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PRACTICES IN THE PREPARATION OF ELEMENTARY
TEACHERS FOR THE TEACHING OF SCIENCE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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The Ohio State University
1965

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CHAPTER I

PHILOSOPHICAL ORIENTATION OF THE STUDY

AND STATEMENT OF THE PROBLEM

Statement of Philosophy

The objectives of an educational system derive from the beliefs and aspirations of the people it serves and the society of which these people are a part. If these concepts are borrowed from a previous generation and are inapplicable to contemporary conditions there is a danger that the schools will function ineffectively. If the concepts are ill-defined or logically inconsistent it follows that there might be confusion about the school's purpose.

Prior to the turn of the century, school curriculum reflected a philosophy of individualism. It was generally believed that provided with basic learning skills and rules of morality, the child could be turned out into the world to seek his place. The industrious person would succeed in proportion to his perseverance and ability, there being no limitations to an individual's accomplishment. Aside from paternalism to the poor, who served as examples of the consequence of sloth and misconduct, man owed little to society and expected little in return. The best government was considered the least government possible.

Such an ethic worked well, perhaps, in an agrarian, pre-technological society where there was room for every man to do as he pleased. With the rise of industrialization, urbanization, and booming
populations, however, it became apparent to educators that a reappraisal of the individual, of society, and of the relationship of man to society was in order. The hand of tradition weighs heavily on American education, however, and the evaluations of 1900 and subsequent years appear at times to have only begun to influence the conduct of practicing educators. Lee and Lee\(^1\) observe that only since 1930 have American educators come to realize the necessity of a careful evaluation of the functions of education with respect to society.

The philosophy upon which this study is based embraces concepts of Democracy as a way of life, and a belief in the importance of individual personality. Dewey expresses such a concept of Democracy:

Democracy...means voluntary choice, based on an intelligence that is the outcome of free association and communication with others. It means a way of living together in which mutual and free consultation rule instead of force, and in which cooperation instead of brutal competition is the law of life; a social order in which all the forces that make for friendship, beauty, and knowledge are cherished in order that each individual may become what he, and he alone is capable of becoming.\(^2\)

With respect to such attitudes toward the individual — his rights, potentialities, responsibilities and obligations — and toward an emerging democratic society, the elementary curriculum should be designed. The curriculum, moreover, should take into consideration


relevant knowledge concerning the nature of children, including the circumstances of life which affect them and how they learn.

Within this framework science can make an indispensable contribution to elementary education. Our scientific-technological society will continue to demand greater and greater numbers of persons with professional scientific background, but, as Craig observes, science instruction for children has greater purpose than preparing them for careers in science: "...Primarily the task involves education for all children for their own and society's benefit, and only secondarily involves concern for the welfare or future of science itself."³

The writer does not contend that science should have a preeminent role in childhood education, but that science education has potential such that it should occupy a strategic position along with other subject matter and skill areas.

The Problem

The potential of science in the elementary curriculum is such that it is incumbent on educators responsible for the education of future teachers to provide them with necessary knowledge, understanding and skill.

The purpose of this study was to discover what curricular arrangements and classroom practices are employed at various teacher-education institutions to meet these needs of elementary teachers.

The teacher-education program cannot stop short at providing excellent science courses, necessary as this is. The professional program must help the future teacher put science in proper perspective with respect to the total curriculum. In addition, the teacher should relate science education to principles of psychology, child-growth and development, and philosophy of education.

While descriptions of programs designed to provide for such needs appear from time to time in the literature, the writer felt the need for a systematic compilation and evaluation of practices employed at many institutions. Such a study would reveal strengths and weaknesses of existing programs which could be of benefit to science educators, including the author himself, involved in evaluating the science education programs at their institutions. The data received could also serve as a sourcebook of ideas for science educators in search of more meaningful activities to include in their science education or professionalized science courses.

Chapter II is a survey of literature relevant to elementary science education, which identifies a number of areas of need of elementary teachers. How this material was used in pursuit of the program is described in Chapter III. Chapter IV consists of a classification of practices reported by educators, summaries and discussion of these practices and a series of recommendations to science educators. Chapter V contains a summary and a number of conclusions drawn from this study of current practices.
CHAPTER II

THE NEEDS OF THE ELEMENTARY TEACHER

WITH RESPECT TO SCIENCE TEACHING

The Teacher's Need in Subject Matter Background

Science educators are virtually unanimous in recommending a substantial science background for elementary teachers. There is, however, some lack of confidence in existing college science courses. Briggs\(^1\) observes that colleges should offer general, liberal education science courses rather than courses which are preparatory for advanced studies. Joyce\(^2\) submits that college courses, often abstract in character, are seldom helpful to elementary teachers.

Attitude studies of elementary teachers indicate that educators should convince teachers that science consists of more than information. Victor\(^3\) found that 71.9 percent of the teachers he surveyed in Illinois feel that practical applications are more important than basic principles, while 79.7 percent believe information should take precedence.


over critical thinking. Surveys by Wytiaz\(^4\) and Gega\(^5\) reveal similar attitudes among teachers, Gega also noting that teachers lack knowledge of basic science generalizations and methods.

Asserting that college science teachers should devote more attention to principles, Syrocki\(^6\) developed a biology course for prospective elementary teachers. Course activities were selected with respect to their relationship to selected principles and how they might provide opportunities for reflective thinking.

Many science educators have expressed the opinion that there is a necessity to provide more than "lip-service" to the objective of critical thinking in science courses at all levels. Boeck\(^7\) concurs, submitting that appropriate science courses for elementary school teachers are "yet to be designed." He would include many experimental activities in such courses and expect future teachers to demonstrate scientific attitudes. Greenlee\(^8\) and Tyndall\(^9\) also recommend laboratory


courses designed to help future teachers develop skill in scientific method. Powers\(^\text{10}\) and Greenlee\(^\text{11}\) urge that such courses help teacher trainees to become aware of the problem-solving potential of community resources.

Tyndall\(^\text{12}\) observes that physical science is often neglected in the grades. It is sometimes supposed that children lack interest in, or are too immature for, physical science. Children studied by Baker\(^\text{13}\), however, demonstrated an interest in physical science at least equal to that in biology. Daniel\(^\text{14}\) is among those recommending a balanced treatment in the elementary grades with respect to various fields of science.

Adams and Harrison\(^\text{15}\) believe the needs of the elementary teacher are sufficiently specialized that separate science courses


\(^12\)Tyndall, op. cit.

\(^13\)Emily V. Baker, Children's Questions and Their Implications for Planning the Curriculum (New York: Bureau of Publication, Teachers College, Columbia University, 1945).


should be designed for them. Ferguson recommends that such courses emphasize objectives of science education, science concepts and sequential arrangements for teaching concepts, teaching methodology, instructional materials, characteristics of children; and should provide future teachers with a reservoir of information.

Youkstetter explains that it is not a matter of changing academic content for professionalized courses, but so organizing content that it is more significant for future teachers. Billig noted in 1930 that a truly professional course should also have general education value.

The science background of elementary education majors is sometimes measured with respect to credit-hour requirements. Snyder reported in 1950 that the mean number of semester hours of science taken by elementary majors is nine. By 1955, according to Mallinson and Sturm, this requirement had risen to a range of eleven to fifteen semester hours.

In a preliminary document prepared under the auspices of NASDTEC and the AAAS\textsuperscript{21}, the recommended science requirement for elementary majors includes two or three courses in physical science, two in biology and one in earth science. Because these would be laboratory courses, the semester-hour total would be between twenty and twenty-four credits.

The content of these courses is defined largely with respect to topical content, and may well be vulnerable to the same criticism as that leveled at many existing courses. It should be noted that increasing requirements to this level would be virtually dependent on adoption of a five-year teacher-education curriculum.

Crowell\textsuperscript{22} suggests an eighteen semester-hour sequence consisting of three six-credit professionalized courses which would include laboratory and field experiences. The three courses would be organized about content in earth science, physical science, and biological science.

Establishment of such courses on college campuses would necessitate an attitude of concern on the part of science instructors. Woodburn\textsuperscript{23} concluded after a survey of literature that college and university instructors are more concerned with efficiency of teaching at elementary or high school levels than at the college undergraduate level.

\textsuperscript{21}John R. Mayor (Dir.), Guidelines for Science and Mathematics in the Preparation Program of Elementary School Teachers (Fifth Draft) (Washington, D.C.: National Association of State Directors of Teacher Education and Certification; and the American Academy for the Advancement of Science, December 1, 1962).


The Teacher's Need for Understanding the Nature of Science and the Role of Science in Our Culture

Studies by Victor, Gega, and Wytiaz indicate that elementary teachers often regard science as a body of factual information, and that teaching of science is communication of this information. Emphasis on memorization of "facts" which are often disassociated from the lives of students is lamented by Whitehead who pleads that the subject matter of all education should be "Life... as it is known in the midst of living it."

Science in the schools cannot be justified solely on the basis of factual content. Mallinson predicts that many plans to bring science into the curriculum are "doomed" because planners concerned with content have failed to define the role of science in the total curriculum. He notes that teachers of specialized science are often lacking in necessary perspective.

Burnett observes that preoccupation with factual content may

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24 Victor, op. cit.
25 Gega, op. cit.
26 Wytiaz, op. cit.
preclude opportunities for children to explore variant and conflicting viewpoints and to raise questions. These vital ingredients should be nurtured rather than ignored.

Insight relevant to the elementary curriculum may be found in the history of science. Smith summarizes concepts emerging from the seventeenth-century scientific revolution:

1. Nature operates on an orderly plan.
2. We can eventually discover natural laws if we but observe carefully and apply orderly thinking (scientific thinking).
3. Once understanding the order of the universe, we can — in many cases — control our environment and our destinies. We must reconcile ourselves to those things which are beyond our control.30

The great significance of the scientific revolution is that it replaced belief in capriciousness of nature and reliance on absolute, external authority with faith in man's intelligence. Bertrand Russell31 notes any attempt to revive authority in intellectual matters is a "retrograde step."

Although science excited man to think about his environment, much science, as taught, ignores process and dwells on the products of science. Bernal32 observes that even "scientific thinking" is often

30 Huston Smith, paraphrased from a lecture delivered at the University of Kentucky, Lexington, Kentucky, March 25, 1963.


reduced to a set of rules taught by rote. Merriam submits that high
school and college (and elementary?) teachers should spend less time
devising palatable ways of presenting material and devote more attention
to providing experiences with actual phenomena and real problems.

The achievements of scientists in areas of energy, medicine and
food supply have had an enormous impact on human society. Berkner dismisses nostalgia for by-gone times, observing that few would care to return to an era in which imminence of disease and hunger precluded hope for individual freedom and personal dignity. He continues that the welfare of society is today conditional to progress in science.

"Science" has not only made possible our way of life, the fruits of scientific research continue to change our lives. Oppenheimer observes recently-developed products surround us; and that knowledge in science (and, consequently, the novelty in our lives) doubles each decade.

Social change and advancement of science, according to Bernal, are inextricably intertwined. As scientists attempt to solve pressing problems of mankind, new problems are generated — many of which are of

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36 Bernal, op. cit.
serious proportion. The perplexing problems of society demand the attention of intelligent and informed persons in many fields and at many levels. Axtelle\(^\text{37}\) observes that experts in a few narrow specialties are not enough to cope effectively with really important concerns.

Aside from providing citizens with reliable information, an obstacle to the solution of social problems is educating citizens to weigh evidence and judgments posed by experts in their fields of specialization. Gurko\(^\text{38}\) is pessimistic, asserting that Americans are, on the whole, suspicious of the intellectual while nearly worshipful of the folklore "man of action." Bronk\(^\text{39}\) is concerned lest the necessary work of scientists be blocked by public antagonism or apathy.

Such expressions are not appeals to have the public approve anything labeled "scientific." Dreher,\(^\text{40}\) for instance, protests as "immoral" the public-accepted government policy of pushing the "moon race" at a pace which he believes exceeds sensible precautions. Laymen must face squarely the grave problems of mankind. Russell\(^\text{41}\) pleads that our age needs compassions and courageous action which is undeterred by any proclivity to accept "pleasant allusions."

\(^{37}\)George Axtelle, "Why Teach Science?," *Science Education*, 34:162-64, April, 1950.


\(^{41}\)Russell, *op. cit.*
The Needs of the Elementary Teacher to Understand
the Characteristics of Children in Relationship
to Science Teaching

Craig, Blough et al., Burnett, Tannenbaum and Stillman, and Hill are among educators testifying to the drive of children to explore and understand their environment. Navarra documented that children are realists who are motivated to develop increasingly more comprehensive concepts relative to observed phenomena. Caswell concurs, noting that a common belief that children of five or six are interested predominantly in fantasy is unsound.

Hubler asserts that when teachers do not recognize the relationship between experience and conceptualization, including understanding of word symbols, they may fail to communicate with children.

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42 Gerald S. Craig, op. cit.
In any group of children each child will be unique with respect to his experiential background and, correspondingly, his conceptual development. Tannenbaum and Stillman urge that the science program be so diversified as to take these differences into consideration.

The opinion has been expressed that primary children are immature for science learning. This is true if science is unrelated to children's experience, but at any age normal children can learn science of some kind. According to Bruner it is only when basic ideas are prematurely formalized into symbols that they are beyond their understanding.

Blough et al., Craig and Croxton recommend that teachers study children, their environment and their activities to determine their developmental level; and take this information into consideration in planning their science program. McCollum developed a children's science questionnaire to be used in such a study.

Several writers refer to the nature of activities appropriate to children in different age groups. Tannenbaum and Stillman believe

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50 Tannenbaum and Stillman, op. cit.
52 Blough et al., op. cit.
53 Craig, op. cit.
56 Tannenbaum and Stillman, op. cit.
"biological readiness" is required for such activities as handling small tools or focusing eyes in a microscope. They recommend "show and tell" methods in lower grades although Blough et al.\(^{57}\) deplore "object study" -- which is suggested by the phrase "show and tell." Streitz\(^{58}\) recommends that experiences for primary children have "social value," i.e., be concerned with the activities of people.

Mogar, who questioned children in Kindergarten and in grades one and four, concluded primary children can think inductively, though not so well as older children. Hill\(^{60}\) notes that as children mature they develop in their ability to carry on discussions, attack problems, carry out plans, work cooperatively, use science materials and reference tools and are more likely to approach discussions with an open mind. Dewey\(^{61}\) observed that children progress from consideration of things which "simply engage" to interest concerned with realization of remote goals.

\(^{57}\)Blough et al., op. cit.


Theman and Haan acknowledge that the field of child growth and development has grown as information concerning the nature of the child has been accumulated by pediatricians, educators, psychologists and other specialists, but note there is lack of cohesion in available data and that there are few generally accepted principles. Theman asserts, nevertheless, that such formulations are necessary to attempt a translation of theoretical findings to classroom application. The twelve statements below are adapted after those made by Ragan, Blough et al., and Haan:

1. Each child grows at his own rate.
2. Growth is a continuous process.
3. Children learn best through lifelike experiences.
4. The child learns through seeking to achieve his purposes.
5. Growth is an active process; the child must be engaged in activity.
6. Personality is developed as a complex response to biological, psychological and socializing factors.
7. Children learn better when curriculum experiences are provided to aid the child in solving internal conflicts.

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65 Blough et al., op. cit.
66 Haan, op. cit.
8. Social growth requires direction. To be satisfying it must give the individual, among other things, a feeling of security and acceptance in the group.

9. Generally, different sub-cultures within our culture have different impacts on socializing.

10. Learning experiences planned with multiple objectives in mind will be more effective than experiences focused on single objectives.

11. With respect to his making personal choices, the child needs help in developing a sense of personal identity.

12. The teacher's personality is a significant factor in the classroom situation.

Blough et al. and Burnett urge that elementary schoolrooms be happy places where children can feel secure and accepted. Ragan concurs, listing these psychosocial needs of children:

1. ...need to achieve status in changing social groups.
2. ...need to grow gradually from dependence to independence.
3. ...need for security and satisfaction.
4. ...need for getting and giving affection.
5. ...need for developing appropriate communicative skills.
6. ...need to learn to face reality.

Science educators are virtually unanimous in recommending that differences among children should be recognized and appropriate learning activities provided accordingly. Neither Craig nor Tannenbaum and Stillman believe, however, that children should be ability-grouped for

67 Blough et al., op. cit.
68 Burnett, op. cit.
70 Craig, op. cit.
71 Tannenbaum and Stillman, op. cit.
science instruction, Craig asserting that in a democratic society it would be dangerous to educate a separate group for "leadership." Carin and Sund compile lists of characteristics which teachers may use in identifying these children, and discuss "How to help the science gifted" and "Science fun for the slow learner."

The Need of the Elementary Teacher to Understand the Role of Science in the Elementary Curriculum

Burnett, among others, submits that omission of science in the elementary curriculum is unfortunate if not indefensible. It is his contention that science is neglected because teachers do not understand the possibilities therein for child growth. Scott deplores what he terms a misuse and overuse of textbooks, identifying one shortcoming as a tendency to teach facts in an authoritarian manner. Teachers should, therefore, clarify for themselves the purposes for teaching science to children. Mallinson observes that teachers generally are unable to do this.

If science is justified in the elementary curriculum it must

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73 Burnett, "The New and the Old...."


contribute to certain basic objectives of elementary education as well as offer something which other curriculum areas cannot provide. Johnson advises that this "special something" be clearly identified.

Although there is relatively little emphasis given health and safety education in science education literature, Craig and Burnett urge that they be included in the science program. Both advise against formalized study and "memorization of rules," recommending that children need help in securing answers to their own questions relative to health and body. Craig asserts that intelligent behavior on the part of children is more likely to result if they are helped to understand principles underlying health and safety than if drilled on rules.

With respect to mental health, one of the statements on page 17 concerns helping children minimize internal conflicts. Lammers states that teachers need to define the role of science in helping children secure "freedom from fear."

In a relaxed atmosphere children should have opportunities to


78 Burnett, Teaching Science. . .


inquire into problems which concern them. Navarra contends that if children are denied an outlet for their experimental drive their educational growth may be stunted. Burnett notes that children must reduce their world to some degree of order and control. Virtually all authorities in science education accord high priority to helping children develop a world view. Briggs asserts that science makes the world more meaningful and interesting, and contributes to a richer life through the satisfaction of curiosity. Caswell believes school programs should compensate for the "poorly balanced lives" of most children.

Many science educators urge that children be permitted to investigate commonplace things and events in the science program. While the child's life-space quite properly constitutes at least a point of departure in science instruction, writers in A Program for Teaching Science contend an exclusion of exotic materials would deprive children of much interesting subject material. Dewey observes that reference to the "unusual" enlivens and illuminates the ordinary.

82 Burnett, op. cit.
83 Briggs, op. cit.
84 Caswell, op. cit.
86 Dewey, op. cit.
Burnett\textsuperscript{87} writes that the increasing complexity of society has created an artificial environment which obscures man's relationship to the natural environment. He holds teachers are obligated to help children realize that "...our existence depends on the corn plant."

Although much elementary science instruction deals with ordinary materials, it is often only at the level of identification. The principal message in \textit{A Program for Teaching Science}\textsuperscript{88} is that meaningful knowledge of the environment is more likely to accrue if teaching emphasizes development of understanding of principles.

Johnson\textsuperscript{89} notes a contemporary concern among science educators for development of attitudes. Jacobson\textsuperscript{90} states that there is evidence that 90 percent of adult personality characteristics are well-developed during childhood, while Ulich\textsuperscript{91} warns that there is no neutrality in teaching -- teachers have a positive obligation with respect to helping children develop attitudes.

Attitudes which should accrue from science teaching listed by

\textsuperscript{87}Burnett, \textit{op. cit.}

\textsuperscript{88}Whipple, \textit{op. cit.}


Burnett, Craig, Johnson, Branley, Kambly and Suttle, and Jacobson and Tannenbaum include recognition of cause and effect, open-mindedness, avoidance of gullibility, tolerance, critical mindedness, intelligent responsibility, recognition that change is a basic condition, developing science interests, and recognition that some problems require cooperative effort. Writers in Science Education in American Schools list:

...Questioning magic as an explanation of event...rejecting personification...or gossip in making explanations; realizing that interpretations advanced by scientists today may be corrected and improved tomorrow...questioning superstition, prejudice...placing confidence in the methods and conclusions of scientists.

Science educators urge involvement of children in activities designed to develop scientific though. Meder compares the activities

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92 Burnett, op. cit.
93 Craig, Science for the Elementary School Teacher
94 Johnson, op. cit.
of scientists with those of children, suggesting that scientific procedure in the classroom follows from encouraging curiosity, observation, imagination and joy of discovery. Obourn analyzed problem-solving activities occurring in classrooms and developed a check-list of skills and activities which may serve as a reference for teachers.

Affirmed in Chapter I, the major purpose of American Elementary Schools is preparation of children to assume the role of citizens in a democratic society. Adams admonishes that ideals of liberty, secured through war, can be lost in classrooms. We can ill afford citizens who act consistently on the basis of prejudice and make decisions which are unsupported by facts.

While science may not customarily be considered a social subject, the social implications are inescapable. Dewey remarked that the tragic weakness of the schools he observed was that they were attempting to prepare future citizens in an atmosphere lacking in social spirit.

Pulliam voicing concern over what he terms "contemporary"


102Dewey, op. cit.

eagerness for economical instruction," submits that evidence from the behavioral sciences indicates that individuals learn as they interact with other human beings. Comparing the lecture-recitation methodology of the past century with some current practices in team-teaching and educational television, he writes:

The student does not learn desired knowledge and skills just from listening, being told and exhorted. The student learns only as he makes knowledge, skills and attitudes his own.... His learning is accomplished through self-discovery and personal experience, in a socio-cultural context, where his discoveries and experiences are interpreted and evaluated, accepted or rejected, learned or not learned.104

Dewey105 noted the paradox that preoccupation with "preparing for the future" causes teachers to neglect the quality of daily experience. He contended that the future is best served by making fullest use of the present. Children should, for example, have experience in cooperative solution of problems having immediate significance.

Neumann, observing that the Puritan (Protestant) individualistic tradition is unfriendly to such a view, wrote:

America has still to learn that the masterful type of self-assertion so necessary in the earlier days has become a positive hindrance in the more settled and congested life of today.106

104 Pulliam, ibid., p. 383.
A Concise Summary of the Role of Science in the Elementary Curriculum

1. Science should contribute to the general goal of developing citizenship in a free society. The methods of science have certain similarities with democratic methods.

2. Science should contribute to the satisfaction of personal needs of children.
   a. provision of basic facts and development of desirable attitudes and habits in health and safety.
   b. provision of an atmosphere free for inquiry where the child may, under the teacher's guidance, find an outlet for his curiosity.

3. Science should contribute to the child's development of a world-view, which should contribute to his feelings of adequacy and security, and his personal creativity.
   a. The child should be able to interpret many commonplace phenomena.
   b. The child's understanding of the commonplace should be enriched through making comparisons with relatively exotic materials.
   c. The child should grow in recognition of the dependence of man on basic environmental conditions and of interdependence among living things.
   d. The child should grow in understanding of those major principles of science which are of wide applicability.
   e. The child should be introduced to appropriate content in the several fields of science.

4. Science should contribute to the child's development of certain desirable attitudes and appreciations.
   a. The child should recognize the principle of cause and effect.
   b. The child should develop habits of open-mindedness.
   c. The child should become increasingly critical in his thinking.
   d. The child should develop increasingly responsible behavior.
e. The child should realize that change is a basic condition.

f. The child should develop scientific interests and a continuing desire to learn.

g. The child should realize that some problems are best approached cooperatively.

h. The child should develop desirable emotional responses.

5. Science should contribute to the child's development of faith in, and ability to use, scientific methods in working with many kinds of problems.

   a. The child should learn many of the skills associated with problem solving.

   b. Scientific thinking should be taught in such a way that the child learns how to learn.

   c. The child should begin to realize the limitations of scientific methods.

6. Science should be so taught that relationships with total human experience and with other curriculum areas are brought out.

   a. Science should be taught in a spirit of social consciousness.

   b. Children should develop an appreciation of the contributions of scientists to our way of life, and to the continued betterment of social welfare.

   c. Science instruction should be enriched through correlation with appropriate materials from other subject fields.

   d. Science should be so integrated in the curriculum that, where appropriate, it contributes to other areas, such as development of communicative skills and mathematics.
Considerations in the Methodology of Science Teaching

A principle of child growth and development is that the child learns through seeking his own purposes (item #4, page 17). While Tannenbaum and Stillman observe that the interest and enthusiasm of the teacher is a key factor in setting the tone of the classroom, Streitz submits that children "...like anything that is brought to them with vigor and enthusiasm." Addressing himself to the practice of buying interest through "seduction", Dewey, observes that interest so stimulated is lost when pressure is released since it depends on external factors rather than personal concern. "Interest" is defined as an involvement, or concern, with a situation, and is requisite for reasoning, deliberation and reflective thinking.

Bingham maintains that children should enjoy science, submitting that interest is lost when children are always told what to do, when they have no opportunities for discovery, when they are forced to memorize "facts" without an opportunity to confirm these facts, and when there is no opportunity to interpret familiar situations.

Provision for a variety of activities in all phases of the curriculum is consistent with what is known about the way children learn.

107 Tannenbaum and Stillman, op. cit.
108 Streitz, op. cit., p. 327
109 Dewey, op. cit.
Science has particularly rich potential for children to construct and manipulate -- professional texts contain hundreds of suggestions. Dewey, however, distinguishes between "activity" and "experience," observing that mere activity does not constitute experience. Dewey writes also that the teacher must take into account external and internal factors in planning educative activity. Externally, the laboratory includes materials for manipulation. Dewey notes that traditional educators were not always remiss in provision of materials, but often failed to take into consideration the quality of response of the pupil.

Craig and Hubler urge that teaching methodology utilize democratic techniques which, among other things, makes use of children's background of experience and permit children to engage in planning activities. Burnett feels the child should be given an opportunity to compare the effectiveness of group attack on problems as compared to individual effort.

Victor addresses himself to the role of discussion in science teaching, noting that in addition to being an excellent means of communication between teacher and children, it is useful in

112 Dewey, Experience....
113 Craig, op. cit.
114 Hubler, op. cit.
115 Burnett, op. cit.
clarifying the means of various experiences. It is also an important tool in evaluation. Craig and Carin and Sund refer to the role of questions in discussions, recommending that teachers develop skill in posing such questions as "Why do you say that?" "Do you think that is information we could accept?," "What do you think will happen if...?" and "What did you observe happening?"

Several writers distinguish between demonstrations and experiments. The former is generally teacher-conducted for the purpose of verifying something already known or suspected by the pupils, or for illustration. An experiment is conducted to test a hypothesis or to discover something. Victor and Blough et al. provide lists of suggestions for conducting both experiments and demonstrations in elementary classrooms.

The Needs of the Teacher Concerning Evaluation of Science Teaching

Tannenbaum and Stillman define evaluation as a careful appraisal of children's progress toward curriculum objectives. Four widely accepted principles of evaluation are discussed below:

117Craig, op. cit., p. 125
118Carin and Sund, op. cit., p. 93
120Blough et al., op. cit.
121Tannenbaum and Stillman, op. cit.
1. Evaluation should be made with respect to all accepted objectives.

Blough\textsuperscript{122} emphasizes that it is not enough to evaluate science teaching-learning in terms of a single goal, such as fact retention. Brown\textsuperscript{123} observing that attitude-development is an often neglected goal, reminds teachers that attitude development is not an inevitable concomitant of factual learning.

2. Different methods of evaluation are necessary.

While paper and pencil tests are commonly used to determine mastery of factual information, they are less frequently designed to measure understanding of science principles. Douglas and Spitzer\textsuperscript{124} urge teachers to extend the scope of their test items so as to measure understanding. Carin and Sund\textsuperscript{125} and Victor\textsuperscript{126} include sections in their professional texts on how teachers can develop greater versatility in various kinds of objectively-graded items.

A number of educators submit that evaluation of behavior requires


\textsuperscript{125}Carin and Sund, \textit{op. cit.}, chapter 10.

\textsuperscript{126}Victor, \textit{op. cit.}, chapter 8.
methods based on observation of behavior. Instruments have been designed to standardize, or simply, the observation task. Lewis and Potter have constructed a series of checklists upon which notations can be made by the alert teacher. These checklists correspond to attitude development of individual children, evaluation of group activity, individual lessons, and a form for teacher-pupil cooperative evaluation.

On a scientific attitude checklist developed by Navarra and Zaffaroni the teacher can note for each child his "status level" (level of development) with respect to each of four "elements":
(a) recognizes cause and effect relationships, (b) heeds various points of view, (c) considers evidence, and (d) searches for reasons.

Anecdotal records kept over a period of time in each child's folder can be helpful in evaluating behavior growth. Hill recommends that anecdotes be short and objective; and that the teacher concentrate on observation of a few children each day.

3. Evaluation should be a continuous and integral part of teaching and learning.

Observing that evaluation should be an integral part of the teaching-learning process, Blough writes:

The evaluation process will lead to the examination of previously accepted goals, of methods being used by teacher and learner in


129Hill *et al.* *op. cit.*
moving toward these goals, and of the merits of the very evaluation procedures themselves.130

4. The teacher should examine his own teaching.

Several authors have developed lists of questions teachers may put to themselves in self-evaluation. Blough131 and Hill132 recommend that teachers ask themselves such questions as "Do I make flexible but careful plans?" "Do I scrutinize my teaching constantly to determine whether or not my goals are desirable and attainable?" "Is there enthusiasm for science in my classroom?" and "Are children using a variety of sources of information?"

