, while the other was designated as lecture-demonstration. The learning experiences in the auto-instructional treatment involved the provision of "hands-on" manipulation of the materials and equipment by the students. In addition, there was little teacher direction other than that provided by the guide sheets for each session. The lecture-demonstration treatment involved the same topics and objectives but the students were not allowed to manipulate the materials and equipment. Data gathering was conducted through instructor-performed activities suggested by the students.

Data were gathered in two ways. First, attitude measures were administered on a pre- and post-test basis, in the first and sixth class sessions, respectively. The instruments used were a Likert type scale developed by Pickering for measuring attitudes toward different methods of science and three semantic differential instruments with the referent concepts Science, Myself Teaching Science, and Science in the Elementary School.

Secondly, the last four small group sessions were used for the presentation of peer-group lessons. During the presentation of these short lessons two teaching behaviors were observed. These behaviors, termed manipulative and exploratory, were considered behaviors related to attitudes held by the subjects toward student and activity centered instructional strategies. The lesson was observed and two observation responses were recorded, using a yes or no system.

1. Did the mini-lesson involve materials for use by the students during the lesson? (Manipulative)
2. Did the teacher allow the students time to explore the materials before initiating any formal lesson? (Exploratory)

Findings

Multivariate analysis of variance was used to analyze the data in the form of mean-gain scores on the dependent variables. No significant differences were found between subjects when grade level of teaching interest and interaction between treatment and grade level of teaching interest were tested. A significant difference was found at the 0.05 level of significance between the auto-instructional and the lecture-demonstration treatment groups when all the dependent variables were considered simultaneously under multivariate analysis of variance. The lecture-demonstration treatment group showed greater positive changes in attitudes than the auto-instructional treatment group. This difference did not extend to the individual dependent variables using the step-down F ratio as the test statistic and alpha = .05 divided by 6, or 0.083.

The findings of this study indicate that instruction in an elementary science methods course can aid the development of more positive attitudes toward science and the teaching of science. Further research is needed to determine what characteristics, previous experiences, and student expectations are related to the change in attitudes resulting from exposure to either of the instructional modes.

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CHAPTER I

THE PROBLEM

Need

"Teachers teach as they were taught" is a familiar, if not overused, axiom of teacher education. This is also the source of a particularly acute problem in science education in the elementary school. This problem is related to the rapidly changing role of the teacher in elementary science as the curricula become more student-centered and activity oriented.

> No longer in modern programs do we find object lessons, nature study or merely substantive content sufficing. Limiting science to the study of objects, forces and phenomena is no longer acceptable in most newer programs. Among other things, the young learner must now concern himself with the means by which scientific knowledge comes into being, how it is communicated, that it is uncertain and changing, that science is an enterprise of people and thus affects the way man views himself and his world.[1]

While the science curriculum changes, the most important aspect of curriculum change, that is, changing the behavior of the teacher, is not keeping pace. As

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[1]Roger G. Olstad, "The Effect of Science Teaching Methods on the Understanding of Science," Science Education, LIII, No. 1 (February, 1969), 9. (Hereinafter referred to as "Effect of Science Teaching.")

recently as 1969, a rather strong indictment of the present state of affairs was presented in the Report of the Cambridge Conference on the Correlation of Science and Mathematics in the Schools.

> Even more disturbing (than mathematics education) is the absence of any genuine science teaching, especially in the elementary grades. At the elementary level it is only recently that the ferment of curricular reforms has penetrated to the sciences, and even the best of the new elementary science curricula have so far made only minor impact in the classroom.[2]

This indictment is extended to include colleges of education when the report states, "The discovery and activities methods featured in present and projected curriculum reform programs will be making new pedagogical demands on teachers and on colleges and schools of education."[3] That these demands are new is the surprising and alarming thing. That they are new demands on the teacher educators is particularly critical and pertinent to this study.

Olstad focuses this need more sharply when he states,

> That a revolution is taking place in the teaching of elementary school science is well known to science educators today. The most significant aspect of the change is the increased attention being given to a broader understanding of the nature of science as processes of scientific inquiry.[4]

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[2]Report of the Cambridge Conference on the Correlation of Science and Mathematics in the Schools (Boston: Houghton Mifflin Co., 1969), p. 79. (Hereinafter referred to as Report of Cambridge Conference.)

[3]Ibid., p. 80.

[4]Olstad, "Effect of Science Teaching."

In regard to a study of preservice elementary teachers, Olstad further states,

> . . . it is necessary for the teacher to more broadly understand science--its methods and processes--if he is to teach this kind of science to children. Do they leave the colleges and universities (or their workshops) with the necessary understandings, attitudes and skills to teach the 'new' science?[5]

Clearly, if we expect science in the elementary school to become activity and discovery oriented we must allow the prospective elementary teacher opportunities to experience this approach to science and science teaching. It is incumbent upon those of us working in teacher education to provide these opportunities.

> Instead of talking about a pupil-activity program, the students themselves are as actively involved in a college learning situation as they are expected to have their future students. This breaks the unrealistic pattern of leaning heavily upon the use of the lecture method in college classes and then expecting students taught this way to adopt pupil activity procedure in their own elementary school teaching.[6]

In addition to the student activity dimension of the problem in effecting significant changes in the teaching of elementary school science there is another important dimension; teacher attitude. Attitudes toward both science and the teaching of science must be given primary consideration whenever one speaks to problems

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[5] Ibid.

[6] Seymour Metzner and Pearl Nelson, "E.I.: Practicing What We Preach," Science Education, LII, No. 3 (April, 1968), 298-99.

related to elementary school science teaching. Using the words of Eloise Soy,

> When prospective elementary teachers arrive at college their attitudes about science are already firmly established. These attitudes are not likely to be positive and apparently little happens in the college program to promote positive feelings toward science.[7]

The message is echoed loudly when one speaks with students in the methods course. Not only do these people generally express negative attitudes toward science, but in many cases they express fear. Any methods course treatment must place major consideration on this dimension. Regardless of the experiences designed for teacher education in science, these prior experiences must be recognized as major obstacles to an easy transition of the prospective elementary teacher to positive attitudes toward a pupil and activity centered science curriculum.

Purpose

Based on the assumption that there is a need for elementary school teachers who exhibit positive attitudes toward science, the teaching of science, and student and activity-centered approaches to learning, this study is an inquiry into the effects on attitudes produced by two instructional techniques employed in the elementary science methods course at Michigan State University.

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[7]Eloise Soy, "Attitudes of Prospective Elementary Teachers Toward Science as a Field of Specialty," School Science and Mathematics (June, 1967), pp. 507-17. (Hereinafter referred to as "Attitudes of Prospective Elementary Teachers.")

The attitude referents used are:

Science

Teaching science in the elementary school

Science in the elementary school

In addition to these referents, an assessment is made of the pre-service elementary teachers attitudes toward different methods of teaching science from teacher-centered through student-centered.

Finally, a behavioral mode of assessment was utilized in observing peer-group mini-lessons to determine whether or not the two methods of instruction produce any different behaviors in these teaching sessions. Specifically, an objective observation will be made which relates the actual behavior in teaching a lesson to peers with the expressed attitudes as measured by the various attitude instruments.

Hypotheses

To investigate the attitude changes and mini-lesson teaching behaviors as outlined in the preceding section, the following hypotheses will be tested:

1. There will be no difference in attitudes toward different methods of teaching science, ranging from teacher centered to pupil centered, when instruction is accomplished through either of the two techniques, auto-instructional, or lecture-demonstration.

2. There will be no difference in attitudes toward science, teaching of science, and science in the elementary school when

instruction is accomplished through either of the two techniques, auto-instructional or lecture-demonstration.

3. There will be no difference in peer-group mini-lesson teaching behavior when instruction is accomplished through either of the two techniques, auto-instructional or lecture-demonstration.

4. There will be no difference in attitudes toward science, teaching science, science in the elementary school and towards different methods of teaching science between subjects interested in teaching early elementary grades and the subjects interested in teaching the later elementary grades.

The above hypotheses are stated in test form in Chapter III.

Definition of Terms

The terms specifically relevant to the present study were defined as follows:

Attitudes--as used in this study, refer to learned, affective reactions toward certain specified referents. Namely, different methods of teaching science, science, teaching science and science in the elementary school. These affective reactions vary in intensity from positive to negative.

Auto-instructional--as used in this study, means a learning situation in which the student accepts the major responsibility for gathering data and experience sufficient for the satisfaction of the specified objectives. The data gathering and experiences are gained through direct manipulation of materials and equipment.

Lecture-demonstration--as used in this study, refers to a learning situation in which the instructor through visual and oral communication makes available data and experiences sufficient for the gathering of data necessary for the meeting of specified objectives. The instructor is the sole person to manipulate the materials and equipment. This is often done at the direction and suggestion of the students.

Peer-group mini-lesson--for the purposes of this investigation, is a five minute lesson presented by a student to a group of five fellow students. The concept or process and the objectives of the lesson are chosen by the student, and no attempt at closure is made.

Teacher-centered approach--is a method or strategy in teaching where the teacher dominates the classroom situation and imparts knowledge to passive students.

Pupil-centered approach--is a method or strategy in which the pupils participate actively with materials and ideas, with the teacher acting as a resource and guide.

Early elementary grades--are those grades designated as kindergarten through third grade.

Later elementary grades--are those grades designated as fourth grade and above.

Manipulative activity--is an experience in which the learner has direct, hands-on contact with the materials or equipment for the purpose of gathering data and experience necessary for the completion of some objective.

Exploratory activity--is an experience in which materials and equipment are provided to the learner for the purpose of freely manipulating and playing so that objectives of interest to the learner might be identified.

Assumptions

1. Attitudes are measurable. They represent predispositions to respond to specific referents. Pencil and paper instruments, such as the Pickering-Likert instrument and the Semantic Differential instrument present such specific referents and as such adequately assess the subjects attitudes toward the presented referents.
2. In responding to the attitude instruments, the subjects presented their honest reactions to the referents. In short, the reactive arrangement of the testing situation within a college course had no effect on the subject's responses.

3. The modeling effect of the instruction technique presented in the course is sufficient to effect changes in the attitudes and teaching behaviors of the subjects.
4. Five, one hour treatment sessions are sufficient to produce a measurable change in attitudes and teaching behaviors.
5. The instructor's interaction with the independent variable designated as treatment variation was negligible.
6. There is no interaction of testing with the treatment or of the post-test with manifested peer-group mini-lesson teaching behaviors.
7. The development of positive attitudes toward science and student-centered approaches to the teaching of science are worthwhile goals for the methods course in light of the needs of classroom teachers implementing elementary science curricula which are in themselves student and activity centered.
8. The history represented by the experiences outside the science methods course was constant across the two treatment groups. History is negated as a source of rival hypotheses suitable for the explanation of any observed differences in this study.

9. The materials developed for use in the two treatments were suitable for the purposes of this study.
10. The use of only two of the possible six small group sections provides for a control on the source of internal invalidity designated as mortality. The use of two sections allows four other sections available for transfers and changes of schedules.
11. The registration procedure at Michigan State University presents no selection bias as a possible threat to the internal validity of the study.

Limitations of the Study

1. The treatments designated as auto-instructional and lecture-demonstration were used for only five sessions each of one hour duration.
2. While there are many teaching behaviors and attitude referents which might be identified relevant to the present study, this study considered only the following attitudes:

   Attitude toward science

   Attitude toward teaching science

Attitude toward science in the elementary school

Attitude toward different methods of teaching science on a continuum from teacher centered to pupil centered

In addition to these attitudes, the only behaviors considered suitable for objective observation during the peer-group mini-lessons, were those designated as manipulative and exploratory.

3. No effort was made to compare the attitudes of the subjects involved in the study with a sample of similar students not enrolled in the science methods course.
4. Sex, as an uncontrolled variable, was not investigated since the number of males in the sample and population was small.
5. No attempt was made to assess changes in science subject matter competency brought about by the two treatments.
6. Variation in the science backgrounds of the students as well as the courses in which they were currently enrolled was not investigated as a possible source of variation in this study.

Overview

In this chapter, the circumstances suggesting a need for studies related to the effects of instruction in elementary science methods courses on the attitudes and teaching behaviors of preservice elementary teachers were presented. The purpose of the study, as related to the cited needs, was presented, followed by relevant hypotheses, definition of terms, assumptions, and limitation used in the study.

In Chapter II, the literature concerning the development of elementary science and the research done in the field of preservice education of elementary teachers in the area of science is reviewed.

The selection of design, a description of the sample and the population, instrumentation, and data analysis procedures are presented in Chapter III.

The analysis of data and results of the analysis are presented in Chapter IV. The final chapter contains the conclusions and implications of the findings of the study.

CHAPTER II

REVIEW OF THE LITERATURE

Elementary Science: An Historical Perspective

Much of what is referred to as new in the area of elementary school science is rooted in the philosophies and practices of the past. The value of a sketch of the significant historical periods and developments from which the practices of present-day elementary science have developed is pointed to by Clark,

> Many of the educational theoreticians of the past and the present have emphasized the value of pupil's learning or creating knowledge themselves. Discovery learning is basic to both the dialectical method of Socrates and the parable method of Jesus. A century ago, Herbert Spencer emphasized the importance of self-development through discovery in his classic, Education. Jerome Bruner and other contemporary writers are now emphasizing its importance more than ever before.[1]

A recently published text designed for use in preservice courses in methods of teaching elementary science includes an historical summary in an early chapter

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[1]Leonard H. Clark, Strategies and Tactics in Secondary School Teaching: A Book of Readings (New York: The MacMillan Company, 1968), p. 171.

devoted to establishing a working philosophy. The authors indicate their rationale for including the historical material by stating, "The basis for many of the current educational practices in science education lies in the past. . . . We gain perspective that will help us better understand the variety of approaches."[2]

In preparing an historical sketch, one is confronted with the problem of deciding what developments are significant in the area of consideration as well as to determining the point of entré where a movement assumes a position of general recognition. That such decisions are difficult is attested to by the differing opinions voiced by authorities in the field of science education. Hurd and Gallagher indicate that it was not until the middle of the nineteenth century that science became part of the elementary school curriculum.[3] Victor and Lerner, however, consider elementary science to ". . . begin around 1930 with the growth of a movement to teach all areas of science in the elementary school and to make science a dynamic and integral part of the curriculum."[4]

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[2]Robert D. Anderson, Alfred Devito, *et al.*, *Developing Children's Thinking Through Science* (Englewood Cliffs, N.J.: Prentice-Hall, Inc.), p. 17.

[3]Paul DeHart Hurd and James Gallagher, *New Directions in Elementary School Science Teaching* (Belmont, Calif.: Wadsworth Publishing Co., 1968), p. 21.

[4]Edward Victor and Marjorie Lerner, *Readings in Science Education for the Elementary School* (New York: The MacMillan Company, 1967), p. 1.

Their choice of 1930 seems to be based upon the two criteria, "all areas of science" and "dynamic and integral part of the curriculum." This choice of date also reflects the impact of Gerald Craig's doctoral dissertation.

In order to be inclusive, the earlier recognition of elementary science was selected. This early position is reflected in the titles of the periods to be presented: The Early Period or Moral Persuasion, Object Teaching, Nature Study, Social Utility, and The Post Sputnik Era.

The Early Period or Moral Persuasion

Just as it is difficult to ascertain the specific time that science was generally recognized as a part of the elementary school curriculum, it is equally as difficult to say when science became part of the school curriculum in the United States. There seems to be some agreement that this occurred during the mid-eighteenth century as Lee, in tracing the evolution of science teaching suggests, "From early colonial days until the mid-eighteenth century virtually no science was included in the school curriculum."[5] If one were to include lessons which were designed to indicate the presence of

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[5]Eugene C. Lee, New Developments in Science Teaching (Belmont, Calif.: Wadsworth Publishing Co., 1967), p. 1.

God in nature, however, one might place the date somewhat earlier; perhaps in the 1820's. Underhill, in a comprehensive historical treatment of the development of elementary school science cites examples from 1827 and 1828 which indicate science as a part of the school curriculum.[6] Whatever the case, this period of elementary science is best described by Hurd and Gallagher, "The text books were written with a moralistic flavor and each lesson closed with an exhortation to be kind, obedient and God-fearing."[7]

Object Teaching

In an early attempt to apply learning principles and to systematize instructions in science, a movement known as "object teaching" developed between 1850 and 1880.[8] This movement was based in the principles of Pestalozzi and suggested a change in emphasis from highly verbal abstract approaches. Young children were to develop skill in observing and describing suitable objects while later mental development in higher thought processes

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[6] Ora C. Underhill, The Origins and Development of Elementary School Science (Chicago: Scott, Foresman and Co., 1941), p. 86, cited by Kuslan and Stone, Teaching Children Science, p. 112.

[7] Hurd and Gallagher, New Directions, p. 21.

[8] Ibid.

was accomplished through repeating experiments mentally and memorizing what was read in texts and from charts.[9]

Since the development of object teaching was viewed as the application of faculty psychology or training of the mind, the usual methods of instruction called for drill and memorization.[10] Object teaching, as a specialized movement of teaching, never progressed much beyond meaningless verbalization, or as Underhill sums it, "Although Object Teaching started out as a means of emphasizing the part played by words, it degenerated into the worst form of verbalistic memorization."[11]

While the preceding paragraphs indicate that, at least on a limited scale, science was included in some elementary schools, Trexler indicates that, ". . . the teaching of science in the elementary school is of rather recent origin, first appearing at the turn of the century as nature study."[12]

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[9]Kuslan and Stone, Teaching Children Science, p. 113.

[10]Harold Tannenbaum, Nathan Stillman, and Albert Piltz, Science Education for Elementary School Teachers (Boston: Allyn and Bacon, 1965), p. 7.

[11]Underhill, Elementary School Science, p. 113.

[12]Clarence Trexler, "The Nature of Science Instruction in the Elementary School and Implications for the Development of a Science Methods Course," Report of the TTT Project in Science and Mathematics (New York: New York University, 1970.

Nature Study

The Third Yearbook of the National Society for the Study of Education, entitled, Nature Study, advocates the importance of the functional relationship between instruction in the elementary school and the natural sciences then studied in the secondary school.[13] The Nature Study Movement, motivated by the need to improve agriculture, reduce the migration of youth from the farms to the cities, and reverse the trend toward larger relief roles,[14] was spear-headed by Liberty Hyde Bailey and her colleagues at Cornell University. The movement had its origins in the late nineteenth century and developed into a national movement during the early 1900's. The widespread use of Anna Botsford Comstock's, Handbook of Nature Study, as well as the widely distributed Cornell Rural School Leaflets, were significant vehicles for its rapid expansion.

Bailey, in characterizing the Nature Study position in science education stated:

> Nature Study is a revolt from the teaching of mere science in the elementary school. . . . Nature

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[13]Nelson B. Henry, ed., Rethinking Science Education, The Fifty-Ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960).

[14]Anderson, DeVito, et al., Developing Children's Thinking, p. 20.

> Study is not science. It is not facts. It is spirit. . . . It is concerned with the child's outlook on the world.[15]

Nature Study, like Object Teaching, had its psychological basis in faculty psychology. In speaking to this point, Jackman indicates that the principle reason for instituting Nature Study was the opportunity it offered for direct sense training.[16]

The subject matter of Nature Study is embodied in the title ascribed to the movement "the kingdoms of earth, air, sky and water. It embraces a search for knowledge of all phenomena and of the laws by which these are associated."[17] The major goal of the movement was to instill a love of nature in the child. More specific objectives included appreciating the value of truth as perceived through unemotional observations.[18]

These lofty goals not withstanding, interest in Nature Study as a national movement in science education began to wane in the 1920's. A case can be made, however,

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[15]Bailey, Liberty Hyde, The Nature Study Idea (New York: Doubleday and Co., 1903) as found in Kuslan and Stone, Teaching Children Science, An Inquiry Approach, p. 115.

[16]National Society For the Study of Education, Third Yearbook, Part II (Chicago: University of Chicago Press, 1902), p. 13.

[17]*Ibid.*, p. 11.

[18]*Ibid.*, p. 15.

for the widespread use of nature study today.[19] Among the reasons cited for the demise of the movement are the following:

> It had little basis in philosophy and psychology of the day.[20]
>
> Teachers needed to know a great deal about nature and the study of nature.[21]
>
> Materials were difficult to obtain and necessary field trips were often neglected.[22]
>
> No consideration was really given to problem solving and reasoning skills.[23]
>
> By its very nature, the physical sciences were excluded.[24]

The technological development of industry, increased urbanization and the greater number of students going on to secondary schools, as well as the philosophical and psychological developments of the 1920's necessitated a re-examination of the role of elementary science in education. An increased emphasis was needed on the social utility aspects of education in general and science

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[19]Trexler, "Nature of Science Instruction," p. 30.

[20]Anderson, Devito, et al., Developing Children's Thinking, p. 21.

[21]Kuslan and Stone, Teaching Children Science, p. 22.

[22]Ibid.

[23]Hurd and Gallagher, New Directions, p. 25.

[24]Ibid.

education in particular. A significant contribution to this end was made by Dr. Gerald Craig's doctoral dissertation of 1927.[25]

Social Utility

In 1927, Gerald Craig stated that a major function of science in the elementary school should be to help children use relevant laws, generalizations, and principles of science to develop an understanding of the world around them. He also saw the utilitarian aspects as they related to the economy, health, and safety. He was aware of more than the cognitive aspects of science instruction and emphasized the affective dimensions; attitudes, appreciations, and interests.[26]

The influence of the pragmatist school of philosophy, notably that of John Dewey, supported such utilitarian goals. Dewey placed great faith in the methods of science as a means for solving a wide variety of problems. The current interest in science as process as well as product seems to reflect what Dewey had to say about science instruction. Quoting Smith in this regard:

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[25]Herbert A. Smith, "Historical Background of Elementary Science," in Readings in Science Education for the Elementary School, ed. by Edward Victor and Marjorie Lerner (New York: MacMillan Co., 1967), p. 35.

[26]Ibid., p. 38.

> Dewey's contributions are numerous; but, perhaps the most significant for the developing field of elementary science was his contention that the methodology of science is at least equal--or perhaps of greater--significance than the actual knowledge accumulated.[27]

In addition to the social implications of Craig's research, attention was focused upon the broad generalizations and principles of science. These generalizations and principles were interdisciplinary in nature which tended to broaden the scope of elementary school science. In support of the generalization or principles point of view as a basis for curriculum organization, the Thirty-first Yearbook of the National Society for the Study of Education "offered a comprehensive program and advocated the definite organization of science instruction in all grades . . . about certain broad generalizations and principles."[27]

Anderson, DeVito, *et al.*, contend that this social utility, principles and problem solving approach never reached fruition. "Unfortunately, the problem solving objectives often became twisted when put into actual practice. Courses of study merely worded traditional material in problem form . . ."[29]

[27] *Ibid.*, p. 37.

[28] NSSE 46th Yearbook, Part I, *Science Education in American Schools* (Chicago: University of Chicago Press, 1947), p. 21.

[29] Anderson, DeVito, *et al.*, *Developing Children's Thinking*, p. 23.

Regardless of the limitations which developed during this era, the period from the late 1920's through the Second World War witnessed the growth of elementary science into a dynamic and integral part of the school curriculum. All areas of science were considered; biological as well as physical science; cognitive as well as affective; product as well as process.[30]

From the close of the Second World War until the late 1950's, the principles and broad generalizations approach was the dominant theme. There was an increased emphasis on the preparation of individuals to live healthfully, successfully and responsibly within a constantly changing society.[31] The major change was the emphasis placed on teacher directed experiments. Laboratory kits, portable laboratory tables and audio-visual aids were introduced to facilitate this new emphasis.

Characteristics of Contemporary Science Programs

The programs available today are the direct result of directing forces developed during the late 1950's and the 1960's. Tyler delineates these forces as follows:

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[30] Victor and Lerner, Readings in Science, p. 1.

[31] R. C. Bradley, N. W. Earp, and T. Sullivan, "A Review of Fifty Years of Science Teaching and Its Implications," Science Education, L (March, 1966), 152.

1. The technological revolution that has resulted in the public recognition of the importance of science's role in today's society.

2. The closer working relationship that has been fostered among university personnel; the research scientist and the classroom teacher.

3. The nature of the knowledge explosion that has altered the conception of science itself--so that it is no longer considered to be the acquisition of basic principles and facts but rather a process of continuing inquiry and reconstruction of knowledge.

4. The wide range of pupil interests, abilities, backgrounds and experiences that actively marshalls a science teaching methodology meeting the varied needs of all students.[32]

In addition to these forces cited by Tyler, there is another facilitator of change; massive federal government financing of curriculum development projects.

The elementary science programs developed in response to these directing forces reflect another significant development of this era; the National Science Teachers Association's, Theory Into Action in Science Curriculum Development. In this publication, the necessary aspects of a viable theory for science instruction are listed:

1. The nature of science: its structure, its processes of inquiry and its conceptual schemes;

2. the nature of the learner: his motives, cognitive style, emotional background, and intellectual potential;

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[32]Ralph W. Tyler, "Forces Redirecting Science Teaching," Science Teacher, XXIX, No. 6 (October, 1962), 22.

3. the nature of the teacher: his cognitive style, ability to communicate, control pattern, educational philosophy and understanding of science;

4. the nature of learning: its processes, contexts, conditions and purposes;

5. the nature of the curriculum: its organization, sequence, and its substantive, attitudinal, and procedural dimensions and

6. the nature of the social structure: the social and cultural forces with their demands and incentives.[33]

With these aspects of a theory of science instruction in mind, what are the major characteristics found to be common to the contemporary science programs?

1. An emphasis upon the investigative nature of science (inquiry and discovery).

2. A conviction that children need to be actively involved with materials that are conceptually rich for the learning of science.

3. An emphasis upon independent learning with opportunities to explore, try out, play with and in other ways initiate their own learning.

4. An attempt to establish a sequence of instruction to help assure the child's acquisition of skills in the processes of science as an important part of their intellectual growth.

5. A valid presentation of science materials so that concepts will not need to be corrected later.[34]

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[33]Paul DeHart Hurd, Theory Into Action in Science Curriculum Development (Washington, D.C.: National Science Teachers Association, 1964), p. 8.

[34]J. Dudley Herron, ed., Preservice Science Education of Elementary School Teachers, American Association for the Advancement of Science Commission on Science Education (Washington, D.C., 1970), pp. 5-6.

This listing of the characteristics common to elementary science programs, as prepared by the American Association for the Advancement of Science's Commission on Science Education, emphasizes in three of the five parts the direct, active involvement of the learner with the learning situation. Restated in a single statement, the common ground of the contemporary science programs lies within the domain of inquiry and active-involvement of the student. Kuslan and Stone, in defining inquiry as an instructional technique, identify some characteristics of this type of instruction. Included are an emphasis on the processes of science, a problem orientation and a lack of importance assigned to the preceding content and the following content.[35]

Anderson, DeVito, _et al._, in arguing that problem-solving has much in common with inquiry or discovery, state:

> In general it can be said that these various approaches have much in common. First, one must have something to process about, . . . something to inquire about, or something to discover about. The something is the science content. The various approaches seem to have a common origin in inquiry--inquiry about some problem, puzzling situation or discrepancy.[36]

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[35]Kuslan and Stone, _Teaching Children Science_, pp. 138-39.

[36]Anderson, DeVito, _et al._, _Developing Children's Thinking_, p. 58.

Inquiry is used in two fundamental ways in the literature. First, there is the characterization of modes of instruction, in which the inquiry processes are used to bring about the learning of some content objective. The other, emphasizes the inclusion of the processes as part of the science structure.[37] This results from the pattern or process structure of the discipline and forms the foundation of Science: A Process Approach.

Included within the characterization of the present-day elementary science programs developed primarily under National Science Foundation funding in the past decade, is a new perspective of the role of the teacher. Suchman's studies on inquiry training have a particularly important meaning within the context teacher role during inquiry lessons. Since the students is searching for meaningful relationships within the problem, processing the available data, discovering and verifying his discoveries, the teacher must facilitate this student inquiry by:

1. Creating a sense of freedom to have and express ideas and to test them with data;

2. providing a responsive environment so that each idea is heard and understood and so that each learner can get the data he requires;

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[37] James Rutherford, "The Role of Inquiry in Science Teaching," Journal of Research in Science Teaching, II (1964), 80-84.

3. helping each learner to discover a direction to move in and a purpose for his intellectual pursuit.[38]

That the teacher is central to the successful implementation of the new inquiry-student activity oriented science programs is attested to by Lee, when he stated:

> The success or failure of any instructional program ultimately depends upon the classroom teacher. . . . The new science programs being recommended definitely require the teacher to change his approach if he is to succeed in getting across to the students the objectives for which the courses were developed.[39]

Preservice Education of Elementary Teachers in Science

The preparation of a literature review pertinent to the topic of the preservice education of elementary school teachers in the area of science leads to the conclusion, as stated by Barnes, "Reviews of the literature by the writer and others reveal the relative scarcity of research on the preparation of elementary teachers for teaching science as compared to that directed toward secondary level."[40]

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[38] John R. Verdium, Jr., Conceptual Models in Teacher Education (Washington, D.C.: American Association of Colleges of Teacher Education, 1967), p. 98.

[39] Lee, New Developments, p. 41.

[40] Steven M. Barnes, "The Reactions of Selected Elementary Teachers to the Training For and Implementation of the Science Curriculum Improvement Study in Selected Schools of Michigan" (unpublished Doctoral Dissertation, College of Education, Michigan State University, East Lansing, 1969), p. 16.

Blosser and Howe,[41] after preparing an analysis of research on elementary teacher education in teaching science referred to this scarcity with the comment, "This situation persists despite the continuing criticisms that many elementary teachers do an inadequate job of teaching science . . ."

Boenig,[42] in an analysis of studies in science education for the period of 1938 through 1947, reveals this scarcity when one investigates the topics of the studies judged to be highly significant. This analysis presents seventy-eight studies in digest form as well as an additional seventy-eight in the annotated bibliography. Of the seventy-eight studies in digest form, only one of these studies is related to the preservice preparation of elementary teachers in science. This study was Ralya and Ralya's[43] investigation of misconceptions in science, thus really bears only obliquely on their education in science. Of the studies listed in the annotated bibliography, five were on topics related directly to preservice preparation

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[41]Patricia E. Blosser and Robert W. Howe, "An Analysis of Research on Elementary Teacher Education Related to the Teaching of Science," Science and Children, VI, No. 5 (January/February, 1969), 50-60.

[42]Robert W. Boenig, Research in Science Education, 1938 through 1947 (New York: Teacher's College Press, Columbia University, 1969).

[43]L. L. Ralya and L. L. Ralya, "Some Misconceptions in Science Held by Prospective Elementary Teachers," Science Education, XXII (October, 1938), 244-51.

in science. These are the studies by Bedell,[44] Burgess,[45] Crosby,[46] Davis,[46] and Richardson.[48] Consequently, of the 156 studies cited in Boenig's work, only six, or slightly less than 4 per cent, were related to the present topic of interest.

It is interesting to note that this analysis of research from 1938 through 1947 would reflect the influence of the Progressive Education Association's, Science in General Education[49] since this was published in the year 1938. This period of time would also reflect the previously published Thirty-first Yearbook[50] of the National Society

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[44]Ralph Bedell, "The Science Interests of Successful Elementary School Teachers," Science Education, XXIV (April, 1940), 193-99.

[45]Anna E. Burgess, "Suggested Preparation for Teachers of Elementary Science," Science Education, XXXI (March, 1947), 61-68.

[46]Richard C. Crosby, "A Study of the Status of the Critic Teacher of Science in the Cooperating Public Schools of the Eastern United States," Science Education, XXII (April, 1938), 171-75.

[47]Warren M. Davis, "Preparation of Ohio Elementary Teachers in the Field of Science," School Science and Mathematics, XL (March, 1940), 238-43.

[48]John S. Richardson, "Some Problems in the Education of Science Teachers," Science Education, XXIX (December, 1945), 249-52.

[49]Progressive Education Association, Science in General Education (New York: Appleton-Century Company, 1938).

[50]NSSE, Thirty-first Yearbook.

for the Study of Education which was published in 1932. The cut-off date of 1947 precludes the possible influence of NSSE's Forty-sixth Yearbook,[51] however, since this was not published until 1947.

In a companion volume prepared by Swift,[52] an analysis of research in science education covering the period of 1948 through 1952 reveals a similar pattern. Two of the forty-four studies which appear in digest form are related to the preservice education of elementary teachers in the area of science. The first of these, by W. W. E. Blanchet[53] is similar to the Ralya and Ralya study in that it explores beliefs in science misconceptions held by in-service teachers and thus bears only obliquely on their preservice education in science. The second study appearing in digest form is a summary of certification requirements for both secondary and elementary teachers prepared by Clarence Pruitt.[54] This, too, does not bear directly on the preservice education of elementary teachers in science.

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[51]NSSE, Forty-sixth Yearbook.

[52]J. Nathan Swift, Research in Science Education, 1948 Through 1952 (New York: Teachers College Press, Columbia University, 1969).

[53]W. W. E. Blanchet, "Prevalence of Belief in Science Misconceptions Among a Group of In-service Teachers in Georgia," Science Education, XLVI (April, 1940), 208-13.

[54]Clarence Pruitt, "Certification Requirements for Teachers in Elementary and Secondary Schools," Science Education, XLVI (April, 1952), 182-93.

Thus, in the two volumes which summarize the most significant research in science education covering the period from 1938 through 1952, not one study presented in digest form has any direct connection with preservice education.

While the implication of the preceding is that until recently there has been little done in the way of research dealing with preservice education this is not to say that other studies and writings are not available which contribute to the development of the principles and practices presently evidenced and suggested. With this in mind, the following section of this chapter deals with portions of the literature which contribute to the historical basis from which the present and very recent past practices have sprung.

The review of the literature relevant to the topic of the preservice education of elementary teachers in the area of science is divided into two areas; Perceptions of the Problem: Inadequate Subject Matter Preparation and Perceptions of the Problem: Teachers' Attitudes.

Perceptions of the Problem: Inadequate Subject Matter Preparation

In the past decade we have witnessed a dramatic change in the emphasis in elementary science courses. Along with the change in the elementary science courses has come a concommitant need for change in the education of elementary teachers in science. At the beginning of of this decade, the principle problem associated with the poor quality, or even lack of elementary school science in the classroom was inadequate subject matter background on the part of the elementary teachers. Maddux,[55] in a 1949 study, concerned with the upper elementary teachers in 114 elementary schools in Cleveland, Ohio, reported that the major problem identified in interviews with these teachers was their insecurity in knowledge of science subject matter.

J. Buck and G. Mallinson,[56] in a 1954 summary of studies dealing with the training of prospective elementary teachers in the field of science revealed a lack of subject matter courses in their backgrounds. J. Mallinson,[57] in a review of science education for the period of 1951 to 1956 concluded that one of the reasons for the inadequate science subject matter backgrounds of elementary science teachers was ". . . courses in science offered them are not of the general, survey type they need." In addition

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[55]Grace C. Maddux, "Helping the Elementary Science Teachers," School Science and Mathematics, XLIX, No. 432 (October, 1949), 534-37.

[56]J. Buck and G. Mallinson, "Some Implications of Recent Research in the Teaching of Science at the Elementary School Level," Science Education, XXXVIII, No. 1 (February, 1954), 81-101.

[57]Jacqueline Mallinson, "What Have Been the Major Emphases in Research in Elementary Science During the Past Five Years?" Science Education, XL (April, 1956), 206-08.

to criticizing the type of science course offered, she also indicated that the amount of science required for graduation and certification was quite small.

Bryant,[58] in a study of required science courses in programs for the preparation of elementary teachers in 225 institutions belonging to the American Association of Colleges of Teacher Education, supports the allegation that the amount of science required is small compared to the amount frequently cited as minimal for teacher competency in science teaching. The mean value reported for all elementary education programs was 17.7 quarter hours of required science, which commonly consisted of survey courses in the biological and physical sciences and a methods course in elementary school science. In addition to the small number of credits required and the survey nature of the courses, this study reports that three quarters of the instructors involved in teaching the courses had no experience in teaching children.

While Bryant's study covered the period of July, 1957 through July, 1959, hence might be somewhat out of date, a more recent study conducted by Verrill[59] found

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[58]Paul Payne Bryant, "Science Understandings Considered Important for Children and the Science Required of Elementary Teachers," Research in the Teaching of Science (Washington, D.C.: U.S. Department of Health, Education and Welfare, 1962), p. 29.

[59]J. E. Verrill, "The Preparation of General Elementary Teachers to Teach Science: 1870 to the

that most of the science courses offered to preservice elementary teachers are general education courses often predicated on the assumption that competency has been gained through high school courses. This assumption of previous competency in itself is not valid, for as Pella[60] reports in a 1967 survey of high school graduates, most have had a course in biology but only 10 per cent have had a course in physics and less than 20 per cent have had a course in chemistry. All too often, the prospective teacher is not included in either the chemistry or physics percentages.

In a subsequent historical analysis, Verrill[61] concluded that elementary teachers have been poorly prepared to teach science through the entire period of 1870 to 1959. Supporting this point of view, Lammers,[62] in a 1949 study based on interviews with 100 teachers in the first six grades of selected schools in Massachussetts, reports that the preservice science preparation was

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Present," Research the Teaching of Science (Washington, D.C.: U.S. Department of Health, Education and Welfare, 1965), pp. 126-27.

[60]Milton O. Pella, "Scientific Literacy and the High School Curriculum," School Science and Mathematics, LXVII (April, 1967), 346-56.

[61]Verrill, "Preparation of General Elementary Teachers."

[62]Theresa J. Lammers, "One Hundred Interviews With Elementary School Teachers Concerning Science Education," Science Education, III (September, 1965), 177-97.

concentrated in biology and nature study. While a considerable amount of in-service training was provided, very little was found to be in science content. In addition, 16 per cent reported no further interest in the continued study of science, and those who did want to pursue further formal study indicated an interest in astronomy as their first choice. Almost predictably chemistry and physics ranked as the lowest of the choices. Thus, with most teachers having survey courses as the major portion of their college science preparation based upon a high school science education program in the biological sciences, little interest was evident in developing further competency in the basic physical sciences.

In two surveys conducted in the mid-nineteen sixties, Blackwood[63] and Victor[64] used questionnaires to assess impediments to elementary science instruction as perceived by school system personnel. Victor's study, restricted to 160 elementary teachers in a particular Illinois city of 25,000 population, reported two reasons for reluctance to teach science as (a) lack of

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[63]Paul E. Blackwood, "Science Teaching in the Elementary School: A Survey of Practices," Journal of Research in Science Teaching, III (September, 1965), 177-97.

[64]Edward Victor, "Why Are Our Elementary Teachers Reluctant to Teach Science?" (Washington, D.C.: U.S. Office of Education, 1965), pp. 16-17.

familiarity with the subject matter and the materials, and (b) the dislike of the uneasy feeling when asked questions which they could not answer. The more extensive study conducted by Blackwood asked for a rank ordering of thirteen items considered as barriers to effective elementary science instruction. Although the data is reported in various tables reflecting variables such as the school population, in general the restrictions related mainly to lack of consultant services, inadequate supplies, and facilities and, in fifth position ranked teachers inadequate in subject matter background.