The Needs of the Teacher to Understand How Science May Be Included in the Curriculum Structure

The shortcomings of much traditional curriculum organization and the task facing modern educators can be appreciated by reference to such general objectives as those submitted by Kearney133 which are, for convenience, substituted below for the concise summary appearing earlier in this chapter (pp. 26-27).

The curriculum should provide for:

a. development of knowledge and understanding.

b. development of attitudes and interests.

c. development of skills and competencies.

d. development of desirable behavior patterns.

130Blough et al., op. cit., p. 144

131Ibid.


The way in which science is included in the curriculum may be a limiting factor in the realization of such objectives. Three means of teaching science discussed by educators are (a) inclusion of science in broad-unit organization, (b) teaching science by a subject-matter approach, (c) teaching science through incidental activities. These are discussed below with reference to Kearney's objectives.

Good defines "unit of work":

[The unit of work is]...an organization of various activities, experiences, and types of learning around a central theme, problem, or purpose, developed cooperatively by a group of pupils under teacher leadership; involves planning, execution of plans and evaluation of results...\(^1\)

The central theme might concern an "area of living" such as "Living in our Community," or be more directly related to a subject field as in "The Westward Expansion."

The attitudes of educators who support inclusion of science in broad-unit activities range from insistant to moderate. Heffernan declares strongly against a "fixed sequence" ("...We are definitely not adding another subject.") and for integration of science with other learning opportunities.

Jacobson and Tannenbaum\(^2\) who believe the elementary science curriculum should consist of a "planned" and a "flexible" dimension, include broad units in the latter category. They observe that the flexible dimension makes heavy demands on teachers but that the potential results are "well worth the investment in effort."


\(^3\)Jacobson and Tannenbaum, op. cit.
Burr names advantages of skilled broad-unit teaching, among which are:

1. Unit teaching provides the best means of getting children oriented to problems.
2. Unit teaching provides a greater opportunity for children to do planning, critical thinking and self-evaluation.
3. Unit teaching provides opportunities for cooperative effort.
4. Unit teaching provides opportunities for crossing subject-matter lines.

These, of course, are matters of relative advantage favoring broad-unit teaching. With respect to science -- in light of Kearney's objectives -- broad-unit work appears to have strength in development of desired behavior patterns, social skills and competencies and, possibly, in development of attitudes. Development of knowledge and understanding might be slighted yet a perception of relationships between science content and content in other fields should more likely accrue.

While not necessarily endorsing broad-unit organization, various writers point out such relationships. Hubler, Caswell, and Kambly and Suttle observe that science can enrich language arts activities. Burnett recommends that meaningful quantitative experiences accompany science activities, noting that quantitative facility may fail to

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137 James B. Burr, from class notes, The Ohio State University, February 28, 1961.
138 Hubler, op. cit.
139 Caswell, op. cit.
140 Kambly and Suttle, op. cit.
141 Burnett, op. cit.
develop if children are not provided such opportunities.

The relationship between science and social living has been noted. Science can also contribute substantially to elementary social studies. An understanding of the nature of people removed from us in time and space, as observed by Michaelis et al., would involve consideration of their food supply, clothing, climate, transportation, industry, diseases, communication and the geographical situation of their communities.

Craig, on the other hand, expressed his reaction to science being taught only within a broad-unit framework when he noted that elementary teachers are sometimes made to feel that all activities undertaken by children must involve a number of subjects. He further deplored the artificiality implied by such questions as, "How can I add some science to my social studies?"

The critics of "subject-matter" organization, however, are concerned that such organization does not take into account principles of child growth and development. Burnett observed that subject-matter teaching is appropriate when, and to the extent that, teachers use the subject matter as a vehicle for child development.

Lewis and Potter state that there is a growing conviction


143Craig, op. cit.

144Burnett, op. cit.

145Lewis and Potter, op. cit.
among educators that children should have a sequential development of science learnings in separate periods of time specifically allocated to science instruction. This contention is borne out in a 1953 statement by the American Association for School Administrators which submits, "...It is imperative that curriculum workers assist classroom teachers to teach subjects more effectively than has been done in the past" (italics added). Jacobson and Tannenbaum believe an advantage of the "planned dimension" is that it may permit greater individualization of instruction through depth studies and put proper emphasis on understanding of principles.

The teacher need not commit himself to either a broad-unit or a subject-matter approach. Burr and Ragan recommend that the school day be proportioned to include both.

Studies such as those by Wytlaz reveal that many teachers express a desire for a specialist to assume all, or part, of the responsibility for teaching elementary science. Educators' opinions differ. McCollum implies that elementary science teaching should

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147 Jacobson and Tannenbaum, op. cit.
148 Burr, op. cit.
149 Ragan, op. cit.
150 Wytlaz, op. cit.
be taught by specialists. Burnett\textsuperscript{152} and Craig\textsuperscript{153} imply otherwise. Field studies, such as one by Gibb and Matala\textsuperscript{154} offer no clear guidelines as to whether or not specialist teachers are desirable. Craig\textsuperscript{155} observes that science instruction may be more accurate with a specialist, but cites a series of possible disadvantages, among which are: (a) Science becomes unrelated to other school activities. (b) Instruction may become fragmentary, and (c) Opportunities for integration with life experiences are lost.

Jacobson and Tannenbaum\textsuperscript{156} recommend the use of a science consultant who serves as a resource person for the classroom teacher.

The introduction of science instruction by television has raised new questions relative to the science curriculum in general, and to the science specialist in particular. While science by educational television appears widely heralded by teachers, administrators and laymen, some educators are openly skeptical. Blackwood\textsuperscript{157} submits that television provides little opportunity for children to invent

\textsuperscript{152}Burnett, op. cit.

\textsuperscript{153}Craig, op. cit.


\textsuperscript{155}Craig, "The Program of Science.......

\textsuperscript{156}Jacobson and Tannenbaum, op. cit.

experiments and speculate or test hypotheses. Shumsky\textsuperscript{158} notes that despite the rich potential of ETV, there are some basic limitations, including encouragement of passivity which is the antithesis of scientific thinking.

According to Lewis and Potter,\textsuperscript{159} incidental teaching preserves in the science program a "timeliness, sparkle and challenge." Jacobson and Tannenbaum\textsuperscript{160} apparently concur, but assert that should incidental teaching become the basis of a science program, there is danger of the incidental becoming the accidental.

What the Teacher Needs to Know About Scope and Sequence in Elementary Science.

Victor\textsuperscript{161} observes that there is increasing agreement about subject-matter content of elementary science, but that matters pertaining to grade-placement are open questions. Dunfee and Greenlee,\textsuperscript{162} commenting on this situation, report that teachers continue to ask for help in planning their science sequence.

The task facing teachers in this area is succinctly described by Haan, who first emphasizes, "Facts are not science":


\textsuperscript{159}Lewis and Potter, \textit{op. cit.}, p. 25.

\textsuperscript{160}Jacobson and Tannenbaum, \textit{op. cit.}, pp. 151-56.

\textsuperscript{161}Victor, \textit{op. cit.}.

The creative task here is to develop experiences that allow for growth in concepts and generalizations through inductive procedures, and then build other experiences that involve the application of principles (generalizations) to new situations. As curriculum workers we shall have to be satisfied with fewer experiences more carefully and intensively developed. This will also be easier to do if further research can yield some clues as to when children can learn these things. Here again the existing research cannot be taken too seriously. As the experience of children with scientific concepts increases outside the school, we should expect to find that research findings on placement would tend to become outdated. Readiness to learn science concepts is like other kinds of readiness dependent on kinds of prior experience, as well as general ability.

A scheme for scope and sequence which also takes into consideration the role of science principles is submitted by Jacobson and Tannenbaum. In their plan, children in grades one through six each year study a topic related to each of the following major areas: geology-meteorology; health and safety; machines, materials and energy; physical environment; and biological environment.

Regardless of the design finally accepted, it is highly desirable that teachers work cooperatively in developing or accepting the sequence. Miel believes that the most effective curriculum planning is done at the level of the individual school. Victor describes a procedure by which teachers can develop a science program, emphasizing the importance of general participation. The evolving plan should be flexible enough to permit each teacher to use it creatively.

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164 Jacobson and Tannenbaum, op. cit., p. 43
166 Victor, op. cit., chapter 3.
Challand discovered that fewer than 25 percent of the teachers in her survey used a flexible sequence developed by the grade school staff. That the majority of teachers in this sample operated more or less independently of each other — using in most cases a textbook as the determiner of scope and sequence — is testimony that teachers must be educated to the necessity and techniques of professional committee work, as well as the desirability of working from a carefully designed program.

CHAPTER III

PROCEDURES

The principal activities of the study were to learn of practices employed in selected teacher education institutions to prepare elementary teachers for the teaching of science and to evaluate these practices with respect to pertinent criteria.

There were four stages to this undertaking:

1. Preparation of the criteria
2. Development of a questionnaire device for the reporting of practices
3. Compiling a list of names of science educators to whom the questionnaire would be forwarded
4. Processing the returned questionnaires

Preparation of the Criteria

The preceding survey of elementary science education literature served as the basis for the development of criteria used in the study. The ideas expressed by these educators, which were considered consistent with democratic educational philosophy, were distilled into a "Preliminary list of criteria to be used in evaluating practices designed to develop the competence of elementary teachers for teaching science."

This list of 32 criteria was forwarded to eight judges whose help was

1Dr. Lucille Lurry (Junior High specialist, University of Kentucky), Dr. Denver Sloan (interest in elementary science education, University of Kentucky), Dr. James T. Moore (elementary curriculum specialist, University of Kentucky), Miss Eloise McElfresh (Elementary science education instructor, The Ohio State University), Mr. Harold Ward (science education, Marshall University), Mr. Kenneth Vordenberg (Science Supervisor, Cincinnati Public Schools), Dr. Donald Stotler (Science Supervisor, Portland Public Schools) and Dr. Fred Fox (Science Education, Oregon State University).
requested in validating and improving the criteria.

Included in the accompanying letter was the following paraphrased statement:

In reviewing the enclosed preliminary set of criteria, indicate whether you think each criterion is (a) highly important, (b) moderately important, or (c) of little importance. Your comments on the following items would be appreciated:

1. Is the meaning of the criterion clear? (Adjust wording if you wish.)
2. Can items be combined, eliminated or split?
3. Is there an omission of some criterion or category which you think should be included?

Suggestions of the judges indicated that indeed some criteria could be combined, some eliminated and others reworded to avoid ambiguities and to clarify meanings. The original list of 32 items was modified into a list of 21 criteria (Appendix A, Item 1) which became the basis of the questionnaire device.

**Developing a Questionnaire for the Reporting of Practices**

The 21 criteria were so arranged that they fell into ten groups, the criteria in each group bearing relatively close relationship. Each of these ten groups became the basis of a single general question on a preliminary questionnaire. These questions, introduced by the phrase "Describe practices in your institution which you feel are particularly effective in..." were designed to permit relatively free response in ten general areas.

To ensure that respondents' discussions would be (1) relevant to the criteria and (2) as complete as possible, it was deemed advisable to subtend each general question with a series of suggestions. Under each of the ten items on the preliminary questionnaire were placed parenthetical questions introduced by the words "For example..."
The preliminary questionnaire was forwarded to seven educators who were requested to complete it and comment on it as they wished.

Reactions of these educators was generally favorable, but the opinion was expressed that the questionnaire was too long for wider distribution. A study of these first responses indicated that the questionnaire could be reduced in length and still elicit descriptions of practices corresponding to each of the 21 criteria. The criteria were regrouped, items reworded and the parenthetical questions altered.

The final questionnaire consisted of eight items, each followed by a series of parenthetical questions. The items and subtending questions are reproduced in Appendix A, Item 2.

Compiling a List of Names of Science Educators to Whom the Questionnaire Would Be Forwarded

It was believed that a return of 75 completed questionnaires would constitute the basis of an adequate study. Because considerable time was necessary for completion of the device, it seemed advisable to secure from the educators their permission to forward the questionnaire to them.

With this courtesy, and efforts to make the questionnaire as compact as possible, it was estimated that a return of 50 percent of the distributed questionnaires could be expected. To secure 75 returns, at least 150 questionnaires should be distributed. The

Miss Eloise McElfresh (Elementary Science Education, The Ohio State University), Dr. Harold Ward (Science Education, Marshall University), Dr. Emery L. Will (Science Education, State University College at Oneonta, New York), Dr. Denver Sloan (Elementary Science Education, University of Kentucky), Mrs. Barbara Tea (Science Education, University of Kentucky), Dr. Joseph C. Thomas (Head, Science Department, Florence State College) and Dr. Irwin Ramsey (Elementary Science Education, The Ohio State University).
educators indicating their willingness to receive it. The number of letters requesting permission would have to be still larger.

A list of educators and their institutions was compiled for the preliminary mailing. The first names included on the list were those of approximately 40 college educators whose publications records indicate a strong interest in elementary science education. This list was extended to include a total of 215 universities and colleges. The 175 names of institutions added to the original 40 were selected from those schools whose elementary education program is approved by the National Council for Accreditation of Teacher Education.\(^3\) The NCATE list was used to ensure that the institutions to which the mailing was forwarded have a dedication to the education of elementary teachers.

It was desired that each of the 48 continental states would be included in the list and that the number of letters going to each state would be roughly proportionate to the population of that state. The preliminary list included names of state universities and colleges as well as private institutions.

College catalogs were consulted to learn names of staff members associated with elementary science education at the institutions on the mailing list. Most of the names located are those of personnel in Departments or Colleges of Education, but also represented are persons in science departments. When catalogs did not indicate science educators, the names of department chairmen or Deans of Colleges of Education were used.

The preliminary mailing consisted of two items -- a letter and a post card. When not sent to a science educator these items were accompanied by a request to forward them to such a person. The letter (Appendix A, Item 3) introduced the investigator, the nature of the study and names of the sponsoring institution and graduate adviser. The eight item questionnaire was specifically mentioned with this statement included:

Because completing the instrument may require more time than do checklist questionnaires I am requesting permission in advance to send it to you. I will be most grateful for your assistance.

On the post card addressed to the investigator, educators could indicate their willingness to receive the questionnaire. They were also invited to list names and addresses of other elementary science educators in their state who might make a contribution to the study. Names of some 25 additional persons were received.

In the following weeks 169 post cards were returned with affirmative responses. As each of these arrived the questionnaire was forwarded along with a cover letter and an addressed, stamped envelope for the return mailing. The letter (Appendix A, Item 4) expressed appreciation to respondents and listed suggestions for completing the questionnaire. Respondents were invited to forward course syllabi or any other material which they might distribute to their students.

The preliminary mailing was distributed on February 29, 1964. This time was thought to be one of two times during the school year when educators would have their schedules least complicated by academic duties.
Processing of Returned Questionnaires

Respondents returned 110 questionnaires (65 percent) of which 99 were useful to some extent. Of the 104 respondents listed in Appendix C:

Ninety-four from 90 institutions returned generally usable questionnaires. This includes three of the preliminary questionnaires which could be used and the investigator's own response.

Ten returned either partially completed questionnaires or letters which provided some information useful in the study. This includes one letter received from a person sent a preliminary questionnaire.

As each return was received a post card was immediately dispatched acknowledging the contribution of the respondent.

It was anticipated that not until all completed questionnaires were returned could there be a final determination of how responses could be processed. One possibility was to classify reported practices according to their correspondence to the 21 criteria. For each criterion there would be a separate section consisting, in part, of practices sub-classified according to emerging differences.

Only for the first and second criteria, for which there was considerable detail in questionnaire discussions, did such an organization appear practicable. Practices corresponding to the third and fourth criteria are reported in a third section. These criteria are more closely related to each other than were the first two, and few reported practices correspond exclusively to only one of these criteria.

It was decided also that there would be no advantage in developing separate sections corresponding to the remaining 17 criteria. An attempt to do this would necessitate many arbitrary discriminations as to which criterion a given practice corresponded. For each question-
naire item except the first, then, there is a corresponding section in Chapter Four.

Practices corresponding to the 21 criteria of the study are treated in a total of ten sections, which include 23 tables. In each section the sub-classification of responses is followed by a summary and discussion of these practices and a series of recommendations to science educators.

Some practices were reported in considerable detail by respondents, while others were only noted. An attempt was made to include all reported practices in the tables regardless of the amount of detail provided. For this reason, many of the practices tabulated or summarized in the tables are not further described in the text. Relatively detailed descriptions are included in the text in appropriate places.

Respondents were asked to describe practices considered "particularly effective," rather than to itemize practices in their courses or at their institutions. Since it must be assumed that "not particularly effective" practices were unreported, it follows then that tables do not represent cross-sections of institutional practices -- which might be the case had the tables been compiled from a checklist instrument. The categories appearing in various tables were constructed after questionnaires were returned.

The plan relative to the nature of the discussions in each section was that practices appearing to be particularly promising or questionable in some respect would be identified and discussed. As returns were studied it became evident that omissions made by science educators are, perhaps, of equal significance. Corresponding to some
of the criteria there were virtually no practices reported, with such notations as, "We are weak here." Directly or indirectly, respondents provided ideas for discussion sections which were unanticipated. Of particular relevance are matters of departmental and interdepartmental cooperation and educators' assumptions about certain classroom practices.

**Limitations of the Study**

1. Each questionnaire item, as well as the first suggestion on the cover letter, requests respondents to describe practices considered "particularly effective" in the education of elementary teachers to teach science. How this was interpreted by different respondents is not known. In some cases it may have inhibited the reporting of practices which would have been useful additions to the study.

2. With questionnaire studies there is a limitation imposed by the size and nature of the population receiving the instrument. It is virtually certain that a number of science educators who could have contributed to this study did not receive questionnaires and that others whom the investigator had hoped to hear from were either unable or unwilling to receive the questionnaire -- or did not complete it. It is hoped that the data contributed by the 104 cooperating educators reflect a generally accurate picture of the present state of affairs in the preparation of elementary teachers to teach science.

3. Most of the questionnaires were forwarded to elementary science educators while only a few were sent to interested individuals in science departments. A more complete study would have included more persons in this latter group as well as personnel in other areas. The assumption made was that the elementary science educator is the best
single source of information about practices relevant to preparation of elementary teachers to teach science.

4. There are limitations inherent in the questionnaire device in wording which was ambiguous (although effort was made to minimize this possibility) and in the length of time necessary to complete it. It is hoped that respondents were able to report many highly regarded practices, but in the limited time devoted to the questionnaire it is very likely that there was much unintentional omission.

5. Also related to the time factor, it was noted that discussions on the first few items were in general considerably more detailed than those on the remaining pages. This was anticipated to some extent since the former items correspond to matters given high priority by many science educators in the literature.

Although it must be conceded that the length of the questionnaire may have been a factor in the shorter responses to the last three items, the interpretation is that brevity of response — or absence of reported practices — is not so much a function of the length of the questionnaire as it is a matter of the relative values of respondents.

6. Observed above, respondents in many cases simply noted practices without going into detail. Some valuable data may thus have been lost to the study. In several cases where practices appeared promising, a letter was sent requesting additional specific information. Respondents were, on the whole, generous in their response to this additional request.
CHAPTER IV

CLASSIFICATION OF DATA, SUMMARIES, DISCUSSIONS AND RECOMMENDATIONS TO SCIENCE EDUCATORS

Practices Reported Corresponding to the First Criterion

Criterion 1: Does the particular practice introduce the teacher to content in the several fields of science which should be presented in a balanced elementary science curriculum (biology, chemistry, physics, geology, astronomy and meteorology)?

This criterion and the three which follow were incorporated into the first item of the questionnaire:

Described practices in your institution which you feel are particularly effective in providing the elementary teacher with an appropriate background of science information.

Classification of Reported Practices

Credit hours of science required of elementary education majors and course distribution

The questionnaire did not request respondents to specify credit-hour requirements in science, but in a majority of cases this information was volunteered. For a more complete comparison, information was secured from available recent college catalogs when not supplied by respondents.

Table 1 summarizes science requirements (credit-hours and

1Health, hygiene, psychology, nutrition and geography are not classified as science courses in this study. An exception is made in the case of geography when respondents indicate that the course includes a substantial block of content in geology.

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their distribution) at 85 institutions for which information was available. In 42 of these institutions students must complete 12 or more semester hours (or 18 quarter hours) of academic science, exclusive of professional science education courses which may have a considerable amount of science content. Forty-three schools require less than 12 semester hours of science.

In six institutions which have a 12 semester-hour requirement there is no specification of courses, although respondents at three of these schools report that students are encouraged to take courses in both biological and physical science. At one of these institutions (Bowling Green State University) a committee has been charged with the responsibility of recommending changes in science courses that would make them more appropriate for elementary majors. No courses are specified for elementary majors at Loyola University although the 12 semester-hour requirement is usually fulfilled with chemistry, physics and biology.

At other institutions at which elementary majors must complete 12 or more semester hours of science, practices range from a total prescription of specified science courses, to requirement of one or two courses and students granted the choice in electing the balance. It is assumed, however, that in most institutions special circumstances may warrant exceptions to the customary pattern of course requirement.

In 34 of 43 institutions where science requirements for elementary majors total less than 12 semester hours, some degree of course prescription is practiced.

Table 2 summarizes course prescription at those institutions
<table>
<thead>
<tr>
<th>The distribution of science courses must include one or more course in each:</th>
<th>Number of schools requiring 12 semester hours (18 qrtr. hrs.) of science, or more</th>
<th>Number of schools requiring less than 12 semester hours (18 qrtr. hrs.) of science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology^a</td>
<td>2</td>
<td>3^d</td>
</tr>
<tr>
<td>Biology^a physical science^b</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Biology^a physical science^b earth science^c</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Physical science^b or general science</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Astronomy</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No specific courses</td>
<td>6</td>
<td>9^d</td>
</tr>
<tr>
<td>Totals</td>
<td>42</td>
<td>43</td>
</tr>
</tbody>
</table>

^a"Biology" may refer either to fused courses in biological science or separate courses in zoology and botany.

^b"Physical science" may refer to fused courses in physics and chemistry or to separate courses in these areas. As used by some respondents the term also refers to courses which include content in the earth sciences. Correction was made for this when detected.

^c"Earth science" may refer to fused courses in geology, astronomy and meteorology, or to geology alone.

^dUnusual distribution practices at three institutions place them in this column. At the State University College at Oswego (New York) students must complete 15 semester-hours in mathematics or science, but, strictly speaking, only a 3-credit biology course is required. Students at Eastern Michigan University must complete a 12 to 13 semester-hour block, while a 15 semester-hour science block is required at Goucher College. At Eastern Michigan, however, psychology and mathematics may fulfill all but six hours of this block. While theoretically, the student at Goucher could take his entire distribution in psychology and mathematics.
at which elementary majors take more than 12 semester hours (or equivalent) of science.

Science courses and sequences specially designed for elementary education majors

Other than requirement of a minimum number of credit-hours or specification of courses, the subject matter needs of teachers in science are met by providing special courses. Table 3 lists institutions at which non-sequential science courses have been designed for teachers, and includes descriptive notes about these courses.

**Utah State University.**— Respondent describes "Forestry 110":

This course is an introduction to the problems of conservation of the natural resources of the United States. The course objectives are: (1) to give the student a better understanding and appreciation of our natural surroundings, (2) to acquaint prospective school teachers...with the inherent values of natural resources, wise use of these resources, and methods of incorporating conservation education into primary and secondary school curriculum....The lab period will be used for field trips to nearby areas of natural resource interest and for practical work in the accumulation of references and unit outline materials for future classroom use.

Table 4 summarizes the situation at institutions at which a sequence of science courses have been designed for elementary majors.

**Austin-Peay State College.**— Elementary majors take a three-quarter general science sequence following completion of 12 hours of introductory science. The instructor of the general science courses writes:

When students enter these courses they know so little science that I believe the most important thing for me to do is to teach science by methods I hope they will adopt and use in their classrooms when they are employed as teachers....I am convinced... that they mimic the teachers they have had in college.
<table>
<thead>
<tr>
<th>Institution</th>
<th>Credit-hour requirement</th>
<th>Courses required and descriptive notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albany State College</td>
<td>20 qrtr. hrs.</td>
<td>Ten credits in both biological and physical science</td>
</tr>
<tr>
<td>Arizona State College</td>
<td>17 sem. hrs.</td>
<td>Physical science, biology, field biology, earth science, and philosophy of science</td>
</tr>
<tr>
<td>Auburn University</td>
<td>20 qrtr. hrs.</td>
<td>Ten credits in both biological and physical sciences</td>
</tr>
<tr>
<td>Austin Peay State College</td>
<td>21 qrtr. hrs.</td>
<td>Twelve credits chosen from biology, chemistry and physics, nine credits of &quot;General Science for Teachers&quot; (3 term seq.)</td>
</tr>
<tr>
<td>Bradley University</td>
<td>16 sem. hrs.</td>
<td>Eight credits in both &quot;Biology for Elementary Teachers&quot; and &quot;Physical Science for Elementary Teachers&quot;</td>
</tr>
<tr>
<td>Brigham Young University</td>
<td>18 sem. hrs.</td>
<td>Geology, physics, chemistry, botany, zoology, and bacteriology</td>
</tr>
<tr>
<td>Indiana University</td>
<td>14 sem. hrs.</td>
<td>Courses distributed in biological and physical sciences</td>
</tr>
<tr>
<td>National College of Education</td>
<td>13 sem. hrs.</td>
<td>Six credits in biological science, three in physical science, plus an, elective</td>
</tr>
<tr>
<td>State University College at Oneonta (New York)</td>
<td>18 sem. hrs.</td>
<td>Three-credit courses in biology, chemistry, earth science, and physics plus two electives from a list of approved science courses</td>
</tr>
<tr>
<td>Institution</td>
<td>Credit-hour requirement</td>
<td>Courses required and descriptive notes</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>University of Alabama</td>
<td>14 sem. hrs.</td>
<td>Eight credits in biology, six credits in &quot;general science&quot;</td>
</tr>
<tr>
<td>University of Georgia</td>
<td>20 qrtr. hrs.</td>
<td>Courses distributed in biological and physical sciences; two courses must include laboratory</td>
</tr>
<tr>
<td>University of Maryland</td>
<td>16 sem. hrs.</td>
<td>Laboratory courses in botany and zoology; two courses elected from physics, chemistry, astronomy, foods and nutrition, and meteorology</td>
</tr>
<tr>
<td>University of Southwestern</td>
<td>13 sem. hrs.</td>
<td>Six credits in physical science; seven in biology</td>
</tr>
<tr>
<td>Louisiana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Tennessee</td>
<td>24 qrtr. hrs.</td>
<td>Twelve-credit sequences in a biological science and in a physical science</td>
</tr>
<tr>
<td>Wisconsin State College at Oshkosh</td>
<td>more than 12 sem. hrs.</td>
<td>Biology (two terms), geography-geology, conservation, physical science</td>
</tr>
<tr>
<td>Institution</td>
<td>Name of course(s)</td>
<td>Descriptive notes</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Indiana State College (Pennsylvania)</td>
<td>Earth Science</td>
<td>No details provided</td>
</tr>
<tr>
<td>Loyola University</td>
<td>Biology, Chemistry, Physics</td>
<td>No details provided; none of these courses specifically required</td>
</tr>
<tr>
<td>Northern State Teachers College</td>
<td>&quot;Physical Science for Elementary Teachers&quot;</td>
<td>(Professionalized course) Selected topics in magnetism, sound, electricity, heat and light; content based on topics studied by elementary children; investigations and demonstrations planned by students; students familiarized with simple equipment as well as manufactured apparatus</td>
</tr>
<tr>
<td>Northwestern State College</td>
<td>Physics, Chemistry</td>
<td>No details provided</td>
</tr>
<tr>
<td>University of Kentucky</td>
<td>&quot;Nature Study&quot;</td>
<td>Not required, pre-requisite; one course in biological science; emphasis on identification of specimens, ecological relationships, some field experience</td>
</tr>
<tr>
<td>University of Maine</td>
<td>&quot;Natural History of Coastal Maine,&quot;</td>
<td>Offered in summers, students taking courses live off-campus; devote ten hours daily to course; &quot;motivation very high,&quot; not required</td>
</tr>
<tr>
<td></td>
<td>&quot;Natural History of Inland Maine&quot;</td>
<td></td>
</tr>
<tr>
<td>Utah State University</td>
<td>&quot;Forestry 110&quot;</td>
<td>Course in conservation designed for prospective elementary and secondary teachers; field trips; course closed to forestry majors</td>
</tr>
<tr>
<td>Institution</td>
<td>Courses in sequence</td>
<td>Descriptive notes</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Austin Peay State College</td>
<td>&quot;General Science for Teachers&quot; (three-quarter sequence)</td>
<td>Instructor uses teaching methods considered suitable for elementary school teaching; broad concepts emphasized</td>
</tr>
<tr>
<td>Brigham Young University</td>
<td>Geology, Physics, Botany, Chemistry, Zoology and Bacteriology</td>
<td>All courses required - present project aims to make courses more appropriate for elementary majors</td>
</tr>
<tr>
<td>East Carolina College</td>
<td>&quot;General Science&quot; (three quarter sequence)</td>
<td>One term of biology, topics included in other terms are astronomy, chemistry, geology, meteorology, topics from classical physics, nuclear energy</td>
</tr>
<tr>
<td>Florence State College</td>
<td>Biology, General Science (two semesters of each)</td>
<td>General science includes topics in astronomy, geology, meteorology, chemistry, physics; meets four hours weekly in lecture-demonstration sessions</td>
</tr>
<tr>
<td>Indiana State College</td>
<td>Biology, Physics, &quot;Earth and Sky&quot;</td>
<td>All required; proposals currently being considered to make courses better suited for elementary majors by improving laboratory opportunities</td>
</tr>
<tr>
<td>Montana State University</td>
<td>&quot;Science for Teachers&quot; (three-quarter sequence)</td>
<td>Selected topics in biological and physical science; students perform exercises with simple apparatus paralleling concepts introduced in lecture</td>
</tr>
<tr>
<td>Rhode Island College</td>
<td>&quot;Science&quot; sequence combines physical and biological science</td>
<td>Students required to complete approximately twelve laboratory problems per semester</td>
</tr>
</tbody>
</table>
TABLE 4 (Contd.)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Courses in sequence</th>
<th>Descriptive notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Cloud State College</td>
<td>Biology, Physical Science</td>
<td>Materials and concepts adaptable to elementary school considered; students present demonstrations, prepare teaching aids, collect specimens</td>
</tr>
<tr>
<td>Trenton State College</td>
<td>&quot;Physical Science in Ele. Education,&quot; &quot;Biological Science in Ele. Education&quot;</td>
<td>Consists of basic subject matter with special emphasis on preparation of instructional materials</td>
</tr>
<tr>
<td>Troy State College</td>
<td>&quot;Science for the Ele. Teacher&quot; (two-quarter sequence)</td>
<td>Pre-requisite; physical science sequence and junior standing; two lectures, two labs weekly; content includes fact, principles, teaching methodology</td>
</tr>
<tr>
<td>University of Iowa</td>
<td>&quot;General Science&quot; (two semester sequence)</td>
<td>Content and materials are those which are commonly used in elementary school science.</td>
</tr>
<tr>
<td>University of Pittsburgh</td>
<td>&quot;Biophysics&quot; (three semester sequence)</td>
<td>Includes topics from many fields of science; emphasis on principles, methods and techniques of science</td>
</tr>
<tr>
<td>University of Southern Mississippi</td>
<td>Recently organized Department of Science Education, jointly sponsored by the College of Arts and Sciences and the school of Education and Psychology will provide all science courses required of elementary majors. Course planning and teaching is to be done by personnel with elementary education background.</td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>Courses in sequence</td>
<td>Descriptive notes</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Wisconsin State College at Oshkosh</td>
<td>Biology (two term sequence) Geography - Geology, Conservation and Physical Science</td>
<td>Consists of basic subject matter with special emphasis on preparation of instructional materials</td>
</tr>
</tbody>
</table>
The procedure used by this respondent in teaching science is itemized below and will be referred to in later discussions:

- a. Science topics are selected by the instructor, the students or by both cooperatively. Topics may be from areas of biological, physical, or earth science.
- b. Students discuss what they know about the topic.
- c. Students itemize what they desire to know about the topic.
- d. Students organize in groups of not more than three persons. Groups choose problems to be solved.
- e. Work periods follow; students identify and define problems and devise methods for their solution.
- f. During discussion periods, groups share their ideas.
- g. Teacher and students evaluate their work.
  1) Daily evaluation: students summarize what they have learned.
  2) Written tests are administered periodically.
  3) Subjective evaluation: based on observation of students by instructor as they share experiences

The respondent emphasizes broad concepts rather than facts.