The preceding studies referred to under the rubris of Perceptions of the Problem: Inadequate Subject Matter Background indicate that the major source of difficulty in implementing elementary science instruction is related to inadequate preparation in the concept and principles of science. Within these studies, however, is a reference to a problem of attitudes. It is not sufficient to lay complete responsibility for the inadequacies of elementary science programs on inadequate content knowledge. The subsequent part of this section relates to this attitudinal problem.

Perceptions of the Problem: Teachers' Attitudes

In speaking to the problem of teachers' attitudes toward science and the teaching of science in the elementary school, Kuslan and Stone write:

> It really matters little what science educators say or think about the nature of science in the elementary school or how this science is best taught. Science teaching, no matter how well grounded, will not become a part of the elementary school curriculum unless elementary school teachers are convinced that they can be successful science teachers. This is certainly the case if the kind of science is process centered, founded on a different conception of the nature of science and of the child's learning capacity.[65]

Just what different authors precisely mean when they speak of attitudes is difficult to say. Pickering, in presenting a review of the literature relative to attitudes in teacher education, identifies the following common characteristics which he detects in the various usages:

1. Attitudes are learned rather than being innate, they have specific social referents and are relatively stable and enduring.
2. Attitudes vary in quality and the intensity on a continuum from positive through neutral to negative, and they possess varying degrees of interrelatedness to each other.
3. Attitudes are based on evaluative concepts regarding characteristics of the referent object, and give rise to motivated behavior.[66]

The implications these characteristics of attitudes have for the preservice education of teachers are reflected by Soy, when she states, "Attitudes underlie behavior in

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[65]Kuslan and Stone, Teaching Children Science.

[66]Robert Pickering, "An Experimental Study of the Effects of Inquiry Experiences on the Attitudes and Competencies of Prospective Elementary Teachers in the Area of Science" (unpublished Doctoral Dissertation, College of Education, Michigan State University, East Lansing, 1970).

such a fundamental way . . . it is necessary to understand attitudes if we are to understand behavior."[67] Since the major goal of teacher education is to affect behavior changes in the classroom, teacher educators must come to grips with the problem of developing positive attitudes toward both teaching science in the elementary school as well as toward student centered approaches to that teaching if the newly developed science curricula are to be widely implemented.

When considering the role of the teacher in inquiry oriented science activities, Staley reports,

> . . . it was possible to find literature which indicated specific types of attitudes teachers should possess to be effective elementary school teacher of inquiry. These were positive attitudes towards:
> 1. Science
> 2. Teaching
> 3. Teaching elementary school science
> 4. Involvement of students in learning activities.[68]

In considering the effects that attitudes play in including science as an integral part of the elementary school curriculum, Todd concluded that the attitudes

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[67]Eloise M. Soy, "Attitudes of Prospective Elementary Teachers Towards Science as a Field of Specialty," School Science and Mathematics, LXVII (June, 1967), 507-17.

[68]Frederick A. Staley, "A Comparison Study of the Effects of Pre-Service Teachers Presenting One or Two Micro-Teaching Lessons to Different Sized Groups of Peers on Selected Teaching Behaviors and Attitudes in an Elementary Science Methods Course" (unpublished Doctoral Dissertation, College of Education, Michigan State University, East Lansing, 1970), p. 58.

displayed by women teachers toward science played a significant role. Bixler,[69] in investigating the relationship between teacher's attitudes and the attitudes and information of their students, indicated that teachers with positive attitudes effected a positive change in both the achievement and the attitude test scores of their pupils. In general, however, there is inconclusive research in regards to the relationship between teachers' attitudes and the achievement of his students in the cognitive domain. On the other hand, there seems to be more agreement that there is a relationship between teacher attitudes and the attitudes which the students develop. This conclusion is supported by the previously cited study by Bixler as well as those of Blackwood, Wick, and Yager.[70] In addition to these studies in science education there is research related to general attitudes as well as specific attitudes toward mathematics or arithmetic which support the feeling that teachers to have a determinable influence upon student development in areas other than academic.

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[69]James Bixler, "The Effect of Teacher Attitude on Elementary Children's Science Information and Science Attitudes" (unpublished Doctoral Dissertation, Palo Alto, Stanford University, 1957), p. 138.

[70]Wick and Yager, "Some Aspects of the Student's Attitude in Science Courses," _School Science and Mathematics,_ LXVI (March, 1966), 267-73.

In an attempt to create some order in the area of terminology related to what is commonly referred to as attitudes, Krathwohl, Bloom, and Masia developed an effective domain taxonomy. Attitudes (and values) are presented as portions of a continuum representing the entire affective domain--the area of educational objectives which emphasize feeling, tone, an emotion or a degree of acceptance or rejection. The continuum is described by the process of internalization, which is defined as incorporating something within the mind or body; adopting as one's own the ideas, practices, standards, or values of another person or of society. Five areas are represented on the continuum: receiving, responding, valuing, organization, and characterization by a value complex.

It is interesting to note that, while this taxonomy has enjoyed wide acceptance and acclaim in education, no specific applications were found in the literature relating it to the preservice education of elementary teachers in science. If, as has been indicated by studies referred to previously, the lack of positive attitudes toward science constitutes a serious problem in developing effective elementary science instruction, more attention to this area seems warranted. This emphasis may require beginning applications at the lowest of the taxonomical classifications, especially those of receiving and responding, if we are to have any effect on the teaching behavior of elementary teachers in presenting science lessons.

In summarizing what has been presented to this point, new elementary science programs have been developed which have in common an inquiry-student activity orientation. Elementary teachers are generally incapable of handling these new programs without in-service reinforcement due to factors of inadequate content background and/or poor attitudes toward science and the teaching of science. The traditional role of the teacher as the director and ultimate source of knowledge is contradictory to the spirit of active investigation using concrete materials as the source of data. Part of the blame for inadequate preparation rests with teacher education institutions and the remainder of this chapter deals with those portions of the literature upon which the present study is based.

Studies Related to the Present Inquiry

The principle motivation for conducting this study is stated in a recent treatment of the preservice science education of elementary teachers: ". . . a teacher who fails to acquire excitement and the spirit of inquiry and relatedness from his own preparation in science is not likely to convey these qualities to his own students."[71] Elsewhere within this publication the role of the modelling effects previous modes of science instruction have upon the teachers own style are emphasized.

> The adage that 'we teach as we are taught' is not without foundation. If elementary teachers are to present science as an exciting exploration of the natural world where pupils have ample opportunity to interact with that world, to ask questions of nature as well as of people, and to discover that even young people can find order there, teachers too, must have such opportunities.[72]

> A recent study of science education for elementary school teachers revealed that many teachers described their programs with near unanimity as 'irrelevant,' 'uninspiring,' and often 'overwhelming.'[73]

If, as has been stated elsewhere in this literature review, one of the principle characteristics of the new elementary science programs is that of student involvement with concrete materials, then one of the principle goals of the elementary science methods course should be to educate teachers to use concrete materials placed in the hands of the learner when presenting science lessons. In addition, the elementary science methods course should develop positive attitudes toward science, teaching science, and the direct involvement of students in concrete, manipulative activities.

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[71] Herron, Preservice Science Education.

[72] Ibid.

[73] Ibid.

In developing the treatment and the design of the study, the work of Pickering played a principle role. In addition, studies done by Coulter, Anderson, Kellogg, Oshima and Litwiller are cited as precursors.

Oshima,[74] in 1966, examined the difference between lecture-demonstration and individual investigation methods with preservice elementary teachers in regard to attitudes toward science and student teaching behavior. No control group was included and both the instruments used and the conditions under which behavior were observed differed from those included in the present study. His findings indicated no significant changes in attitude toward science for either group. The major emphasis of his study was on achievement in science and confidence toward teaching science.

Kellogg,[75] in comparing laboratory-discovery methods with demonstration-discovery methods as related to the ability of preservice elementary teachers to analyze and interprete graphs, found that students assigned to the laboratory-discovery section indicated a strong preference for that approach.

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[74]Maurice Grant Kellogg, "The Effect of Laboratory-Discovery Methods and Demonstration-Discovery Methods Upon Elementary Science Students' Abilities to Analyze and Interpret Graphs," Dissertation Abstracts, 27:3345-A, No. 10, 1966.

[75]Eugene A. Oshima, "Changes in Attitudes Toward Science and Confidence in Teaching Science of Prospective Elementary Teachers," Dissertation Abstracts, 27:4157-A, No. 12, 1966.

Anderson,[76] dealing with a population of secondary science teachers and training in problem solving found that brainstorming, while not effecting any significant changes in problem solving abilities, resulted in improved attitude toward problem solving. He recommended that laboratory experiences, in particular, should be provided to help students develop skill in problem solving and confidence in that skill.

Litwiller,[77] in attempting to change the attitudes of preservice elementary teachers towards mathematics, used an enrichment program which featured problem-solving. She concluded that attitudes toward mathematics can be improved through instructional techniques, including problem-oriented enrichment.

Coulter,[78] compared the effects of inductive demonstration versus deductive laboratory techniques of instruction in biology for preservice elementary teachers upon attitudes. In comparing these techniques with a

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[76] Hans O. Anderson, "An Analysis of a Method for Improving Problem Solving Skills Possessed by College Students Preparing to Pursue Science Teaching as a Profession," Dissertation Abstracts, 27:3332-A, No. 10, 1966.

[77] Bonnie H. Litwiller, "Enrichment: A Method of Changing the Attitudes of Prospective Elementary Teachers Toward Mathematics," Dissertation Abstracts, 29:1808-A, No. 6, 1968.

[78] John C. Coulter, "The Effectiveness of Inductive Laboratory, Inductive Demonstration and Deductive Laboratory in Biology," Journal of Research in Science Teaching, VI (1966), 185-86.

traditional, deductive approach, no significant change in attitude resulted.

Pickering,[79] concluded that inquiry-laboratory work was more effective in developing positive attitudes in the area of science than was either the lecture or inquiry-demonstration technique. It was also concluded that the inquiry-laboratory technique was more effective in developing positive attitudes toward pupil centered instructional techniques than either of the other methods. In this study, the treatment was within the confines of a carefully developed sequence of inquiry processes; originating the problem, formulating the hypotheses, collecting relevant data, analyzing the data and drawing conclusions. The inquiry-laboratory section involved the instructor originating the problem, then the students following through on the remaining processes using laboratory work. The demonstration-inquiry section performed all of the processes with the instructor through a class discussion and the instructor performing experiments suggested by the students. The lecture group used only oral presentations from the instructor, with no manipulation of equipment, either by the instructor or by the students.

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[79] Pickering, "An Experimental Study."

The present study uses no structured pattern of processes, and places an emphasis upon the students identifying problems through manipulation of the equipment, in the "hands-on" group. Some objectives of the session were suggested on a guide sheet, but no emphasis was placed on completing those objectives. The lecture-demonstration group also allowed for student identification of problems, but only the instructor manipulated the equipment, in response to suggested manipulations made by the students. The instrument developed by Pickering for assessing attitudes toward selected techniques of science instruction, placing a student on a continuum from student-centered to teacher centered was modified and used in the present study.

Summary

The review of the literature related to the historical perspective of elementary science education indicates that much of what is considered appropriate today has developed over a long period of time. Much of what is presented as being new has been suggested before. Certain aspects of the present elementary science programs can be obviously directly traced to earlier precursors. For example: the emphasis on direct student involvement in the learning activities; an interdisciplinary approach to the science content organization; and the inclusion of the processes of science as well as the knowledge of science.

Of particular importance to this study was the indication that the apparent failure of many previous programs, as well as those of the present, can be traced to the insecurity felt by elementary teachers in the area of science content. This insecurity is complicated by an equally important teacher factor; a poor attitude toward science and the teaching of science.

In reviewing the characteristics of the present elementary science programs, it was found that many objectives have persisted from the 1920's and before. While the objectives have changed slightly, there has been a shift in teaching strategies from one in which the teacher was perceived as the source of knowledge to one in which the individual student's thinking skills and use of the processes of science are of central importance. The role of the student has shifted from that of the passive receptor of knowledge to that of an active participant in the learning process. The present programs emphasize the activities involved in learning rather than the activity of teaching. In this respect, the role of the teacher has shifted to that of facilitator of learning experiences.

Finally, there have been very few studies done relative to preservice education of elementary teachers in the area of science. This is particularly true when the effects of these preservice science experiences upon the attitudes of the elementary teacher are considered. While there are many articles expressing opinions concerning the nature of the preservice science experiences, as well as surveys of the kinds and number of courses taken by teachers in their undergraduate programs, few studies have contributed data related to the existant practices in these courses.

This reviewer concluded that much additional inquiry is needed in the area of preservice science education for elementary school teachers. If the "new" science curricula are to enjoy any large scale implementation, teachers with positive attitudes toward science and student-activity centered strategies must be provided in the classroom. Preservice education will, therefore, necessarily play an important role in meaningful curriculum improvement. It is with such a concern that the subsequent chapter on the design of the study is presented.

CHAPTER III

DESIGN AND IMPLEMENTATION OF THE STUDY

Overview

This investigation originated with the development and piloting of the instructional materials used in an experimental treatment group of preservice teacher candidates during the 1969-1970 academic year. The gathering of data and the implementation of the treatments were accomplished during the fall term of the 1970-1971 academic year. The purpose of the experimental phase was to determine the relative effects of manipulative science experiences during small group instruction as compared to non-manipulative, lecture-demonstration experiences. The effects were observed in terms of attitude changes toward science, teaching science, science in the elementary school, certain methods of teaching science and the use of certain strategies in presenting a peer-group mini-lesson.

The Population

The study was conducted with elementary and special education majors at Michigan State University, East Lansing, Michigan during the fall term of 1970. Eighty students participated in the inquiry, with forty-one in the group designated as the experimental treatment group and thirty-nine in the group designated as the alternative treatment or lecture-demonstration control group.

These students were junior and senior level students who had completed the basic college level courses comprising the initial forty-eight term credits required of all Michigan State students. This included twelve credits of instruction in Natural Science. In addition, the students were in various stages of completing the required courses in biological science and physical science, each of four credits. The students had completed both of the courses, Biological Science 202 and Physical Science 203, or had completed one and were enrolled in the other at the time of participating in the experiment. It was assumed that this difference in the student group did not constitute a relevant antecedent variable. In addition to the methods course in science, many of the students were completing four other methods courses and a course described as Common Elements. Taking these courses as a block, however, was not required in the same term, and all students were not taking the same courses. This was assumed to be inconsequential as a possible source of variation in the study.

Sample

The subjects involved in this study were eighty prospective elementary school teachers enrolled in two of the small group sections of the elementary science methods course, 325f, offered during the fall term of 1970. While it was not possible to constitute these small groups via a randomization procedure, there was no basis upon which the students were enrolled in the various sections, other than student designation at the time of registration. This procedure, however, did not allow the assumption of equality between the groups as would be allowed under a random assignment procedure. To permit the administration of the pretest to each of the two groups before any other contact had been made with the course or the instructor, both of the groups selected met on the same day of the week. The group designated as experimental treatment group was randomly assigned to the afternoon section and the morning group was then designated as the alternative treatment group.

Before the administration of the pretest, forty students were randomly selected from each of the groups. While the pretest was administered to all of the group members, designation of the subjects of the study was made to facilitate control over mortality. In this way, the threat mortality poses to the internal validity of the study could be controlled.

The Elementary Science Methods Course

The elementary science methods course, Teaching Science in the Elementary School, 325f, was a three term-credit course. The schedule of class meeting provided for a two hour lecture session which met once a week, with all students enrolled in the course expected to attend. The remaining one hour per week was scheduled for small group sessions, meeting at one of six times during the week. The size of these small group sections ranged from 35 to 52, with a total of 268 students enrolled in the six sections.

Nine lecture sessions were conducted during the ten week term, and covered such topics as the "new" elementary science curricula, psychological foundations of science teaching, the role of the teacher in the science lesson, outdoor education, inquiry oriented demonstration techniques and the use of everyday things in teaching science. In addition, regular assignments were made in a text. Since these experiences were designed for all students enrolled in the course, they were not considered as a source of variation in the study.

The small group sessions, which met one hour per week for nine weeks, were divided into two phases:

1. Sample materials from current elementary science programs and their application.
2. Peer-group mini-lesson presentations.

The first phase lasted five weeks with each small group participating in five sessions related to studying sample materials from current elementary curricula. It was within these sessions that the experimental and alternative treatments were administered.

In the treatment designated as experimental or auto-instructional the students were provided with guide sheets giving some background information concerning the activity available as well as the program from which it had been adapted. In addition, sufficient materials were prepared and made available so that each student could have a hands-on manipulative experience. In some cases specific objectives to be achieved during the session were provided; in others, the students were encouraged to identify questions or objectives of their own. Copies of the guide sheets may be found in Appendix C.

The lecture-demonstration alternative treatment was provided with similar guide sheets. The objectives specified were the same in each of the two groups. The controlled variation, however, lacked the hands-on manipulative experience provided for the experimental treatment group. In the lecture-demonstration treatment group, the students suggested activities and manipulations which might help in meeting the specified objectives, and the instructor performed the suggested manipulations. At no time were the subjects in the lecture-demonstration group themselves allowed to manipulate the equipment.

The second phase, involving the peer-group mini-lessons, was conducted during the remaining four weeks of the course. During these four sessions, each of the students was expected to present a science lesson. No restrictions were placed on the lessons, other than they would be stopped after five minutes. There were two purposes served by this experience. First, it was deemed a valuable educational experience and, secondly, it provided the opportunity for observing teaching behaviors relevant to this study. It was hypothesized that students holding a student centered perspective toward science teaching would place materials in the hands of the students during the mini-lesson and would encourage the students to explore the materials before initiating any formal teaching. Thus, two observable aspects of the mini-lesson were selected for observation: first, did the teacher present materials to the students? Secondly, were the students allowed to manipulate and explore the materials before any formal teaching was initiated? The observer's response to these two questions constituted the behavioral measures termed manipulative and exploratory used in this study.

Experimental Design

Of principle concern in the selection of an experimental design were threats to internal and external validity as described by Campbell and Stanley[1] and the necessity of using intact groups rather than random assignment to treatment groups. The latter consideration is existant due to the nature of the registration procedures used at Michigan State University. All students enrolled in the elementary science methods course, 325f, are required to enroll in the large-group lecture session as well as one of the six available small group sessions. Thus, the composition of the small group sections is determined by the student choice of section at the time of enrollment. There is no reason to believe that such a procedure introduces a bias into the group, but the design of the study and the data treatment procedures selected reflected and accounted for any non-equivalence between the two groups.

The design paradigm chosen was described by Campbell and Stanley as a quasi-experimental design and is termed, "The Non-equivalent Control Group Design."[2] The value of this design is reflected in the statement:

> In particular, it should be noted that the addition of even an unmatched or nonequivalent control group reduces greatly the equivocality of interpretation over what is obtained in Design 2, the One-Group

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[1]Donald Campbell and Julian C. Stanley, "Experimental and Quasiexperimental Designs for Research on Teaching," as found in Handbook of Research on Teaching, N. L. Gage, ed. (Chicago: Rand McNally & Co., 1963).

[2]*Ibid.*, pp. 217-20.

> Pre-test-Post-test Design. The more similar the experimental and control groups are in their recruitment, and the more this similarity is confirmed by scores on the pretest, the more effective this control becomes.[3]

The following is a symbolic representation of the experimental design using Campbell and Stanley notation:

$$\frac{O_1 \quad X \quad O_2 \quad O_3}{O_4 \quad Y \quad O_5 \quad O_6}$$

Where the symbols:

O_1 and O_4 represent the pretests administered to the two separate treatment groups

X and Y represent the auto-instructional and lecture demonstration treatments, respectively.

O_2 and O_5 represent the post-tests administered to the separate treatment groups

and O_3 and O_6 represent the observation of the teaching of the peer-group mini-lessons.

External and Internal Threats to Validity

In considering the threats to external and internal validity inherent in this design, as well as the positive attributes involved regarding exclusion of rival hypotheses, Campbell and Stanley indicate the "main

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[3] *Ibid.*, pp. 217-18.

effects of history, maturation, testing and instrumentation can be disregarded."[4] There is, however, the possibility of interaction between history, selection, and maturation which pose a threat to internal validity. In general, such interactions are quite unlikely, and the conditions of this study were judged unlikely to produce such interactive effects. Thus, the assumption was made that such interactive threats to internal validity would not operate.

In addition to these interactive effects, the problem of regression toward the mean as a threat to internal validity was not considered to operate in this study since there was no selection of samples based on extremes relative to some antecedent independent variable.

In summary of the threats to internal validity and their consideration in this study, Table 3.1 is presented.[5]

Campbell and Stanley categorize threats to external validity or representativeness into reactive or interaction effect of testing, interaction effects of experimental variable and selection biases, reactive effects of experimental arrangements and multiple treatment interferences.[6] The latter threat, multiple treatment interference, can be negated in this study since the same subjects do not receive multiple treatments.

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[5] <u>Ibid</u>., p. 210. [6] <u>Ibid</u>.

TABLE 3.1.--Sources of Threats to Internal Validity.

Source of Invalidity (Internal)	Accounted For By
History--the specific events occurring between the pre and post-test in addition to the experimental variable.	Design
Maturation--time related processes internal to subject.	Design
Testing--the effects of taking a test upon the post-test scores.	Design
Instrumentation--changes in scoring procedures, observers or calibration of instrument.	Design
Statistical regression--regression toward the mean when assignment to groups based upon extremes on some antecedent independent variable.	Assignment not made on such basis.
Mortality--effect of loss of subjects.	Use of only two groups and eighty subjects allowed ready follow up and retention.
Selection--bias introduced by differential selection.	No basis for differential selection.
Selection--maturation interaction.	Short duration of treatment and similarity of treatments lead to assumption that such interaction is not of importance in this study.

Interaction effects of the pretest and the treatment are most likely when the pretest, especially in the case of attitude studies, present highly unusual and strongly worded negative statements. The attitude instruments used in this study were not highly unusual, as they dealt with a teaching situation similar to that which the subjects expected to find themselves. In addition, the number of strongly worded negative statements was kept at a minimum. Therefore, it was assumed that there was no interaction of the pretest with the treatment.

In considering the interaction of selection and experimental variable, the quasi-experimental design using intact groups offers a distinct advantage over a true experimental design in which subjects are randomly assigned to treatment groups from some larger population. In using the intact groups, there was no labeling of groups as either experimental or control and the materials and objectives used were similar in each of the treatment groups. Thus, it was assumed that no interaction of the experimental variable and the selection process occurred.

The remaining threat to external validity is found in the possibility of a reactive arrangement effect. In this effect, highly unique physical or social arrangements are used in one of the treatments. This alone could suggest a rival hypothesis explaining any differences detected between the two treatment groups. Both of the groups involved in this study were taught by the same instructor, attended the small group sessions in the same room and instruction was centered upon identical topics of interest. The only variable identified as independent was that of placing the equipment in the hands of the students as contrasted with showing them the equipment in meeting the objectives of the session. Otherwise, the situation was common in either section and it was assumed that no reactive arrangement interaction effects were operating.

Instrumentation

The instruments used in this study may be described in two categories: pencil and paper measures and performance based measures. In reviewing the literature for instruments previously used in assessing preservice elementary teacher's attitudes related to science and the teaching of science, the studies of Pickering[7] and Staley[8] proved particularly appropriate and useful. Each of these studies used populations similar to the present group, but each used different instruments. The Pickering instrument was a Likert-type scale assessing attitudes toward different methods of teaching science while Staley used a form of the Semantic Differential to assess attitudes in the

[7]Pickering, "An Experimental Study."

[8]Staley, "Comparison Study in the Effects of Pre-Service Teachers."

evaluative dimension of the meaning space in regard to concepts associated with science and the teaching of science in the elementary school. The following two sections describe these paper and pencil instruments, first the Pickering instrument, then the Staley developed instrument using the Semantic Differential.

The Pickering-Likert Type Attitude Instrument: Attitudes Toward Different Methods of Teaching Science (See Appendix A)

A research of the literature revealed that there was no attitude instrument available for measuring attitudes toward different methods of teaching science prior to 1969. Robert Pickering, however, developed such an instrument in the process of completing a study similar to the present one. This instrument is a Likert-type scale containing forty items placed into four categories, each representative of a point on the hypothesized continuum of teaching strategies; teacher-centered through teacher-oriented and student-oriented to student-centered. There are ten items within each of the categories, half of them positive items and the other half negative items. These items were than randomized to give the completed forty item scale.

The validity of the instrument was determined through a procedure in which a group of fifty-four randomly selected elementary student teachers from the Oshkosh campus of Wisconsin State University completed the instrument and then the supervisors from the University adjudged the consistency of the expressed attitude with the classroom strategies employed while student teaching. Pickering reported that,

> . . . in general, student teachers who had indicated a preference for the teacher-centered approach or teacher-oriented approach tended to follow these procedures in the classroom. The same results were indicated for student teachers who had selected the pupil-oriented or pupil-centered approach.[9]

The internal consistency of the total scale was determined using a split-halves technique recommended by Cronbach.[10] The procedure used by Pickering involved the administration of the scale and the scoring in two parts. The subsequent computation of the correlation between the two half-tests indicated an internal consistency of 0.95. Pickering inferred from this that the negative items in the scale were highly correlated with their corresponding matched positive items.[11]

The total reliability of the instrument was determined through the use of a test-retest procedure. The test was administered to a group of elementary education majors during the first week of the pilot study

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[9]Pickering, "An Experimental Study," p. 102.

[10]Lee J. Cronbach, Essentials of Psychology Testing (New York: Harper and Row, 1960), p. 141.

[11]Pickering, "An Experimental Study," p. 102.

semester and then, using the same scale, retested at the end of the semester, sixteen weeks later. Using a computational procedure indicated by Cronbach, a coefficient of stability of 0.81 was indicated.[12]

The Semantic Differential Instrument (See Appendix B)

The primary source of information related to the topic of the semantic differential is found in the work of Osgood, Suci, and Tannenbaum.[13] The technique was developed to measure meanings an individual associates with concepts or concept phrases. Since attitudes toward the concepts Science, Science in the Elementary School, and Myself Teaching Science were of interest in this inquiry the semantic differential was chosen as an appropriate instrument. In addition, these were among the seven concepts phrases judged by Staley to be relevant in his studies dealing with the effects of peer-group microteaching experiences upon the attitudes of preservice elementary teacher.[14]

In constructing the instrument, the evaluative dimension of the meaning space was selected. As such,

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[12] Ibid., p. 103.

[13] C. E. Osgood, G. J. Suci, and P. H. Tannenbaum, The Measurement of Meaning (Urbana: University of Illinois Press, 1957).

[14] Staley, "Comparison Study of the Effects of Pre-Service Teachers," p. 127.

the scales used under each of the concept phrases consisted of bipolar pairs of words selected from a list of bipolar pairs judged significant in this dimension. The pairs of words selected were separated by a continuum represented by a line divided into seven equal intervals by sets of colons

word 1 ——|——|——|——|——|——|—— word 2

Since twenty bipolar pairs were used for each concept phrase, twenty continua, each with a word at each end, were placed vertically under the concept phrase. The same order of bipolar pairs was used for each concept phrase. To avoid central tendency invalidity, the scales directionality was randomized, thus, some scales had the positive word on the left while others had the positive word on the right.

The word pairs were described as bipolar since the two words have opposite meanings in the evaluative dimension of the meaning space. The center space on the continuum represents a neutral or "no" association response for the particular referent concept, while spaces to the left or right indicated a direction of meaning, either positive or negative. The distance from the center or neutral space is taken as a measure of the intensity of feeling toward the concept phrase.

The choice of the evaluative dimension of the meaning space as appropriate for use in the instrument is based in Osgood's statement:

> Most authorities agree that attitudes are learned and implicit--they are inferred states of the organism that are presumably acquired in much the same manner that other internal learned activity is acquired. Further, they are predispositions to respond, but are distinguished from other states of readiness in that they predispose toward an evaluative response. Thus, attitudes are referred to as 'tendencies of approach or avoidance' or as 'favorable or unfavorable' and so on. This notion is related to another shared view--that attitudes can be ascribed to some basic bipolar continuum with a neutral or zero reference point, implying that they have both direction and intensity and providing a basis for quantitative indexing of attitudes.[15]

Reliability and Validity of the Semantic Differential

The early work of Osgood included factor analysis studies in which reliability data for semantic differential instruments were gathered. In his procedure, Osgood used a test-retest procedure with one hundred subjects reacting to twenty concepts appearing twice in the instrument. Using these data, a reliability coefficient of 0.85 was computed.[16]

Tannenbaum used the same procedure and six of the evaluative scales and computed a test-retest reliability of from 0.87 to 0.93.[17] These results were substantiated when Tannenbaum used a Thurston scaling technique for the same concepts.

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[15] Osgood, Suci, and Tannenbaum, The Measurement of Meaning, p. 79.

[16] Ibid., p. 127.

[17] Ibid., p. 192.

Staley, using a procedure suggested by Hoyt[18] for the computation of the internal consistency reliability coefficients and the twenty bipolar word pairs used in this and his study, determined the following coefficients:

Concept Phrase	Reliability
1. Teaching in the elementary school	0.92
2. Science in the elementary school	0.95
3. Myself teaching science in the elementary school	0.94[19]

In selecting the concept phrases for use in this study, the data gathered by Staley suggested the use of the referents, Science in the Elementary School and Myself Teaching Science in the Elementary School. The third phrase used in this study, science, was an abbreviated form of Staley's phrase, Science in the Elementary School. Since this phrase was slightly different, the Hoyt procedure was used to determine an internal consistency reliability coefficient using the pre-test data on the semantic differential instrument using science as the referent concept. This procedure yielded a value of 0.89.

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[18] C. J. Hoyt, "Test Reliability Estimated by Analysis of Variance," Psychometrika, VI (1941), 153-60.

[19] Staley, "Comparison Study of the Effects of Pre-Service Teachers," p, 133.

The validity of the semantic differential is primarily argued from two points of view; face validity and comparison with social behavior. Osgood stated that, "The evaluative dimension of the semantic differential displays reasonable face validity as a measure of attitude."[20] Osgood supports this opinion with data showing a high degree of correlation between scores on evaluative dimension scores and both Guttman and Thurston scales.[21]

Walker used a laboratory analogue of social learning and determined the predictive validity of an evaluative semantic differential. While not completely verifying the usefulness of the evaluative semantic differential, there was partial confirmation.[22]

Kerlinger, in a discussion of the possible applications of the semantic differential in behavioral research states,

> Attitude learning and change studies might well have a sensitive and helpful companion in the Semantic Differential. If the Staats and Staats study is any criterion, it is a fairly good measure of attitude change. Indeed, Osgood believes that the Semantic Differential can be used as a generalized attitude

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[20]Osgood, Suci, and Tannenbaum, <u>The Measurement of Meaning</u>, p. 192.

[21]<u>Ibid.</u>, p. 193.

[22]Lawrence Walker, "A Concept Formation Analogue of Attitude Development," <u>Dissertation Abstracts</u>, 22:2482-2483, 1962.

> measure technique, provided that evaluative adjective pairs are used.[23]

Considering the stature that the work of Staats and Staats has in research on conditioning of attitudes, this seems to be a strong endorsement of the semantic differential.

Data Collection Procedures

The desirability of administering the pretest battery before the subjects involved in the study had any exposure to the course or the instructor made the use of the small group sections in this study advisable.

The first meeting of the sessions was used to administer the pretest battery and to gather demographic data deemed pertinent to this study. The students were asked to complete three by five index cards on which they included the data:

1. Grade level of teaching desired
2. High school science courses completed
3. University science courses completed

Next, the modified Pickering-Likert instrument, Attitudes toward different Methods of Teaching Science was administered. This was followed by the administration

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[23]Fred Nikerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart and Winston, Inc., 1965), p. 579.

of the three concept Semantic Differential instruments. The total administration time was forty minutes.

The administration of the pretest session was followed by five weeks of treatment sessions. At the close of the fifth treatment session, a schedule of peer-group micro teaching assignments was distributed. In addition, a brief description of the micro-teaching experience was given. No specific directions for micro-lessons were given, other than the lesson would be presented to five members of the class with the remaining members of the class acting as observers, no restriction was placed on topic or grade level selected, and that the lesson would be terminated after about five minutes.

At the beginning of the seventh session the post-test battery was administered. This included the same instruments as were administered during the first session. The administration time was twenty minutes, since no demographic data were required.

Hypotheses

The study was concerned with the testing of three multivariate hypotheses. In addition to the multivariate hypotheses, each of the dependent variables may be used to state a univariate hypothesis under the related multivariate hypothesis. It should be noted, however, that the statistical test employed using multivariate analysis of variance is designed to test the multivariate hypothesis directly. If significance is demonstrated for the multivariate F-ratio, then a form of post-hoc testing for the univariate hypothesis is provided using the step-down F-ratio related to each of the dependent variables within the multivariate test.

The following hypotheses are stated in null form. Both the univariate and multivariate hypotheses are stated.

Multivariate Hypothesis H_O 1.0
Treatment Effect

There will be no difference between the auto-instructional treatment group and the lecture demonstration group with respect to mean gain scores as measured by the modified Pickering-Likert instrument, Attitudes Toward Different Methods of Teaching Science, the three semantic differential scales and the micro-teaching behaviors designated as manipulative and exploratory.

Univariate Hypothesis 1.1

There will be no difference between the auto-instructional treatment group and the lecture demonstration group with respect to the mean gain scores as measured by the modified Pickering-Likert instrument, Attitudes Toward Certain Methods of Teaching Science.

Univariate Hypothesis 1.2

There will be no difference between the auto-instructional treatment group and the lecture-demonstration group with respect to the mean gain scores as measured by the semantic differential instrument using the referent concept, Science.

Univariate Hypothesis 1.3

There will be no difference between the auto-instructional treatment group and the lecture-demonstration group with respect to mean gain scores as measured by the semantic differential instrument using the referent concept, Myself teaching science in the elementary school.

Univariate Hypothesis 1.4

There will be no difference between the auto-instructional treatment group and the lecture-demonstration group with respect to mean gain scores as measured by the semantic differential instrument using the referent concept, Science in the elementary school.

Univariate Hypothesis 1.5

There will be no difference between the auto-instructional treatment group and the lecture-demonstration group with respect to the use of the micro-teaching behavior designated as, Manipulative.

Univariate Hypothesis 1.6

There will be no difference between the auto-instructional treatment group and the lecture-demonstration group with respect to the use of the micro-teaching behavior designated as, Exploratory.

Multivariate Hypothesis 2.0
Level of Teaching Interest

There will be no difference between those subjects designating an interest in teaching in grades designated as early elementary, K-3, and those subjects designating later elementary, grades 4 and above, with respect to mean gain scores as measured by the modified Pickering-Likert instrument, Attitudes Toward Different Methods of Teaching Science, the three semantic differential scales and the micro-teaching behaviors designated as manipulative and exploratory.

Univariate Hypothesis 2.1

There will be no difference between those subjects designating an interest in teaching early elementary grades and those designating later elementary grades with respect to the mean gain scores on the Modified Pickering-Likert Instrument, Attitudes Toward Different Methods of Teaching Science.

Univariate Hypothesis 2.2

There will be no difference between those subjects designating an interest in teaching early elementary grades and those designating later elementary grades with respect to mean gain scores on the semantic differential instrument using the referent concept, Science.

Univariate Hypothesis 2.3

There will be no difference between those subjects designating an interest in teaching early elementary grades and those designating later elementary grades with respect to mean gain scores on the semantic differential instrument using the referent concept, Myself teaching science in the elementary school.

Univariate Hypothesis 2.4

There will be no difference between those subjects designating an interest in teaching early elementary grades and those designating later elementary grades with respect to mean gain scores on the semantic differential instrument using the referent concept, Science in the elementary school.

Univariate Hypothesis 2.5

There will be no difference between those subjects designating an interest in teaching early elementary grades and those designating later elementary grades with respect to the micro-teaching behavior designated as, Manipulative.

Univariate Hypothesis 2.6

There will be no difference between those subjects designating an interest in teaching early elementary grades and those designating later elementary grades with respect to the micro-teaching behavior designated, Exploratory.

Multivariate Hypothesis 3.0
Interaction Effects

There will be no significant interaction between the levels of treatment and the levels of designated grade levels of teaching interest with respect to mean gain scores as measured by the modified Pickering-Likert instrument, Attitudes Toward Different Methods of Teaching Science, the three semantic differential scales and the micro-teaching behaviors designated as manipulative and exploratory.

Univariate Hypothesis 3.1

There will be no significant interaction between the levels of treatment and the levels of designated teaching interest with respect to mean gain scores as measured by the modified Pickering-Likert instrument, Attitudes Toward Different Methods of Teaching Science.

Univariate Hypothesis 3.2

There will be no significant interaction between the levels of treatment and the levels of designated grade levels of teaching interest with respect to mean gain scores on the semantic differential instrument using the concept referent, Science.

Univariate Hypothesis 3.3

There will be no significant interaction between the levels of treatment and the levels of designated grade levels of teaching interest with respect to mean gain scores on the semantic differential instrument using the referent concept, Myself teaching science in the elementary school.

Univariate Hypothesis 3.4

There will be no significant interaction between the levels of treatment and the levels of designated grade levels of teaching interest with respect to mean gain scores on the semantic differential instrument using the referent concept, Science in the elementary school.

Univariate Hypothesis 3.5

There will be no significant interaction between the levels of treatment and the levels of designated grade levels of teaching interest with respect to the micro-teaching behavior designated as Manipulative.

Univariate Hypothesis 3.6

There will be no significant interaction between the levels of treatment and the levels of designated grade levels of teaching interest with respect to the micro-teaching behavior designated as Exploratory.

Analysis of Data

Research specialists of the Office of Research Consultation of the College of Education, Michigan State University, assisted in the selection of appropriate statistical procedures, computer programs, and in the preparation of parameter cards. They recommended a multivariate analysis of variance using the Finn[24] program. Since, gain scores were used from the pretest-postest data for the assessment of the change in attitudes it was deemed unnecessary to use a multivariate analysis of covariance. This technique, Multivariate Analysis of Variance, hereafter referred to as MANOVA, resulted from recent advances in computer science as well as

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[24] Jeremy D. Finn, Multivariate: Fortran Program for Univariate and Multivariate Analysis of Variance and Covariance (Buffalo, N.Y.: Department of Educational Psychology, State University of New York at Buffalo, May, 1967).

breakthroughs in theoretical statistics. Previous to the development of the MANOVA procedures, it was necessary to use an Analysis of Variance procedure when more than one dependent variable was present. The major difficulty in using the MANOVA procedure was the assumption that the dependent variables are independent of one another. The MANOVA technique is not robust with regard to this assumption and it is rare to find dependent variables which are truly independent of one another. Until recently, this problem has been "swept under the rug" because a more viable approach was not available.

In the application of the ANOVA procedure, an F ratio for each factor in the experimental design was computed and an F ratio was computed for each order interaction with the dependent variable under test.