"The content is made very practical.....It is down to earth, everyday science."

**Brigham Young University.**— Although students complete 18 semester hours of science, the respondent reports efforts to improve the offerings:

At the present time we are contemplating setting up a physical science course in the College of Physical Science which is even more closely related to the kind of preparation in science needed by our future teachers. It would be a single course extending over two semesters which would be developed and taught by a team of specialists from the areas of chemistry, geology and physics. A lab will be held in conjunction with the course in which students will not only use modern science equipment, but will also have a chance to use simple science equipment of the type they would utilize in their elementary classrooms as teachers.

**Indiana State College (Indiana).**— A proposed physics course (Appendix B, Item 1) will include appropriate laboratory experiences, while a laboratory section is being planned for "Earth and Sky" (an established course). In addition, a 5-credit course is being planned to replace the existing two-credit science education course. The new course would provide additional science content and laboratory experience,
with particular emphasis being given to the nature of scientific method.  

Montana State University.— The elementary major completes his 12 quarter hour science requirement in a special sequence courses. The respondent writes:

It is assumed that the students in these courses have had little or no work in secondary science other than biology. The first quarter is devoted to the various physical science concepts such as force and motion, chemical symbolism, chemical reactions, and organic chemistry. The second quarter is a gradual transition from the physical to biological science using organic chemistry as the bridge. In the second quarter concepts pertaining to hydrocarbons, carbohydrates, fats, proteins, ATP, DNA, RNA, cell organelles, and inheritance are developed. The third quarter takes up the concepts related to the life cycles of plants and animals.

The instruction consists of three lectures and one two-hour laboratory per week. In the lab the students perform various exercises using simple and sometimes crude instruments to develop understanding of the concepts and principles developed in lecture. These instruments are of the types that might be found in the elementary classroom...in other cases more complex instruments and materials...[are used].

University of Pittsburgh.— The respondent writes:

All of our undergraduates in elementary education are required to have at least twelve credits in "Biophysics". The courses are especially designed for teachers in the elementary area...[and] are taught by regular members of the Natural Science faculty. The content of the course is to give students an understanding of the basic principles involved in science phenomena and help them develop techniques and methods to explain these phenomena. This requirement is expected to be increased gradually to 24 hours.

<table>
<thead>
<tr>
<th>Science content as a major component</th>
<th>of the professional science education course</th>
</tr>
</thead>
</table>

Table 5 lists institutions at which science content has a prominent role in the science education course. It should be noted there is no sharp distinction between these courses and some of the professionalized science courses in Table 4.
Albany State College.—"Methods and Materials in Elementary Science," a three-credit professional course, is required in addition to 20 quarter-hours of science. A large proportion of time in this course is devoted to laboratory exercises dealing with such topics as "tiny animals," "magnetism," "surface of the earth," etc. During laboratory sessions groups of students rotate among five stations prepared by the instructor. Each station is equipped with materials selected to develop concepts related to the topic under consideration. Examinations given to students emphasize applications of these concepts. Excerpts from one of the topic sheets distributed to students appear in Appendix B, Item 2.

Teachers College, Columbia University.—"Science in Childhood Education" is a two-semester graduate sequence in which science content is closely integrated with methodology and philosophy of science education. In each course a series of science topics is considered. Excerpts from the prospecti of these courses and excerpts from an outline of one of the science topics studied are in Appendix B, Items 3 and 4, respectively.

University of Louisville.—Approximately 25 percent of class time in the science education sequence is devoted to study of science topics. For each topic students are given material listing major concepts, vocabulary, guiding questions, and main subtopics. Guided by these, students devote a month to background reading, at the end of which time an objective-type test is administered. Excerpts from one of the guide sheets and an abridged course outline appear in Appendix B, Items 5 and 6, respectively.
<table>
<thead>
<tr>
<th>Institution</th>
<th>Descriptive notes on science coverage</th>
<th>Administrative notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albany State College</td>
<td>Large proportion of class time devoted to lab exercises on selected science topics</td>
<td>Required in addition to twenty-two quarter hours of science</td>
</tr>
<tr>
<td>Duke University</td>
<td>&quot;Science in the Elementary School&quot;: emphasis on physical science content; lab work emphasizes &quot;measurement processes of science.&quot;</td>
<td>Few persons entering this course have college background in science courses other than biological science.</td>
</tr>
<tr>
<td>New Mexico State</td>
<td>Purpose is to organize and synthesize materials from college courses along lines suitable for elementary teachers; emphasis on experimental nature of science</td>
<td>Taken in senior year after students complete regular science requirements</td>
</tr>
<tr>
<td>University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Texas State</td>
<td>&quot;Science for Children&quot;: New course to deal in part with subject matter appropriate for elementary schools; lab work to emphasize materials available to elementary schools</td>
<td>Three lectures and one two-hour lab each week; students to use curriculum laboratory containing elementary texts, tradebooks and courses of study</td>
</tr>
<tr>
<td>University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rutgers University</td>
<td>Physical science topics taught in such a way as to serve as example for future elementary teachers; students required to keep a note file on semi-technical and non-technical science articles</td>
<td>Largely graduate enrollment; science methodology is considered in same course as mathematics and physical education methodology; extent of science coverage varies with instructor</td>
</tr>
</tbody>
</table>
### TABLE 5 (Contd.)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Descriptive notes on science coverage</th>
<th>Administrative notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers College Columbia</td>
<td>Year sequence, &quot;Science in Childhood Education&quot;; methods combined with content; provides background information corresponding to that found in elementary science textbooks; recent science developments considered</td>
<td>All courses at graduate level</td>
</tr>
<tr>
<td>University of Louisville</td>
<td>&quot;Natural Science 465&quot; and &quot;Natural Science 466&quot;; biological topics considered in first course; physical science topics in second course</td>
<td>&quot;Natural Science 465&quot; required, other course optional; approximately 25 percent of class time devoted to study of science content in each course</td>
</tr>
<tr>
<td>University of Southern Mississippi</td>
<td>Subject matter selected to meet interests and needs of elementary children; students work with simple apparatus and audio-visual resources (two-quarter sequence)</td>
<td>Pre-requisite: sixteen quarter hours of science, meets twice weekly for lecture and twice weekly in double period lab sessions; students have access to an elementary curriculum laboratory</td>
</tr>
</tbody>
</table>

**Note:** A required assignment in many elementary science education courses is the development of a teaching unit or a resource unit (Table 11) in an area of science. Such an assignment would provide some exposure to science content.
An assignment required in many elementary science education courses is development of a teaching unit in an area of science. Some exposure to science information would be involved. In other courses emphasis is placed on compilation of teaching ideas — resource units, demonstrations, displays, audio-visual materials, etc. Such practices will be treated in sections which follow.

Science courses or course sequences not designed especially for teachers but which are considered particularly appropriate for teachers

A number of respondents referred to general education science courses offered at their institutions which, because of organization, sequence, or some other characteristic, are thought to be especially suitable for elementary majors. These courses are summarized in Table 6.

Arizona State College. — Elementary majors are required to complete 17 semester hours in the following courses:

Physical Science 125 — Man and His Physical World — Principles, techniques and facts from the fields of astronomy, chemistry, geology, meteorology and physics which affect everyday living in the complex world of today. (4 hours)

Biology 126 — Man and His Biological World — An Introduction to the physico-chemical functions of life and the biotic environment, and the origin and diversity of living forms. (4 hours)

Anthropology 151 — General Anthropology: Origin and Antiquity of Man — Introduction to human biology and evolution of the primates, including man. (3 hours)

Biology 307 — Field Biology — To acquaint elementary education majors with ecology and systematics of the more common groups of plants and animals. (2 hours)

Geography 305 — Earth Science — A study of the earth, its structure, motions, atmosphere (weather and climate) and oceans. (2 hours)

Science 321 — Philosophy of Science (2 hours)
<table>
<thead>
<tr>
<th>Institution</th>
<th>Course, or course sequence</th>
<th>Descriptive notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona State College</td>
<td>physical science, biology, anthropology, field biology, earth science, philosophy of science</td>
<td>See pg. 66 for course descriptions</td>
</tr>
<tr>
<td>Ball State Teachers College</td>
<td>&quot;Introduction to Biological Science,&quot; &quot;Civic Biology and Conservation,&quot; &quot;Elements of Physical Geography,&quot; &quot;Physical Science,&quot; and &quot;Development of Physical Science.&quot;</td>
<td>All courses include laboratory and field work considered useful for elementary teachers</td>
</tr>
<tr>
<td>Colorado State College</td>
<td>physical science, biological science, earth science</td>
<td>Courses offered in the General Science Department</td>
</tr>
<tr>
<td>Eastern Michigan University</td>
<td>biology, physical science</td>
<td>No details provided</td>
</tr>
<tr>
<td>Moorhead State College</td>
<td>physics, chemistry, biology, philosophy of science</td>
<td>Courses designed &quot;...for general education for the adult citizen.&quot;</td>
</tr>
<tr>
<td>San Jose State College</td>
<td>&quot;Science Education 10A and 10B&quot;; physical science</td>
<td>10A includes topics in plant and animal science with ecological approach; 10B deals with topics selected from earth science</td>
</tr>
<tr>
<td>State College of Iowa</td>
<td>biology, physical science</td>
<td>No details provided</td>
</tr>
<tr>
<td>Troy State College</td>
<td>&quot;Bio-Social Development of the Individual&quot; (two-quarter sequence); &quot;Physical Science&quot; (three-quarter sequence)</td>
<td>The former combines concepts of biology psychology and sociology; the latter includes topics from physics, astronomy, chemistry, meteorology and geology.</td>
</tr>
</tbody>
</table>
TABLE 6 (Contd.)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Course, or course sequence</th>
<th>Descriptive notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Bridgeport</td>
<td>&quot;Basic Concepts in Biological Sciences,&quot; &quot;Basic Concepts inPhysical Sciences&quot;</td>
<td>No details provided</td>
</tr>
<tr>
<td>University of Colorado</td>
<td>biological science (one year sequence), physical science, earth science</td>
<td>No details provided</td>
</tr>
<tr>
<td>University of Denver</td>
<td>&quot;Science in Modern Life&quot;</td>
<td>General education course in chemistry, physics and biology</td>
</tr>
<tr>
<td>University of Miami (Florida)</td>
<td>biological science, physical science (two terms in each)</td>
<td>Non-laboratory courses; video-taped lectures</td>
</tr>
<tr>
<td>University of South-Western Louisiana</td>
<td>physical science (two-term sequence) general biology, human biology</td>
<td>No details provided</td>
</tr>
<tr>
<td>Winona State College</td>
<td>physical science, earth science human biology, general biology</td>
<td>Any of these courses may be waived if student plans to take advanced courses in same field.</td>
</tr>
</tbody>
</table>
San Jose State College.-- The respondent reports that his institution is "one of a few" with a Science Education Department established in the science division:

Our science education and education departments feel that the science background of future elementary school teachers should be related to the understanding needed by average people and is best acquired in a pragmatic context. Our science education courses are therefore tailored to the needs of the elementary school teacher who teaches in a self-contained classroom. The basic foundation courses are general courses as well as teacher education courses.

Troy State College.-- An interdisciplinary general education is described in material forwarded by the respondent:

The Bio-Social Development of the Individual: Six credit hours each quarter. Required of all freshmen. Credit will be listed on transcript as: biology 9 hours, psychology 6 hours, sociology 3 hours.

The content of this course was originally chosen by the technique of a three-way survey: (1) of student interest, (2) of textbooks in sociology, biology, and psychology, and (3) of the opinions of competent judges. The Mooney Check List was among the instruments used to survey student needs. Those problems or topics which were found to be emphasized in all three areas were included in the course. Chief among these are: human development; biological and social factors that may facilitate, inhibit or distort development; biological, psychological, and social needs, the conflicts that arise in the satisfaction of these needs; democracy in contrast to other forms of human relationships; the impact of rapid change; [on] social institutions; (etc.).

University of Miami.-- The University College offers four three-credit courses which are believed to provide a "unique breadth" of background. There are two courses each in physical and biological science:

These courses...are presented in a special building designed as an instructional and materials center. Four instructors design the courses, and lectures are video-taped about one week in advance and then projected from a central projection area via rear-screen technique into four classrooms, each having about three hundred students. Members of the Natural Science Department are in each of the classrooms during projection. There are voluntary seminar
sections, conducted by the staff, meeting several times a week for individual help, counseling, ...(etc.).

For some elementary majors a special laboratory was set up experimentally in 1963-64, conducted by a science education specialist on partial release to the University College. Students were provided opportunities to work with materials related to course content but appropriate also for children. The extension of this experience to all elementary majors was expected in 1964-65.

Winona State College.— A 13 quarter hour sequence is described:

"Physical Science" (4 credits): Elements of physics, chemistry, and astronomy serve as subjects to provide a background for understanding the scientific and technological advances of the present.

"Earth Science" (4 credits): Introduction to the physical aspects of earth, solar relationships, locations on sphere, projections, climates, landforms and processes, the earth's history.

"Human Biology" (2 credits): A basic study of the essential facts of human anatomy and the functioning of parts of the human body.

"General Biology" (3 credits): A generalized approach to living things with emphasis on scientific method, biological principles and survey of living things.

Arrangements in which elementary majors may take science courses in addition to minimum requirements

At several institutions elementary majors must include academic majors, minors, or fields of concentration in their curriculum design. While the student must have a minimum number of credits in science, as well as in other subject areas, he may elect additional science to satisfy the "concentration" requirement. The arrangements at schools reporting this are summarized in Table 7.
### TABLE 7. -- Summary of arrangements by which elementary majors at some institutions may take science courses in addition to the minimum requirement

<table>
<thead>
<tr>
<th>Institution</th>
<th>Arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado State College</td>
<td>Elementary majors must have a 27-credit minor, or two 15 credit concentrations, for which they may elect science (9 qrtr. hrs. science required).</td>
</tr>
<tr>
<td>Fort Hays Kansas State College</td>
<td>Elementary majors must have two areas of concentration -- one or both of which may be in science (ten sem. hrs. required).</td>
</tr>
<tr>
<td>Sam Houston State Teachers College</td>
<td>Elementary majors may choose science for a required 24 semester hour minor (12 sem. hrs. required).</td>
</tr>
<tr>
<td>State College of Iowa</td>
<td>Elementary majors must have 21 semester hours in a &quot;subject field&quot; which may be taken in science (10 sem. hrs. science required).</td>
</tr>
<tr>
<td>State University College at Oneonta (New York)</td>
<td>Elementary majors must have a 24 semester-hour field of concentration, which may be in science (18 sem. hrs. science required).</td>
</tr>
<tr>
<td>University of Alabama</td>
<td>Elementary majors must have 18 semester-hour concentration in a subject area, which may be science (14 sem. hrs. science required).</td>
</tr>
<tr>
<td>University of Southern Mississippi</td>
<td>Elementary majors may elect to take &quot;general science&quot; for a required 36 quarter hour minor (16 qrtr. hrs. science required).</td>
</tr>
<tr>
<td>University of Tulsa</td>
<td>Elementary majors must fulfill liberal arts requirements in a &quot;major area,&quot; which may be in science (12 sem. hrs. science required).</td>
</tr>
</tbody>
</table>

**Note:** California certification requirements specify that elementary teachers must have an academic major and minor -- one or both of which may be elected in the sciences.
Counseling of Elementary Majors into Appropriate Science Courses

Trenton State College.-- Students may select two courses from introductory offerings (physics, chemistry, astronomy, meteorology, general biology, and philosophy of science) to satisfy requirements. Advisors refer to students' high school science backgrounds in helping them select appropriate courses.

(A similar procedure was reported from the University of Georgia and the University of Nevada.)

Troy State College.-- An "extensive" testing program, coupled with a student advisory service is utilized to a great extent with all elementary education majors. Upper level courses in science are recommended to outstanding students thus identified, or to those who otherwise indicate above average interest and ability in science.

Pennsylvania State University.-- Nine hours of biology and chemistry are required. In addition, students are encouraged to take courses in meteorology, geology, physics, astronomy and physical science. In the first three areas, courses designed for non-majors are available.

(Several respondents noted on their questionnaire that certain science courses on their campuses are regarded as especially suitable for elementary majors by virtue of a special emphasis or quality imparted by particular instructors. Thus, one respondent urges his advisees to enroll in a particular microbiology course because of problem solving character of the course; another recommends the general physics course at his institution because the instructor is a dynamic, inspiring person.)
Summary and Discussion of Practices Reported Corresponding to Criterion 1

Minimum requirement and distribution practices.-- Practices relative to the minimum number of credit hours of science required of elementary majors range from virtually none at one institution in the sample to 18 semester hours at two schools. Forty-two of 85 institutions compared in this respect (Table 1) require 12 or more semester hours of science. Of the 43 schools requiring less than 12 semester hours, 16 schools require 10 or 11 semester hours while only 9 schools require 6 credits or less.

As indicated on Table 1, schools requiring a higher number of science credits (12 or more) do not necessarily provide their elementary majors with a better balanced science coverage than do schools which require less work in science. The most frequent distribution practice, for instance, is requirement of a course (or courses) in both biological and physical sciences. The proportion of institutions specifying this distribution is only slightly higher among those which require 12 semester hours of science (59%) than those requiring less than 12 semester hours (49%).

Only 17 schools represented in Table 1 require course work in biological, physical and earth science. This includes 21% of those institutions requiring 12 semester hours or more of science and 19% of those requiring less than 12 hours. Only 5 of 15 schools requiring more than 12 semester hours (Table 2) specify biological, physical and earth science.

Even this latter requirement does not ensure that each of the six
areas of science listed in Criterion 1 (biology, chemistry, physics, astronomy, geology and meteorology) receive attention (see footnotes "b" and "e" to Table 1.)

The following situation exists among the institutions studied:

1. At least 44 schools offer a fused biological science course or course sequence.
2. At least 38 schools offer a fused physical science course or course sequence.
3. At least 12 schools offer a fused earth science course.

In addition, at least five institutions provide a general science sequence which includes material from the biological, physical and earth sciences.

It must be assumed that where elementary majors are not required to take courses in each of these areas, the majority of students preparing for elementary certification in that institution will not have a balanced science background.

Specially designed courses for elementary education majors.---

A number of institutions provide science courses which are designed for elementary majors. These courses may be classified as "professionalized courses" -- which are usually in a sequence -- and "modified subject-matter courses" -- which are not ordinarily in a sequence.

The modified subject matter course (Table 3) places emphasis on content having general education value, and includes information which the instructor believes constitutes important background for teachers. The social significance and practical aspects are usually emphasized. Examples of this type course are found at Utah State University and at the University of Maine.
Professionalized courses are also designed to provide general background information, but in contrast to modified courses, there is greater emphasis on materials which could be used in elementary classrooms. All sequences listed in Table 4 would be considered professionalized science sequences. Seven of these sequences have been designed to introduce the student to content in the biological, physical and earth sciences.

Science content in science education courses.— In a number of institutions the professional science education course is designed, in part, to compensate for deficiencies in the student's science background. Several respondents reported that their efforts in the science education course are directed largely at teaching science content needed by teachers. Table 5 lists specific practices reported.

It is possible that such content-oriented science education courses fail to provide a background of professional information, theory, and philosophy needed by future teachers. This may be even more likely where the course is a single-term course, and particularly where the course carries only two credits.

Providing appropriate science courses.— Twelve respondents remarked that their institutions lack appropriate science courses for elementary majors. Comments include, "I regret that our science content courses are not very appropriate for general education or teacher education at the elementary level," "We are currently unhappy with the pattern of required courses," and "For the most part, available science courses are designed for future engineers and scientists and do not provide our elementary teachers with the type of content they need for effective teaching in the elementary school."
There is no ready solution to the problem of providing adequate science content coverage within a 12 to 14 semester-hour limitation in a four-year curriculum. Difficulties, moreover, cannot always be solved through raising the minimum science requirement. Such action might well involve a faculty in a large-scale revision of its teacher education program, in which it must be decided which existing requirements are to be eliminated to make room for the new ones. Complicating such a procedure, courses cannot be readily dropped if they are prescribed by the state certification agency.

Raising the science requirement, moreover, does not deal squarely with the problem of improving existing courses, or developing more appropriate courses to replace old ones. Such action is also fraught with complications, but it may well be a more realistic line of endeavor than attempting to increase the science load of elementary majors.

The problem of providing appropriate science courses for elementary majors has been approached in at least two ways, (1) development of general education courses, and (2) development of professionalized courses. A debate as to which is more desirable is pointless if it focuses on labels rather than course content and objectives.

Whether it be in a general education sequence or a professionalized sequence, the elementary major should be exposed to content in each of the previously designated fields of science. It is probably preferable to treat a limited number of topics in depth in these courses than to cover a wider range of material and risk superficiality. The topics should be selected on the bases of their being representative of our scientific heritage, having significance for contemporary direction in science, and dealing with matters of social significance.
The major distinction between the general education course and the professionalized course is that in the latter there is a more or less continual reference to children and the teaching of science in elementary classrooms. In both types of courses, the student should become acquainted with ideas and information designed to make him a more effective citizen. The need for a professionalized course is greatly diminished if a sound general education sequence is followed by a well designed professional science education course.

The science educator should find ways of communicating with personnel in the several science departments, and expressing as clearly as possible the subject-matter needs of elementary teachers. Building in a foundation of understandings, arrangements such as those suggested in the first two recommendations, below, might develop.

Providing for individual differences of students.— It is apparent that the high school science background of elementary teacher candidates is seldom considered in advising underclassmen into the most appropriate college level science courses. It is difficult to reconcile such practice with principles of educational psychology.

As well-conceived as some college science programs are with respect to the preparation of most elementary education majors when they enter college, the courses may be but little more advanced in content than many excellent high school science programs. Differences in student backgrounds, moreover, should become increasingly evident as high school offerings improve.

There may be considerable merit in those programs which require elementary majors to designate a subject-matter minor or area of concentration in addition to required general education background.
Persons electing to take their additional courses in science should not only develop greater competence for teaching science, but should be able to provide some leadership in science curriculum development at the level of the individual school.

Recommendations Evolving from a Study of Current Practices

1. A required sequence of science courses should be established which is specially designed for prospective elementary teachers in that (a) the major areas of science are considered, (b) laboratory experiences are provided which give the student an opportunity to manipulate materials appropriate for elementary schools, and (c) the student may participate in field work.

   -or-

2. A required general education science sequence should be established which, while not specifically oriented to the needs of elementary teachers, is designed to provide a non-technical science background in the biological, physical and earth sciences for the educated citizen. Laboratory and field experiences should be included.

In both recommendations above, the development of fused (or combined) courses is implied.

3. The recommendations above, notwithstanding, all students may not need the same sequence of courses. Sufficient data should be available on each student so that he is counseled into appropriate courses.

4. Science content should be emphasized to some extent in the professional science education course, but not to the exclusion of professional matters. Where science education courses must temporarily assume some responsibility for providing science content, the course should either be in a two-term sequence or carry sufficient credit to make the necessary task possible.

5. Elementary majors should be encouraged to elect additional science courses where this can be done. Advisers have a responsibility to guide promising students into such courses as "Conservation," "History and Philosophy of Science," "Field Biology," "Nature Study," "Human Biology," etc.


**Practices Reported Corresponding to the Second Criterion**

**Criterion 2:** Does the particular practice help the teacher understand some of the major principles of science to arrive at understanding by inductive experiences in the classroom, to understand phenomena in the "everyday environment" with respect to these principles, and to apply them deductively?

The majority of practices classified in this section were described on the first questionnaire item, which suggested to respondents, "What unique types of experiences make science principles meaningful to future teachers?" Some practices included in this section were reported elsewhere on the questionnaire than on item 1, particularly on item 2 which listed this sub-question: "What types of experiences do future teachers have in developing their ability to think inductively?"

**Classification of Reported Practices**

**Practices reported in science courses**

The relatively few practices corresponding to this criterion reported in science courses are summarized in Table 8.

**Western Washington State College** --- In addition to science courses required of all elementary majors (p. 59) is a three-quarter "methods and content" sequence: "Biology in the Elementary School," "Physical Science in the Elementary School," and "Earth Science in the Elementary School." Laboratory work in these courses is designed to develop understanding of scientific methodology, inductive thinking, and ability to interpret phenomena in the environment.

Illustrative of activities included in the biology course -- students develop an insect collection in applying these generalizations: "Life comes in many forms," and "In adapting to many environmental
<table>
<thead>
<tr>
<th>Institution</th>
<th>Course</th>
<th>Summary of practice</th>
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<tbody>
<tr>
<td>Western Washington State College</td>
<td>&quot;Biology in the Elementary School,&quot;</td>
<td>Laboratory work designed to develop understanding of scientific methodology and</td>
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<tr>
<td></td>
<td>&quot;Physical Science in the Ele. School,&quot;</td>
<td>inductive thinking; emphasis on interpretation of ordinary phenomena</td>
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<td></td>
<td>&quot;Earth Science in the Elementary School&quot;</td>
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<tr>
<td>East Carolina College</td>
<td>&quot;Physical Science (professionalized course)&quot;</td>
<td>Laboratory investigations designed to help students develop &quot;unifying concepts&quot;</td>
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<td></td>
<td></td>
<td>rather than &quot;isolated facts&quot;</td>
</tr>
<tr>
<td>Kansas State College at Pittsburg</td>
<td>&quot;Biology (general education course)&quot;</td>
<td>Techniques similar to those used in botany course at Ohio State, below;</td>
</tr>
<tr>
<td>The Ohio State University</td>
<td>&quot;Botany&quot; (two-quarter introductory sequence)</td>
<td>Lecture-laboratory periods; sessions often used in discussions developed between</td>
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<td></td>
<td></td>
<td>instructor and student relative to accurate observation and interpretation of</td>
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<td></td>
<td></td>
<td>demonstrated phenomena</td>
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<tr>
<td>University of Oklahoma</td>
<td>&quot;Botany&quot;</td>
<td>Similar to program at Ohio State, above</td>
</tr>
<tr>
<td>University of Pittsburgh</td>
<td>&quot;Biophysics&quot; (professionalized course)</td>
<td>Content designed...&quot;to give students understanding of the basic principles involved in science phenomena.&quot;</td>
</tr>
</tbody>
</table>
niches available to terrestrial organisms, insects speciate."