The MANOVA procedure, using the computer program developed by Finn, yields two types of F ratios. One type is known as a multivariate F ratio and the other a univariate F ratio. The multivariate F ratio indicates whether or not all dependent variables are simultaneously statistically significant at a given alpha level for a given hypothesis under test. The univariate F ratios for each dependent variable associated with the hypothesis being tested indicates whether or not a given dependent variable is statistically significant at a given alpha level.[25]

In other words, the Finn program for MANOVA is a discriminatory analysis program in which all the dependent variables are analyzed at one time to determine what single derived value best reflects the difference between the two samples. The value derived from the analysis of variance is termed a discriminant function. It is assumed that the samples have multivariate normal distributions for the characteristics being considered with different means, but common variances.

In applying the univariate F ratio, four different alternative sets of statistical criteria have been developed. They are, Hotelling's true criterion procedure, Roy's largest root, Wilk's lambda procedure and the step-down F ratio. It was suggested by the consultant in the office of Research Consultation that the step-down F ratio procedure be used. Two aspects of the application and interpretation of the step-down F ratio should be considered.

First, the exact alpha level for each univariate hypothesis under test and its related step-down F ratio

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[25]Richard Darnell, "The Influence of Professional Role Identification Upon the Development of Interest in Horizontal Career Mobility by Nursing Students" (unpublished Doctoral Dissertation, East Lansing, Michigan State University, 1971).

is determined. This provides the probability of a Type 1 error as it exists adjusted for the effects of the other dependent variables. Since six dependent variables were involved in this study, the alpha level of the univariate F ratio is determined by dividing the alpha level selected for the multivariate F ratio, .05 in this case, by the total number of dependent variables used, six. Thus, $.05 \div 6 = 0.0083$. This suggests that the null hypothesis should fail to be rejected unless the value obtained for the step-down F ratio equals or exceeds the tabled F ratio value at alpha = .0083.

Summary

Eighty junior and senior level preservice elementary and special education teachers at Michigan State University were subjects in a study comparing two modes of instruction in the elementary science methods course. The experimental treatment designated as auto-instructional, used manipulative-exploratory experiences using materials adapted from current elementary science programs. The lecture-demonstration treatment group considered the same topics and materials, but at no time directly manipulated the materials. All manipulations in this group were performed by the instructor. The basis for comparison were mean gain scores on instruments designed to assess attitudes toward:

1. Different methods of teaching science, on a continuum ranging from teacher centered through student centered
2. Science
3. Teaching science in the elementary school
4. Science in the elementary school

In addition to the attitude measures listed above, a behavioral assessment was made during the presentation of peer-group micro-lessons. The observer noted whether or not the teacher provided:

1. Manipulative experiences, that is, were materials placed in the hands of the students?
2. Exploratory opportunities, that is, were the students allowed to explore the materials and identify questions of interest to him before the teacher initiated a formal lesson.

CHAPTER IV

ANALYSIS OF RESULTS

Sample

The subjects involved in this study are characterized by the data presented in Appendix D, along with the data collected relevant to the testing of the hypotheses of interests. Originally, forty students were randomly selected from each of the two groups involved in the study. One subject transferred from the lecture-demonstration treatment group to the auto-instructional treatment group following the administration of the pretest but before the initial treatment session. Thus, forty-one subjects appear in the auto-instructional treatment sample and thirty-nine in the lecture-demonstration treatment sample.

Table 4.1 is a description of the cell compositions as described by the two independent variables of interest, treatment and grade level of teaching interest.

Cell Means

Cell mean gain scores for each of the dependent variables within each of the cells created by crossing

TABLE 4.1.--Cell Compositions.

	Treatment 1	Treatment 2
Early Elementary	26	23
Later Elementary	15	16

Total N = 80

Early Elementary--those students who have specified an interest in teaching grades kindergarten through third grade.

Later Elementary--those students who have specified an interest in teaching grades four and above.

the levels of treatment with the levels of grade level of teaching are presented in Table 4.2.

The first hypothesis of interest in this study was concerned with the effect associated with the two different treatments; the experimental treatment designated auto-instructional or manipulative-exploratory and the alternative treatment, designated as lecture-demonstration. This hypothesis stated that there will be no difference between the two treatment groups with respect to mean gain scores on the four attitude instruments, and the two micro-teaching behaviors designated as manipulative and exploratory.

Multivariate analysis of variance indicated that the null hypothesis concerning treatment effect should be

TABLE 4.2--Cell Mean-Gain Scores.

Cell Code	Modified Pickering-Likert Instrument	S.D.A.	S.D.B.	S.D.C.	Manipulative	Exploratory
1	1.38846	5.73077	6.61538	5.30769	0.61538	0.26923
2	1.50667	3.00000	1.00000	-1.26667	0.60000	0.20000
3	2.02609	11.47826	5.73913	8.00000	0.69565	0.17391
4	1.95000	6.00000	2.75000	7.25000	0.56250	0.06250

Key:

Cell Code 1--Auto-instructional treatment crossed with early elementary (K-3) teaching interest.
Cell Code 2--Auto-instructional treatment crossed with later elementary (4 and up) teaching interest.
Cell Code 3--Lecture-demonstration treatment crossed with early elementary teaching interest.
Cell Code 4--Lecture-demonstration treatment crossed with later elementary teaching interest.
Modified Pickering-Likert Instrument--Likert type scale assessing attitudes toward pupil-centered through teacher centered approaches to teaching science.
S.D.A.--Semantic Differential using the referent concept, Science.
S.D.B.--Semantic Differential using the referent concept, Myself teaching science in the elementary school.
S.D.C.--Semantic Differential using the referent concept, Science in the elementary school.
Manipulative--A micro-teaching behavior in which the teacher places equipment in the hands of the student.
Exploratory--A micro-teaching behavior in which the teacher allows exploration with the equipment provided before initiating any teacher directed activities.

rejected at the .05 level of significance. The direction of the difference indicated the lecture-demonstration treatment produced more positive gains in the dependent variables than did the auto-instructional treatment. While the multivariate test indicated a significant difference at the .95 level of confidence, none of the univariate tests associated with the individual dependent variables were found to be significant at this same level. This indicated that the entire battery of instruments was necessary to descriminate between the two treatments. Data pertinent to the testing of the multivariate and univariate hypotheses related to treatment are presented in Table 4.3.

The second multivariate hypothesis of interest in this study was concerned with the effect introduced by stratifying the subjects according to the expressed grade level of teaching interest. This was dichotomized to place the subjects in one or the other of two categories; those specifying an interest in teaching in early elementary grades, kindergarten through third grade, and those specifying later elementary, grades four and above. The hypothesis stated that there will be no difference between those specifying one or the other of the grade levels of teaching interest with respect to mean gain scores on the four attitude instruments and the two microteaching behaviors designated as manipulative and exploratory.

TABLE 4.3.--Multivariate Test of Equality of Mean Vectors Associated With Treatment Effect.

F ratio for Multivariate Test of Equality of Mean Vectors Associated with Treatment Effects

F ratio for multivariate test of equality of mean vectors = 2.6362
D.F. = 6 and 71.00 p less than 0.0230
(Using alpha = .05, reject null hypothesis H_o1.0 since 0.0230 is less than .05)

Univariate Tests for Significance

Variable	Between Mean Square	Univariate F	p Less Than	Step-down F	p Less Than
Modified Pickering-Likert	6.3391	3.6816	0.0588	3.6816	0.0588
S.D.A.	404.5781	3.7239	0.0574	3.5529	0.0634
S.D.B.	0.0463	0.0001	0.9905	0.4151	0.5214
S.D.C.	458.5701	4.6323	0.0346	3.5142	0.0649
Manipulative	0.0195	0.0800	0.7781	0.0046	0.9464
Exploratory	0.2676	1.7295	0.1925	4.0040	0.0493

Degrees of Freedom for Hypothesis = 1
Degrees of Freedom for Error = 76

(At alpha = 0.0083 for each invariate test, or 0.05 + 6, each shows no significant difference since none of the p values is less than 0.0083)

Multivariate analysis of variance reveals that there is no difference, at the .05 level, between the levels of grades of teaching interest, thus the null hypothesis could not be rejected. Consequently, no significant differences would be shown by any of the univariate tests. Data relevant to the testing of this hypothesis are found in Table 4.4.

The third multivariate hypothesis of interest in this study was concerned with the possibility of interaction between the levels of treatment and the levels of specified grade level of teaching interest. The hypothesis stated that there would be no interaction between the two treatments and the two levels associated with grade level of teaching interests.

Multivariate analysis of variance revealed that there was no interaction between the treatment and the specified levels of teaching interest, at the .05 level of significance. Data relevant to the testing of this hypothesis of interaction are presented in Table 4.5.

Summary of Results

The following is a summary of the hypotheses tested and the results found. The hypotheses stated in this summary are in an abbreviated form. A complete summary of the hypotheses and the results are found in Chapter V.

TABLE 4.4.--Multivariate Test of Equality of Mean Vectors Associated With Grade Level of Teaching Interest.

F ratio for Multivariate Test of Equality of Mean Vectors for Main Effect Associated With Grade Level of Teaching Interest

F ratio for multivariate test of equality of mean vectors = 0.9492
D.F. = 6 and 71.00   p less than 0.4659
let $\alpha = .05$ since $.05 < .4659$, fail to reject null hypothesis H_o

Univariate Tests for Significance

Variable	Between Mean Square	Univariate F	p Less Than	Step-down F	p Less Than
Modified Pickering-Likert	0.0087	0.0051	0.9435	0.0051	0.9435
S.D.A.	318.3595	2.9303	0.0911	2.8901	0.0933
S.D.B.	351.5808	1.0821	0.3002	0.2334	0.6805
S.D.C.	255.7535	2.5835	0.1122	1.1946	0.2780
Manipulative	0.1038	0.4252	0.5164	0.9367	0.3364
Exploratory	0.1543	0.9973	0.3212	0.4967	0.4833

Degrees of Freedom for Hypothesis = 1
Degrees of Freedom for Error = 76

TABLE 4.5.--Multivariate Test of Equality of Mean Vectors Associated With Interaction.

F ratio for the Multivariate Test of Equality of Mean Vectors Associated With Interaction

F ratio for multivariate test of equality of mean vectors = 0.5141
D.F. = 6 and 71.00 p less than 0.7958
let $\alpha = .05$ since $0.7958 > .05$, fail to reject null hypothesis H_{o_3}

Univariate Tests for Significance

Variable	Between Mean Square	Univariate F	p Less Than	Step-down F	p Less Than
Modified Pickering-Likert	0.1788	0.1039	0.7482	0.1039	0.7482
S.D.A.	35.7578	0.3291	0.5679	0.3269	0.5693
S.D.B.	36.6717	0.1011	0.7514	0.2810	0.5977
S.D.C.	160.6922	1.6233	0.2066	2.1185	0.1499
Manipulative	0.0657	0.2690	0.6056	0.3188	0.5741
Exploratory	0.0084	0.0545	0.8161	0.0001	0.9925

Degree of Freedom for Hypothesis = 1
Degree of Freedom for Error = 76

Hypothesis	Result
Multivariate Hypothesis $H_O1.0$	
There will be no difference between the two treatments when mean gain scores on the four attitude instruments and the use of the peer-group mini-lesson teaching behaviors are considered.	The null hypothesis was rejected at the 0.05 level of significance.
Univariate Hypothesis $H_O1.1$ Through $H_O1.6$	
The univariate hypotheses stating there will be no difference between the two treatments when mean gain scores on each of the attitude instruments are considered separately and the two mini-teaching behaviors are considered separately were tested since the related multivariate hypothesis showed significance.	Each univariate null hypothesis failed to be rejected at the 0.083 level.
Multivariate Hypothesis $H_O2.0$	
There will be no difference between those specifying an interest in teaching early elementary grades and those specifying later elementary grades when mean gain scores of the four attitude instruments and the use of the peer-group mini-teaching behaviors are considered.	The null hypothesis failed to be rejected at the 0.05 level.
Multivariate Hypothesis $H_O3.0$	
There will be no interaction between the levels of treatment and the levels of specified teaching grade level of interest.	The null hypothesis failed to be rejected at the 0.05 level.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to assess and compare the effects of two modes of instruction employed in the small group sessions of the elementary science methods course at Michigan State University during the fall term of 1970. The effects assessed and compared fell into two categories, attitudes and specified teaching behaviors.

Three semantic differential scales were utilized to measure the referent concepts, Science, Myself Teaching Science, and Science in the Elementary School. A Likert-type scale developed by Pickering was used to assess the subjects attitudes toward different methods of teaching science, ranging from pupil-centered through teacher-centered. Both the Semantic Differential scales and the Likert-type scale were administered on a pretest and post-test basis to provide gain scores for the testing of the hypotheses of interest in the study.

The specific peer-group mini-lesson teaching behaviors observed were termed manipulative and exploratory. More precisely, the teaching session was observed and two questions were answered:

1. Did the teacher place materials and/or equipment in the hands of the students?
2. Did the teacher allow free, undirected exploration with the materials and/or equipment before initiating any formal or teacher directed lesson?

The two treatments were administered to the separate groups once a week for a five week period. The auto-instructional treatment group was provided with guide sheets and materials, then encouraged to satisfy the objectives through direct manipulation of the equipment. The lecture-demonstration treatment group was provided with similar guide sheets and objectives, but no materials were provided to the students. Thus, there was no direct manipulation of the materials by the students during the course of the session, although the instructor manipulated the materials and equipment at the suggestion of members of the group for the purpose of gathering data.

The attitude instruments were administered as pre- and posttests at the first and sixth class sessions, respectively. Peer-group mini-lessons were presented during the sixth through ninth weeks of the term. During the science lesson presentation to fellow students, the specified teaching behaviors were observed and recorded.

The hypotheses were tested using multivariate analysis of variance. The CDC 3600 computer was used with the Finn program. All multivariate hypotheses were tested at the .05 level, while each of the univariate hypotheses were tested, where appropriate at a level = .05/6 = .0083, using step-down F ratios. The summary of findings described below outlines the pertinent results of the data analysis in this study.

Summary of the Results of Hypothesis Testing

Hypothesis	Result
Multivariate Hypothesis $H_O1.0$	
There will be no difference between the auto-instructional treatment group and the lecture-demonstration treatment group with respect to mean gain scores as measured by the modified Pickering-Likert instrument, Attitudes Toward Different Methods of Teaching Science, the three Semantic Differential scales using the referents, Science, Myself Teaching Science, and Science in the Elementary School and the two mini-teaching behaviors designated as manipulative and exploratory.	The null hypothesis was rejected at the .05 level on the basis of multivariate analysis of variance. The direction of the difference indicated that more positive attitude changes were associated with the lecture-demonstration treatment than with the auto-instructional treatment.
Univariate Hypothesis $H_O1.1$	
There will be no difference between the auto-instructional treatment group and the lecture-demonstration treatment group with respect	The null hypothesis was not rejected at the .083 level, thus it could be inferred that subjects treated through either of

to mean gain scores as measured by the modified Pickering-Likert instrument, Attitudes Toward Different Methods of Teaching Science.

the two methods displayed no difference in attitude change. In both cases, the direction of the change was towards a more positive attitude toward student-centered instruction.

Univariate Hypothesis $H_o1.2$

There will be no difference between the auto-instructional treatment group and the lecture-demonstration treatment group with respect to mean gain scores on the semantic differential instrument using the referent concept, Science.

The null hypothesis was not rejected at the .083 level, thus it could be inferred that the change in attitude toward the concept science was no different for either of the treatment groups. The direction of the change in each case was a more positive attitude toward science.

Univariate Hypothesis $H_o1.3$

There will be no difference between the auto-instructional group and the lecture-demonstration treatment group with respect to mean gain scores on the semantic differential instrument using the referent concept, Myself Teaching Science in the Elementary School.

The null hypothesis was not rejected at the .083 level thus it could be inferred that subjects treated through either of the two methods have the same change in attitude toward teaching science in the elementary school. The direction of the change indicated that the changes in both cases were towards a more positive attitude toward teaching science in the elementary school.

Univariate Hypothesis $H_o1.4$

There will be no difference between the auto-instructional treatment group and the lecture-demonstration treatment group with respect to mean gain scores on the

The null hypothesis was not rejected at the .083 level thus it could be inferred that the same change in attitude toward science in the elementary semantic differential instrument using the referent concept, <u>Science in the Elementary School</u>.

school developed with either treatment. The direction of change indicated that a more positive attitude toward science in the elementary school developed in both treatments. It is interesting to note that the later elementary interest group receiving the treatment designated as auto-instructional had a slight decrease in score on this instrument, suggesting a less positive attitude toward elementary school science after treatment.

<u>Univariate Hypothesis $H_O1.5$</u>

There will be no difference between the auto-instructional treatment group and the lecture-demonstration treatment group with respect to the use of the mini-teaching behavior designated as <u>manipulative</u>.

The null hypothesis was not rejected at the .083 level thus it could be inferred that subjects conducting peer-group mini-lessons used manipulative experiences in their lessons to the same extent, no matter what previous treatment they had received.

<u>Univariate Hypothesis $H_O1.6$</u>

There will be no difference between the auto-instructional treatment group and the lecture-demonstration treatment group with respect to the use of the peer-group mini-teaching behavior designated as <u>exploratory</u>.

The null hypothesis was not rejected at the .083 level.

<u>Multivariate Hypothesis $H_O2.0$</u>

There will be no difference between those subjects designating an interest in teaching early elementary grades, K-3, and

The null hypothesis was not rejected at the .05 level on the basis of multivariate analysis of variance.

those subjects designating an interest in teaching upper elementary grades, 4 and above, with respect to mean gain scores as measured by the modified Pickering-Likert Instrument, the three semantic differential scales using the referent concepts, Science, Myself Teaching Science, and Science in the Elementary School and the use of the two mini-teaching behaviors designated as manipulative and exploratory.

Univariate Hypotheses Related to Grade Level of Teaching Interest

The use of the univariate step-down F ratios is dependent upon the multivariate F ratio showing significance. Since the multivariate F ratio showed no difference based upon grade level of teaching interest, no univariate step-down F ratios will show significance. On this basis, it was concluded that all six univariate hypotheses relating the dependent variables to the independent variable, grade level of teaching interest, would not be rejected at the .083 level.

Multivariate Hypothesis $H_O3.0$

There will be no interaction between levels of treatment and the levels of designated grade levels of teaching interest with respect to mean gain scores as measured by the modified Pickering-Likert Instrument, Attitudes Toward Different Methods of Teaching Science, the three semantic differential instruments using the referent

The null hypothesis failed to be rejected at the .05 level on the basis of multivariate analysis of variance.

concepts, Science, Myself Teaching Science, and Science in the Elementary School, and the mini-teaching behaviors designated as manipulative and exploratory.

Univariate Hypotheses Related to Interaction Effects

The use of the multivariate analysis of variance technique again failed to indicate any interaction between the levels of the independent variables. This precludes the possibility of finding any interaction related to each of the dependent variables when considered separately under a univariate analysis of variance. Thus, it could be inferred that none of the null hypotheses relating each of the dependent variables separately to interaction effects would be rejected.

Summary of the Findings

1. A significant difference for treatment effect was found when all the dependent variables were considered simultaneously under multivariate analysis of variance. The direction of the difference indicated greater mean gain scores on the attitude instruments were achieved by the lecture-demonstration treatment group subjects than by the auto-instructional treatment group subjects.
2. When the six dependent variables used in this study were subjected to a univariate analysis

of variance to detect any difference related to treatment effect, no differences were shown. Thus, no differences in mean gain scores on any of the measures used for assessing attitudes toward science, teaching science, and science in the elementary school were found. In addition, there was no difference in attitude change toward different methods of teaching science or in the use of the two specified mini-teaching behaviors. It was necessary to employ the entire battery of instruments to demonstrate differences between the methods of small group instruction in the elementary science methods course.