The Ohio State University. A botany course designed to develop inductive thinking and certain scientific habits was developed in the early 1930's by a team including the late Drs. Homer C. Sampson and Lewis H. Tiffany. The course has continued to the present, with modifications, and was adopted in some form at the University of Tennessee and the University of Oklahoma.

The course is designed to develop dialogues between the instructor and his students. These discussions emphasize careful observation and drawing of valid inferences from evidence, usually with reference to live plant material demonstrated in class. The classes, which meet daily, are restricted in enrollment to approximately 35 students.

Kansas State College at Pittsburg. A fused biology course taught by the respondent is developed along lines similar to the Ohio State botany sequence.

East Carolina College. With reference to a professionalized physical science course, the respondent writes:

Exercises in class discussions and in the laboratory are approached with an atmosphere of scientific inquiry. In order to think inductively some pre-developed concepts are necessary. Before a student can learn photosynthesis, he has to know certain facts. Is it better to omit the process of food-making until the student has had chemistry and learned to balance equations, or should it be taught involving chemical concepts without an emphasis on balancing equations? To avoid a forest of confusion we believe in unifying concepts and then investigating in order to arrive at a logical generalization or principle.

---

2 A description of the botany course, how it came to be developed and detailed descriptions of several lessons are found in: Homer C. Sampson and Lewis H. Tiffany, "The Methods Followed in the Teaching of General Botany," Service Studies in Higher Education, Monograph No. 15 (Columbus, Ohio: Bureau of Educational Research, Ohio State University, 1932).
Table 9 tabulates activities reported in elementary science education courses corresponding to criterion 2. Six categories of activities are recognized.

Instructor teaches sample lessons illustrating inductive process

Bowling Green State University. The respondent describes his lessons:

The experiments performed in class are usually of two types: demonstration experiments, and student participation experiments. In the former...the materials are carefully explained and then the experiment is performed. The students are asked to observe carefully and a number of them discuss what has happened. A problem is developed from this...and they go about trying to think their way through to a reasonable solution....Stress is placed upon the need to allow students to think.

In the participation type experiment, the class is divided into groups of three students and the material is handed out to each group....Each group proceeds to perform the experiment...and report upon its observations and a line of questioning is used to help the students arrive at a reasonable conclusion. The conclusions may be verified through a reference to literature or through other experiments.

Students then present a lesson to classmates, using similar techniques. The respondent continues:

Although the class recognizes that knowledge of the various science areas is essential to good teaching, the students also realize that the development of techniques directed toward growth in the process of inductive thinking is of basic importance.

University of Kentucky. The procedure is similar to that above:

One or more demonstration lessons illustrate inductive teaching technique. Typically, a silent demonstration is performed by the instructor. Afterwards, he attempts to elicit comments, identification of a problem, and suggestions for a tentative hypothesis to account for observed phenomena. Students are expected to observe carefully and to distinguish facts from inferences. The instructor avoids answering questions, but leads the discussion through asking questions.

One demonstration concerns buoyancy: the water content of a small screw-top jar is adjusted until the jar has very nearly the same specific gravity of cold water. The students observe the jar "barely floating" in a battery jar of cold water. A second battery jar of hot water is nearby. Students are led to speculate on whether
# TABLE 9

Tabulation of practices reported in science education courses designed to develop understanding of science principles and inductive and deductive thinking.

<table>
<thead>
<tr>
<th>Instructor teaches sample lessons illustrating inductive process</th>
<th>Instructor teaches sample lessons illustrating deductive process</th>
<th>Students teach lessons in which concepts or principles are developed</th>
<th>Students urged to apply principles to commonplace circumstances</th>
<th>Students develop a science unit organized about principles</th>
<th>Principles emphasized as students study selected science topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albany State College</td>
<td>X</td>
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<tr>
<td>Appalachian State Teachers Coll.</td>
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<td>Austin Peay State College</td>
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<tr>
<td>Bowling Green State Univ. (Ohio)</td>
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<td>Brigham Young University</td>
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<tr>
<td>Cornell University</td>
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<td>Harris Teachers College</td>
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<tr>
<td>Indiana State College (Indiana)</td>
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<td>Indiana State College (Penna.)</td>
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<td>Indiana University</td>
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<td>Lewis and Clark College</td>
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<td>Marshall University</td>
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<td>X</td>
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<td>Maryland State College at Towson</td>
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<td>Mississippi College</td>
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<td>Montana State University</td>
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<td>National College of Education</td>
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<td>X</td>
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<tr>
<td>Northern State Teachers College</td>
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<tr>
<td>New Mexico State University</td>
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</table>

- X indicates the practice was reported.
<table>
<thead>
<tr>
<th>Institution</th>
<th>Instructor teaches sample lessons illustrating inductive process</th>
<th>Instructor teaches sample lessons illustrating deductive process</th>
<th>Student teaches lessons in which concepts or principles are developed</th>
<th>Students develop a science unit organized about principles</th>
<th>Principles emphasized as students study selected science topics</th>
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<tr>
<td>Ohio State University</td>
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<td>Pennsylvania State University</td>
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<td>Rutgers University</td>
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<td>San Diego State University</td>
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<td>Sam Houston State Teachers Coll.</td>
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<td>St. Cloud State College</td>
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<td>Teachers Coll., Columbia Univ.</td>
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<td>University of Arizona</td>
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<td>University of Iowa</td>
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<td>University of Missouri</td>
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<td>University of Nevada</td>
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<td>University of Oklahoma</td>
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<td>University of Pittsburgh</td>
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</table>

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<table>
<thead>
<tr>
<th>Principles emphasized as students study selected science topics</th>
<th>Students develop a science unit organized on principles</th>
<th>Student urged to apply principles to commonplace circumstances</th>
<th>Student teaches lessons in which concepts or principles are developed</th>
<th>Instructor teaches sample lessons illustrating inductive process</th>
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**TABLE 9 (Contd.)**
the small jar will sink or float in the hot water, and why.

University of Kansas.— The respondent comments on his approach, similar to that described at the University of Kentucky, above:

Through this process it is hoped that they see the value of this type of teaching. For many it is the first time they have been exposed to it.

Instructor teaches sample lessons illustrating deductive process

The procedure usually involves presenting, or explaining, a given principle to a class, and following this up with an application of the principle.

University of Kentucky.— It is emphasized that the deductive process is complementary to the inductive process, and that an important value in learning principles lies in the ability one has to apply them to novel circumstances (a "problem situation"). After reviewing a principle, students are confronted with a situation to be explained in terms of the principle. They may be asked to explain a diagram or chart. It is emphasized that deductive teaching can utilize a problem approach.

Students teach lessons in which concepts or principles are developed

The most frequent practice is requiring students to select a principle, or concept, and demonstrating to their classmates how it may be taught to children. At some institutions students have an opportunity to teach science lessons to children.

Sam Houston State Teachers College.— Students are expected to apply principles to commonplace phenomena in their lessons. When teaching a lesson on expansion of metals when heated, for example, the student might refer to the relatively greater sag of telephones wires in
summer than in winter. Further, students are encouraged to identify relationships between the lessons they teach and their classmates.

**Winona State College.**—The respondent reports a "constant concern" with inductive methodology:

Students are challenged and encouraged to present their work in terms of "How can we stimulate students' interest so they will raise questions?" and "How can we lead children to do investigations such that they will arrive at generalizations?" This is achieved primarily through questions by myself as instructor and other class members as students make their presentations.

With respect to an assigned science topic, students are responsible for the following:

1. Developing a series of four lesson plans corresponding to four class periods
2. Constructing a concept chart showing concepts appropriate to a given level of maturity
3. Making a 20 minute demonstration to the class (related to the concept chart) designed to illustrate or prove a concept, or to help pupils generalize
4. Designing a bulletin board display relative to a concept in the chart

**San Diego State College.**—Students are urged to begin and end each lesson with applications of generalizations studied:

A problem that begins with an application is likely to be interesting and provide something concrete to hypothesize about. Application after activity broadens the generalization's meaning and usefulness.

**University of Kentucky.**—Students further their understanding of science principles in teaching sample lessons to children:

Each student is assigned to an elementary classroom in a local school for approximately fifteen hours of observation and participation. At the end of the observation, students are asked to teach a science lesson to children. The sample lesson must be designed to develop a science concept, or principle, and to involve children in a problem situation.
Students urged to apply principles to commonplace circumstances

These are, of course, deductive exercises, but unlike practices listed in the second category of Table 2, respondents did not indicate that a purpose of these practices was emphasizing the nature of deduction.

University of Pittsburgh.—Prospective teachers are taught to orient their pupils to their environment — to relate science principles to events in the home, community and school. Teachers are encouraged to utilize community resources and ordinary materials in science teaching.

University of Arizona.—The respondent writes:

In our science methods class, teachers are constantly shown and asked to show for themselves how science relates to everyday life — for example, Bernoulli's principle, when studied, is applied to the aerator in a faucet, a carburetor, etc.

(Practices reported by other respondents are similar to those described above.)

Students develop a science unit organized about principles

Development of a science teaching unit is a required activity in many science education courses. The emphasis in this activity varies with the institution; in many cases it is on the development of science principles.

Winona State College.—Students develop four lesson plans corresponding to several principles (p. 87).

University of Kentucky.—Students develop teaching units based on topics and corresponding "important generalizations" recommended by
Principles emphasized as students study selected science topics

Noted elsewhere, a major portion of a number of science education is devoted to study of selected science topics. In several cases respondents report an emphasis on the principles associated with these topics. Detailed information was not provided.

Summary and Discussion of Practices Reported Corresponding to the Second Criterion

References to practices designed to help students develop understanding of science principles, or inductive and deductive thinking in science courses were rare. A number of respondents volunteered criticisms of science courses at their institutions charging "inappropriateness ...because of failure to expose students to broad, underlying generalizations in science" or from failure to teach skill in inductive thinking.

Personnel in education departments are apparently, in many cases, incompletely informed as to the methodology employed by teachers in the science departments. Generally, respondents who are teachers of science education courses offered little information relative to science courses, several remarking to the effect that science courses at their institutions emphasize "inductive process" or "principles" without providing further detail.

It would seem fitting, in view of the importance of these factors in the education of future teachers, that science educators not

3 Jacobson and Tannenbaum, op. cit.
only be acquainted personally with teachers of science courses, but that there be mutual understanding of teaching emphasis and procedure.

The botany sequence at The Ohio State University, designed to be an appropriate science course for the general student as well as the first course for the botany major, seems unusually well-suited to help students develop an understanding of principles and to develop skill in inductive thinking. In the more than thirty years since its inception, however, the course initiated on the Columbus campus has not been widely imitated. A reason for this, undoubtedly, is the relatively high expense of the program, occasioned by need for well-trained instructors, assistants, many instructional materials, and a low pupil-teacher ratio. It is also very likely that the rationale supporting the course is not widely understood.

Many students in institutions of higher education are apparently denied systematic opportunity to develop their abilities to reason inductively and deductively with respect to science. Courses designed to develop their understanding of broad principles, as well as to provide them a fund of information were reported by comparatively few respondents. It is particularly wasteful that future teachers should not benefit from such experiences.

Data received on questionnaires suggest that arrangements to introduce future teachers to science principles and inductive and deductive thinking are more likely to be found in the science education courses than in science courses.

The most frequently reported practice is presentation by the instructor of one or more lessons using inductive teaching methods. By contrast, few respondents reported that science lessons were taught
illustrating deductive procedure. In any event, these lessons would be illustrative only, and do not pretend to develop depth of understanding on the part of the student.

Several respondents reported that following the illustrative lesson, students are required to develop similar lessons of their own. These lessons are usually presented to classmates, but at a few institutions students have an opportunity to teach them to children.

Science principles are occasionally emphasized in those science education courses which are science content-oriented, but not often.

In many science education courses, students are required to construct teaching units or resource units. Assignment of a unit may be to accomplish any one of several instructional purposes, among which may be furthering the student's understanding of science principles.

Generally, emphasis on understanding of principles and development of skill in inductive and deductive thinking appears to be neglected in professional education courses, though not so much perhaps as in science courses. The science educator often places greatest emphasis on such matters as manipulation of science equipment, science curriculum organization, and supplementing the students' fund of science information. It is conceded that these considerations are important, but, judging from responses on the questionnaire, it would seem that an examination of relative emphasis in science education courses is in order at some institutions.
Recommendations Evolving from a Study of Current Practices

6. Every elementary education major should have available to him a series of science courses which, among other things, have been designed to develop the student's ability to reason inductively and deductively. In these courses, students should have many opportunities to observe phenomena and develop skill in inferential thinking relative to these phenomena. Group discussions, led by a skilled instructor, may be the most important component of such courses.

7. The instructors of science courses should identify those principles which are basic and put particular instructional emphasis on these. Students, by means of carefully designed lectures, discussions, laboratory experiences, and long-term projects, and imaginatively selected readings, should not only develop depth of understanding of a relatively limited number of generalizations, but should gain an appreciation of the intellectual accomplishment embodied in these principles.

8. Depending on institutional limitations and tradition, the courses which place substantial emphasis on development of principles and inductive-deductive thinking processes should be either general education science courses provided for all non-science majors, or courses especially designed for elementary teachers (professionalized courses). Because this special emphasis, even when given to only selected topics, consumes much instructional time, it is likely that some breadth of subject matter coverage will have to be sacrificed.

9. The science educator, building on a foundation established in academic science courses, should accept these responsibilities: (a) helping future teachers become aware of the way science principles can be used in the selection and organization of content for teaching children and (b) helping future teachers further consider inductive and deductive processes relative to the teaching of science to children.

4 Recommendations appearing throughout Chapter IV are numbered consecutively.
Practices Reported Corresponding to the Third and Fourth Criteria

Criterion 3: Does the particular practice provide the teacher with an opportunity to develop skill in the use of common laboratory materials and techniques?

Criterion 4: Does the particular practice familiarize the teacher with a variety of materials and their appropriate use which, in addition to science materials and facilities, includes science literature, films, tape recorders, television, still pictures, maps, community resources and teaching machines?

Because practices satisfying one of these criteria often satisfy the other, practices corresponding to them are treated together. Responses corresponding to these criteria were most often described under item 1 of the questionnaire, under which the following questions were placed: "How are future teachers helped to develop skill in the selection and use of simple science equipment?" and "What experiences acquaint students with science teaching resources?"

Classification of Practices

Provision for teachers to become familiar with science materials and techniques are provided in both science courses and science education courses.

Practices reported in science courses

Table 10 summarizes arrangements reported in science courses through which elementary majors develop familiarity with science materials and laboratory skills. Most of the courses listed in Table 10 are professionalized courses designed especially for elementary majors or for prospective elementary and secondary teachers.
TABLE 10.--- Summary of activities reported in science courses through which elementary education majors develop laboratory skills and familiarity with science resources appropriate for elementary classrooms

<table>
<thead>
<tr>
<th>Institution</th>
<th>Course, or courses, and descriptive notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austin Peay State College</td>
<td>Laboratory in professionalized science courses (Table 4)</td>
</tr>
<tr>
<td>Montana State University</td>
<td>Laboratory in professionalized science courses (Table 4)</td>
</tr>
<tr>
<td>Northern State Teachers College</td>
<td>Laboratory in professionalized science course (Table 3)</td>
</tr>
<tr>
<td>St. Cloud State College</td>
<td>Laboratory in professionalized science courses (Table 4)</td>
</tr>
<tr>
<td>San Jose State College</td>
<td>Laboratory, use of audiovisual devices and field trips emphasized in general education courses in biology and physical science</td>
</tr>
<tr>
<td>Trenton State College</td>
<td>Laboratory in professionalized science courses (Table 4), students perform demonstrations before classmates</td>
</tr>
<tr>
<td>Troy State College</td>
<td>Laboratory in professionalized science courses (Table 4), students examine elementary science resource literature</td>
</tr>
<tr>
<td>University of Iowa</td>
<td>Laboratory in professionalized science courses (Table 4)</td>
</tr>
<tr>
<td>University of Kentucky</td>
<td>&quot;Nature Study&quot;: elective course, activities include identification of specimens, field trips, preparation of teaching aids</td>
</tr>
<tr>
<td>University of Maine</td>
<td>Natural history courses available as electives (Table 3), field trips and collecting</td>
</tr>
<tr>
<td>University of Miami</td>
<td>Special laboratories for elementary majors offered in conjunction with general education science courses (Table 6)</td>
</tr>
<tr>
<td>Institution</td>
<td>Course, or courses, and descriptive notes</td>
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<tr>
<td>University of Pittsburgh</td>
<td>&quot;Biophysics&quot; (Table 4), emphasis on techniques and methods useful in explaining science phenomena</td>
</tr>
<tr>
<td>University of Southern Mississippi</td>
<td>Laboratory in professionalized science courses (Table 4), study of elementary science texts, audio-visual resources, field trips</td>
</tr>
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<td>Utah State University</td>
<td>&quot;Forestry 110&quot; - field trips examination and preparation of curricular materials</td>
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<tr>
<td>Western Washington State College</td>
<td>Laboratory in professionalized science courses (Table 4)</td>
</tr>
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<td>Winona State College</td>
<td>&quot;Nature Study&quot; - elective course, activities include identification of specimens, &quot;investigative projects,&quot; field trips</td>
</tr>
<tr>
<td>Wisconsin State College at Oshkosh</td>
<td>Laboratory in professionalized science courses (Table 4)</td>
</tr>
</tbody>
</table>
University of Miami.— The televised general education science courses at Miami have been described (p. 69). On a trial basis in 1963-64, special laboratory sections for elementary majors were introduced in conjunction with these courses. Laboratory activities corresponded to lecture content, but materials used were those that might be used in elementary classrooms. An elementary science education course is also offered at Miami.

University of Maine, Utah State University.— The natural history courses offered at Maine and the forestry course at Utah State are described on pages 57 and 54, respectively.

Winona State College, University of Kentucky.— Elective courses in "Nature Study" are available for elementary majors. Courses at both institutions involve students in such activities as preparation of aquaria and terraria, collection methods, and field trips.

Northern State Teachers College.— The respondent describes the organization of "Physical Science for Elementary Teachers:"

1. Content is based on topics studied by elementary children.
2. Experiments, demonstrations, and investigations are planned and conducted by students.
3. Students are encouraged to use simple science equipment which would be available in any classroom, but commercial equipment is also used.

University of Southern Mississippi.— The respondent describes the laboratory arrangements in his professionalized course:

Two double periods per week are devoted to laboratory experiments, demonstrations, and chiefly audio-visual work consisting of slides, filmstrips, motion pictures, records, etc. in one class and chiefly field excursions in the other. All experiences are done with the simplest apparatus possible, using home appliances whenever possible. A departmental library is maintained with the most useful books and magazines....Several series of elementary science text-books are included.
St. Cloud State College.-- Elementary majors are required to take "Biology 326" and "Science 327." The respondent writes:

These courses cover the areas of biology and physical science, using the materials and concepts readily adaptable to the elementary school classroom. Students actually work with the materials, demonstrate with their equipment in the role of the teacher before the class, making certain the principle is clearly shown. They are required to construct some teaching aids which they can take with them, such as skulls of carnivores and rodents, galvanometers, cages, traps, insect collections, [etc.]... Students are required to make a "science calendar" of observations related to objects, events, and/or phenomena. These are to be observations in the environment and of everyday events generally not referred to in books. During some quarters students will be required to do some kind of individual study, possibly a survey, which may be usable in an elementary classroom.

San Jose State College.-- Laboratory arrangements in the professionalized science courses are described:

1. Laboratories use the "station" format, i.e., each station has a set of materials or equipment. Students go from station to station and work out laboratory problems at each.
2. The guide sheets emphasize individual and small group work by students.
3. The laboratory format minimizes "telling" by the instructor and emphasizes student self-learning.

A series of science education courses are available to elementary majors at San Jose (pps. 106 and 108). The respondent writes:

In all courses we stress first-hand contact with and use of materials and equipment....Considering all courses together, the following experiences are covered: study of the literature of elementary science, with laboratory to test the author's experiments, ideas and approaches against a set of criteria; study of and testing in laboratory of science experiments described by a variety of authors; study of and practical experience in procedures suggested by various authors in caring for and using living biological specimens; study in and practical experience in a variety of techniques for preserving and preparing biological specimens for study; and practice in a variety of laboratory techniques for preparing teaching equipment and specimen mounts.

(Both professionalized science courses and science education courses are available to elementary majors also at Northern State Teachers College, the University of Iowa and Wisconsin State College at Oshkosh.)
Table 11 is a tabulation of practices reported in elementary science education courses through which elementary majors can develop laboratory skills and familiarity with science equipment and other resources for science teaching. These practices can be classified into 7 categories. All practices included in elementary science education courses involving use of materials suitable for science teaching are tabulated in Table 11, although some of these practices were described by respondents elsewhere on the questionnaire than on the first item. Further details on some of these practices will appear in later sections.

Students perform exercises and manipulate materials during laboratory periods.

In virtually all cases reported, priority is given to the use of commonplace materials considered appropriate for elementary science teaching, such as homemade equipment, household items, simple commercial apparatus, etc.

University of California at Santa Barbara.— The elementary science education course is content-oriented, including consideration of such topics as "chemistry for children," "astronomy," etc. Lectures twice weekly are followed by laboratory sessions in which students set up related demonstrations. An elementary science resource book is used for the text. Equipment provided for laboratory work includes three mobile laboratories, several science kits and auxiliary equipment.

Temple University.— A newly organized course, "Science in the Elementary School," was offered Fall, 1964. There are two videotape lectures and one laboratory period each week. Twelve of the fourteen

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TABLE II. -- Tabulation of activities reported in elementary science education courses through which elementary majors develop laboratory skills and familiarity with resource materials for teaching science

<table>
<thead>
<tr>
<th></th>
<th>Students perform exercises</th>
<th>Students teach science lessons to classmates or to children</th>
<th>Students develop units, or compile a file of science exercises</th>
<th>Students examine elementary science books, curriculum guides, resource materials</th>
<th>Students take field trips, use community resources</th>
<th>Students conduct minor projects, develop science fair exhibits, etc.</th>
<th>Students use variety of audio-visual resources</th>
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TABLE 11 (Contd.)

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<th>Students teach science lessons to classmates or children</th>
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<th>Students examine elementary science books and curriculum materials</th>
<th>Students take field trips, use community resources</th>
<th>Students conduct minor projects, develop &quot;science fair&quot; exhibits etc.</th>
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TABLE 119 (Contd.)

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<th>Students perform exercises, manipulate materials during laboratory</th>
<th>Students teach science lessons to classmates or to children</th>
<th>Students develop or compile a file of science exercises</th>
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laboratories involve students in activities and corresponding to areas of science included in an elementary science education text: \(6\) forces, motion and machines; chemistry and heat; magnetism, static and current electricity, etc. The first two laboratories are devoted to the topics "materials and resources" and "methods."

Duke University.— Money has been invested in all science equipment that North Carolina approves for N.D.E.A. purchase for grade school use. A required two-credit course operates on a workshop-type organization. The respondent has developed a junior high school course titled "Quantitative Physical Science." The course at present includes 35 laboratory exercises which emphasize measurement process. The exercises have been named "Manipulative Learning Operations" (\(\text{MLO}^6\)s). The respondent writes:

It appears that a selection of these, carefully chosen, will serve ideally to prepare the prospective or existing grade-school teacher with as solid a foundation for teaching science as we can furnish in the very limited college-course time available. Some of these MLO's might be adapted for use in the grade school, but our immediate objective is development of knowledge and skill \(\text{of} \) the teacher.

Pennsylvania State University.— The relationship between materials and problem solving is emphasized:

In setting up demonstrations students are instructed to first clearly identify the problem and secondly to consider what materials are needed, considering the degree of control and accuracy required to answer the problem.

University of Nevada.— Laboratory experiences will be emphasized in a modern science classroom being developed in the department of elementary education. The new facility will contain much equipment suitable for elementary classrooms.

\(6\)Slough, et al., \textit{op. cit.}
Students teach science lessons to classmates or to children

Although this activity was in nearly all cases reported elsewhere on the questionnaire than on the first item, it is included in Table 11 because it often provides the future teacher an opportunity to manipulate materials in a relatively realistic situation. In some instances this demonstration teaching is part of a science unit developed by the student. The teaching is usually designed to develop a specific concept, and emphasis is placed on selection of appropriate demonstration materials. Only one example is singled out at this point:

University of California at Santa Barbara.— The emphasis is on preparedness. The respondent writes:

Each student comes to the lab ready to teach a lesson from the major topic....Being ready means being READY. They must have everything they need down to the last match....Each week they are graded on their materials and plan. Some are selected to teach their lesson while the rest role-play. Discussion is held on the good and bad points of the lesson. They do not know who will be chosen so all must be ready.

Students develop teaching units or compile a file of science exercises

Again, these activities are usually reported in other places on the questionnaire than on the first item, but they are cited at this point because they would necessarily involve the student in a consideration of science resource materials.

At several institutions students are required to develop a resource unit corresponding to an assigned science topic. A resource unit, which may or may not represent a teaching sequence, consists of many instructional ideas and resources: demonstrations, field trips,
visiting speakers, films, recordings, pictures, books, etc. Such units are usually assembled by several students working in a committee, who duplicate their final product for class distribution. Students are encouraged to improvise demonstrations from readily available materials as well as to learn how to use commercial laboratory apparatus.

**University of Kentucky.**— Until the school year 1964-65 students prepared science resource units on assigned topics. The first section in these units was a list of principles which children can develop through study of the topic. Students keyed each activity described in their unit to one or more of these principles to develop the habit of associating demonstrations, audio-visual resources, etc., with concept development.

Feedback from student teachers (student teaching follows the course in science education) indicated that students would prefer development of teaching units to resource units, inasmuch as the former is felt to be "more useful." The students' suggestion was adopted.

**University of Bridgeport.**— A science and social studies methods course is completed in a four-week period, during which time students meet some 30 hours per week. Attention is given to teaching materials in the development of a resource unit. (Excerpts from the course outline appear in Appendix B, Item 7.)

(Resource units are developed also at Fort Hays Kansas State College, State College of Iowa, San Jose State College, and Marshall University. Notebooks, or file-card collections, listing demonstrations are developed by students at Bradley University and Western New Mexico University.)
Mississippi College.—Students develop "shoe-box" demonstrations. The shoe boxes are intended as a means of enrichment for "exceptional," or highly motivated children.

Each shoe box has equipment and directions necessary to complete a simple discovery. A child may become involved with a "box" at the discretion of the teacher.

Students examine elementary science books, curriculum guides, and other resource material.

Florence State College.—The respondent lists the following activities included in the science education course:

1. Development of lists of free and inexpensive materials that are readily available
2. Development of lists of science books that the teacher should have for reference

San Jose State College.—One of the courses available to undergraduates in the Science Education department is "Sci. Ed. 106," which has as its subject "Elementary Science Literature."

Moorhead State College, University of Kentucky.—Students examine elementary science books (other than texts) in required library science courses.

(Science trade books are reportedly available for student examination also at Rhode Island College, Albany State College and North Texas State College. A number of respondents reported that curriculum laboratories containing children's texts and tradebooks as well as teacher references are in existence, or are being developed at their institutions.)

(Relatively few respondents mentioned the use of a specific elementary science education text used in conjunction with their courses. It can probably be assumed that one or more texts are used
in conjunction with most courses. Inasmuch as the texts in widest usage consist largely of science content with suggested activities for the elementary classroom, students would be exposed to materials, at least vicariously, through the use of these texts. Students at Newark State College and the University of Kentucky become acquainted with a variety of professional texts; no single text is used. Students in other courses are expected to refer to texts other than the one specifically required by the instructor.)

Students take field trips, encouraged to use community resources.

Pennsylvania State University.—Science education students take field trips to ponds, streams, strip mines, etc.

Wisconsin State College at Eau Claire.—Students take field trips to nearby 200-acre Putnam Park to observe ecological relationships and seasonal changes.

Loyola University.—Students visit science fair exhibits.

Harris Teachers College.—Representatives of various community agencies are invited to speak to classes. Guests include representatives from the conservation commission, the Academy of Science, St. Louis Botanical Garden and the Committee for Nuclear Information.

University of Louisville.—A member of the Junior Astronomical Society addresses the science education class about telescopes and the activities of the society.

Eastern Michigan University.—Students are encouraged to assist in school camp situations for a one-week period. Many area camps use students.
San Jose State College.-- One of several elective courses is "Science Education 147: Field Trips in Natural History."

Students conduct minor projects, develop "science fair" exhibits, etc.

Wisconsin State College at Eau Claire.-- Science education facilities permit students to carry on long-term experiments such as egg incubation and frog egg development. Ecological changes are noted on regular field trips.

University of Southwest Louisiana.-- Students are required to prepare a display of materials and suggested activities corresponding to a selected topic.