3. No difference was found between those subjects specifying an interest in teaching children in the early elementary grades and those subjects specifying an interest in teaching children in the later elementary grades when the six dependent variables were considered simultaneously under multivariate analysis of variance. Consequently, none of the univariate hypotheses related to each of the dependent variables showed a difference related to the respondents specified grade level of teaching interest.

4. There was no interaction detected between the two levels of treatment and the two levels of grade level of teaching interest.

Conclusions

Based on the findings of this study, the following conclusions would seem to be justified:

1. The attitudes of preservice elementary teachers toward science can be improved through instruction in an elementary science methods course.
2. The attitudes of preservice elementary teachers toward teaching science can be improved through instruction in an elementary science methods course.
3. The attitudes of preservice elementary teachers toward the field of science in the elementary school can be improved through instruction in an elementary science methods course.
4. The attitudes of preservice elementary teachers toward student-centered methods of teaching science can be improved through instruction in an elementary science methods course.
5. When the group of attitudes identified above are considered simultaneously, a lecture-demonstration mode of small group instruction in the elementary science methods course

produced greater positive changes in attitudes than did the auto-instructional mode. The identifiable difference, however, does not extend to each of the attitude referents when the gain scores are considered separately.

Implications From the Study

Based on the data collected and the findings of this study, the following implications are presented for consideration:

1. Contemporary science programs are student and activity centered. It is essential to the successful implementation of these programs that students become directly involved in the manipulation of science materials and equipment. To the end that elementary teachers must develop positive attitudes toward such student and activity centered methods of science instruction, methods courses in elementary science must strive to produce such positive attitudes. Future developments in the conduct of such methods courses must place considerable emphasis upon the affective dimension of learning.
2. The effects of an elementary science methods course should not be limited in assessment to pencil-and-paper instruments. Behavioral

measures are necessary and informative. The peer-group mini-lesson sessions provides such opportunities for observing practiced behaviors and offers the opportunity to develop skills and techniques consistent with positive attitudes toward student and activity centered science instruction.

3. The use of lecture-demonstration techniques in providing instruction in the small group sessions of an elementary science methods course should not be viewed as inconsistent with the goal of developing positive attitudes toward science and the teaching of science.
4. Since both instructional modes employed in this study produced improved attitudes toward science and the teaching of science, the provision of both types of instruction in teacher preparation would seem advisable.

Recommendations for Future Investigations

Based on the findings, conclusions, and implications from this study the following recommendations would seem justified:

1. One of the basic assumptions of this study concerned the need for elementary teachers who hold positive attitudes toward science and the teaching of science. Surveys of current

practices in elementary science instruction in the classroom are needed to determine the validity of this assumption. In addition, the expectations held by supervisory personnel of the teachers science instruction should be assessed to determine whether elementary teachers are, in fact, expected to offer student and activity centered science instruction.

2. The experiences preservice elementary teachers have in a science methods course produce changes in attitudes toward science and the teaching of science. These attitude changes were measured over a short period of time. How permanent are these effects? Does retention decay rapidly after the completion of the science methods course treatment? Longitudinal and follow-up studies are needed to follow the subjects into their teaching careers and to determine the long term effects of the elementary science methods course treatments.
3. Both of the treatments administered in this study produced positive changes in attitudes toward science and the teaching of science. If the length of time either treatment is employed were extended, would the attitude

changes continue to become more positive or is there a point of diminishing return? A time-series study would seem in order to investigate this.

4. Both the treatments administered produced positive attitude changes toward science and the teaching of science. Is there some unique combination of the two treatments that will yield even greater positive changes in attitudes? The use of a multiple treatment design utilizing various treatment combinations would seem appropriate for such a study.

5. There is the possibility of interaction of the treatments administered and previous experiences in science gained by the individual subjects. Are there assessable characteristics which can be utilized to prescribe particular treatment modes to effect maximum possible positive attitude changes? Correlational studies are needed to identify possible characteristics and to generate hypotheses related to the interaction of these characteristics and the various modes of instruction utilized in the science methods course.

6. Development and validation of affective domain objectives for instruction in elementary science methods courses is necessary to provide direction for improving science instruction in the elementary school.

7. Recommendation 5 refers to the possibility of interaction between treatments and subject-specific characteristics. One area of particular concern is related to perceptions and expectations held by the students at the beginning of instruction. Research directed at identifying such perceptions and expectations is needed. Then results of such studies could be used to design inquiries into the interactions of these perceptions and expectations with various methods course instructional techniques.

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APPENDICES

APPENDIX A

PICKERING-LIKERT SCALE, ATTITUDES TOWARD DIFFERENT METHODS OF TEACHING SCIENCE

APPENDIX A

PICKERING-LIKERT SCALE, ATTITUDES TOWARD DIFFERENT METHODS OF TEACHING SCIENCE

Your response to the following items will permit us to determine what prospective elementary school teachers think of various techniques for teaching science. There are no right or wrong responses to the items in this booklet and the results will NOT BE USED IN ANY WAY FOR GRADING PURPOSES IN THIS COURSE.

Please indicate the degree to which you agree or disagree with each of the statements by responding on the separate answer sheet. Mark your response to each item in the following way:

1. Strongly agree
2. Agree
3. Undecided or neutral
4. Disagree
5. Strongly disagree

Thus, if you strongly agree with an item, darken the space under response 1 for that particular item.

Please respond to all of the items.

Please do not write on the item booklet.

1. Laboratory activities, which encourage all pupils to arrive at the same answer, are probably of little value in developing real scientific understandings.

2. If all teachers of elementary science were to subscribe to the notion that children should "find out things for themselves," we would have some poorly informed elementary pupils.

3. The teacher demonstration frequently accomplishes little more than to provide entertainment for the elementary science pupils.

4. The teacher of elementary science should consistently provide opportunities for children to apply their new ideas, and he should encourage divergent paths of thinking, followed by independent study or investigation.

5. Since children in the elementary school lack many of the skills necessary for laboratory work, the laboratory exercise is most effective when it provides specific directions for conducting experiments and obtaining appropriate results.

6. Teachers of elementary science should spend considerable time explaining scientific principles, which the pupils have difficulty in understanding.

7. The effectiveness of an elementary science program, which promotes the sequential development of simple to complex skills, is highly questionable.

8. In order to be meaningful, the elementary science curriculum should not be established by the pupils, but it should be structured by the teachers according to their own preconceived goals.

9. The value of the textbook, in providing the elementary pupil with basic scientific understandings is, at best, highly questionable.

10. Pupil response to teacher questioning seldom reveals whether the children have developed understandings of the scientific principles presented through teacher demonstration.

11. A good elementary science program should not downgrade the role of the teacher, thus encouraging the child to learn through trial and error.

12. Elementary science programs should de-emphasize the importance of scientific content and concentrate on the teacher guided development of the skills of investigation.

13. One of the most important functions of elementary science teachers, is providing children with the "right answers" to their questions.

14. A science program based on teacher guided activities, which are aimed at developing specific observable behaviors in the pupils, is most appropriate for the elementary school.

15. One of the biggest wastes of time, which can best be described as "busy work," is the practice of answering questions in the textbooks.

16. It is doubtful whether teacher questioning, designed to lead children to their own conclusions during a demonstration, would be an effective means of developing a good understanding of scientific principles on the elementary level.

17. Elementary teachers should base their science teaching on the philosophy that every time we tell a child something, we deprive him of the opportunity of learning it for himself.

18. Teacher demonstrations are very effective in developing scientific understanding when members of the class are allowed to plan and assist with the presentations.

19. Teacher demonstration is one of the most effective means of developing a good understanding of basic scientific principles.

20. It is questionable whether the elementary science program should provide class time for pupils to pursue areas of their own choosing, even when some guidance is provided by the teacher.

21. It is better to provide elementary pupils with situations where they can discover scientific principles for themselves, without interference from the teacher, than to systematically teach them the same principles.

22. Too frequently, teachers of elementary science waste valuable time explaining basic scientific principles, which could be learned more effectively through some other type of activity.

23. Elementary science teachers, who generally encourage pupils to study and investigate their own ideas independently, can usually look forward to classroom disorder where development of the more basic scientific understandings is often lacking.

24. Teacher assignment of science projects and reports is a valuable means of expanding pupil interest and understanding of basic scientific principles.

25. Development of scientific understandings is not promoted through laboratory activities which include specific directions for setting up the apparatus, experimental procedures to use, and questions to answer.

26. Good elementary science teachers seldom provide ready answers to pupils' questions.

27. The learning situation in the elementary science classroom should be determined by the purposes or goals set by the learner as a result of his prior investigations.

28. Teacher questioning with student response, following a teacher demonstration, is an excellent means of determining whether the children have developed a good understanding of the scientific principles being dealt with.

29. The technique of assigned readings, in the elementary science text, is an indispensible means of providing a good understanding of basic science principles.

30. The teacher of elementary science should be advised to, "leave the child alone. Let him make his own mistakes. Don't give him any answers right away. It is better to have him make mistakes than to be given the correct answers."

31. One of the most effective elementary science teaching techniques is the use of demonstrations, accompanied by teacher guided-student interactions which have been designed to lead pupils to their own solutions.

32. Answering the questions at the end of a reading assignment is still a good practice even though some of the "ivory tower" educators disapprove.

33. The involvement of pupils, through planning and assisting with teacher demonstrations, really adds very little to the total development of scientific understandings.

34. Placing children in positions where they can discover certain scientific principles, without any teacher guidance, is a rather idealistic method to use in the elementary science classroom.

35. Teachers of elementary science would do well to promote a program of guided project work in which the child explores his own areas of interest with minimal direction from the teacher.

36. Science projects or reports, when teacher assigned, are generally a waste of time in developing better understandings of the scientific principles being taught.

37. Science programs, which emphasize the development of specific pupil behaviors through teacher guided activities, should not be stressed at the elementary level.

38. Well structured laboratory exercises, designed to find answers to specific questions, are more effective and meaningful than those that encourage pupils to go in many different directions.

39. A good elementary science program will provide a step-by-step development of scientific skills, beginning with the very basic and leading to the more complex.

40. Teachers of elementary science, who spend most of their time systematically developing the child's problem solving skills, frequently fail to provide pupils with adequate science content.

APPENDIX B

SEMANTIC DIFFERENTIAL INSTRUMENT

APPENDIX B

SEMANTIC DIFFERENTIAL INSTRUMENT

THIS IS NOT A TEST AND WILL NOT BE
USED IN ANY WAY TO DETERMINE A
GRADE FOR THIS COURSE

INSTRUCTIONS

The purpose of this instrument is to measure the meanings of certain things to various people by having them judge them against a series of descriptive scales. In completing this instrument, please make your judgments on the basis of what these things mean to you. At the top of each page in this booklet you will find a different phrase to be judged and beneath it a set of scales. You are to rate the phrase on each of these scales in order.

Here is how you are to use these scales:

If you feel that the phrase at the top of the page is very closely related to one end of the scale, you should place your check-mark as follows:

fair__X__:_____:_____:_____:_____:_____:_____unfair

or

fair_____:_____:_____:_____:_____:_____:__X__unfair

If you feel that the phrase is quite closely related to one or the other end of the scale (but not extremely), you should place your check-mark as follows:

strong_____:__X__:_____:_____:_____:_____:_____weak

or

strong_____:_____:_____:_____:_____:__X__:_____weak

If the phrase seems only slightly related to one side as opposed to the other side (but is not really neutral), then you should check as follows:

active_____:_____:__X__:_____:_____:_____:_____passive

or

active_____:_____:_____:_____:__X__:_____:_____passive

The direction toward which you check, of course, depends upon which of the two ends of the scale seem most characteristic of the thing you're judging. If you consider the phrase to be neutral on the scale, both sides of the scale, equally associated with the phrase, or if the scale is completely irrelevant, unrelated to the phrase, then you should place your check-mark in the middle space:

safe_____:_____:_____:__X__:_____:_____:_____dangerous

IMPORTANT: (1) Place your check-marks in the middle of spaces, not on the boundries:

THIS NOT THIS

_____:_____:__X__:_____:_____X_____:_____

(2) Be sure you check every scale for every phase--do not omit any.

(3) Never put more than one check-mark on a single scale.

Sometimes you may feel as though you've had the same item before on the instrument. This will not be the case, so do not look back and forth through the items. Do not try to remember how you checked similar items earlier in the instrument. Make each item a separate and independent judgment. Work at fairly high speed through this test. Do not worry or puzzle over individual items. It is your first impressions, the immediate "feelings" about the items, that we want. On the other hand, please do not be careless, because we want your true impressions.

SCIENCE

pleasant_____:_____:_____:_____:_____:_____:_____unpleasant

bad_____:_____:_____:_____:_____:_____:_____good

negative_____:_____:_____:_____:_____:_____:_____positive

progressive_____:_____:_____:_____:_____:_____:_____traditional

interesting_____:_____:_____:_____:_____:_____:_____boring

successful_____:_____:_____:_____:_____:_____:_____unsuccessful

untimely_____:_____:_____:_____:_____:_____:_____timely

complete_____:_____:_____:_____:_____:_____:_____incomplete

unfair_____:_____:_____:_____:_____:_____:_____fair

meaningless_____:_____:_____:_____:_____:_____:_____meaningful

harmonious_____:_____:_____:_____:_____:_____:_____dissonant

wise_____:_____:_____:_____:_____:_____:_____foolish

permissive_____:_____:_____:_____:_____:_____:_____restrictive

pessimistic_____:_____:_____:_____:_____:_____:_____optimistic

reputable_____:_____:_____:_____:_____:_____:_____disreputable

worthless_____:_____:_____:_____:_____:_____:_____valuable

awful_____:_____:_____:_____:_____:_____:_____nice

important_____:_____:_____:_____:_____:_____:_____unimportant

painful_____:_____:_____:_____:_____:_____:_____pleasurable

dishonest_____:_____:_____:_____:_____:_____:_____honest

SCIENCE IN THE ELEMENTARY SCHOOL

pleasant_____:_____:_____:_____:_____:_____:_____unpleasant

bad_____:_____:_____:_____:_____:_____:_____good

negative_____:_____:_____:_____:_____:_____:_____positive

progressive_____:_____:_____:_____:_____:_____:_____traditional

interesting_____:_____:_____:_____:_____:_____:_____boring

successful_____:_____:_____:_____:_____:_____:_____unsuccessful

untimely_____:_____:_____:_____:_____:_____:_____timely

complete_____:_____:_____:_____:_____:_____:_____incomplete

unfair_____:_____:_____:_____:_____:_____:_____fair

meaningless_____:_____:_____:_____:_____:_____:_____meaningful

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pessimistic_____:_____:_____:_____:_____:_____:_____optimistic

reputable_____:_____:_____:_____:_____:_____:_____disreputable

worthless_____:_____:_____:_____:_____:_____:_____valuable

awful_____:_____:_____:_____:_____:_____:_____nice

important_____:_____:_____:_____:_____:_____:_____unimportant

painful_____:_____:_____:_____:_____:_____:_____pleasurable

dishonest_____:_____:_____:_____:_____:_____:_____honest

MYSELF TEACHING SCIENCE IN THE ELEMENTARY SCHOOL

pleasant_____:_____:_____:_____:_____:_____:_____unpleasant

bad_____:_____:_____:_____:_____:_____:_____good

negative_____:_____:_____:_____:_____:_____:_____positive

progressive_____:_____:_____:_____:_____:_____:_____traditional

interesting_____:_____:_____:_____:_____:_____:_____boring

successful_____:_____:_____:_____:_____:_____:_____unsuccessful

untimely_____:_____:_____:_____:_____:_____:_____timely

complete_____:_____:_____:_____:_____:_____:_____incomplete

unfair_____:_____:_____:_____:_____:_____:_____fair

meaningless_____:_____:_____:_____:_____:_____:_____meaningful

harmonious_____:_____:_____:_____:_____:_____:_____dissonant

wise_____:_____:_____:_____:_____:_____:_____foolish

permissive_____:_____:_____:_____:_____:_____:_____restrictive

pessimistic_____:_____:_____:_____:_____:_____:_____optimistic

reputable_____:_____:_____:_____:_____:_____:_____disreputable

worthless_____:_____:_____:_____:_____:_____:_____valuable

awful_____:_____:_____:_____:_____:_____:_____nice

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dishonest_____:_____:_____:_____:_____:_____:_____honest

APPENDIX C

SMALL GROUP SESSION GUIDE SHEETS

APPENDIX C

SMALL GROUP SESSION GUIDE SHEETS

325f Small Group, Session 1 — SCIS Material Objects, AAAS Action Words

The objectives for today's session are listed below. You are not expected to demonstrate mastery of each of the objectives at this time but may be expected to do so on future examinations. The general purpose of this session is to provide you the opportunity to gain first-hand experience with materials and activities suitable for science teaching in the early elementary grades. You are left on your own to complete the specific objectives stated below.

After completing Session I, the student should be able to:

1. Write objectives, suitable for the elementary school level, using the AAAS (American Association for the Advancement of Science) Action Words.
2. Write objectives for each of the eight SCIS (Science Curriculum Improvement Study) Material Objects activities presented in this session.
3. Identify the three major parts of the SCIS Unit, Material Objects.

4. Describe the role of the teacher in each of the activities presented as applied to an elementary classroom situation.
5. Construct and Demonstrate learning activities suitable for teaching the concepts listed as the main concepts in the SCIS unit, Material Objects.
6. Identify personal objectives set and/or achieved by you during the session.
7. Define each of the main concepts of the SCIS unit, Material Objects.

There are eight activities selected from the SCIS unit, Material Objects, available in the room today. Five minutes has been allocated for investigation of each activity. Take one of the activity sheets (copied from the SCIS Teachers Guide for Material Objects) when you get to it. You are encouraged to perform the activities suggested on the sheet to "sample the flavor" of the activity. Keep in mind the main concepts of this unit as you proceed and attempt to rationalize each activity as to how it contributes to the goals and objectives of the unit. You are invited to discuss your thoughts with others, including the instructors.

In addition to the eight activities selected by the instructor, the entire Materials Objects kit, along with complete teachers guides, is available for your inspection. Additional activities may be done as time permits.

325f Small Group, Session I — SCIS Material Objects
AAAS Action Words

The objectives for today's session are listed below. You are not expected to demonstrate mastery of each of the objectives at this time but may be expected to do so on future examinations. The general purpose of this session is to provide the opportunity to see and discuss activities suitable for science learning in the early elementary grades. You are left on your own to complete the specific objectives listed below.

After completing Session I, the student should be able to:

1. Write objectives, suitable for the early elementary school level, using the AAAS (American Association for the Advancement of Science) Action Words.
2. Write objectives for each of the eight SCIS (Science Curriculum Improvement Study) Material Objects Unit activities presented in this session.
3. Identify the three major parts of the SCIS unit, Material Objects.
4. Describe the role of the teacher in each of the activities presented as applied to an elementary classroom situation.

5. Construct and demonstrate learning activities suitable for teaching the concepts listed as the main concepts in the SCIS Unit, Material Objects.
6. Identify personal objectives set and/or achieved by you during this session.
7. Define each of the main concepts of the SCIS unit, Material Objects.

SCIS--Science Curriculum Improvement Study

Material Objects
Grade Level: Early Elementary

In the SCIS Program, the first year physical science unit is Material Objects while the first year biological science unit is Organisms. These units have certain common objectives: to sharpen children's powers of observation, descrimination, and accurate description. The objectives are accomplished as children care for aquatic plants and animals, raise seedlings, and investigate the properties of a broad range of nonliving solid specimens (metal, wood, plastic, snad, ice), liquids (water, oil), and gases (air, Freon). The units complement each other and can be taught effectively in either order.