University of the Pacific.-- Students have an option of preparing a display, making a scientific collection, taking a field trip, or engaging in some other activity having implications for elementary science teaching.

San Jose State College.-- Two elective courses offered to undergraduates through the science education department are "Aquarium and Terrarium Animals" and "Science Experiments in the Elementary School."

(Opportunities for students to be involved in minor research projects will be discussed in greater detail in the section corresponding to the fifth and sixth criteria of the study.)

Students use a variety of audio-visual resources

University of Louisville.-- Students view video-tapes from an elementary science series. These "telecasts" and the manuals which accompany them are subsequently evaluated.

(Similar activity is undertaken at the University of Kentucky, where students may also view science telecasts in elementary classrooms.)
Telecasts are also viewed and discussed at the National College of Education.

**Winona State College.**—Students design a bulletin board display to help teach or reinforce a point or points related to concepts.

**Loyola University.**—Students prepare a bulletin board display on "current science."

**University of Miami.**—Special emphasis is placed on visual aids, including overhead projectors, film strips and films, programmed material, single-concept loop films and closed circuit television.

**University of Kentucky.**—When presenting their plans for a science unit to classmates, students must demonstrate resourcefulness in use of visual aids. Shortly after topics are assigned to groups, each group meets with the instructor for a half-hour conference. During this time the unit assignment is clarified and suggestions are made concerning availability of appropriate visual aids. Depending on the unit topic, students prepare transparencies for the overhead projector, 2 x 2 slides, bulletin boards, charts, puppets and mock-ups. Every committee has an opportunity to view motion picture films and film strips.

**Utah State University.**—Considerable emphasis is placed on preparation of audio-visual aids during unit development. Students are required to prepare a teaching model and a bulletin board display.

(Excerpts from "Assignment sheet for Ed. 109" appear in Appendix B, Item 8.)
Summary and Discussion of Practices Reported
Corresponding to Criteria 3 and 4

A concern common to elementary science educators is providing opportunities for elementary education majors to become familiar with science materials suitable for use in elementary schools and to develop appropriate skills. Activities designed to accomplish this can be classified into seven categories (Table 11) and are reported most often in elementary science education (professional) courses and in professionalized science courses.

The role of academic science courses in the development of such knowledge was less frequently mentioned by respondents. It can be assumed that these are accomplished to some extent in laboratory science courses taken by future teachers, but as indicated on questionnaires there are apparently many teacher education programs in which elementary majors are not required to take laboratory courses.

Elementary education majors should have available to them appropriate general education science courses, as discussed in preceding recommendations, which provide laboratory experience. While future teachers should certainly benefit "professionally" from experience with materials in such laboratories, it need not be the function of these laboratories to familiarize the student with materials adaptable to the elementary classroom. The laboratory associated with the general education science course has other important functions, to be treated in the section related to the fifth and sixth criteria.

Although another item on the questionnaire deals with such matters as "... (sensitization of) future teachers to children and their responsiveness to phenomena in the environment," and "... the relation-
ship of experience to conceptualization," an observation relative to these criteria is in order at this point.

The phrases in quotation marks, above, taken from questionnaire item 4, pertain to the relationships between science resource materials and the child's educational growth in science.

In dealing with science materials, is proper emphasis given to these relationships?

The institutions listed in Table 11 offer one or more courses in science education. An answer to the question, above, may be suggested by comparing the responses made by teachers of science education courses to item 4 of the questionnaire ("...helping the elementary teacher understand and apply learning theory to science teaching situations") to their discussions relative to the third and fourth criteria.

Questionnaires from 70 institutions can be so compared. In each case, students in the elementary science education course (Table 11) manipulate science materials.

In 45 of these 70 science education courses there is an apparent emphasis on both material resources and on the relationships of these to science learning of children. In 12 cases, the respondent has either not commented on item 4 or made a statement which was too brief to be meaningful. In 13 cases the respondent's discussion on item 4 had no apparent correlation to criteria 3 and 4.

In at least 25 of the 70 science education courses so compared, then, there may be an insufficient emphasis on the relationships of science resource material to the way children are motivated, the way they learn science, etc.

The responses on the questionnaire and interpretations given
them by the investigator may not, of course, give an accurate picture of the actual situation in elementary science education courses. It must be asked, however, if some science educators might be neglecting important professional implications while weighting their courses heavily with manipulatory exercises.

It is the opinion of the investigator that science educators should avoid requiring students to amass a repertoire of "things to do" while assuming that the relationships of these to the way children learn science are obvious to their students, or that developing such understanding is automatic.

In developing knowledge of science resource materials, together with an understanding of the significance of their use in teaching, the most promising practices appear to be those in which students use materials in a meaningful context, i.e., a situation that simulates as nearly as possible a situation the student will meet later as a teacher.

In many science education classes, for instance, students teach demonstration lessons to each other using appropriate materials. An even more meaningful situation would be one in which the student teaches one or more lessons to children. A few respondents reported that such opportunities are provided through their science education classes. This practice evidently enjoys considerable success where employed.

The student should also find the preparation of a teaching unit a meaningful activity. This unit should be developed according to educationally sound criteria and, if possible, should be adaptable for use during student teaching. These provisions should motivate the student to give careful attention to appropriate selection of materials.
While criterion 3 deals with the future teacher's development of skill in use of laboratory materials and techniques, the term "technique" didn't appear in the first questionnaire item, nor elsewhere. It is maintained, however, that the parenthetical questions under the first item strongly imply development of techniques.

In any event, few respondents referred to development of specific techniques. Perhaps science educators take for granted that laboratory techniques useful to the elementary teacher are learned in science courses, but this can be questioned.

Where, in the elementary education curriculum, should the future teacher develop appropriate laboratory techniques?

In view of this problem, and others revealed throughout this study, it is apparent that a spirit of cooperation between science educators and the instructional staff in science is necessary for the adequate preparation of elementary teachers to teach science.

Decisions as to what laboratory techniques are believed most useful for the elementary teacher and when they should be taught, for instance, can develop from discussions and cooperative arrangements (see recommendations).

An inference drawn after examination of questionnaires is that some science educators conceive their responsibility as providing background for elementary majors that they feel should be developed in regular science courses, but isn't. The great emphasis placed on compiling demonstration ideas and involving students in manipulatory exercises in a few science education courses is apparently an effort to compensate for alleged weaknesses of science courses made available to elementary majors, or to provide background in certain areas in which
students have not had formal course work.

It is here submitted that time devoted to familiarizing students with science apparatus and other instructional materials is largely meaningless for those who lack understanding of basic principles.

The position taken here is that the professional science education course should be developed on a foundation established in appropriate science courses. As specified in recommendations one through eight, this foundation should include information in each of the important science areas and an understanding of basic principles in each of these areas. (In institutions which offer professionalized science courses in lieu of, or in addition to, science education courses, it becomes feasible to combine teaching of basic principles with content of a professional nature -- methodology, teaching philosophy, use of unsophisticated materials, etc.)

It does not follow, however, that the science educator has no responsibility with respect to helping his students develop understanding of science principles. As future teachers study inductive and deductive teaching methodology, manipulate simple materials, develop unit and lesson plans, etc. they should be assisted in clearing up misconceptions and further developing understanding which can be applied to an ever-wider range of phenomena.

Recommendations evolving from a Study of Current Practices

10. The major responsibility for introducing future teachers to science equipment suitable for elementary science teaching should be accepted by the science educator in the elementary science education course or in the professionalized science course.

Science facilities and equipment should be available to students in their professional classes and arrangements made for students to use them.
11. The relationships of science materials to such considerations as (a) the child's development of concepts and principles, (b) involvement of the child in discovery, and (c) development of the child's skill in problem solving should be emphasized.

12. The responsibility of helping students to develop laboratory techniques should be shared by science educators and science instructors, particularly in institutions which do not offer professionalized science courses.

A procedure which might be attempted would first involve the compilation of a list of laboratory techniques and associated knowledges considered useful to elementary teachers. Corresponding to the biological sciences, for example, might be the following:

- Care and use of the microscope and micro-projector
- Preparation of temporary microscope slides
- Construction and care of aquaria and terraria
- Dissection techniques
- Handling and care of small animals and plants
- Making collections
- Identification of ordinary species of birds, mammals, trees, insects, reptiles, etc.
- Use of simple, artificial keys
- Knowledge of reference material to use in identification
- Where to look for various organisms on field trips
- Preparation of bacterial cultures

When such a list has been compiled arrangements should be made for inclusion of techniques in appropriate courses. Some would, or could, be included in regular science courses, or in special laboratory sections of regular science courses. Other techniques can be provided for in the professional or professionalized course.

13. Students in science education classes should be familiarized with a variety of teaching resources other than science equipment, e.g., elementary science textbooks and tradebooks, courses of study, teacher resource-books, audio-visual materials (including films, flat pictures, television, etc.) and programmed learning materials.

14. The value of community resources should receive attention in the science education course. A series of excursions in the science education or professionalized science course is advisable.
15. When students are becoming acquainted with various resources for elementary science teaching, the science educator should consider the context in which the learning is taking place. The situation should be meaningful; it should be related to problems of elementary school teaching.

**Practices Reported Corresponding to the Fifth and Sixth Criteria**

**Criterion 5:** Does the particular practice develop the concept of science as a human enterprise -- an effort on the part of man to interpret phenomena in the environment?

**Criterion 6:** Does the particular practice provide opportunity for the teacher to develop skill in scientific method, or reflective thinking, and associated attitudes including experiences in such activities as identification of problems, suggesting hypotheses, designing experiments, gathering data, willingness to listen to opinions of others, desire to withhold judgment until sufficient evidence is in, etc.?

These criteria were incorporated in the second item of the questionnaire:

`Describe practices in your institution which you feel are particularly effective in helping the elementary teacher understand and appreciate the nature of science.`

**Classification of Practices**

The practices reported in this section are arbitrarily classified into those reported in elementary science education courses and those practiced in courses other than science education. Table 12 tabulates practices reported in elementary science education courses. Some of the more completely described practices follow.

**Students confronted with a problem situation**

A number of respondents teach one or more lessons in which a problem is introduced. Generally, the entire class is involved in the
TABLE 12: Practices in elementary science education courses designed to help the elementary teacher understand and appreciate the nature of science

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<th>Appalachian State Teach. Coll.</th>
<th>Ball State Teachers Coll.</th>
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<th>Duke University</th>
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<th>Florence State College</th>
<th>Fort Hays Kansas State Coll.</th>
<th>Harris Teachers College</th>
<th>Indiana State Coll. (Penna.)</th>
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<th>Marshall University</th>
<th>Maryland State Coll. at Towson</th>
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**Legend:**
- X: Practice followed
- _: Practice not followed
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<th>Institution</th>
<th>Students Confronted with a Problem Situation</th>
<th>Laboratory Exercises Emphasize Scientific Methods</th>
<th>Students Involved in Class Projects</th>
<th>Students Work on Problems Alone or in Small Groups</th>
<th>Students Emphasize Problem-Solving in Unit Development and Lesson Planning</th>
<th>Students Study Curriculum Materials Which Emphasize a Methodology of Attitudes</th>
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<td>Students work on problems alone or in small groups</td>
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situation. An important component of the lesson is the discussion in which students are expected to play an active part.

**Indiana State College** (Indiana).-- The instructor devises problem situations both in the laboratory and in the field. In the laboratory, for instance, he may demonstrate a dust explosion and ask his students, "What has happened?...Why?" The instructor attempts to avoid "telling." With respect to outdoor exercises he writes:

> To me elementary science is really ecology — the relationship of the organism (the child) to his total environment. Hence it is that the teacher should understand the environment. (Here environment means the physical and biological.) For this reason I spend six of the eighteen weeks on a unit in ecology. We try to determine the effect of the physical and biological aspects of a number of different environments. The majority of this work is in the field observing what is there and trying to find out why.

At the same time the students are required to go on a two hour bird walk a week for six weeks. I am not interested primarily in the identification of birds but in observing the changing environment over the course of six weeks.

**University of Pittsburgh.**-- The respondent writes:

> I generally conduct an "experiment" in front of the entire class without comment, allowing them to observe, and then we begin to discuss various aspects of the demonstration after they have made a written statement listing the problem, the procedure, materials used, general hypothesis, etc. I find this to be very good in the sense that many people have difficulty in recognizing certain aspects of a demonstration or tend to overlook minutia at times. A very simple demonstration of a high and low pressure with respect to water can be very revealing for some students.

Subsequent discussions consider the use of the various senses in collecting data and arriving at inferences based on these observations. Toward the end of the course the application of this type of technique to other curricular areas of the elementary school is discussed.

**Montana State University.**-- Students are asked to write down their observations relative to a demonstration. The instructor then
leads the class in a discussion elaborating on all possible observations. At a later time, students submit their written observations on a second demonstration to the instructor. The two demonstrations used are "electrolysis of water" and "a burning candle."

Students are also given a set of data in the form of a graph, a table, or both, along with a brief explanation of the procedure used in obtaining data. They are asked to determine the validity of the data of the basis of the information given and to draw the conclusions from the data.

Lewis and Clark College.— The respondent writes:

Several class experiences are contrived using simple materials and procedure. Questions are used to elicit responses....Observing and drawing inferences from drops of water placed on wax paper and other materials has been one effective device. Several classroom demonstrations end in "What did you observe?" "What caused this to happen?" "What other methods might be used to demonstrate the principle?"

University of Oklahoma.— The respondent writes:

Students are provided a small car about the size of a roller skate. Brief instructions are to set a weight in the car and pull the car forward very rapidly. Setting a second weight in the car and putting it into motion, students are then to stop the motion suddenly. In each case, students are to observe what happens.

We are aiming, of course, towards getting them to discover the law of inertia....After the experiment...I ask them to describe what they saw, or think they saw....The students always say that when a weight is placed on a car and the car is jerked very rapidly, the weight moves in the opposite direction from which the car moved....I ask them if they can prove this statement. Eventually they come around to the point where they cannot....Had I not challenged them to prove what they thought, they would have come up with a completely erroneous concept. Now coming up with the erroneous concept is not nearly as important as for them to realize that they would have - had they not been questioned. In our "sit-down" sessions I ask them to analyze my behavior. What did I do to stop them from coming up with an erroneous concept? Did I tell them the answer? Did I ask them questions which would lead them to another experiment, etc.? These are the techniques which I have used in this (elementary science education) laboratory. We have four or five such experiments each semester and the first point I have to get across to the students is that we are not there to find an answer.
Students, it seems to me, are always looking for the answer. I am trying to show them that the teacher must be a guide, a prompter to action, a person who provides cues and clues when a student is stuck. But most of all the teacher has to be a person who asks questions and does not give answers.

**Pennsylvania State University.**—A sequence of experiences are structured to involve many aspects of the nature of science. Discussion during and after these experiences calls attention to scientific process. Examples of such experiences include:

1. Pendulum study—raising of questions, identification and testing of variables, identifying the appropriateness of a graph to investigate the relationship between period and length, interpretation of the graph
2. Noticing bubbles in water immediately after it is drawn from tap, hypothesizing as to cause, experimenting to check hypothesis, limiting conclusions

**East Carolina State College.**—The respondent attempts to establish an atmosphere in which problems can be approached in a scientific manner. Assumptions are used in acquiring data. From these data the assumption is accepted, modified or rejected. For instance, a class may discuss eclipses. Questions might be: "When do they occur," or "Which are more frequent—lunar or solar eclipses?" Developing from this, moon watches are established and data recorded.

**New Mexico State University.**—Problem situations are described:

The activities...begin with a statement of the problem to be dealt with followed by a sequential collection and analysis of data. Students are encouraged to develop their powers of observation, and particularly to look beneath the surface of phenomena taking place about them wherever they go. They are told to ask WHY about everything.

The nature of prejudice is explored, particularly as it relates to animal life. Do toads produce warts?

Laboratory exercises emphasize scientific methodology

For purposes of classification, arbitrary distinctions were made which depress the number of cases reported in this category. "Laboratory
exercises" refers here to tasks assigned to students individually or in small groups which would normally be completed in a period of time not exceeding one laboratory period. "Laboratory exercises" does not include problems or projects requiring longer lengths of time, in or out of a laboratory, or "problem situations" in which the situation is essentially dominated by the instructor.

University of Maine.— The respondent writes:

The kinds of questions scientists ask, the assumptions they make, the kinds of thinking they do in their search for answers, the kinds of regularities they attempt to find and the ways they try to put them into words, the different kinds of respect they try to show for facts -- all these things I try to emphasize directly through verbal illustrations, demonstrations and experiments. The last two categories of activities always involve the students actively....In carrying out the lab exercises...students are further required to practice the skills of critical thinking as they seek answers to questions that arise from observations and the manipulation of materials.

University of Colorado.— Students have an opportunity to examine elementary science materials from Educational Services Incorporated and to manipulate these in laboratory.

Duke University.— The emphasis in the science education course is measurement process in the laboratory (p. 103). The respondent feels that courses emphasizing such activity are "beneficial to anyone who is likely to be a responsible citizen....One gets a better look at science than that obtained from a textbook."

Students involved in class projects

Utah State University.— The entire class in involved in a simple project coordinated by the instructor. One such activity was directed toward answering the question, "How much water does a normal mouse consume daily?"
The class constructed the six cages with required apparatus, designed the data sheets, determined the kinds of data that should be kept and kept data. Being a team effort, some surveyed the literature, others made charts with others making graphs, etc. The experiment will be written up and submitted to an appropriate journal for consideration.

Wisconsin State College at Eau Claire.--Students are taken on a series of field trips to note and keep record of seasonal changes and ecological relationships.

Students work on problems alone or in small groups.

Pennsylvania State University.--Individual projects grow out of the instructor's emphasis on natural history:

Effort is made to develop curiosity and appreciation for interpreting and applying science experiences in home, classroom and in the natural environment....During the course -- when possible -- there are individual term projects on maintenance, care and study of a natural science classroom environment project such as planaria, mealworms, crayfish, snails, vegetative propagation, etc.

Another arrangement was described:

One practice used with some success is to assign students individually or in pairs to depth projects. The student selects one small area of science and becomes knowledgeable in that area through reading and experimenting. The project must involve a controlled experiment on a mature level. Usually the student, in setting up the experiment or in collecting information...has contact with academic science personnel on campus. This contact frequently seems to be of significant value to students. At times this is evidenced through improved design of the experiment, in research reading or in going back to the consulting scientist to report the outcome of the project.

University of Bridgeport.-- The science education workshop arrangement was noted on page 105 and an outline of the course appears in Appendix B, Item 7. Following a lecture on the nature of science, student groups select topics for study. Students develop problems and sub-problems and pursue these utilizing available laboratory facilities.
Utah State University.— Half of the students in the methods class are required to perform a simple research project and report the results to the remainder of the class in seminar fashion. Projects are exhibited in a science fair which is managed by the class. Committees handle publicity, arrangements, judging, awards, clean-up.

Teachers College, Columbia University.— The respondent writes:

Recently, we have been giving a great deal of emphasis to investigations in science. Each of our students is asked to undertake some kind of "research" investigation. Hopefully, these are the kinds of investigations that can actually be carried out by children.

The respondent supplies his students with a list of "suggested investigations" or, if they prefer, they may devise their own problem. Items from the list are included in Appendix B, Item 9.

Appalachian State Teachers College.— In the course of demonstrations performed by students questions may arise which suggest further experimentation or study. Students "get the feel" of problem-solving by following through on such ideas and reporting results of experiments in later demonstration sessions.

University of Texas.— The respondent writes:

One third of the course... is devoted to the individual investigations each student makes. The assumption is made that unless the teacher has at least on occasion explored and experienced the frustration, etc. of investigating a problem to which she does not know the answer, she will not be successful in doing this with children in the classroom. Therefore, this situation is structured so that the student (1) identifies a problem to which she does not know the answer, (2) determines how she might find the answer, sets up a hypothesis and procedure (3) investigates the problem and records the results, (4) describes the results and supports her conclusions from the data, (5) initiates a discussion as to the "why" of her findings which usually results in the initiation of another investigation.

Indiana State College (Pennsylvania).— A major part of the science education course consists of a project in which students do
some scientific exploration. They work under the guidance of either a staff member or a graduate assistant. This activity is designed to "expose them briefly to the true meaning of science" and reduce their fear of science and scientific apparatus. Results of the project and a review of the literature must be written up. Examples of student investigations include (1) the relationship of feeding habits of rabbits to weather conditions, (2) the relationship of temperature to altitude on a mountainside, (3) determination of pH and chemical content of soil and (4) determination of local wind patterns and wind flow.

At all times the instructor keeps in mind that these students are not science majors....I feel that the success we have had with this aspect of the program justifies the time and energy needed to supervise it.

Edinboro State College.— Investigative activities constitute 75 percent of the science methods course. Students make studies on such problems as "Do the leaves grow longer on the south side of a tree than those on the north side?"

Our attempts are first to convince the prospective teacher of the value of scientific methodology in the hope they will then wish to develop these understandings in their children.

University of Pittsburgh.— Students work on individual science exercises such as collecting weather data over a month-long period, growing bacteria, leaf collecting, etc. When students collect weather information, additional information is requested concerning related phenomena:

I request them to list the type of clothing that they have worn and ask if there is any relationship to atmospheric conditions; likewise, has there been any change in their eating habits....It has been my experience in any single month of the year there is usually a phenomenon occurring, such as winter lightning followed by a snowstorm.
By calling such phenomena to the students' attention it is hoped that the student teacher will be able to help children understand relationships of phenomena.

The Ohio State University.— Students do a short, original research project on a selected "microclimate." (Appendix B, Item 10).

Students emphasize "problem-solving" in unit development and lesson planning.

Marshall University.— Demonstration lessons presented by students are analyzed with respect to problem-solving techniques used.

Harris Teachers College.— The respondent comments:

Actually, every lesson given by professor or students is criticized severely if it lacks opportunities for inductive thinking and weighing, and leaving some questions open.

Students study curriculum materials which emphasize scientific methodology and attitudes.

The materials produced by elementary science curriculum groups is studied in several science education courses. The "Illinois Astronomy Materials" are examined at Harris Teachers College and the University of Kansas. The Pennsylvania "Science in Action" program is studied at Edinboro State College and Indiana State College (Pennsylvania). Educational Services, Inc. materials are used at the University of Kansas and the University of Colorado. The Physical science units developed by Robert Karplus at the University of California are also studied at the University of Kansas.

Scientific methodology, attitudes emphasized in lectures, films, texts and discussions.

Mississippi College.— Students read biographies of scientists and descriptions of their methods, such as the accidental discovery of
effects of penicillin by Alexander Fleming and the controlled experiments of Walter Reed.

University of Missouri.— The instructor includes in his course a unit titled "Scientific method and the philosophy of science." Material in Conant's *Science and Common Sense* is utilized.

(This reference is utilized also at the University of Missouri at Kansas City, along with books and essays by Bronowski, Schwab, Brandwein, Snow, etc. The instructor emphasizes "the philosophical presuppositions of science" and delves into the role of values in the scientific enterprise.

University of Oregon.— The respondent writes:

Students are asked to read the biography of a scientist and to describe experiments which this scientist conducted during his life, as well as to identify behavior of the scientist which they consider to be indicative of his scientific attitudes.

National College of Education.— Students are asked to make critical review of research reported in current science journals.

University of Miami.— The respondent notes that choice of textbooks is based on such considerations as those suggested on the second item of the questionnaire. In addition to the text by Tannenbaum and Stillman five paper-backs are used:


University of Louisville.— Films are used which depict scientists and their methods of working. Scientific methodology is discussed in lecture and students receive duplicated sheets summarizing "problem-solving" teaching methodology and scientific attitude. The latter
includes the following items: (1) the habit of honesty and the desire for truth, (2) intellectual honesty, (3) the habit of looking for natural causes, (4) the habit of open-mindedness, (5) the habit of suspended judgment, and (6) the habit of critical thinking.

**University of Southern Mississippi.**— The respondent writes:

Motion picture films (at least three), reading assignments and lengthy discussions are used in an advanced course to give an outline of the skills in scientific thinking. Demonstrations of science experiences are presented....In most instances experiments are illustrative of some phase of scientific thinking, such as purposeful observation, analysis-synthesis, etc.

**University of Kentucky.**— One lecture deals specifically with "scientific method". Referring to the heliocentric theory of Copernicus, an idealized sequence of scientific methodology is cited:

1. observation of nature,
2. sensing a discontinuity -- "something needs explaining",
3. discovery, or definition, of a problem,
4. establishment of a hypothesis,
5. further observation -- experimentation,
6. gathering and analysis of data, and
7. drawing a tentative conclusion.

At this point and elsewhere in the course, the importance of observing phenomena and raising questions relative to causation is emphasized. The instructor believes that if any one kind of act can be termed "the" scientific act, this would be the discovery of a problem.

This is what teachers should encourage in their classrooms, and it can be brought about, in part, through direct examination of "nature." In lessons which students teach to elementary children, therefore, provision must be made for the children to observe nature directly or see a concrete demonstration, and then be encouraged to ask questions concerning it.

Throughout the course, particularly at the time when demonstrations are made by the instructor before the class, an emphasis is placed
on distinguishing facts (sensory perceptions) from inferences, or interpretations of these facts. This emphasis is continued when students submit a report on their public school observation. The report must be in two clearly distinguishable parts: (1) objective observation, and (2) interpretation, or commentary. In all written work precision of expression is encouraged, which includes careful choice of words. It is emphasized that persons with scientific habits strive to express themselves as accurately and unambiguously as possible.

Maryland State College at Towson. The respondent comments at length:

Since it seems to me far more important that elementary students understand the nature of science than that they learn the so-called "facts" of science, our course for teachers stresses ways of developing the appreciation of scientific method using subject matter merely as illustration. By the scientific method is meant the recognition and definition of problems and questions, the review of what is known about them from one's own experience and that of others, the development of hypothesis with emphasis on careful observation, the use of checks and controls, the careful analysis of results, the formulation of limited conclusions, the attempt to see where these might be applicable in other situations and publication of findings.

The first two or three weeks of the course are a struggle to build in the future teachers a realization that they cannot and should not take an authoritative attitude with the children, satisfying their curiosity and questions with answers and facts as they (the teachers) see them. I try to put this idea across by "swamping" the class with so much from the frontiers of science that even the conceited ones recognize their inability to "know it all." From their basic insecurity some then think the solution is to turn to specialists and we discuss the dangers inherent in a teacher always saying, "Let's see what the book says." We have a session of critical thinking about everything that is written or spoken which develops a healthy skepticism. Some students then feel there is nothing left to stand on; they know little, the specialists are subject to error; what is there to teach? In this atmosphere we develop ideas of how we or the scientists "know" anything. The phases of the scientific method come naturally to their attention. There are few who at this point do not readily recognize that this is the precious essence of science.
Table 13 tabulates activities reported in courses other than elementary science education courses through which elementary majors develop an understanding of the nature of science. The types of courses included in this section are introductory science courses, general education science courses, professionalized science courses, and courses in the history and philosophy of science.

Scientific methodology, attitudes emphasized in laboratory work

Troy State College. In the laboratory sessions of "Science for the Elementary Teacher" considerable effort is exerted to help students learn valid scientific procedure, as well as the limitations of scientific theory and methodology. The respondent writes:

Insofar as practicable, controlled experiments are used in place of the conventional demonstration...in which much is taken on faith. For example, the detection of carbon dioxide in exhaled human breath would involve much more than the mere breathing into a sample of limewater through a soda straw....Several protracted investigations are undertaken by students in an effort to learn more about data collection, interpretation, and generalization. Validity, precision, reliability and accuracy are considered in their "scientific" meanings but with emphasis upon what is "teachable" about them.

Evidence vs proof is also a major concern. Through both the laboratory and reading investigations, the students are guided toward more critical approaches to problems.

Rhode Island College. In a professionalized physical science course designed for elementary teachers, twelve laboratory problems are assigned for the semester. Laboratory manuals are not used.

University of Pittsburgh. In the professionalized "Biophysics" course (p. 62), students are required to explain the procedure of scientific thought and be able to account for various steps in the process of conducting any type of experiment or demonstration.
TABLE 13.—Practices designed to help the elementary teacher understand and appreciate the nature of science, reported in courses other than elementary science education courses

<table>
<thead>
<tr>
<th>Institution</th>
<th>Courses including the activity</th>
<th>Scientific methodology designed to help the student develop scientific attitudes emphasized in laboratory work</th>
<th>Students practice scientific procedure during personal investigations</th>
<th>Students read descriptions of scientific discovery</th>
<th>Scientific methodology and attitudes considered in lectures and discussions</th>
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<tr>
<td>Arizona State College</td>
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<td>Bradley University</td>
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<td>Brigham Young University</td>
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<td>East Carolina College</td>
<td>All professionalized science courses</td>
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<td>St. Cloud State College</td>
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<td>San Jose State College</td>
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<td>Troy State College</td>
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TABLE 13 (Contd.)

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<th>Institution</th>
<th>Courses including the activity</th>
<th>Scientific methodology and attitudes emphasized in laboratory</th>
<th>Students practice scientific procedure during personal investigations</th>
<th>Students read descriptions of scientific discovery</th>
<th>Scientific methodology and attitudes considered in lectures and discussions</th>
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<td>University of Oklahoma</td>
<td>&quot;Botany&quot;</td>
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<td>University of Pittsburgh</td>
<td>&quot;Biophysics&quot; (professionalized)</td>
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<td>Western Wash. State College</td>
<td>Professionalized science courses</td>
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Western Washington State College.— The respondent, who teaches the course "Biology for the Elementary School" operates an "open-ended laboratory that seeks truths in nature using methods described best by Joseph Schwab."