In Material Objects, the concepts basic to the science program are introduced and used repeatedly:

object	serial ordering
property	change
material	evidence

This unit consists of twenty-one chapters or activities, divided into three parts:

Part One--Introducing Objects and Their Properties

Part Two--Introducing the Concept of Material

Part Three--Experimenting With Material Objects

The Objectives of Part One are:

To understand that the work object refers to a piece of matter.

To describe objects by their properties.

To identify objects present in the kit and the environment from given properties.

To sort objects into groups according to properties.

The Objectives for Part Two are:

To identify examples of solids, liquids, and gases as objects.

To identify some of the materials of which objects are made.

To realize that an object's form can change while its material remains the same.

To sort objects according to the materials of which they are made.

To distinguish between objects composed of one material and objects made of several materials.

To arrange collections of similar objects in serial order according to property.

The Objectives for Part Three are:

To experiment with various objects in order to observe changes in them.

To interpret differences in a set of pictures as changes occuring in a given object or objects over a period of time.

To keep written records of experiments with objects.

(Adapted from Material Objects Teacher's Guide, Science Curriculum Improvement Study, Rand McNally and Co., 1970).

There once was a teacher
Whose principal feature
Was hidden in quite an odd way.
Students by millions
or possibly zillions
Surrounded him all of the day.

When finally seen
By his scholarly dean
And asked how he managed the deed,
He lifted three fingers
And said, "All you swingers
Need only to follow my lead.

"To rise from a zero
To big campus hero,
To answer these questions you'll strive:
Where am I going
How shall I get there, and
How will I know I've arrived?"

Robert F. Mager, Developing Attitude Toward Learning (Palo Alto: Fearon Publishers, Inc., 1968), p. vii.

Gagné[1] has said, "content needs to be stated as objectives, and that these objectives mean things that the student is able to accomplish." If one analyzes the stated objectives of courses of study one finds that the resulting statements of what the student should be able to do on completion of the course will represent a description of the course which is topical. What is needed are objectives stated in terms of the expected and observable changes in the students behavior.

Mager[2] suggests that a useful objective identifies the performance expected, describes the conditions under which the learner will be expected to demonstrate his competency and specifies the minimum quality of performance that will be acceptable.

The following Action Words, used by AAAS in Science--A Process Approach, are suggested for use in writing behavioral objectives. It would be helpful to underline these words when used.

Action words: Definitions and examples

Identify--The individual selects a named or described object by pointing to it, touching it, or picking it up.

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[1] Gagné R. Tyler and M. Scriven, Perspectives of Curriculum Evaluation (Chicago: Rand McNally & Co., 1967).

[2] R. F. Mager, Preparing Instructional Objectives San Francisco: Fearon Publishers, 1962.

Example: When presented with a variety of geometric shapes the student is asked which are rectangles. The objective might be stated as: "When given a collection of cardboard geometric shapes the student will identify all which are rectangles."

Name--The individual specifies what an object, event or relationship is called.

Example: When presented with a collection of objects all belonging to the same class of objects, say triangles, the student is asked what the objects are called. "Given a collection of dissimilar triangles, the student will name the class of shapes, triangle, when asked what one would call each of these shapes.

Order--The individual arranges three or more objects or events in a sequence based on some stated property.

Example: When presented with a collection of cubes of different volumes, the student is asked to order the cubes from smallest to largest.

Describe--The individual states observable properties sufficient to identify an object, event, or relationship.

Example: When given an object and asked to describe it, the student responds. "The object is a cylinder. It is 6 centimeters in diameter and 10 centimeters long. The surface is red and smooth and harder than my fingernail.

Distinguish--The individual selects an object or event from two or more which might be confused. When asked to raise his left hand, the student raises his left hand which indicates he has distinguished the left hand from the right hand.

Construct--The individual makes a physical object, a drawing or a written or a verbal statement.

Demonstrate--The individual performs a sequence of operations necessary to carry out a specified instruction.

State a rule--The individual communicates verbally or in writing a relationship or principle that could be used to solve a problem or perform a task.

Apply a rule--The individual derives an answer to a problem by using a stated principle or relationship.

ACTIVITY 6 Grandma's Button Box

Objectives of the Learning Experiences

Sorts objects by size, shape, color, or other properties.

Groups objects according to different properties chosen by the teacher.

Teaching Materials

For each child:

a handful of approximately 30 assorted buttons
1 cardboard tray

Teaching Suggestions

Give each child a handful of buttons from the kit. After you and the class have discussed the properties of the buttons and their similarities and differences, suggest to the children that they sort their button collections by color. They should choose their own methods and number of groups. For example, some may make one pile of red buttons and another pile of all others; others may separate each individual color into a different pile; some may even separate by the shade of color. All these choices are correct and should be accepted. Encourage individual pupils to describe the ways in which they sorted their collections.

After you have completed the discussion of color sorting, ask the children to sort their buttons by a property other than color. The number of groups and the properties they use in sorting should again be left completely to the pupils. Offer suggestions only if a child seems very confused. When they have finished sorting in this way, ask a few children to describe the ways in which they sorted and let other children look at the groups being discussed. This activity can be carried out more than once, and you may also want to let the children return to it at a later date.

Another way of using the buttons is to have the children make specified numbers of groups, say, first one, then two, then three ... , on the basis of whatever properties they choose. Again, ask several children to tell you what properties they used to make their groupings.

NOTE: If a child has trouble sorting his collection of buttons, try giving him only eight or ten buttons to sort during another session. Let the children have access to the buttons so that interested individuals or groups can continue to sort them during free periods in the day, to improve their methods of sorting.

ACTIVITY 12 Sorting Wood

Objectives of the Learning Experiences

Identifies and sorts pieces of wood by property and kind.

Applies the concept of material to the task of sorting a collection of pieces of different woods.

Teaching Materials

For each child:

- 8 pieces of wood chosen by the child at random from a collection of 250 pieces of pine, oak, walnut, redwood, and balsa
- 1 cardboard tray
- 8 pieces of wood tape, 2 each of walnut, birch, pine, and oak

For demonstration purposes:

- 1 labeled display sample of woods (from Activity 9)
- 4 cardboard trays

Teaching Suggestions

Beforehand, distribute the 250 pieces of wood into four trays so that each tray has samples of the five different kinds of wood, and set out one cardboard tray for each child.

Each child should take eight pieces of wood from one of the trays. If children ask you how to select their objects, tell them to use any method they wish. When the children have returned to their desks, encourage them to use their magnifiers to examine the wood carefully. Tell them to look for ways in which the objects are alike or different from each other, and ask them to choose a method for sorting their pieces into groups. Have a few pupils tell how they sorted their collections. The children should observe various groupings and try to decide what sorting methods were used.

After this preliminary sorting has taken place, ask the children to decide how many different kinds of wood each of them has. Allow them time to discuss this; they should feel free to refer to the labeled display samples. Hold up each labeled sample of wood, identify it by name, and ask each child in the class to hold up one of his pieces of wood if he thinks it is of the same material as the one you are showing. Check the choices visually, and ask, if you wish, one or two questions of children who have made correct choices. These questions should be related to the observed properties, so as to help the children justify their decisions. Then urge all the children to examine their pieces again to determine whether they were correct in their selections.

Ask children to work in pairs, sorting their pooled pieces according to kinds of wood. Some pairs may have pieces that they feel do not belong in any group, and others may make errors in sorting their collections. It is better to allow an object to remain in a wrong group or an unsorted group if a child does not understand the reason for the correct placement; instructing him to move certain objects from one pile to another, if he does not see the reason for the change, may only confuse him.

If some children are very confused or if you feel they need more help, let them again sort a simpler collection of objects such as the buttons or colored blocks. When they show confidence and ability in sorting a simple collection, then you can let them have another try at the more complex situation of sorting wood. Children who quickly learn to sort wood can be encouraged to bring wood samples from home to add to the collection they are sorting. This will increase the complexity of the activity and challenge these children's interest and abilities.

Leave the wood pieces in a place where interested groups of children can use them in the same way as they used the metals.

Suggested Use of the Student Activity Pages

The children's responses to page 24 will help you decide whether they understand the purpose of the magnifier and how to use it. The question "What is your evidence?" should be used to develop a discussion which emphasizes the fact that in the magnified objects you can see more detail, such as the fine structure of the grain.

Use page 25 during class, while the children are sorting wood, as a means of making a record of the pieces of wood they sort, or afterwards as a way of evaluating whether the children can differentiate among the various kinds of wood pictured.

Page 26 is to be used as an evaluation activity. Give each child two pieces of each kind of wood tape, and tell the children to sort and glue all their pieces onto the page. You should review these pages alone before you discuss them with the class. Your analysis of their work should be helpful in deciding whether the children need additional experience in working with the pieces of wood. The birch is a "new" wood with which the children have not worked before. Their ability to categorize the birch by elimination will be an indication of their knowledge of the properties of different kinds of wood.

ACTIVITY 11 Sorting Metals

Objectives of the Learning Experiences

Identifies properties of a metal object.

Identifies similarities and differences among a variety of metallic specimens.

Sorts pieces of metal by kind.

Teaching Materials

For each child:

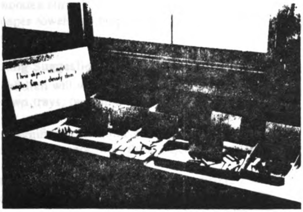
- 11 (approximately) pieces of different metals in sheet, wire, shot, foil, and other forms (include rectangular pieces of steel, lead, brass, and aluminum from Activity 8)
- 1 cardboard tray

For demonstration purposes:

- 8 cardboard trays
- 1 shoe rasp (from Activity 9)
- 1 labeled display sample of metals (from Activity 9)

Teaching Suggestions

Session A: Before class starts, place all the metals on four cardboard trays so that each tray has an assortment of the various pieces of metals. When the class starts, tell the children that they are going to study different kinds of metals. Call their attention to the labeled samples of brass, aluminum, steel, and lead. Give each child a cardboard tray and let him select any seven or eight metal pieces from the trays.



Tell the pupils to examine their objects carefully and suggest that they use their magnifiers. They may bend the wire and other pieces during this observation period. Suggest that they and their neighbors compare pieces. Scrape or file some pieces if the children ask you to test a piece in this way.

After the children have had time for observations, begin the discussion by asking a pupil to hold up a piece of metal and tell the class about its properties. Other class members then hold up a piece made of the same metal, if they have it. Some children will hold up different-shaped pieces of the same metal. Whether the kind of metal being held up is right or wrong, say, "Look around, children. Is everybody holding up a piece of . . . [name the metal]?" Let the children try to decide whether the pieces are the same metal; if there is unresolved disagreement, set the disputed pieces aside for a follow-up session.

Repeat this activity with other children, letting them describe the properties of other pieces. You might lead this discussion into a consideration of the similarities and differences among the pieces.

In conclusion, ask each child to sort his metals by some property of his own choice. Call upon some children to tell how they sorted their objects. All objects should then be returned to the trays.

Session B: In this follow-up session, give each team of four pupils an assortment of about thirty objects from the trays. Tell them to sort these objects by making a separate pile for each kind of metal. The labeled samples will again be useful for reference. Allow time for each group to move around the room to see how the other teams have sorted their objects. The children may think that some objects do not fit in any group. These may be placed in a separate pile.

To close the session, put out eight empty trays and ask the pupils to return their pieces of metal by sorting each kind of metal into a separate tray. Later, a committee of particularly interested children can go through the trays to find whether any different metals were placed in the same tray, or whether the contents of any two trays should be combined because they are alike. Finally, each tray can be labeled after its contents are compared with the sample set.

Use any metals considered unsortable during Session B to challenge a small group of particularly able students, who can try to sort these objects. Make up simpler collections for children who need further experience in sorting metals by material. A collection of only rectangular pieces would be the simplest possible.

Leave the metal pieces in an accessible place, so that small groups of interested pupils can work with them during free time.

ACTIVITY 25 Rock Candy and Lump Sugar

Objectives of the Learning Experiences

Recognizes that the material of an object may remain the same, even though the object's appearance changes.

Recognizes that two objects may appear to be different but are still made of the same material.

Background Information

Objects that appear different in form may be made of the same material; wood pieces, shavings, and dust may be made of the same kind of wood. In this activity, pieces of sugar will be ground into smaller and smaller pieces; though they change in appearance, they are still made of the same material.

Please note that the sugar cube, the granulated sugar, and the powdered sugar are all solids. Though at first it may seem inaccurate to call the powder a solid, of course you could not call it a liquid or a gas. Also note that the smaller pieces of sugar, even the tiny particles, are objects. This is another instance where parts of objects may be thought of as objects.

Teaching Materials

For each group of four children:

- 2 or more cubes of sugar
- 2 or more pieces of rock candy (approximately the size of a sugar cube)
- 2 cardboard trays
- 2 wooden stirrers
- 2 paper towels (to be provided by the teacher)
- 1 mortar and pestle

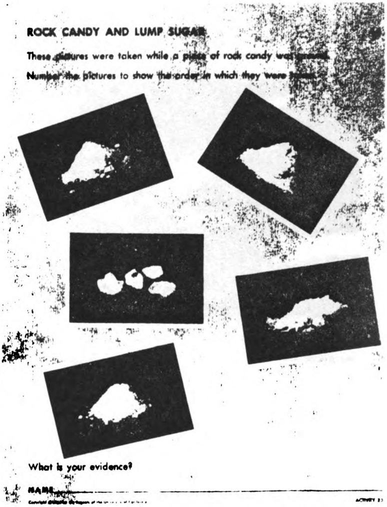
Teaching Suggestions

The children will work in teams of four. Give each team two trays, two cubes of sugar, and two pieces of rock candy, and suggest that the children use their magnifiers to examine both kinds of sugar. Ask the children to report how these objects appear alike and how they appear different.

Then give each team two wooden stirrers and a mortar and pestle. Tell the children to put one cube of sugar into the mortar and to break it into smaller pieces with the pestle. (If necessary, show them how to do this.) When the cube is broken into smaller pieces, the children should examine these objects and tell each other how the smaller pieces appear to be similar to and different from the sugar cube. Some of these small pieces should be placed on one of the cardboard trays. Then the team members can take turns grinding the rest of the small pieces of sugar into fine powder. With the wooden stirrer they can scrape the powder onto the same cardboard tray with the small pieces. The mortar and the pestle should be wiped with a *dry* paper towel to remove any powder that still remains. The team's second sugar cube is placed in the tray with the sugar powder and pieces of sugar.

Each team now goes through the same steps with the rock candy as they did with the sugar cube. Their examination, with magnifiers, of the rock candy as it is broken down is an important part of the experiment. The participation of each child in the grinding process is also important. Using the other stirrer, the children should put the powder and small pieces onto the other cardboard tray along with the second piece of rock candy.

To conclude the session, let each child examine the powder and small pieces on both trays by using a magnifier, by touching, and by rubbing the powder between his fingers. As the children describe the properties of the powdery materials, listen carefully



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ACTIVITY 29 Experimenting with Air

Objectives of the Learning Experiences

Recognizes that a sample of air may be considered an object.

Observes that air occupies space, takes the shape of the container, and is compressible.

Teaching Materials

For each child:
- 1 plastic 10 cc syringe
- 1 clear plastic bag

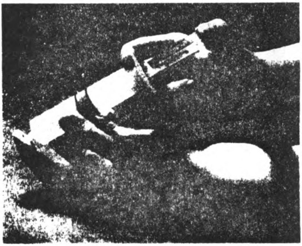
For demonstration purposes:
- 2 plastic 30 cc syringes
- 1 clear plastic bag

Teaching Suggestions

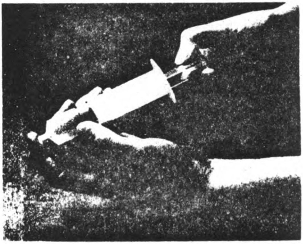
Tell the children to clear their desks. Hold up a flattened plastic bag and ask the children to describe this object. After the group has mentioned a few properties, give each child a plastic bag and tell him to put an object or objects inside. Tell him not to use objects from his desk. Some children will put hands or fingers into the bags, and you should accept these decisions. One or more of the children will probably trap air in the bag. Encourage the children to mention the properties of the objects they have put into their bags. Check to see if they are able (especially in the case of the air) to think of the objects as being separate from the bags. Trap some air in your bag and ask the children to do the same; then discuss the properties of the air in the bag. You or the children should mention the facts that the air is colorless ("see-through color," according to one first-grader), can be squeezed, and takes the shape of the bag. The properties of a bag filled with air should then be contrasted to the properties of another bag filled with solid objects. Either fill one demonstration bag with some solid objects or, if you feel the group is having trouble, give each child a few solid objects so that he can directly experience the contrast.

For the next part of this activity, give each child one 10 cc syringe. Encourage the children to explore possible uses of the syringes for a few minutes. The children may discover that the syringes can be used to trap and move samples of air. After the free activity, demonstrate the following two situations; then let the children explore each one:

(1) After pulling the plunger of the syringe out to the end of the barrel, place your finger tightly over the nozzle and try to push the plunger in. This should help emphasize the fact that there is a sample of air in the syringe and that, until you remove your finger from the nozzle and let the air out, it is very difficult to push the plunger in.



(2) After pushing the plunger all the way in, put your finger on the nozzle and try to pull the plunger out. This is hard to do, because the pressure of the air outside the plunger tends to push it back. This is a very complicated idea for first-graders, but the important point at this time is that they experience the difficulty in pulling the plunger out.



Suggested Use of the Student Activity Pages

The questions on page 57 can be used to begin another discussion about the properties of a sample of air. Have a plastic bag available for demonstration when you discuss this page.

On pages 58 and 59, the children are asked to indicate how moving the plunger affects the size of the balloon attached to the end of the syringe. After they complete these pages, look over their work to

ACTIVITY 17 Sorting Rocks

Objectives of the Learning Experiences

Sorts rocks by kind.

Sorts rocks by property when the properties are less well defined.

Recognizes some materials which make up rocks in an assortment.

Teaching Materials

For each child:

- 7 assorted rocks chosen by the child (from Activity 16)
- 1 cardboard tray

For demonstration purposes:

- 1 labeled display sample of rocks
- 15 cardboard trays

Teaching Suggestions

The children should choose rocks in the same way as in Activity 16. Start a discussion by asking a child to show one of his rocks and to tell the class about its properties. Follow up this discussion in ways you found productive when metals and woods were being compared. Similarities and differences can be pointed out, matching rocks can be held up, or another object-identification game can be played.

These rocks are especially suitable for study, because many of them are composed of more than one material. The children should closely examine the collection to see whether some appear to be made of only one material while others have parts made of several materials. You should encourage them to discuss their findings. If some children come to different conclusions, ask them to give their evidence. Explain that each of their specimens is considered to be one kind of rock, even though different materials may be combined in it.

In groups of four, children can combine their collections of seven rocks to form a new collection of twenty-eight rocks. It is helpful to do this experiment at large tables or at two desks pushed together to form a table. Each group should sort its rocks into piles, putting together all rocks that are of the same kind. Remind the children that they can refer to the labeled display samples which include the same kinds of rocks.

To close this activity, have fifteen empty trays available, and ask the pupils to return their sorted collections by putting each kind of rock into a separate tray. Perhaps the children will use all of the trays. A committee of particularly interested children can check the trays to see whether any different kinds of rocks were placed in the same tray, and whether the contents of any two trays should be combined because they are alike. After the contents of each tray are compared with the display sample, each tray can be labeled with the name of the rocks. Keep the rocks available in the room so that interested students can work with them during free time.

ACTIVITY 18 Observing Liquids

Objective of the Learning Experience
Describes properties of different liquid samples.