(The respondent from National College of Education also reports the use of "open-ended" laboratory exercises, but comments, "These need to be worked on further.")

Kansas State College at Pittsburg.— In the laboratory of "Biology 111" there is emphasis on scientific thinking. Students proceed with minimum instructions provided on laboratory outlines with supplementary instructions from the instructor. When results are secured from the exercises the class is led in discussion by the instructor who asks for (1) accurate observations, and (2) an interpretation of what is observed. Emphasis is placed on logical, inferential reasoning.

Laboratory meets once weekly, is restricted to 32 students per section, and is taught by the same instructor who lectures. An example of a laboratory exercise is given in Appendix B, Item 11.

(The procedures described above are similar to those employed in the introductory botany course at The Ohio State University (p. 81).)

Students practice scientific procedure during personal investigations

The three practices in this sub-category are classified and described elsewhere as well as here. See: Troy State College ("protracted investigations," p. 131), St. Cloud State College ("Science Calendar, p. 97"), and Austin Peay State College (Teacher-pupil planning procedure, p. 54).
Students read descriptions of scientific discovery

National College of Education.— In required liberal arts science courses students choose and read a piece of original research from a list of "science classics."

Colorado State College.— The respondent writes:

The nature and purpose of science is emphasized in both the professional and academic courses....In the freshman courses (biological, physical and earth science) particular emphasis is given to the historical development of concepts, to illustrate the ways that knowledge has developed (and) the methods and processes used by scientists to generate new knowledge.

(In four other cases classified in this sub-category, the reading dealing with scientists and scientific case studies is done in philosophy of science courses. In each case the course is either required of elementary majors or taken by a substantial fraction of them. Further details were not provided.)

Scientific methodology and attitudes considered in lectures and discussions

This practice was reported in two professionalized science courses, two general education courses and three philosophy of science courses. Further details were not provided.

Summary and Discussion of Practices Reported Corresponding to the Fifth and Sixth Criteria

Nearly all practices reported corresponding to these criteria occur either in elementary science education courses or in science courses designed for, and usually limited, to elementary education majors. It must be acknowledged, of course, that a more accurate approximation of the situation in science courses would have to be based on a
survey reaching more science teachers that were contacted in this study.

The most frequently reported practice is that in which the instructor teaches lessons designed to involve students in problem-solving activities. The emphasis is usually on careful observation and description of phenomena, and subsequent interpretation.

Other activities reported in science education courses include (1) preparation of teaching units or lesson plans, designed to help children develop skill in scientific methodology, (2) study of curriculum materials emphasizing scientific methodology, and (3) consideration of the nature of science in lectures and readings.

The arrangements, while acquainting elementary majors with certain characteristics of scientific enterprise, are essentially instructor-dominated. The extent to which students become involved in scientific activities — assuming responsibility for identification of problems, suggesting hypotheses, designing and executing experiments, etc. — is probably very limited in such activities.

Seventeen respondents reported activities in science education courses through which students can identify themselves as "science investigators." These practices involve the future teacher in individual, small group, or large group (entire class) investigations or projects.

Little was learned about provisions made in other kinds of courses relative to the fifth and sixth criteria. The 22 courses, or course sequences, classified in Table 13 are of four types:

- Professionalized science courses..................nine tabulations
- General education science courses..................four tabulations
- Introductory or liberal arts science courses.........five tabulations
- History and philosophy of science courses.........four tabulations
In only nine institutions, then, were non-professionalized science courses reported which are designed in part to help students understand the nature of science. In most cases descriptive notes on these were brief. In two of these cases, moreover, respondents expressed a general lack of confidence in science courses offered to elementary majors. One educator commented, "Most of them [science courses] leave the student with a superficial, trite, naive conception of the scientific method as a rigid catechism of discovery employed by all scientists to solve all problems."

Comments volunteered by other respondents are similar: "Liberal arts science courses are limited to memorizing facts and pouring back these facts" and "From my informal observations of students at the junior and senior levels I feel they cannot think in science. They also appear not to be able to relate one area of science to another."

It is submitted that it is essential that elementary majors have available to them science courses designed to help them develop an understanding of the nature of science.

The efforts of instructors of science education courses to include "problem-solving" and elementary research activities in their courses is commendable. It must be questioned, however, in view of other important functions of this course, whether such activities belong primarily in the science education course or in science courses required of elementary majors.

The view that research-type activities should be a normal component of science courses required of elementary majors suggests an important issue: should there be a special, or professionalized, series of science courses designed for prospective elementary teachers where
A simple answer cannot be given to this question, but an examination of practices attributed to professionalized courses suggests that establishment of such courses merits serious consideration.

The terms "professionalized," "general education," and "introductory" as descriptive of science courses were used by respondents without benefit of definitions supplied in the questionnaire. Consequently, some degree of ambiguity enters into this discussion. It is significant, nevertheless, that in approximately half of the science courses described as professionalized there is an opportunity for students to engage in elementary investigative activity. Such activities are found in about one-fourth of the "general education" science courses reported, and are usually absent from introductory-type courses.

Despite evidence that many professionalized courses are performing a task usually neglected in introductory courses, prejudice toward the professionalized course may preclude its adoption. This may be especially true at larger institutions having only a peripheral dedication to teacher education. Not only academicians, but personnel in departments of education express suspicion of subject-matter courses designed for teachers. The attitude is implicit in the comment made by one respondent in discussing science courses taken by elementary majors at his institution, "These courses are not watered-down courses — they are the same courses as taken by any other student."

It should hardly be necessary to point out that the content, activities, and excellence of instruction determine the value of a course and not the course title. The time is past due when the content and desired outcomes of instruction relative to science courses for elementary
teachers should be identified by science educators and science teachers on each college campus. Decisions should be made as to what experiences can be incorporated into introductory, or general education courses, or whether an entirely different kind of course is indicated. If a bill of particulars indicates that a course different from the one(s) offered to other students is needed, no apology need be offered for the introduction of a professionalized course.

It is possible, moreover, that the experiences needed by future teachers in their science courses would make these courses more appropriate for other students as well.

The sixth criterion suggests also a range of experiences which have implications for courses other than science and science education. If students are to develop ability to apply scientific method to many kinds of situations, the college curriculum should provide opportunities for this to happen in areas other than in the natural sciences.

No respondent referred to courses in behavioral sciences, social sciences and the humanities with respect to the student's identification of problems, gathering of data, learning to consider the opinions of others, etc. While such references were not expected from a large number of respondents, the complete silence could indicate a general sickness of college curricula.

To what extent are our colleges dealing effectively with the education of "whole men" -- meaning, in this context, helping students develop skills, understanding and attitudes useful in dealing intelligently and morally with a wide range of life situations?
Recommendations Evolving From a Study of Current Practices

16. Elementary education majors should have opportunities to develop functional understandings of scientific method through becoming involved in a series of investigative activities. These activities should develop the students' abilities to identify problems, plan observations, gather and organize data, come to tentative conclusions, etc. Such activities are appropriate for some "non-science" courses as well as science courses.

17. Teachers of science courses and science education courses should experiment with teaching methods that enable the student to develop his ability to think clearly and to express himself precisely in written and oral communication. A greater degree of freedom of expression on the part of the student than is often indicated in classrooms appears to be necessary to develop such attitudes as (a) desiring to gather factual evidence regarding problem situations, (b) withholding judgment, (c) considering the evidence and opinions tendered by others, (d) eliminating anthropomorphistic and teleological explanations, (f) seeking natural causes, etc.

18. In addition to personal involvement in elementary investigations the future teacher should have an opportunity to become acquainted with our scientific heritage: the investigations and discoveries of great scientific personalities and the impact of these on our living. Science should be seen as the efforts of many men, using different methods and working at different times and places, seeking to understand and control their environment. An elective or required course in "History of Science" may be worthy of consideration in this respect.
Practices Reported Corresponding to the Seventh and Eighth Criteria

Criterion 7: Does the particular practice help the teacher put science into the perspective of total human experience including: realization of the role of scientific method and associated attitudes in many life situations, consideration of the history of lines of scientific inquiry, the impact of scientific inquiry and its applications on our culture, the role of scientific inquiry in our future, the limitations of scientific inquiry, etc?

Criterion 8: Does the particular practice help the teacher understand the possible contributions of science education to development of citizenship and relationship of science to democracy including: the citizen's need to think reflectively in individual and group situations and have his behavior influenced by scientific attitudes, the citizen's need to have a general background of science information, the responsibility of citizens in formulation of public policy in matters relating to science -- while recognizing the role of the expert in such matters, and the citizen's need for certain social skills which might be developed concommitantly with the science program?

These criteria were incorporated in questionnaire item 3:

Describe practices in your institution which you feel are particularly effective in helping the elementary teacher understand the relationship of science education to social living and to total human experience.

This item was designed to reveal practice which emphasize the social and cultural role of science, as contrasted with the previous item which deals more with procedural and philosophic aspects of science. There is no sharp distinction, of course, and some practices which overlap the fifth through eighth criteria are tabulated in both this and the previous section. Practices reported in this section represent a departure from the laboratory, where science is concerned with relatively objective investigations of the physical environment, and a movement into the arena of personal and group life.
Classification of Practices

Practices can be classified arbitrarily into (1) those reported in professional science education courses and other education courses, and (2) those reported in science, philosophy of science and interdisciplinary general education courses. Table 14 lists practices corresponding to the seventh and eighth criteria, reported in science education and other education courses.

Class discussions, lectures and films deal with science-society relationship

A number of respondents reported that matters such as those suggested in the third questionnaire item are considered in class, but volunteered no elaboration of specific practices. As expressed by one educator, "These ideas are consistently represented in my classes, but it is difficult to pinpoint specific practices." More detailed responses follow.

Maryland State College at Towson.—— The respondent writes:

Through discussion in the initial weeks I try to stress the danger of scientific knowledge developed by specialists being lost if our civilization breaks down. I give the students a half hour to try to imagine what it would be like if they survived an atomic war. I ask such simple questions as, "Could you make your own shoes?" "Would you know what plants to eat if you were stranded in the woods?" "Would you know whether you were actually from radiation?", "How would you behave?" From this we attempt safe to support a feeling that as human beings they can and should have a rational response to their environment and that if all else were lost this would ultimately rebuild a human civilization with a fund of scientific knowledge.

Our civilization, and particularly our democracy, are in danger of breaking down if specialists give us knowledge which is acted upon emotionally by uneducated people. I stress that the strength of democracy rests on an intelligent, discriminating electorate which it is the duty of teachers to develop.
TABLE 14.— Practices reported in elementary science education courses designed to help the elementary teacher understand the relationship of science to social living and total human experience

| Auburn University                           | X |                |                |                |                |
| Bowling Green State University             | X |                |                |                |                |
| Duquesne University                        | X |                |                |                |                |
| Eastern Kentucky State College             | X |                |                |                |                |
| Eastern Michigan University                | X |                |                |                |                |
| Florence State College                     | X |                |                |                |                |
| George Washington University               | X |                |                |                |                |
| Goucher College                            | X |                |                |                |                |
| Lewis and Clark College                    | X |                |                |                |                |
| Loyola University                          | X |                |                |                |                |
| Maryland State College at Towson           | X |                |                |                |                |
| Mississippi College                        | X |                |                |                |                |
| Moorhead State College                     | X |                |                |                |                |
| National College of Education              | X |                |                |                |                |
| Newark State College                       | X |                |                |                |                |

Legend:
- X: Practice reported
- No X: Practice not reported
<table>
<thead>
<tr>
<th>University of Kansas</th>
<th>University of Iowa</th>
<th>University of Colorado</th>
<th>University of Bridgeport</th>
<th>Iowa State College</th>
<th>Troy State College</th>
<th>Teachers College, Colubmia University</th>
<th>State University College at Oswego (New York)</th>
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<td>San Diego State College</td>
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<td>Sam Houston State Teachers College</td>
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<td>St. Cloud State College</td>
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<td>Rutgers University</td>
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<td>Rhode Island College</td>
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<td></td>
<td>Northern State Teachers College</td>
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TABLE 14, (Cont.)
**TABLE 14* (Contd.)

<table>
<thead>
<tr>
<th>University of Kentucky</th>
<th>University of Louisville</th>
<th>University of Maryland</th>
<th>University of Miami</th>
<th>University of Missouri at Kansas City</th>
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<tbody>
<tr>
<td>University of Oregon</td>
<td>University of Southern Mississippi</td>
<td>University of Southwestern Louisiana</td>
<td>University of Tennessee</td>
<td>X</td>
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<tr>
<td>University of Nebraska</td>
<td>University of Nevada</td>
<td>University of Missouri</td>
<td>University of Nevada</td>
<td>X</td>
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</tbody>
</table>

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*These practices reported in education courses other than science education courses

These practices reported in both science education and other education courses

Class discussions, lectures, and films deal with science-society relationship

- Students study the impact of science on society through reading current materials
- Students prepare units emphasizing social role of science
- Democratic atmosphere is fostered in classroom
- Students read text, other selected readings on social role of science
- Attention given to controversial issues involving science
- Relationship of science and social studies emphasized through field trips
University of Kentucky.— The following points are developed in a lecture:

1. The pre-scientific mind accepted frivolity of nature and did not assume or search out causes.
2. The scientific mind not only postulates that events have causes but has the faith that, ultimately, man can understand all of nature and have the capacity of controlling much of it.
3. The faith that man has the ability to understand and control nature elevated man's self-concept to a position of dignity, and independence from nature.
4. The concept that man possesses the power to determine his destiny through study and control of his environment led to research and development in fields of medicine, chemistry, agriculture, transportation, communication, warfare, etc.
5. Control over the environment, beneficial from many standpoints resulted in many new problems, such as proliferation of the human species and harmful pressure on other species.

Pennsylvania State University.— The instructor develops a discussion concerning the relation of the "search for evidence" to citizenship responsibilities — i.e., voting. "When is majority vote appropriate to make decisions in terms of 'best evidence'? What is 'best evidence'? etc."

In the same course, concerted effort is made to relate science teaching methods and objectives to consumer education. Television commercials may be discussed with some experimenting to check advertising claims.

Duquesne University.— The respondent writes:

I place heavy weight on the student gaining facts and making judgments based on facts. Too many students speak without knowing the facts. We stress this to show how society can be better if we don't go off half cocked.

University of Maryland.— The respondent writes:

Emphasis is placed on seeing the relationship of methods of discovery in science to methods of discovery elsewhere — and on seeing the relationship between so-called scientific attitudes and attitudes essential in living in a democracy.
University of Miami. The respondent writes:

Application of basic science principles to understanding today's technology is a part of the course content (working of T.V., radio, fuel cells, rockets, jet engines, etc.)

Troy State College. The respondent writes:

Many films, filmstrips, and other materials are used to develop understanding regarding science, technology and society. (For example, the Iron and Steel Institute filmstrip: "Science, Technology and Society").

A number of respondents reported that considerations such as those suggested in the third item of the questionnaire are treated in education courses other than science education, but details were not given in any of these cases. At Newark State College these topics are discussed in such required courses as "Elementary School Curriculum," "Human Growth and Development," and "Development of Educational Thought." At the University of Tennessee and the University of Missouri at Kansas City, they are treated in elementary curriculum courses as well as in the science education course. Such matters are considered at the time of student teaching at Northwestern State College and in an orientation course for education majors at Oregon State University. At the last named institution, the students meet twice weekly in relatively small discussion groups.

Students study the impact of science on society through reading current materials.

Florence State College. Students locate science materials found in current magazines and newspapers to illustrate that much science information is found outside science texts and journals. Students also develop lists of books that should be found in school libraries. The list is to include not only science titles but books illustrating
science in history, mathematics, etc.

**Lewis and Clark College.**-- Students bring current newspaper and magazine articles to class which describe new scientific advances.

**University of Kentucky.**-- A professional course combines science and social studies education. In this course students are required to read several articles of social significance appearing in a specified list of magazines, including *Harpers*, *Saturday Review*, *Atlantic* and *New Republic*. The instructor has discovered that approximately 80 percent of his students have never read articles in these magazines. The primary purpose of this reading is to acquaint students with worthy reading material, and the development of reading habits to keep the student abreast of current opinion. Occasions often present themselves, however, to emphasize the relationship of science to society:

There are discussions of articles dealing with recent scientific advances or controversy involving science, such as nuclear disarmament, the "moon race" and atmospheric pollution.

At least once each semester an article is found which illustrates how scientific thinking and attitude might influence behavior in a situation which is "nonscientific" in the conventional sense. For instance, an article discussed in the spring semester of 1964 dealt with the allegedly careless attention given by Dallas police to facts in the assassination of President Kennedy. In a previous semester an article was discovered in a woman's magazine which built an argument on a series of assertions made by the author which were improperly labeled "facts."

**San Diego State College.**-- The respondent writes:

Each student is responsible for one brief current event report, in which he describes a recent research or technological development, explains the scientific principle(s) involved, and brings out (with discussion) the implications for daily living.

**Loyola University.**-- A "news" bulletin board on scientific discoveries is kept by students.
Students prepare units emphasizing the social role of science

**Sam Houston State Teachers College.**— The respondent writes:

In the problem solving approach to the study of social areas, the student has ample opportunity to search for cause and effect relationships.

During the social studies experiences, students are urged to find cause and effect of living conditions in the countries being studied. They are urged to plan their units on such problems as why do the Swiss people build sturdy homes with steep roofs, or why do they pursue many inside crafts and hobbies?

**Goucher College.**— The respondent states that the elementary curriculum course, through lectures, discussions and assigned readings, is "slanted" toward considerations such as those suggested in the third questionnaire item. He continues:

While preparing a social studies resource unit, students are asked to show how their plans would provide attention to the relationship of the physical environment to the social environment and vice versa.

**Bowling Green State University.**— The respondent writes:

A considerable amount of time is spent in clarifying the importance of science objectives in the development of units....Technological progress is related to the practical aspects of science as derived from the process of science. Students are helped to realize that science is not composed of products, but involves processes of thinking, methods of inquiry, and desirable attitudes.

**University of Nevada.**— The respondent believes his department is attempting to combine more of the science and social studies than is normally accomplished at other universities. This awareness is done in part through development of units. Emphasis is on the self-contained classroom where the teacher will have responsibility for teaching both science and social learnings.
Northern State Teachers College.-- This is one of several schools which has a combined professional course: "Social Studies and Science Methods." Students prepare units in both the social studies and science which include as objectives the development of citizenship.

The instructor attempts to foster a democratic atmosphere in the classroom.

Lewis and Clark College.-- The respondent writes:

The one practice that is attempted to help future teachers understand the relationship of science to democratic societies is fostering in the college classroom an atmosphere that is democratic in terms of freedom to question, to inquire, to test ideas, to disagree with the instructor, to hold judgments until the facts are in or can be tested to the satisfaction of the group.

National College of Education.-- The respondent writes:

"Science for Teachers" is organized on this philosophy [reference to third item of the questionnaire]. At the beginning of the term students and teacher set up the agenda of topics to talk about and things to do for the semester. They also make out tests, grade each other and also [do] self evaluation.

Time is spent considering Lasswell and Arnspiger's eight social values (respect, power, skill, enlightenment, rectitude, well being, affection, wealth) and how science contributes to the wider sharing of these values in the elementary classroom.

University of Kentucky.-- The film "Experimental Studies in Group Climates" is shown and discussed for its relevance to the social atmosphere in which science and social learnings may take place. The film is based on studies by Lewis, Lippett and White and contrasts the behavior of children in autocratic, laissez-faire and democratic situations. During the discussion which follows, and at other times during the course, it is emphasized that man in a free society must develop the scientific habits of observing his social environment and

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7 This film available from Indiana University Film Service, Bloomington, Indiana.
raising questions relative to his observations. The instructor believes this habit should be nurtured in the classroom, where an atmosphere can be created in which the child is free to participate and raise questions.

Students read text, other selected readings on the social role of science

Northern State Teachers College.— Textbooks are chosen which stress the need for knowledge of science information and scientific attitude in developing effective citizenship. The respondent believes that this course "...directly links the relationship of science education to social living and total human living."

Troy State College.— The respondent writes:

Most of the students are able to read selections from books no more difficult than J. D. Bernal's The Social Functions of Science. Related articles from Bulletin of Atomic Scientists and the Scientific American (to name two) help define some of the social aspects of science.

Selected topics from the history and biography of science help to identify areas in which social values and science are related. The many examples to be found in the mass media are used to an extent.

University of Southern Mississippi.— The respondent writes:

The experiences designed to help prospective teachers realize the social values which may accrue from science teaching are given through readings in science philosophy, current magazines and current literature of science plus the lectures, discussions, textbooks and assignments. At least one of the textbooks used covers most of the aspects of this question unusually effectively. A brief survey of the history of science and science education is made to compare the effects of these subjects on culture of the modern world.

Textbooks named by the respondent are Elementary Science and How to Teach It by Blough, Schwartz and Huggett; and Social Studies for Children in a Democracy by John U. Michaelis.
Rhode Island College.— The role of science in child development is brought out through a study of Lee and Lee's *The Child and His Curriculum*.

Rutgers University.— The respondent refers specifically to chapters one through six of Gerald Craig's *Science for the Elementary School Teacher* as required reading in his course. These chapters relate to the social values of science.

(Collateral readings used at the University of Miami were cited on p. 128.)

Attention is given to controversial issues involving science.

Teachers College, Columbia University.— The respondent writes:

In dealing with the area of "water resources" we have considered the pros and cons of the fluoridation issue. We pay special attention to the scientific evidence that is mustered on both sides of the issue.

Soon after the publication of *Silent Spring* we considered some of the problems raised by this book as we dealt with the topic of ecology and conservation.

Troy State College.— The respondent writes:

Specific problem areas like: "What has been the influence of photographic film on society?" or "What have been some of the social influences of scientific research on living specimens?" are used to help students see some of the area of interaction between science and society.

Another area of interest is the role which changing technology plays on society; for example, the influence of speed of transportation and communication on world politics.

Mississippi College.— The respondent writes:

Science and social studies are related by having students investigate the cause and effect of poverty, illiteracy and poor health.

University of Oregon.— Science methods are taught in a combined course titled "Methods and materials in teaching social studies and science." The respondent writes:
The instructors endeavor to show the relationship between these two fields. Attention is given to trying to determine what is science and to distinguish between science and the applications of science. Students are requested to examine one or two issues in the community to determine what science background would be necessary to make an appropriate decision about the issue. The thought being that there are very few decisions made in our democratic society which could not be made more effectively with some background knowledge in science as it relates to the issues.

**Relationship of science and social studies emphasized through field trips**

Eastern Kentucky State College.— Discussions of how science has influenced healthful living and control of disease is accompanied by visits to local hospitals, the county health department, water treatment plant and observations of garbage collection and disposal.

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Table 15 summarizes practices corresponding to the seventh and eighth criteria which were reported in courses other than professional education courses. These fall into three sub-categories: (1) multidisciplinary general education courses, (2) history and philosophy of science courses, and (3) general education and professionalized science courses.

**Practices in multidisciplinary courses designed to acquaint elementary majors with relationship of science to society**

Arizona State College.— The respondent cites the following courses on questionnaire item 3:

- Political Science 160: "Political-Economic Institutions"
- Social Science 354: "Political and Economic Issues"
- Technology 381: "Culture and the Home"
- Technology 382: "Technology and Culture"
TABLE 15.-- Practices reported in courses other than professional education courses, designed to help the elementary teacher understand the relationship of science to social living and to total human experience

<table>
<thead>
<tr>
<th>Institution (course or courses)</th>
<th>Descriptive notes</th>
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<tbody>
<tr>
<td>Appalachian State Teachers College (Biology)</td>
<td>Field trips to reforestation projects, polluted streams; survey of native shrubs having commercial value</td>
</tr>
<tr>
<td>Austin Peay State College (General science sequence)</td>
<td>Democratic atmosphere fostered in class; students participate in course planning</td>
</tr>
<tr>
<td>Ball State Teachers College (&quot;Civic Biology&quot;)</td>
<td>Topics considered include conservation, ecology, eugenics and civic responsibility; field trips to dairies, water works, sewage disposal plant, conservation areas</td>
</tr>
<tr>
<td>Colorado State College (General education science)</td>
<td>Topics considered include conservation, applications of nuclear energy, effects of overpopulation, etc.; field trips, speakers</td>
</tr>
<tr>
<td>East Carolina College (Professionalized science courses)</td>
<td>Impact of industry on society considered; field trips to local industries</td>
</tr>
<tr>
<td>Florence State College (Freshman - sophomore science courses)</td>
<td>Emphasis of these courses on science as it relates to an educated citizenry as opposed to &quot;strictly theoretical science&quot;; historical approaches utilized</td>
</tr>
<tr>
<td>Fort Hays State College (Biology)</td>
<td>Students encouraged to relate science to other human endeavors; emphasis on teaching science in connection with other subject matter areas (no formal activities designed)</td>
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<tr>
<td>Institution (course or courses)</td>
<td>Descriptive notes</td>
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<tr>
<td>Glassboro State College</td>
<td>Considers such matters as suggested in item 3 of questionnaire; 25 percent of elementary majors enroll</td>
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<tr>
<td>(&quot;History and Philosophy of Science&quot;)</td>
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<tr>
<td>Moorhead State College</td>
<td>All are required courses. Relationship of science to society is subject of lectures and discussions.</td>
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<tr>
<td>(General education courses in &quot;Science&quot; and &quot;Philosophy of Science&quot;)</td>
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<tr>
<td>San Jose State College</td>
<td>Science–society relationship considered in lectures; topic of conservation included in biological science sequence</td>
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<tr>
<td>(Introductory science courses)</td>
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<tr>
<td>State College of Iowa</td>
<td>Elective course; attempts to relate science to total culture</td>
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<tr>
<td>(&quot;The Nature of Science&quot;)</td>
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<tr>
<td>Trenton State College</td>
<td>Course treats history of science as related to society</td>
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<tr>
<td>(&quot;Growth of Scientific Ideas&quot;)</td>
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<tr>
<td>Troy State College</td>
<td>Combines content from fields of biology, psychology and sociology</td>
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<tr>
<td>(&quot;Bio-social Development of the Individual&quot;)</td>
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<tr>
<td>University of Alabama</td>
<td>Attempt made to make students conscious of relationship of science to society</td>
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<tr>
<td>(&quot;General Science&quot;)</td>
<td>&quot;Some stress is placed...on helping the teacher understand the relationship of science education to other areas of living</td>
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<tr>
<td>University of Colorado</td>
<td>Students select designated number of courses from &quot;basic courses&quot; including anthropology, geography etc. Selected courses expose student to science–society relationship</td>
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<tr>
<td>(Biology)</td>
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<tr>
<td>Institution (course or courses)</td>
<td>Descriptive notes</td>
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<tr>
<td>University of Maine</td>
<td>Both courses required; matters relating to science-society relationship treated in lecture and discussions</td>
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<tr>
<td>(&quot;Man and His Environment&quot;</td>
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<tr>
<td>&quot;Modern Perspectives in Culture&quot;)</td>
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<tr>
<td>University of Missouri at Kansas City</td>
<td>Required; attempts to provide some insight into cultural institutions, political inventions, etc.</td>
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<tr>
<td>(&quot;Social Anthropology&quot;)</td>
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<tr>
<td>Western Washington State College</td>
<td>Required courses; in freshman course students study impact of Darwin on society; in senior &quot;Great Issues&quot; course topics studied include &quot;population expansion&quot; and &quot;bomb testing;&quot; in the biology course the relationship of science to society receives attention in a specific lecture; class atmosphere fosters scientific thinking in democratic context</td>
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<tr>
<td>(Freshman level humanities: &quot;Great Issues,&quot; &quot;Biology for the Elementary School&quot;)</td>
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<tr>
<td>Winona State College</td>
<td>Considers relationship science to society</td>
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<tr>
<td>(General education science course)</td>
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</table>
The respondent notes elsewhere that students also take Philosophy 150 - "Problems of Human Relations," and Science 321 - "Philosophy of Science."

Western Washington State College.— A required senior level course entitled "Great Issues" has been concerned with science and society through such topics as "the population explosion" and "bomb testing." In a freshman level humanities course students study the impact of Darwin on society.

Troy State College.— A multidisciplinary course draws from the fields of biology, psychology and sociology (p. 69 ).

Practices in philosophy and philosophy of science courses

University of Maine.— Senior take two required courses which "...deal heavily with the social meanings of modern science." According to the respondent:

One is called "Man and His Environment," a lecture-discussion course taught by four scientists in which the nature of science, some crucial historical achievements, some significant developments and some important current problems (fall-out, pollution, resource management, fluoridation, pesticides, etc.) are explored at length.

The second course is offered by the Philosophy Department and is called "Modern Perspectives in Culture." The philosophy of science and its meanings in various types of cultures constitute major parts of this course. It too follows a lecture-discussion pattern.

Trenton State College.— A new course, "Growth of Scientific Ideas," has content which the respondent reports are similar to the suggestions on the third questionnaire item. The course is elective, but growing in popularity. He adds:

The course attempts to trace the history and philosophy of science as related to society with the laboratory slanted toward (1) replication of historic experiments, and (2) experiments in inquiry.
Practices in science courses

Florence State College.-- A theme of the required science survey courses is that "We are living in the age of science and every citizen should have some understanding and appreciation for what this age of science has done for everyone." Emphasis in these courses is on science "...as it relates to an educated citizenry as opposed to strictly theoretical science." Historical approaches are used to introduce many topics.

East Carolina College.-- Problems are raised relative to the role of the chemical industry and its effect on the locality of the college. A nearby chemical plant is visited and studied.

Appalachian State Teachers College.-- The respondent writes:

Perhaps the most effective contributions to social applications of science are accomplished in biology. A few exercises will illustrate: (a) visit to reforestation projects - social objective is understanding of water and forest conservation and their relationship to industry, poverty, etc. (b) visits to streams with varying amounts of pollution - comparative study of abundance of organisms, (c) role call of native shrubs with commercial possibilities and methods of propagation.

Colorado State College.-- The respondent writes:

In the freshman (science) courses...particular emphasis is given to the historical development of concepts, to illustrate the ways knowledge has developed, to the methods and process used by scientists to generate new knowledge. Efforts are made to update the student's knowledge, to lead each pre-service teacher to see how science makes its impact upon him and society, and how to teach science as a discovery method. The impact of science on human living is recognized in each of the academic areas. The interactions of society and scientific knowledge may be represented by such topics as effects of conservation on the economy of the mountain states, use of atomics to further man's control of disease, food processes and other biological and physical process, the effect of overpopulation, the effect of social mobility in the United States and the necessity for the modification of education to meet the biological-psychological needs of pupils.
Field trips to various parts of the state, films, selected speakers depict the positive effect of science and technology such as engineering, control of resources, the emergence of industry and research centers that are changing the area from an agricultural economy to one of industrial economy. The history of the area as associated with its natural resources is stressed.

**Ball State Teachers College.**—A course titled "Civic Biology" deals with such topics as conservation, ecology, eugenics and civic responsibility.

Field trips are made to local businesses such as dairy, water works, and sewage disposal plan. A conservation trip is taken to emphasize the importance and need for science in the community.

**Austin Peay State College.**—In the general science sequence students work in groups and learn to solve problems scientifically and to share their findings with their classmates. (p. 54).

**Western Washington State College.**—The respondent writes:

In the "Biology for the Elementary School" course which I teach, one lecture of ten is specifically devoted to the development of a rationale for the teaching of science. Hopefully, the relationship pervades other activities, i.e., it is visible in my behavior as teacher, it is perceived as we discuss the breadth of most phenomena.

(In several other professionalized science courses reported, the relationship of science to social living, or democratic living, receives emphasis through the way the course is organized or the conduct of the instructor.)

**Summary and Discussion of Practices Corresponding to the Seventh and Eighth Criteria**

Several respondents observed, in effect, that "little is done" at their institutions to relate science to social living and to total human experience. Other questionnaires returned with little or
no comment on the third item. That respondents may have found this item difficult to complete is suggested by the comment of one respondent:

This is a little difficult for me to assess. I suspect that one assumes students are aware of the social impact of the scientific revolution. [With respect to] the social impact of science, the problems raised by expanding technology, an economy of abundance, etc. I think the closest thing done, outside of mundane verbal platitudes, is discussion of current social and scientific developments and the interrelationships that exist.

An attitude expressed on four questionnaires was that such practices as suggested on item 3 are unnecessary, irrelevant, or otherwise not the concern of science educators. According to one educator:

If the goals of science instruction are the practice and understanding of science, and specifically [if] individual instruction is directed toward helping the child in the elementary school establish the foundation for autonomy in investigation, then the relationship of science education and social living assumes a very minor or secondary role. To be more specific, in our philosophy, science education must [develop] understanding of science through the practice of science and not with a study of many social applications.

Another respondent writes:

This area is left to the social science departments and it's assumed that the elementary teachers in the science methods classes are aware of the relationships without spending further class time on them.

Still another:

We have adopted the viewpoint that social and human values belong in the social sciences. Science is a search for Truth, true, a humanistic behavior however process is contrasted with the technology-product aspect of science. Social studies methods courses have taken over much of the human engineering aspect of the former science methods area.

Lastly:

The methods course teaches the value of scientific inquiry; but the rest of these questions [suggestions under item 3] I am not sure of. They sound very pedagogical or very "core" like. Granted these are values we hold for the elementary school; but can we teach them? We emphasize the value of the inductive approach and critical thinking and hope that these other values are inherent in these processes.
A fifth respondent reflected that such interrelationships receive great emphasis and are, indeed, supported by the philosophy of his institution, but this very emphasis -- in his opinion -- "...may get in the way of sufficient devotion of time and effort to the objective, scientific sides of a learning topic."

The point of view supported in this study is that the science education of elementary majors lacks an important dimension if curriculum arrangements and classroom practices do not satisfy the seventh and eighth criteria. While the majority of educators who returned the questionnaires apparently recognize their responsibility in this area, the quotations, above, indicate that in some schools negative attitudes block a completeness of treatment of the relationship of science to social living. These attitudes may be abstracted and listed:

1. These matters are antithetical to purposes of science education, which should be concerned with development of the autonomous investigator.

2. Contemporary students are already so knowledgeable in these matters that it is unnecessary to devote class time to them in science or science education courses.

3. Reference to social applications of science is inappropriate in the science or science education courses. If such matters are to be treated anywhere it should be done in a philosophy of social science course.

4. Reference to technical applications of science is likewise inappropriate for the science course. To include such references tends to lower the value of a course which should deal with science as a method.

5. As a result of emphasis on scientific methodology in the science laboratory, the student should be able to transfer similar methods and attitudes to personal and social contexts.

6. It is doubtful that values such as these can be taught.

Persons concerned with the science education of elementary teachers should consider the consequences possible when reference to
social application is omitted from science or science education courses — or given niggardly attention while substantial emphasis is given: science information, science laboratory activities, or scientific investigation relative to matters having little or no social significance. If the student is exposed to discussions dealing with humanitarian or social aspects of science only through non-science channels while inundated by something quite different from (or antagonistic to) this in science or science education courses, how will his attitude toward scientists and science-education be shaped?

Assuming that most science educators accept responsibility in this area, it must be inferred, nevertheless, that well-developed practices designed to develop "scientific social consciousness" are lacking in many institutions. Many responses to item three merely listed a few courses in which "this is done" or respondents stated, "There are reading assignments relative to this." The problems involved here, as with previously discussed criteria, should be approached on two levels: the courses made available to students and the practices of instructors who teach these courses.

The need for courses which are specifically designed to include a treatment of the social implications of science seems apparent. The danger that such matters will be neglected if left to the preference of teachers of introductory courses is altogether real. The judgment of the writer is that this aspect of the science education of elementary teachers can be dealt with on three or four fronts: (1) interdisciplinary general education courses, (2) general education or professionalized science courses, (3) science education courses, and, possibly, (4) philosophy of science courses. All were represented in practices reported.
It is not enough, however, that courses be merely designated. In dealing with such matters, particularly those pertaining to criterion 8, there are subtle emotional components to be considered as well as the subject matter. This focuses attention on the methods employed by instructors.

While conscientiously prepared lectures, readings, viewing of appropriate films, etc. should be continued and further developed, these kinds of activities may permit students to consider in only a detached manner attitudes which should be "internalized." Development of attitudes suggested by such phrases as "...the citizen's need to think reflectively in individual and group situations" and "the responsibility of citizens in formulation of public policy in matters relating to science" require classroom procedures in which students themselves assume some degree of responsibility.

Teachers should, therefore, search for and develop methods which involve students in activities through which they may come to examine their personal beliefs, attitudes and habits of behavior; think reflectively in real or simulated situations; and participate (at least vicariously) in civic affairs and controversial matters.

Some of the more promising practices described by respondents include (1) involving students in debate on a controversial idea, (2) specifying "social significance" as one of the criteria guiding students in unit development, (3) developing a democratic atmosphere in college classes in which students are encouraged to question, inquire, test ideas and disagree with the instructor, and (4) involving students
in a study of social problems (poverty, illiteracy, etc.) based on acceptable scientific procedure.

While some respondents have exercised considerable initiative in designing classroom practices to develop science-related social consciousness, this is clearly an area where research effort and imagination needs to be applied.

At six responding institutions the professional course in which science teaching is considered also includes social studies methods. These are: Sam Houston State Teachers College, Ohio University, University of Oregon, Northern State Teachers College, the University of Kentucky and Auburn University. At three institutions (University of Tulsa, University of Georgia and State University College at Buffalo) science methods are included in a course which also considers methods in social studies and mathematics. While such combined courses might more readily provide opportunities for meaningful experiences relative to criteria 7 and 8, it is not possible to generalize on the basis of data collected.

Recommendations Evolving from a Study of Current Practices

19. Every student preparing for elementary school teaching should be required to take a series of general education courses which, interdisciplinary in nature, should be concerned with the study of man and his contemporary culture. In a carefully conceived and executed program -- one which proposes to help students become more effective citizens in a democratic society -- the implications of science should receive due attention.

20. Required general education science course (or professionalized science courses) should provide the prospective teacher with opportunities to (a) investigate controversial issues involving science (such as bomb testing, water fluoridation, etc.) (b) study the relationships of science to health (medicine, physiology, psychology) and (c) become familiar with principles of ecology, with special reference to water and air pollution, insect control etc.
21. Students should have available to them — at least on an elective basis — a history and philosophy of science course. In such a course progress in several broad areas of science may be traced while the work and contributions of individual scientists may be studied in social and cultural context.

22. Instructors of general education science courses, science education courses, interdisciplinary courses having science implications and philosophy of science courses should experiment with methods of teaching through which students may be helped to develop scientific attitudes relative to social application. Such methods will probably involve granting the student greater responsibility and freedom in making decisions relative to course activities and content.

Practices Reported Corresponding to the Ninth Through Twelfth Criteria

Criterion 9: Does the particular practice help the teacher apply to science teaching-learning situations principles of educational psychology, including what is known about the processes by which children develop concepts and generalizations?

Criterion 10: Does the particular practice acquaint the teacher with the characteristic responsiveness of children toward phenomena in their environment (curiosity, experimental-mindedness, initiative, etc.)?

Criterion 11: Does the particular practice help the teacher understand that the spirit of inquiry is greatly affected by the atmosphere created in the classroom?

Criterion 12: Does the particular practice help the teacher understand the value and techniques of teaching in which problems are discovered and solved by children; and to distinguish this type of teaching from that in which primary emphasis is given to presentation and recalling of information?

These criteria were incorporated in the fourth item of the questionnaire:

Describe practices in your institutions which you feel are particularly effective in helping the elementary teacher understand and apply learning theory to science teaching situations.

The distinctions between these criteria are a matter of relative emphasis — the emphasis being placed in turn on the nature of the child, interaction of child and environment, environmental atmosphere and
teaching in a problem context. Suggestions to the respondent appearing under item 4 were intended to elicit descriptions of practices reflecting concern with these several emphases.

Classification of Practices

An examination of responses to item 4 revealed that practices corresponding to these criteria could be sub-classified into six categories, as given in Table 16. The following pages give more complete descriptions of reported practices.

Application of learning theory is emphasized as students observe children being taught science

Colorado State College.-- A series of professional courses "...give ample opportunity for the education major to apply basic principles of learning." Students taking these courses observe children at work in a laboratory classroom environment of the campus school where the teacher is a specialist in elementary school science. Opportunities are arranged for observation and participation in the campus school. Participation includes preparation of materials and design of learning activities that help to develop discovery practices.

University of Kentucky.-- Students taking science education course are required to observe in an elementary classroom for fifteen hours (p. 87). Approximately half of the students observe science being taught. The teachers cooperating in this arrangement are volunteers and are not selected on the basis of their science teaching. In any event, the relevance of the observation to science teaching is considered in subsequent class discussions.

The goals of the observation are to develop understanding
TABLE 16.— Tabulation of reported practices through which prospective teachers are helped to understand learning theory and apply it to science teaching

| Appalachian State Teachers College | | | | | | |
| Arizona State College | X | | | | | X |
| Austin Peay State College | | | | | | X |
| Auburn University | X | | | | | |
| Ball State Teachers College | | | | | | X |
| Bowling Green State University | X | | | | | X |
| Brigham Young University | | | | | | X |
| Colorado State College | X | | | | | X |
| Cornell University | | | | | | X |
| Duke University | X | | | | | |
| Duquesne University | | | | | | X |
| Eastern Kentucky State College | | | | | | X |
| Eastern Michigan University | X | | | | | X |
| Florence State College | | X | | | | X |
| Glassboro State College | X | | | | | X |
| Goucher College | X | | | | | |
| Harris Teachers College | X | | | | | X |
| Indiana State College (Indiana) | X | | | | | X |
| Indiana University | | | | | | X |
TABLE 16, (Contd.)

<table>
<thead>
<tr>
<th>Students observe children being taught science</th>
<th>Students teach science lessons to children other than during student teaching</th>
<th>Learning theory illustrated in lectures, films, readings etc.</th>
<th>Instructor illustrates application of learning theory in demonstration lessons</th>
<th>Learning theory applied in development of units and lesson plans</th>
<th>Emphasis on application of learning theory during student teaching or intern teaching</th>
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<td>Students teach science lessons to children other than during student teaching</td>
<td>Learning theory considered in lectures, readings, etc.</td>
<td>Instructor illustrates application of learning theory in demonstration lessons</td>
<td>Learning theory applied in development of units and lessons plans</td>
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TABLE 16s (Contd.)

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<td>x Practice reported in a course other than Elementary Science Education</td>
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of classroom management and the relationship of a proper emotional environment to inquiry. Cooperating teachers are encouraged to permit students to participate in classroom activity and to teach a science lesson.

University of Iowa.---The respondent reports that students have "numerous opportunities" to observe children being taught science with various materials and several approaches in the University Experimental School, where the program emphasizes "problem-solving." Detailed discussions follow observations.

University of Southwestern Louisiana.---An observation course carries three hours credit. Students observe in the laboratory school two hours each week and attend class for three hours. Students observe children engaging in many activities, including science. During class meetings the different purposes of observations are clarified, reading assignments are made and previous observations are discussed. A list of the objectives of the observations include the following:

1. To see how the teacher manages the classroom
2. To see the variety of techniques used by teachers
3. To see independent work of children
4. To see evidences of teacher-pupil planning
5. To notice types of questions asked by teachers
6. To observe how teachers and children evaluate lessons

After observations relative to lesson planning, the student prepares a report using a form (Appendix B, Item 12) which emphasizes application of educational psychology.

Ohio University.---Students in the "Methods of Teaching Social Studies and Science" class spend one week with an elementary class in the University School, during which time they may be called on to assist the teacher in science or social studies teaching activities. Several
of these observations are devoted specifically to classrooms in which problem solving is being attempted. A closed-circuit television arrangement is being installed which will increase opportunities for observation of University School classes.

(Closed circuit television is used for observation of campus school teaching at the University of Missouri.)

Bowling Green State University.— During observation in public school classrooms students are asked to take particular note of the classroom atmosphere. These observations are discussed in educational psychology classes. The respondent writes:

Our people in educational psychology stress relationship of experience to conceptualization by [relating] the lecture material to the observations of our students as they visit in the schools. Each student is required to spend a given number of hours in the schools, observing various classes in action. This procedure is most helpful to our students.

Harris Teachers College.— In addition to practice teaching, students have an apprenticeship semester, during which they spend some time in every elementary grade. According to the respondent, at least one teacher so contacted will be helpful with such matters as suggested on item 4.

University of Denver.— The respondent writes:

All students participate in an off-campus program before student teaching.... [There is] a follow up session three days a week on campus. Attention is given to social studies, language arts, math and science. Students take educational psychology at the same time.

Arizona State College.— The respondent writes:

Required of elementary education majors: 40 hours of contact experiences in the classroom assisting teachers and students in various ways. This is more than just observing the teacher at work and is required before the actual student teaching experience begins. In connection with the elementary curriculum class the students
actually plan and carry out the teaching of a unit under the direction of the course instructor and supervising teacher.

University of Colorado.—Concurrently with the science education course students take another education course which involves some four hours of observation each week in public school classrooms. Students have an opportunity to observe the spirit of inquiry, proceeding from experience to conceptualization in selected classrooms, as well as have it demonstrated in the science education classroom.

Auburn University.—Students enroll in a pre-teaching observation experience at the beginning of the junior year. This is two weeks in length and is done in September before the beginning of the Fall term. Students must assume responsibility in making arrangements. Prior to this observation students are enrolled in a foundations course, "Principles and practices in Education," which prepares students for the experience.

While the observation is not directly related to science...we have found in the methods classes that the experience the students have encountered add much to the understanding of the job to be done. They are able to relate what is being done in the college class to their own experience (though brief) in the actual classroom situation. Interest is high. The students have opportunities to participate in all of the school activities as well as observe.

(A similar "September experience" is arranged at the Ohio State University and Oregon State University.)

Northwestern State College.—Students are required to observe five hours of science teaching in the campus elementary school:

Through observing teachers use of children's interests to extend their understandings of the world...future teachers gain ideas of how science can be related to individual needs of children.

Lewis and Clark College.—In the term prior to student teaching students are assigned to an elementary classroom for observation and
participation. Many students remain in the same classroom for student teaching. Weekly seminars are held at which time discussions center on students' observation experiences and plans are made for subsequent observations. This program is new and being developed:

This coming Fall I hope to set it up so these students will have an opportunity to plan and carry out some aspects of the science program in rooms where they have observations.

University of Miami.— The respondent writes:

The course "Science in the Elementary School" is taken as part of their junior block semester during which time students participate about one-third of the semester as a full time teacher-aide in the public schools....They have concrete experiences in observation and participation in the on-going science program of a particular class of elementary school pupils concurrently with the "theory" in course work.

Newark State College.— An extensive amount of experience with children is required in the junior year, which is largely a professional year. Prior to the junior year the student must have completed a minimum of 65 hours of work with young people in such activities as summer camps, "Y" activities, etc. During the junior year the student is required to take an eight week field practicum in the field.

Ed. 305-306: The purpose of the practicum is to induct the student into a wide range of public school experiences which include actual classroom teaching together with an understanding of the role of the classroom teacher....The total experiences consist of; two visits during the junior year, a full-time off-campus practicum period and a return to the practicum for a week in the fall before the beginning of the senior college year.

The respondent adds that students are asked to distribute their experiences through a number of curricular areas, including science.

State University College at Oswego.— The respondent describes as "dynamic and influential" a program of observation in the sophomore
year which involves the student in two hours of observation daily for seven weeks in the campus school. The student teaching handbook recommends that students participate in 44 kinds of activities, classified into five categories:

1. Participation in pupil activities (such as group discussions)
2. Assisting in directing or guiding pupil activities (such as helping children with reading, locating materials etc.)
3. Participation in routine activities of the school (such as supervising playground)
4. Preparation and use of materials of instruction (posters and charts, etc.)
5. Participation in housekeeping activities (such as learning to arrange furniture and equipment)

University of Georgia.— Experiences pointing out the relationship of science to children’s lives are provided for students prior to and during student teaching. Student teachers usually develop and teach a science unit. The respondent continues:

As part of curriculum and methods block during the senior year students become acquainted with science methodology. This block takes four hours a day, and includes experiences with children totalling about forty hours.

Northwestern State College.— In addition to members of the science education class visiting classrooms of the campus school during teaching of science lessons, children visit the college classroom:

Since the Laboratory School and the School of Education are located in the same building, we are also able to have children share with college classes particularly exciting occurrences, such as the emergence of a moth from a cocoon. These...must be incidental, but they bring the child’s freshness and enthusiasm right into the college classroom.

(At approximately half of the institutions where observation of elementary children is reported there are campus-associated schools. In addition to schools already named, these include Trenton State College,
Application of learning theory emphasized as students teach science lessons to children (other than student teaching.)

Teaching exercises or participation were mentioned by respondents in connection with observation activities at Arizona State College (p. 171), Lewis and Clark College (p. 172), University of Miami (p. 173), State University College at Oswego (p. 173) and the University of Tennessee (p. 186).

Northwestern State College of Louisiana. The respondent writes:

In the science methods course, each student is asked to prepare an experiment which he can use with children for demonstration and/or participation. The experiments are planned so that they will coincide with an area being studied in the elementary classrooms of the laboratory school. The future teachers present their experiments to small groups of children.... Where the experiment is one children can perform, they are allowed to do so. The opportunity to talk with small groups of children helps the future teacher to develop better insight into the children's responsiveness to learning about his environment. In discussion, they also help children verbalize concepts they have learned from experiments and other activities in the area of study.

Rhode Island College. As part of a practicum course in science for the elementary grades students, working in teams, prepare and teach a complete science unit to children in the campus school. This teaching is done at least twice weekly for the duration of the unit.

Indiana State College (Indiana). The teaching of a science lesson to children is, in the opinion of the respondent, "about the single strongest and most beneficial point of the entire methods course."
Pennsylvania State University.-- Students teach science lessons in local schools:

A team of two to four students is assigned to a classroom. They first observe and get to know children and teacher. They then plan a series of lessons which they teach during a two week period. Planning is done on the basis of a series of conferences (usually three for each lesson) with course instructor.

Teaching experiences are discussed in methods class after all teaching has taken place.

Because of the close supervision and extensive conferences, planning can be directed to include maximum opportunities for problem solving. The instructor feels that more effective methods instruction takes place within this framework than in any other plan which seems possible at this time. "...It's time consuming for all concerned but students are almost unanimous in stating that it is worth it and it should not be changed."

Temple University.-- The science education program is at the graduate level. The graduate (in-service) students are required to prepare and present a lesson to the college class and to their own elementary classes. Subsequently there is a verbal analysis of the presentations:

The net results are considerable improvement in the quality of the later demonstrations in class and a high frequency of carry-over to the elementary schools as expressed by the teachers themselves and supervisory personnel with whom I am in touch.

State University College at Oswego.-- The respondent writes:

In my science section of last semester I experimented with five students and assigned them to do their science demonstrations in front of regular students from the campus school. Since these students ...were well qualified...they all did a very capable bit of teaching. I would like to do more of this type of work with my students but the amount of work involved in making arrangements...is staggering.
Cornell University.— Elementary science education is at the graduate level. The respondent wrote the following about situations involving application of learning theory:

I asked a class of in-service teachers to open an investigation of anything with their classes, recording the manner in which they opened the investigation, the questions and guesses of the pupils, the avenues of investigation pursued by the pupils, and understandings that the teacher hoped to develop, what the pupils really did develop, the particular ideas with which the pupils had difficulty, and the minimum background that the teacher (in retrospect) thought essential in order to teach the topic in question.

By way of the kind of report turned in, one teacher worked on the questions, "Are the wheels on opposite sides of a child's wagon solidly connected, so that if one turns, its opposite turns at the same time?" A thorough investigation of this by her first-grade pupils turned up some [authentic] science, including the observation that the difference in number of turns that the right and left wheels make does not depend upon the size of the circle that the wagon is drawn in. Records of their experimenting, their quick answers and subsequent testing of hypotheses, and final generalizations, brought into play all the skill and insight that the teacher was capable of. It also made every teacher who put forth an honest effort a better science teacher — by their own admission.

National College of Education.— Children from the demonstration school are brought into the science education class and taught a science lesson by two college students while the rest of the college students observe. This is done at all levels from Kindergarten through eighth grade and in eight different areas of science. After the children leave the room there is a discussion and evaluation of the lesson.

University of Kentucky.— Near the end of their fifteen-hour observation (p. 166) students are expected to make arrangements with cooperating public school teachers to teach a science lesson to children. The topic should be chosen from an area of science which the children are studying, if possible. Students must submit reports of their teaching and are expected to accomplish the following:
1. Stimulate children to participate (discuss) by using materials which interest children.

2. Develop skill in "teaching without telling.

3. Help the children develop understanding of a specified science concept.

Learning theory considered in lectures, discussions, readings, etc.

Brigham Young University. -- The respondent has developed a thirty minute film and a set of charts which, among other things, are designed to illustrate how children learn science concepts. The charts could be used in one or more lectures and relate to several of the criteria developed in the present study: "The nature of science," "Purposes of teaching science," "Development of children's interests," "Attitudes and scientific method," and "Unit planning."

The last named topic emphasizes identification of important concepts and selection of methods and activities by which these concepts may be developed by children. One chart illustrates children engaging in several types of activities (discussion, reading, experimenting, and looking at pictures) and has this legend: "Our best teaching takes place when we can teach a science concept through a series of learning experiences."

My purpose for developing the charts and the film was to give meaning to my lectures as I worked with teachers in helping them become more effective teachers of elementary science. The charts served as springboards to discussion centered around concepts I had stated on the charts. The film, which describes basic learning experiences through which we teach the concepts of science to children, was developed to follow Chart 16.

Chart 16 displays these statements:

1. Don't feel too handicapped because you may lack teaching equipment.
2. Let pupils experiment and handle materials.

3. Teaching a unit of work in which you have some familiarity will give you confidence in teaching science.

4. Don't expect to know all the answers to the questions children ask.

5. Help children learn how to work out the solutions to their problems.

6. Keep your lesson plans, pictures and other teaching materials for use another time or to share with other teachers.

Indiana University. The respondent writes:

Careful step by step sequential analysis of how children learn in science is stressed in science methods course....We are more interested in children being guided by their own curiosity through personal challenges than an adult imposed procedure.

University of the Pacific. Several films are used which the respondent believes are "very good" with respect to application of learning theory. They are "Unit Teaching in the Kindergarten (Magnetism)," "Unit Teaching in Second Grade Science (Air)," "Unit Teaching in Fourth Grade Science (Eye)," and "Unit Teaching in Sixth Grade Science (Sound)."

New Mexico State University. The respondent writes:

Emphasis is placed upon learning through all five senses. Exploration with hands is at least as effective as reading about matter. All that is needed is direction by the teacher so that the observations may be organized into large concepts....First hand observations by each child duplicates the method of science. Each person is the explorer, the discoverer. Each collects the facts and draws his own conclusions from the facts at hand.

University of Louisville. The value of classroom science corners is discussed, with particular reference to creating an atmosphere which is stimulating to children. Excerpts from a duplicated sheet which is distributed to students appears in Appendix B, Item 13.

10 These films are available from the extension division, State University of Iowa, Iowa City, Iowa.)
University of Kentucky.-- Learning theory is discussed in several class sessions:

1. Concept formation and development of understanding of science principles is discussed with particular reference to purposeful, first-hand experiences of the learner. This is contrasted sharply with textbook-oriented science instruction and over-dependence on television science.

2. The film "An Experiment in Group Climates" is shown. The film contrasts the atmosphere generated in boys' club groups under the influence of different kinds of leadership: autocratic, laissez-faire and democratic. Implications of these social climates for classroom inquiry in a science program is emphasized in discussion (see also p. 149).  

3. Discussion problems are improvised to help the student develop an understanding of the role of the teacher in science teaching. A duplicated paragraph directs the student's attention to a hypothetical science-teaching dilemma. Students read the paragraph and, working in small groups, discuss different courses of action. One such problem follows:

You have taught your pupils that toads do not cause warts. The next day Alfred says, "My mother says toads do cause warts." That afternoon Alfred's mother pays a visit to the principle claiming that you are not teaching children to respect their parents.

How do you react to this situation? Do you think you could have avoided the predicament, or is it unavoidable? What would you do?

Following group discussion, students express themselves to the entire class. The idea I attempt to develop is that it would be difficult to defend this teacher's actions if she taught the conclusion dogmatically. Do we accept the principle that science teaching should help children discover and define their own problems and come to their own tentative conclusions?

(The child's responsiveness to his environment and other psychological principles are treated in lecture and discussions at the University of Bridgeport (Appendix B, Item 7), Rhode Island College (Appendix B, Item 14) and Wisconsin State College at Oshkosh (Appendix B, Item 15).

Film available from Indiana University film service, Bloomington, Indiana.)
Instructor illustrates application of learning theory in demonstration lessons and laboratory

University of Maine. -- "Concept formation" is discussed and illustrated in the human development course, conducted by a team of five instructors. Weekly lectures and other course material have been placed on videotape. The class meets twice weekly in smaller group sections. The respondent writes:

We have one lecture session devoted to some elementary notions of concept formation. Three of us conduct this particular session. Using such simple materials as bottles and beakers, I try to illustrate some elements in the formation of the concept of pitch. The psychological ideas of discrimination, generalization, trial, reconstruction and assimilation are illustrated by the sequence of demonstrations. The way concepts become structured (with their denotative and connotative aspects) and the optimum conditions for concept formation in schools are discussed by the other two instructors.

University of Wisconsin. -- The respondent writes:

Problems are posed to the class during the course of a discussion. In the discussion periods the laboratory procedures are proposed and refined by the instructors and students. The students then work in the laboratories to answer the questions. Following this, the problems are again discussed by the class and instructor. Example: In the study of electricity questions may include, "How can we wire a light bulb and dry cell so that the bulb lights?" "How can we wire two bulbs so that both are bright?"

University of the Pacific. -- The respondent wrote at length concerning his emphasis on how children are motivated:

We use different techniques, all usable in the elementary classroom, to motivate questions. For example, interest objects such as a lodestone, magnets, small toy electric motor...[may be used].

Another technique is to distribute trade reference books (for browsing). For each topic we insert a few leading questions to be looking for as they thumb through the book. Invariably they run on to things they wish to know more about and will later raise questions.