Teaching Materials
For each group of four children:

4 liquid samples in screw-top vials, 1 each of:
- water
- glycerin
- motor oil
- liquid starch

For each child:
- 1 sheet of plastic
- 1 cardboard tray

Teaching Suggestions
Give each team of four children a set of the four liquids in vials. (The children should not yet take off the caps.) After the children have manipulated the vials and observed the liquids for a while, ask them to describe some properties of the liquids and to make comparisons among the liquids. Encourage the children to name properties that other children or teams have not yet thought of. Ask teams to group their liquids by property; let the children describe their own team's grouping, and let other children question these groupings.

For the concluding experience of this activity, give each child a sheet of plastic, which should be placed in his cardboard tray. Tell the children to carefully pour a few drops of each of the four liquids in different places on the plastic in the trays. (The members of a team will be sharing the contents of their vials.) This will give the children an opportunity to feel and smell the liquids instead of merely looking at them. The children can use their fingers to spread the liquids around on the plastic sheets; they may also mix the liquids, if they wish. Discuss with the children the fact that each liquid is apparently made of only one material. When this activity is completed, the children should wash their hands and then walk around the room to observe other children's trays.

Most of the used plastic sheets can be thrown away, but you should set aside some trays which contain liquids that have not been mixed. These should be left uncovered someplace in the classroom

Photo by Fred Schmidt, Oklahoma

Mystery Powders
Adaped from ESS (Elementary Science Study) Webster Division McGraw-Hill Book Co.

The activities in Mystery Powders deal with the properties of ordinary white powders and the use of indicators in identifying them and in detecting their presence in mixtures.

Children are allowed to take home samples of the unnamed powders and are encouraged to identify them by tasting, smelling, feeling, and comparing them to known substances found in the home. (One should use tasting with great care, and, in my opinion only under carefully controlled conditions.) The emphasis in this stage should be upon observing properties rather than on getting the correct name.

Next, the children spend a few sessions playing or messing around with the powders in order to find out more about the properties. Additional tests are then made using heat, iodine solution and vinegar. After gathering as much information as possible using their senses and interactions with the additional substances, the children are then challenged to identify unlabeled samples of the original powders and them samples containing two powders mixed together.

This unit introduces the children to detailed examination of some chemical and physical properties of familiar substances and the use of analytical techniques. It also requires the use of recording and communication skills. It has been found particularly useful for introducing both students and teachers to investigatory science: science in which the student obtains answers to his own questions directly from the real world, rather than from some authority such as the text or the teacher. The unit requires no previous science experience and the materials are inexpensive and readily available. It has been used primarily in the third and fourth grade but is also suitable for older children.

Procedure

You will "proceed" by satisfying the following objectives:

1. Identify each of the mystery powders by name. Labeled (in their original packages) samples of each of the substances will be found on the gray cabinets on the door side of the room.
2. Describe each substance completely with regard to physical properties and interaction with other substances.
3. Identify the component substances found in a sample of mystery powder mixture.

The mystery powders and the mixtures are located on the front table in containers labled only with letters. The small paper cups are provided for obtaining samples of each powder for work at your table.

Use the wax paper and coffee stirrers for any mixing.

The Whirley Bird System, SCIS

The Science Curriculum Improvement Study is one of the "new" elementary science curricula developed under a grant from the National Science Foundation (NSF). In the section, General Background and Introduction, of the Teachers' Guide to Interaction, the following is stated:

> Today, more and more educators are beginning to believe that the young child should be given concrete experiences upon which he can begin to base abstractions. In the age range from 6 to 14, the child accumulates experiences and progresses through a gradual transition from thinking in concrete terms to thinking in abstract terms. During this developmental process the child must be provided with a conceptual framework that will enable him to integrate his experiences into a meaningful whole. Then, and only then, will the early learning form a base for the assimilation of experiences that come latter--experiences that may consist of direct observation or the reports of observations made by others.
>
> The Science Curriculum Improvement Study is attempting to produce a program which both guides the child's development in his experiences with natural phenomena and provides him with a conceptual framework in which to view these experiences.

The objectives for this activity are:

1. To identify functional subsystems of a simple mechanical system.
2. To contribute data for the construction of an histogram or bar graph.
3. To identify variables that may contribute to the outcome of an experiment with a simple mechanical system.
4. To determine the effect of changes in one variable of a simple mechanical system.

Investigations

Using the apparatus provided, satisfy each of the listed objectives and your own curiosity.

The Whirly Bird System, SCIS

Introduction, SCIS

The Science Curriculum Improvement Study is one of the "new" elementary science curricula developed under a grant from the National Science Foundation (NSF). In the section, General Background and Introduction, of the Teacher's Guide to Interaction, the following is stated:

> Today, more and more educators are beginning to believe that the young child should be given concrete experiences upon which he can begin to base abstractions. In the age range from 6 to 14 years, the child accumulates experiences and progresses through a gradual transition from thinking in concrete terms to thinking in abstract terms. During this developmental process the child must be provided with a conceptual framework that will enable him to integrate his experiences into a meaningful whole. Then, and only then, will the early learning form a base for the assimilation of experiences that come latter--experiences that may consist of direct observation or the reports of observations made by others.
>
> The Science Curriculum Improvement Study is attempting to produce a program which both guides the child's development in his experiences with natural phenomena and provides him with a framework in which to view these experiences.

Out of such a philosophy has developed many unusual units in a stimulating new program. The Science Math Teaching Center library has these materials for your inspection and Dr. Glenn Berkheimer of the staff is a regional coordinator for the project. One of the units is Systems and Subsystems. From this unit, Whirly Bird is a representative experience.

The objectives for this activity are as follows:

1. To identify functional subsystems of a simple mechanical system.
2. To contribute data for the construction of a histogram or bar graph.
3. To identify variables that may affect the outcome of an experiment with a simple mechanical system.
4. To determine the effect of changes in one variable of a simple mechanical system.

Controlling Variables

The following is adapted from The American Association for the Advancement of Sciences elementary science program, Science: A Process Approach, Commentary for Teachers, Xerox, 1970.

After completing this activity, the student should be able to:

1. Identify variables which may influence the behavior or the properties of a physical or biological system.
2. Identify variables which are manipulated, responding or held constant in an investigation or an experiment.
3. Distinguish between conditions which hold a given variable constant and conditions which do not hold a variable constant.
4. Construct a test to determine the effects of one or more variables on a responding variable.
5. Identify and name variables which are not held constant in a description of an investigation, although they are varied in the same way in all treatments or were randomized.

Using the cylinders provided and rolling them down the incline two at a time, you will be able to compare rolling times by pairs. Try a few pairs of cylinders.

Identify some of the variables which you think might have an effect on the rolling time for a cylinder. After identifying these variables, design and perform tests your hypotheses.

Are the variables which you have selected independent of one another?

Identify the manipulated and responding variable(s) in your tests.

Circuit Boards and the Process
of Inferring Colored
Solutions or Liquids

Circuit Boards and Inferring

Objectives:

1. Construct inferred wiring diagrams consistent with observations made on the circuit boards using a circuit tester composed of a dry cell, wires, socket, and bulb.
2. Construct and demonstrate procedures suitable for testing the inferred wiring diagrams, using the circuit tester and removing only one clip at a time.
3. Identify data which supports inferred wiring diagrams.
4. Distinguish between an observation and an inference.

An observation is an experience obtained through one of the senses. An inference is a proposed explanation of an observation.

A siren is heard. What are some inferences one could draw from this observation?

Procedure

Using the dry cell, wires, bulb, and socket construct a circuit in which the light bulb lights. Is this an open or a closed circuit?

Construct a circuit in such a way that two wires may be separated to make the light go out. What things can you place between the two wire ends which cause the light to light? We will use this set-up of dry cell, wires and bulb as a circuit tester. Whenever the two ends of wire are connected across a closed circuit or across an electrical conducter the light will light.

Place metal clips on each of the pairs of metal posts sticking out from the four terminal circuit board. When each (of the pairs) is connected we will call the two posts and the clip a terminal. Using your circuit tester, connect any two terminals and observe the bulb. With the knowledge that no more than two wires originate at any terminal (that is, only one wire is connected to each post underneath the cardboard) infer some wiring patterns or diagrams which could explain this observation. To test an inference which requires the electricity to flow through a particular terminal, one needs simply to remove the metal clip at that terminal since this will open the circuit by no longer connecting the two posts electrically.

Continue to make observations on the circuit board by connecting other terminal in a pairwise fashion and infer wiring patterns. Test these inferences by removing metal clips one at a time until you are satisfied that you have drawn the "correct" wiring diagram for the four terminal board. Repeat this procedure with the six terminal board.

Colored Solutions--Adapted From an Ess Unit

Objectives:

1. Sereal order the four colored liquids in terms of "upness" and "downness." That is, arrange them from upest to downest.
2. Operationally define upness and downess. You may find doing this easier if you observe CAREFULLY what happens to a drop of one liquid when it is placed in a vialfull of each of the others.
3. Using the upness-downess data, predict, then prepare all 2, 3, and 4 layer liquid sandwiches in a clear plastic straw.

APPENDIX D

DEMOGRAPHIC AND RAW DATA

APPENDIX D

DEMOGRAPHIC AND RAW DATA

The following table is constructed using the following coding system:

Treatment 1--Auto-instructional

Treatment 2--Lecture-Demonstration

Teaching Level 1--Early elementary grades, K-3.

Teaching Level 2--Later elementary grades, 4 and above

In all other categories, a 0 represents a course <u>not</u> taken while a 1 represents a course taken.

TABLE D.1.

Subject Identification #	Treatment	Teaching Level	High School Biology	High School Chemistry	High School Physics	Biological Science 202	Physical Science 203	Subject Identification #	Treatment	Teaching Level	High School Biology	High School Chemistry	High School Physics	Biological Science 202	Physical Science 203	Subject Identification #	Treatment	Teaching Level	High School Biology	High School Chemistry	High School Physics	Biological Science 202	Physical Science 202
01	1	1	1	1	1	1	0	28	1	2	1	1	0	0	0	55	2	2	1	1	0	1	1
02	1	2	1	1	0	1	1	29	1	1	1	0	0	1	1	56	2	1	1	1	0	1	0
03	1	1	1	1	0	1	1	30	1	2	1	0	0	1	1	57	2	1	1	0	0	1	1
04	1	1	1	1	1	1	1	31	1	2	1	0	0	1	1	58	2	1	1	0	0	1	1
05	1	1	1	0	0	0	0	32	1	1	1	0	0	1	0	59	2	1	1	1	0	1	1
06	1	1	1	0	0	1	0	33	1	1	1	0	0	1	1	60	2	2	1	0	1	1	1
07	1	2	1	1	0	1	0	34	1	2	1	1	1	1	1	61	2	1	1	1	0	1	1
08	1	1	1	1	0	1	1	35	1	1	1	1	0	1	0	62	2	1	1	1	0	1	1
09	1	2	1	0	0	1	1	36	1	1	1	0	0	1	1	63	2	2	1	1	1	0	0
10	1	1	1	1	0	1	1	37	1	2	1	1	1	1	1	64	2	2	1	1	1	0	0
11	1	1	0	0	0	1	1	38	1	1	1	1	0	1	1	65	2	1	1	1	1	1	1
12	1	2	1	1	0	1	1	39	1	1	1	0	0	1	1	66	2	1	1	0	1	0	1
13	1	2	1	0	0	1	1	40	1	1	1	1	1	0	0	67	2	2	1	1	0	1	1
14	1	1	1	1	1	1	0	41	1	1	1	0	0	1	1	68	2	2	1	0	0	1	1
15	1	1	1	1	0	1	1	42	2	2	1	1	1	1	1	69	2	1	1	1	0	1	1
16	1	2	1	1	0	1	1	43	2	1	1	1	0	1	1	70	2	1	1	1	1	0	0
17	1	2	1	1	0	0	1	44	2	1	1	0	0	1	1	71	2	1	0	1	1	1	1
18	1	2	1	1	0	1	1	45	2	1	1	0	0	1	1	72	2	2	1	1	0	1	1
19	1	2	1	1	0	1	1	46	2	1	0	0	0	1	1	73	2	1	1	1	0	1	1
20	1	1	1	1	1	1	1	47	2	1	1	1	0	1	1	74	2	1	1	1	1	1	0
21	1	1	1	1	0	1	1	48	2	2	1	1	1	0	0	75	2	2	0	1	1	1	0
22	1	1	1	1	0	1	1	49	2	2	1	1	0	1	0	76	2	1	1	1	0	1	1
23	1	1	1	1	0	1	1	50	2	1	1	0	0	1	1	77	2	1	1	1	0	1	0
24	1	1	1	1	0	1	0	51	2	1	1	0	0	0	1	78	2	2	1	1	0	1	1
25	1	1	1	1	0	1	1	52	2	2	1	1	0	1	1	79	2	2	1	1	1	1	1
26	1	1	1	1	0	1	1	53	2	2	1	1	1	1	1	80	2	1	1	1	0	1	0
27	1	2	1	1	0	1	1	54	2	2	1	0	0	1	1								

Data

This key applies to the following table:

ID	=	Subject Identifaction Number
T	=	Treatment 1 represents auto-instructional 2 represents lecture-demonstration
ATD	=	Attitude Toward Different Methods of Teaching Science (Modified Pickering-Likert)
SDA	=	Semantic differential using Science as referent concept
SDB	=	Semantic differential using Myself Teaching Science as referent concept
SDC	=	Semantic differential using Science in the Elementary School as referent concept
Pre	=	Pre-test score
Post	=	Post-test score
Man	=	Manipulative. A (1) indicates students given materials during mini-lesson. A (0) indicates no materials provided.
Exp.	=	Exploratory. A (1) indicates students allowed to explore materials freely. A (0) indicates no exploratory time allowed.

TABLE D.2.

T	L	ID	Pre ATD	Post ATD	Pre SDA	Pre SDB	Pre SDC	Post SDA	Post SDB	Post SDC	Man	Exp
1	1	01	.2	1.7	107	76	86	94	77	96	1	1
1	2	02	1.0	2.6	112	128	127	105	140	129	1	1
1	1	03	2.0	1.8	120	76	123	114	120	138	0	1
1	1	04	-.3	.8	118	114	111	117	89	106	0	0
1	1	05	-1.7	.1	117	131	137	132	139	139	1	1
1	1	06	-.8	.2	125	124	106	127	124	118	0	0
1	2	07	2.9	4.7	110	115	121	100	95	116	0	1
1	1	08	-.9	.7	99	99	97	107	104	97	0	1
1	2	09	.5	2.0	98	96	108	93	98	114	0	1
1	1	10	-.2	2.2	122	107	114	118	119	119	1	1
1	1	11	1.8	2.1	63	56	79	53	42	83	0	0
1	2	12	-.3	1.6	81	78	98	87	87	87	0	0
1	2	13	-.4	.5	78	74	86	76	88	77	0	1
1	1	14	-.6	3.7	128	120	121	135	113	123	1	1
1	1	15	2.0	3.4	106	122	127	134	134	130	1	1
1	2	16	-.2	3.1	109	130	107	99	115	99	0	0
1	2	17	.7	-.3	111	110	98	111	109	104	0	0
1	2	18	.7	2.6	117	118	120	130	124	135	1	1
1	2	19	.4	.9	102	115	128	121	112	126	0	1
1	1	20	1.1	2.9	99	89	91	115	117	119	0	0
1	1	21	.7	3.0	96	93	102	107	113	116	1	1
1	1	22	2.0	4.8	122	122	133	112	94	123	0	1
1	1	23	.3	1.9	114	102	93	122	86	86	0	1
1	1	24	1.3	1.9	118	128	135	124	123	134	0	0
1	1	25	1.6	2.4	120	113	121	125	132	129	0	0
1	1	26	-.1	1.2	111	85	110	105	102	110	0	1
1	2	27	1.8	3.2	94	111	105	99	100	103	0	0
1	2	28	2.2	3.9	88	103	102	104	109	107	0	1
1	1	29	1.6	1.9	126	85	121	122	133	118	0	0
1	2	30	.5	2.5	115	96	104	100	91	94	1	1
1	2	31	1.0	3.5	104	107	117	118	118	120	0	0
1	1	32	.2	.1	112	111	121	125	120	125	1	0
1	1	33	1.7	1.0	96	109	94	115	125	87	0	0
1	2	34	.6	1.8	110	101	121	137	135	137	0	0
1	1	35	1.2	3.0	102	111	113	128	136	136	1	0
1	1	36	1.4	1.0	96	103	101	103	104	102	0	0
1	2	37	.8	2.2	120	123	133	115	99	108	1	0
1	1	38	-1.6	2.9	105	91	103	117	123	126	0	0
1	1	39	1.4	1.8	98	106	110	102	97	109	1	0
1	1	40	1.8	3.3	111	99	92	119	98	103	1	1
1	1	41	-.4	2.0	119	111	123	122	111	125	1	0
2	2	42	.3	.2	115	96	134	124	94	136	0	0
2	1	43	-2.5	.8	102	72	121	106	80	126	1	0
2	1	44	1.3	2.4	101	95	105	119	121	118	0	0
2	1	45	.8	3.1	105	91	96	114	127	121	0	0

T	L	ID	Pre ATD	Post ATD	Pre SDA	Pre SDB	Pre SDC	Post SDA	Post SDB	Post SDC	Man	Exp
2	1	46	.0	1.8	111	106	103	119	118	120	1	0
2	1	47	1.4	4.4	109	123	111	117	104	116	1	0
2	2	48	-.1	2.5	122	124	126	119	128	131	1	0
2	2	49	.4	.9	130	116	134	130	92	125	0	0
2	1	50	1.4	2.4	92	96	103	100	102	114	1	0
2	1	51	-.5	2.5	84	123	93	89	126	115	1	0
2	2	52	.8	4.1	90	72	115	111	76	111	0	0
2	2	53	-.3	1.2	114	90	118	96	93	95	1	0
2	2	54	1.2	2.9	103	101	122	119	102	134	1	0
2	2	55	.8	2.4	118	120	107	110	112	112	1	1
2	1	56	2.1	2.4	96	103	97	115	99	84	1	0
2	1	57	-.1	.6	114	121	110	118	116	113	0	0
2	1	58	.0	3.7	93	90	111	103	91	126	0	0
2	1	59	-.9	3.1	69	59	77	77	74	94	1	0
2	2	60	1.2	2.0	116	104	118	120	117	125	1	0
2	1	61	1.0	3.9	113	128	129	127	129	119	0	0
2	1	62	.4	1.3	114	118	111	136	136	138	0	0
2	2	63	-1.2	2.7	108	76	93	109	106	107	1	0
2	2	64	-1.7	2.7	104	95	107	113	56	122	1	0
2	1	65	.2	2.8	103	90	106	116	103	113	1	1
2	1	66	1.5	2.2	105	116	124	114	113	125	1	0
2	2	67	2.0	1.2	100	104	111	100	78	107	1	0
2	2	68	-.4	.4	89	106	123	118	118	131	0	0
2	1	69	-.1	3.0	78	82	121	101	124	132	1	0
2	1	70	3.0	5.0	106	97	106	107	82	107	1	0
2	1	71	.3	1.7	123	107	132	114	99	122	1	0
2	2	72	2.5	4.1	110	107	112	112	125	122	0	0
2	1	73	2.6	2.8	82	78	97	100	98	109	1	0
2	1	74	1.3	4.6	106	68	113	125	30	115	1	1
2	2	75	1.3	4.9	105	93	124	120	131	140	0	0
2	1	76	.3	-1.2	94	98	109	114	119	118	0	0
2	1	77	.9	4.7	122	122	137	133	110	139	1	1
2	2	78	.8	2.6	116	91	121	126	115	138	1	0
2	1	79	.0	3.0	116	115	124	136	134	136	1	1
2	2	80	3.0	6.4	139	138	138	140	140	137	0	0