Another motivational introduction is the use of a demonstration that illustrates a principle important to our study. The demonstration is designed to raise questions, not answer them, so little explanation is given by the teacher. An example of this is burning a candle in an inverted jar sitting in a pan of water. All have seen
this but most believe the resulting rise in water level is due to
the oxygen being burned. However, by observing several demonstrations
the water level isn't always the same. The question is asked, "Is the oxygen destroyed?" The discussion that follows usually raises
a few questions concerning chemical combination and air pressure.

Another method used is to read to the class an interesting account
of some scientific endeavor. These are usually found in magazines
or newspapers and sometimes in books. They are chosen for their
high interest value to get the pupils to think and ask questions.

Of course bulletin boards are used with appropriate questions
accompanying the pictures. Not all of these techniques listed are
used for each topic, but at least two are. Questions are then
raised and these serve as a basis for study.

San Diego State College. The respondent writes:

We show contrasting ways to approach the study of a generalization. One way we tell, the other way we ask questions all the
way through a "Socratic approach."

Rutgers University. The respondent writes:

In a graduate level science education course I attempt to
provide the future teachers with a model they may emulate. I
use all the techniques I'd like them to use. Throughout the
semester I discuss the nature of science, relationships to social
learning, learning theory, satisfaction of needs, science in the
curriculum, evaluation, and curriculum development wherever
appropriate.

Marshall University. The respondent writes:

We teach demonstration classes in an attempt to show the
spirit of inquiry and emphasize the spirit of inquiry in (a)
student demonstrations, (b) laboratory exercises, and (c) reports
and projects. An attempt is made to make every activity a problem-
solving activity.

St. Cloud State College. In a professionalized biology course
(p. 97):

Subject matter of science and processes of science are woven
into one situation — stated another way, content and methods are
taught together, the way it should be, not separated from one
another in time and distance. In assigning teaching aids which
students may make and take with them, it is adequately shown that
teaching with these materials makes the concepts meaningful and
real, not word symbols from a book.
University of Oklahoma. -- During the laboratory portion of the methods course, the primary objective is to develop skill in a problem-solving approach to science teaching. After the instructor teaches demonstration lessons, his behavior is analyzed by his students.

Teachers College, Columbia University. -- The respondent writes:

Demonstration of activities that can be carried out in school situations are given. For example, we have just completed a study of electricity. Considerable time was given to the discussion of how children could be taught the difference between a series and a parallel circuit.

University of Kentucky. -- The instructor teaches several lessons using inductive teaching methods (p. 82):

Later discussions bring out the importance of direct experience in concept development. The complementarity of inductive and deductive teaching methods are discussed following an illustrative deductive lesson. It is demonstrated that a deductive approach is appropriate (a) when certain principles cannot be readily taught by an inductive approach, and (b) to give pupils experience in applying principles to a new situation.

(Several respondents reported that an attempt is made to foster a democratic atmosphere in their classrooms. Reported elsewhere (pps. 149 - 150), these practices illustrate the application of learning theory.

Learning theory applied in development of units and in lesson planning

Ohio University. -- Students in methods classes present demonstration exercises at which time the other class members play the role of children the age for which the demonstration is intended:

Observation of children and a knowledge of their needs is essential to successful participation in this exercise. Better grades are given to those students who utilize their classmates and individualize their instruction.

Mississippi College. -- The respondent writes:
Elementary teachers conduct "silent demonstrations." That is, each student demonstrates a particular principle of science without telling classmates what is taking place. Questions asked by the demonstrator help her determine whether those viewing the display understand what is taking place.

**Trenton State College.**—A collection of children's science questions was compiled. Students in the "Physical Science in Elementary Education" course draw a question and prepare a demonstration lesson based on the question. "Chalk talks" are not allowed.

**Duquesne University.**—When students demonstrate in front of classmates questions are encouraged. "By making them aware of the many questions [children] may ask them later they are more eager to have their classmates ask now."

**Ball State Teachers College.**—Students prepare and present science lessons to classmates, which is followed by an evaluation by instructor and classmates. At a later time selected students may teach science lessons to children.

**Brigham Young University.**—The respondent writes:

In our science methods courses students are required to demonstrate to their fellow students, using simple equipment, how they would teach boys and girls science concepts using the discovery approach in their experiments.

**San Diego State College.**—The respondent writes:

Each student is placed in a small group. He presents at least six experiments himself at a grade level, and observes and participates as a mock pupil when the other five or six in his group do the same. He receives an evaluation from each of the others... He studies the evaluation and returns them to the instructor next day with his comments as to what he did well and what needs improvement.

The evaluation card used at San Diego is reproduced in Appendix B, Item 16.
Eastern Michigan University.-- The respondent writes:

Our methods courses have laboratory time during which students are required to demonstrate principles to their classmates and are asked "why" until they give satisfactory explanations in simple language.

Maryland State College at Towson.-- Under item 2 of the questionnaire the respondent states his conviction that it is more important for elementary majors to develop an understanding of the nature of science than to acquire a mass of facts. Included in his statement:

One or two students take the role of teacher and for ten or fifteen minutes lead the class in a true experiment....The class tries to imagine themselves as children and react accordingly. These experiences are experiments, not demonstrations, since the student teacher attempts to draw from the class hypotheses regarding a simple problem and ways to test these hypotheses. The outcome is not known. Often his preconceived procedures are not suggested by the class and he must show expert leadership and flexibility in following out other ways that the class has raised. Even the conclusions may be different from what he expected. Most of the students becomes very enthusiastic about this real experimentation once they overcome their fear of the unknown and they realize that nobody is going to frown on them for seemingly silly or inconsequential ideas or mistakes. We can always slip back into the college level and I can make suggestions if help is needed or the confidence of the student teacher is too badly shaken by getting up a blind alley. Frank, constructive criticism is given by all at the end of the session.

The directions given to students at Towson for their science presentations appear in Appendix B, Item 17.

Sam Houston State Teachers College.-- Students prepare and present lessons, chosen for appropriateness to the grade level they intend to teach. The respondent writes:

When these lessons are taught before the class, the students see the same area of science developed at first, second, third and so on, grades. This...gives them an understanding of how the same principles are developed simply...and in a more complex manner. Students plan for discussion periods, for references to other science learnings so that associations may be built up, and direct such questions as may cause the child to state principles in his own words.
Our students learn to do many science experiments, meanwhile directing attention of their classmates to what is happening, what they think will happen, and in weighing possibilities. They are urged to permit and encourage their pupils to search for additional experiments and to bring in some of their own. Almost always the student who teaches uses the assistance of many of her classmates.

Frequently demonstrations or experiments do not work out as planned and the students are urged to direct the thinking and investigation of their classmates along analytical lines in order to determine why.

University of Maryland.— The respondent writes:

Once during the semester students plan a lesson for a specific grade and the university instructor teaches this plan (with adaptations that are necessary as the lesson goes on) to pupils in a nearby public school. In this way, prospective teachers see pupils in a science class and can see theories in action.

University of Tennessee.— Work with unit planning emphasizes concept formation. Concepts must be clearly stated and students perform the activities selected to develop these concepts. Students also have an opportunity to try out parts of their units with third and fourth grade children in a nearby school. "Every student has a part in preparation and presentation, thus demanding some attention to evaluation, criticism and modification of plans."

Northern State Teachers College.— The respondent writes:

Writing units in science helps future teachers to understand the relationships of experience to development of concepts. Creating bulletin boards, charts and other audio-visual material to help build a classroom atmosphere of interest and curiosity help illustrate to our students the importance of this approach in science. Preparing units of study on various science topics aids the students in developing skills in the use of a problem-solving approach.

University of Miami.— The unit plan developed by students is designed to develop understanding of, and application of, learning theory to science teaching: "It is designed to maximize transfer of learning and to show...how generalizations are developed from concepts and how these in turn (are) developed from concrete sensory experiences."
University of Texas.— The respondent writes:

Part of our methods course is devoted to the development of a model of the science curriculum for the kindergarten through high school. One highly important factor is the contributions of the psychologist to an understanding of what experiences should be provided, and why some experiences for children are much more successful than others. Using this model as a criterion, the students evaluate the appropriateness of the experiences in their units for children at different levels. For example, a unit for second grade on the universe was recently discarded because students concluded that since at this level children benefit more from direct experience with concrete objects, and since there is little in the universe that can be so treated, this unit would fit better at another point in the curriculum.

(Similar activities in curriculum organization and unit planning are done at Colorado State College.)

The respondent at Texas continues:

The relationship of experience to conceptualization is carefully analyzed for the students, or described as concepts representing patterns of merged perceptions. This means that at an early level, a broad experience and a high amount of skillful direction on the part of the teacher is necessary in order for concepts to be learned.

Learning theory emphasized in student teaching or intern teaching

University of Nevada.— Application of psychology in student teaching is encouraged through a close relationship between the courses taught and the student teaching experiences:

The individuals supervising student teachers are well informed of the procedures and methods followed in the science course. Our Department of Elementary Education is small — consisting of five individuals — and we attempt to maintain a close understanding of what is being accomplished in the other person's area of work. The supervising teachers do have regular seminars with the student teachers and frequently I (who teach the science course) have conferences with the supervisors of student teaching. I feel that within our teacher education program the left hand knows what the right hand is doing.

University of Missouri at Kansas City.— The student teaching is believed to be "particularly helpful;"
In the student teaching centers the elementary teachers who serve as "master teachers" do a good job of teaching science... science is considered a major part of the curriculum, not an incidental or enrichment activity.

_Western Washington State College._— According to the respondent, "translation of theory into practice" is a major objective of the student teaching program, and is an administrative consideration in the selection of methods teachers, psychology of learning teachers, cooperating teachers and supervisors. Student teaching at Western Washington may carry from sixteen to twenty-four credits and may be done over a two-quarter period.

_Moorhead State College._— Students have an opportunity to teach science and observe it being taught during student teaching. The respondent conducted a survey of student teachers over a five year period, however, and found that science teaching during student teaching is "rather pitiful." Excerpts from the survey instrument are given in Appendix B, Item 18.

Other activities in the science education classes at Moorhead are:

1. Observing and discussing observation of elementary science classes.

2. Reading on such topics as "children's interests," "motivation" etc.


_Marshall University._— Although science education personnel have no direct role in student teaching supervision they are active in the intern program. The respondent is "on call" to any intern who wants help in teaching science.
Summary and Discussion of Practices Corresponding
to Criteria 9 through 12

A practice reported by 33 respondents on item 4 involves
observation of children in elementary classrooms. Students may observe
different approaches to science teaching and the circumstances under
which science is taught (or not taught) and discuss their findings in
subsequent class sessions.

Many of the observational arrangements reported, however, are
not under the direct supervision of the science educator. These are
as follows:

1. Observation in connection with professional education courses
   such as Educational Psychology, Elementary Curriculum, etc.
2. A course devoted largely to observation included in the
   professional sequence
3. A portion of a "professional semester" devoted to full-time,
   or extensive, observation
4. Observation during one or two weeks prior to beginning of
   student's junior year, with student usually assuming some
   degree of responsibility in making arrangements

In such arrangements students may have opportunities to observe
science teaching as well as to see other areas of curriculum practice.
The science educator may then draw upon the student's reservoir of
observation experience to illustrate and develop matters relevant to
science education.

At some institutions the involvement of prospective teachers
in elementary classroom activities is effected through a more or less
highly organized procedure which is separate from, but theoretically
correlated with, other pre-professional experiences. Undoubtedly such
field experience is successful in many respects, but the cautious wording
of some responses suggests that the relevance to science education is sometimes limited. Observation experience routinely required of all prospective teachers which, for reasons of efficiency, is administered through a "field coordinator" may lack fullest possible articulation with the science education course.

Such disarticulation is even more apparent in the case of student teaching of which one respondent remarks that opportunities for observing and teaching science are "pathetic." Of 73 respondents reporting practices relative to criteria 9 through 12, only 12 mentioned science education activities coordinated with student teaching or intern teaching. Some of these practices, moreover, do not appear to be carefully structured.

An ideal arrangement would be assignment of the student to a supervising teacher who teaches science imaginatively and whose enthusiasm is infectious. This, however, is only one criterion to be considered in selection of supervising teachers. It would seem unavoidable, particularly when supervising teachers in a given area are in short supply, that some teachers will be pressed into supervisory duty who are weak in science.

In these cases, the institutional supervisor should be ready to lend assistance and encouragement. The science educator should explore possibilities for furthering teaching competence in science through the student teacher - supervising teacher - institutional supervisor relationship.

The importance which educators attach to student experiences with children suggests that no science educator can disqualify himself
from sharing responsibility for giving direction to these aspects of professional education. Where the science educator has no direct role in placing students into classrooms for observation, participation, or student teaching, he should seek to exert appropriate influence on those who do to ensure that these activities will have relevance to science education.

Those institutions which support a campus school undoubtedly have advantages with respect to student observation not enjoyed by other colleges. Many campus schools have good science facilities and materials and teachers skilled in teaching of science. Students are assured of observing excellent teachers at work and, in some cases, participating in the development of science materials for use in their classrooms. Where lines of communication are kept open, the science educator will be alerted to current activities so that students will have optimum opportunity to schedule observation at strategic moments. In one case reported, children are invited to visit the college classroom to share their activities and enthusiasm with the prospective teachers.

Arranging student observations -- observation of science teaching in particular -- is more difficult at institutions where there is no campus school. Especially where the teacher education program is relatively large and the surrounding community is relatively small, the education faculty might encounter public relations complications if procedures relative to observation are not sensitively developed and scrupulously followed. Institutions in such situations do manage observation experiences for students, however, and the "time consuming effort" -- as suggested by several respondents -- is not an unreasonable
price to pay for the benefit realized.

Although only 15 respondents reported that students in their elementary science education classes have an opportunity to teach science lessons to children, few practices were reported with greater enthusiasm. It is evident that while much time can be consumed in making necessary arrangements, that this practice is highly valued by students and instructors where it is employed. Probably the most elaborate arrangement is practiced at Pennsylvania State University, where small groups of students plan a sequence of science lessons in consultation with the instructor. After the unit is taught there is a follow-up discussion in class. Such meticulous structuring of this experience should maximize the possibilities of applying principles of learning theory in a realistic context.

As beneficial as short-range teaching of children may be, it is subject to limitations which would be noted particularly by educators who believe that at least a portion of the child's science experiences should be in a broad-unit context.

Teaching of single lessons, or a sequence of lessons, could help the student understand how children can be motivated, how simple concepts are developed, the effect of classroom atmosphere, and other matters related to application of learning theory.

The student would have more difficulty perceiving from a brief experience how children can be guided into discovery of problems, development of hypotheses, design of experiments, collection of data, library research and drawing conclusions. Activities of this nature are more likely to emerge from study which spans a period of several weeks.
This observation supports the recommendation that science educators should seek to become involved in providing some direction for the student teaching program.

Another highly regarded practice is requiring students to present science lessons to classmates. In these exercises students may develop skill in involving "pupils" in problem situations, asking questions rather than lecturing, using materials in eliciting comments and discussion, etc. Obviously, however, the general situation would be much different than that in an elementary classroom.

Lessons taught to classmates are often subjected to evaluation by classmates. While this procedure may have certain advantages it may be questioned also. This matter is considered in the discussion relative to evaluation (p. 263).

Student preparation of teaching units, mentioned on other items of the questionnaire, was cited again on item 4, this time as a vehicle for helping students develop understanding of learning theory. Emphasis is usually on identification of concepts and principles to be taught, and the planning of activities through which children may develop these understandings.

The teaching of demonstration lessons by the college instructor, also cited on item 2, was listed by respondents as a means of helping students develop understanding of "problem-solving" teaching methodology. Most of the practices reported occur in science education courses.

Twenty respondents reported that such matters relative to learning theory are considered in discussions and lectures, through films and class exercises. Details were not provided in most of these cases.
Films used at one institution illustrate children being taught science in a classroom; at another the films emphasize the effect of a democratic environment. Carefully structured discussions and lectures are reported by several respondents.

Undoubtedly, appropriate films, selected readings, well-planned lectures and lively discussions have an impact on the student's emerging understanding and attitudes. The educator should be aware, however, that understandings as subtle as how learning theory may be applied to dynamic, unpredictable classroom situations are difficult to develop. "Ordinary" vicarious experiences may have little effect on student behaviour when he becomes a classroom teacher. To facilitate development of understanding, the educator should seek techniques which maximize thoughtful participation of students.

The writer has developed discussion problems in which student participation takes the form of expression on hypothetical situations similar to those an elementary teacher might encounter in teaching science. This technique, under development in other fields, is not widely used in elementary science education. It may have considerable potential in helping students develop insights which are otherwise difficult to develop in classroom situations.

Students evidently are often inhibited from expressing them-

12 Phi Delta Kappa (Bloomington, Indiana) has published a volume Simulation Models for Education. Co-editor Michele Fattu writes in an advertisement appearing in the January 1965 Phi Delta Kappan (XLV1:5, p. 250), "Properly exploited....simulation can be a significant breakthrough for improving educational practice. It will permit us to replace the defeatist attitude that education cannot study "real" problems. Simulation permits the researcher to put together a large number of speculative propositions into a realistic predictive model..."
when there is a risk of personality involvement. There is less apt to be a psychological impasse in expressing opinions on the behavior of an anonymous teacher, or suggesting for him a course of action.

The writer hypothesizes that while the student speculates on the situation of the fictional teacher, he is projecting himself into the situation and weighing his own values. Through such vicarious involvement his ability to cope with real situations may be enhanced.

While several respondents referred to education psychology courses, only one educator indicated an intimate understanding of how the topic of concept formation is handled in such a course. The respondent in this case served as a resource person for the educational psychology instructor by delivering several presentations relative to concept formation in science.

Recommendations Evolving from a Study of Current Practices

23. A substantial portion of time in the elementary science education course should be devoted to helping students apply learning theory to science teaching. A variety of activities should be utilized, including all or some of the following:

a. Lectures, readings, discussions, films and verbal exercises
b. Observation of children in science learning situations
c. Demonstrations of science-teaching methodology by the instructor
d. Presentation of science lessons by students to their classmates
e. Teaching of science lessons by students to elementary children
f. Student development of teaching units emphasizing concept formation and effective methodology

Those activities which involve students with children appear to have special merit.

The science educator should seek to make activities in which students are vicariously involved as meaningful as possible. The student should be a thoughtful participant.

24. A complementary relationship should exist between the science education course and the educational psychology course. The science educator should understand the nature of the educational psychology course and in his own course complement and supplement
principles of learning theory which are relevant to the teaching of science. The science educator and educational psychologist may serve each other as resource persons, providing for students more meaningful experiences relative to such matters as conceptualization, inductive-deductive thinking, nature of problem solving, effect of learning environment, nature of experience, nature and needs of children, effect of teacher attitude, etc.

25. Where observation and participation in elementary classrooms cannot be arranged by the science educator, but is handled through a coordinator of field experience, the science educator should seek to exert appropriate influence on the direction of the program to the end that such observation will contribute to the student's development of understanding of science teaching.

26. The science educator should assume some degree of responsibility in the supervision of students during their student teaching. While direct observation of student teachers may be impractical, he may serve effectively in a consultant capacity, having such duties as:

a. Meeting with student teachers during seminars to discuss matters relative to science teaching

b. Working with college coordinators of student teaching to develop ideas for strengthening science teaching activities during student teaching, establishing guide lines, developing evaluation check lists, etc.

Practices Reported Corresponding to the Thirteenth and Fourteenth Criteria

Criterion 13: Does the particular practice help the teacher understand the differences which exist among children in such factors as general intelligence, age (maturity), socio-economic background and experiential background and the implications of these differences for teaching of science?

Criterion 14: Does the particular practice help the teacher understand the possible contributions of science education in helping children satisfy personal needs including: need for information relative to health and safety, need to make a healthy adjustment to the physical world, need for aesthetic enrichment through introduction to new ideas and things, and personal benefit from the ability to think scientifically?

These criteria were incorporated in the fifth questionnaire item;
Describe practices in your institution which you feel are parti­cularly effective in preparing the elementary teacher for teaching science in such a way that it contributes to the satisfaction of personal needs of children.

Whereas the third item of the questionnaire concerns the cultural and social implications of science, item 5 was designed to reveal those practices which help teachers realize how science may contribute to the relatively private dimensions of children's lives. Suggestions appearing under item 5 encouraged respondents to relate how students at their institution are taught to adapt science instruction to needs of individual children and to understand the relationship of science to the personal life and habits of children.

Classification of Practices

Responses to item 5 fall into six categories as given in Table 17. In the following pages appear some of the more complete descriptions of reported practices.

Students observe children in various situations, and interview children

University of Arizona.— The respondent writes:

The needs, interests and attitudes of children are deeply explored with particular emphasis on how they relate to science experiences....Students are asked to try to determine science interests of a first grader...and then compare this with what (curriculum studies) advocate -- the final question is always, "Does it fit the nature of children?"

In a later communication the respondent elaborated on the experiences students have with elementary children:

Actually there are two interviews. One is structured with pre­determined questions. The other is open-ended. The student thereby sees the youngster in two situations. Such things as any expressions related to science, observation, etc. are all noticed."
TABLE 17.-- Tabulation of reported practices through which future teachers are helped to understand how science may contribute to satisfaction of personal needs of children

<table>
<thead>
<tr>
<th>Students observe children in various interview situations, and</th>
<th>Emphasis placed on providing for individual needs during student teaching</th>
<th>Individual differences, personal consider in lectures, discussions, etc.</th>
<th>Students consider in individual needs in unit planning, preparation, and planning of enriching activities</th>
<th>Reference to contribution of courses other than science, education, and student teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appalachian State Teachers College</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Arizona State College</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ball State Teachers College</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Bowling Green State University</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Brigham Young University</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Colorado State College</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Duquesne University</td>
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<td>East Carolina College</td>
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<td>X</td>
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<tr>
<td>Eastern Kentucky State College</td>
<td>X</td>
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<tr>
<td>Edinboro State College</td>
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<tr>
<td>Farmington State Teachers College</td>
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<tr>
<td>Florence State College</td>
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<tr>
<td>Fort Hays-Kansas State College</td>
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<tr>
<td>George Washington University</td>
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<tr>
<td>Glassboro State College</td>
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<tr>
<td>Goucher College</td>
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<td>X</td>
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<tr>
<td>Harris Teachers College</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Indiana State College (Indiana)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Lewis and Clark College</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Marshall University</td>
<td>X</td>
<td>X</td>
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<td>X</td>
</tr>
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</table>
Students observe

<table>
<thead>
<tr>
<th>Individual needs in child teaching experience and student teaching activities</th>
<th>Consideration of child needs in individual and group activities</th>
<th>Individual needs in various situations</th>
<th>Individual needs in student teaching</th>
<th>Individual needs in child teaching preparation</th>
<th>Individual needs in child teaching conversation, discussions, etc.</th>
<th>Individual needs in child teaching planning and delivery of materials and activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference to center, reference to professional formation, reference to elementary school education, etc., and student teaching activities</td>
<td>Students consider the individual needs of children considered in individual needs in group activities, etc., and student teaching activities</td>
<td>Individual needs in various situations</td>
<td>Individual needs in student teaching preparation</td>
<td>Individual needs in child teaching conversation, discussions, etc.</td>
<td>Individual needs in child teaching planning and delivery of materials and activities</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 17 (Contd.)**
<p>| University of Arizona | X | | | | |
| University of Bridgeport | | X | | | |
| University of Colorado | X | X | X | | |
| University of Denver | X | X | X | | |
| University of Georgia | X | | | | |
| University of Idaho | X | X | | | |
| University of Iowa | X | | | | |
| University of Kansas | X | | | | |
| University of Kentucky | X | X | | | |
| University of Louisville | X | | | | |
| University of Maine | X | | | | |
| University of Miami | X | | | | |
| University of Nevada | X | X | | | |
| University of Oregon | X | | | | |
| University of the Pacific | X | X | | | |
| University of Southern Mississippi | X | | | | |
| University of Southwestern Louisiana | X | X | X | X | X |
| University of Tennessee | X | X | X | X | X |
| University of Texas | X | X | X | X | X |
| University of Wisconsin | X | X | X | X | X |
| Western Washington State College | X | | | | |</p>
<table>
<thead>
<tr>
<th>Title</th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students observe children in various situations, and interview children</td>
<td>Emphasis placed on providing for individual needs during student teaching</td>
<td>Individual differences, personal needs of children considered in lectures, discussions, readings, etc.</td>
</tr>
<tr>
<td></td>
<td>Students consider individual needs in unit preparation, lesson planning</td>
<td>Individual needs considered in preparation of teaching aids and planning of enrichment activities</td>
<td>Reference to contribution of professional courses other than elementary science education and student teaching</td>
</tr>
</tbody>
</table>
University of Kentucky.—

An interview with children appeared to have merit but was dropped in recent semesters because of time limitations in a combined science and social learnings class. Students administered an oral science questionnaire to children using materials carried in a small "kit" and a portfolio of mounted pictures.

Students were instructed to discuss science with children rather than engage them in question answering. The same materials and general questions were used with children grades one through six, the interviewers being encouraged to adapt discussions accordingly.

The questionnaire consisted of items in the areas of weather, living things, geology, astronomy, space, simple machines, and magnetism and electricity. The kit contained rock samples, a magnet, a thermometer, dry cell, doorbell, etc. The portfolio contained pictures of clouds, trees, animals etc.

Subsequent discussion dealt with individual differences of children and the characteristic responses of children in different age groups. It was emphasized that a teacher may assess the level of a child's understanding through involving him in activity and discussion.

Teachers College, Columbia University.— The respondent writes:

We have tried to bring children into our laboratory so that the teachers (graduate students) can have experience in working with children. At various times we have collected questions on various topics from children. These questions serve as a basis for planning the experiences in an area of study. A duplicated sheet listing typical children's questions is distributed to students.

University of Southern Mississippi.— The respondent writes:

Studies are made from college level textbooks in science education of subject matter designed for (different) grade levels. An outline that has been prepared to compare all grade levels is a major item in one of the professionalized courses. Through assignments, lectures and discussions prospective teachers are made to understand the different levels of abilities and interests. Children are occasionally invited to join a class for a field trip excursion or a motion picture film and allowed to take part in discussions so that the prospective teachers can observe their reactions to the particular situation.

Moorhead State College.— The respondent lists a number of activities, including observation, which would satisfy criteria 13 and 14;

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13 The questionnaire was adapted after one developed by Clifford G. McCollum. Op. cit.
1. In the required two-credit elementary science methods class the following activities are recommended:

Unit planning -- individual differences accounted for in activities
Elementary class observations -- check list and discussion stresses methods of adjusting to individual differences
Observations of products of children's science work -- science displays in elementary and secondary schools
Readings, class discussion
Displays of science books, with variations in type and level stressed

2. In the elective upper division special science methods course, students engage in these activities:

Observations and discussions of elementary science classes
Working with individuals and small groups on science laboratory work (elementary school children)
Planning study sheets, evaluation sheets, laboratory guides...
Planning ways of introducing science activities
Preparing a science display for viewing by elementary students and conducting the observation of the display
Preparing bibliographies of children's science books, indicating levels and variety in topics, possible uses

Colorado State College.-- During required observations elementary major observe various types of creative work in progress, or the tangible results of completed work. Students are expected to recognize the meaning of creativity and the environment essential for creativity.

University of Colorado.-- Particular emphasis is given theories of child growth in discussing science content appropriate for different age groups of children. Opportunities for the student to make practical applications of these understandings are provided in observation-participation exercises and in student teaching.

Fort Hays Kansas State College.-- The respondent writes:

At least one visit to schools is not only expected but observation reports are required....[Subsequently] we discuss individual differences as exists within the sciences and among scientists, and as we may expect to see between and among elementary school children. Emphasis is placed on understanding that all children do not have the same expectations for themselves and this can't be changed.
Appalachian State Teachers College. -- The respondent writes:

Perhaps the adaptation of science to personal needs of children is best coordinated through a general methods class in the education department. College students participate with elementary students through cooperation of the laboratory school. A particularly effective method has been for the college student to present science materials to small groups of elementary students in school and scout activities.

(See also Northwestern State College (p. 173), and Ohio University (p. 171).

Eastern Michigan University. -- Individual differences of children may be observed by students who voluntarily assist in school camp situations. Students are encouraged to work for week long periods. There is also an opportunity for students to help with underprivileged groups.

Emphasis placed on providing for individual needs during student teaching

Although 13 respondents referred to practices associated with student teaching, few details were provided.

Wisconsin State College at Eau Claire. -- The respondent serves as a resource person for student teachers, who come to him for consultation concerning use and selection of appropriate laboratory materials.

(Similar consultation services are provided for student teachers at Farmington State Teachers College.)

East Carolina College. -- The respondent writes:

In student teaching we try to create an interest in and appreciation for the world in which we live. A child would not be interested in something he has never heard about. Future teachers should try to create a natural interest [in] and appreciation [for] the marvelous order of the whole universe. Man could not dream up a more perfect dwelling place. Incidental activities capitalize on scientific information at hand -- toads, magnets, storms, frost etc.
The respondent noted that he emphasizes a problem-solving approach which provides opportunities for children to have a greater interest in and appreciation for their environment.

Individual differences, personal needs of children considered in lectures, discussions, readings, etc.

Northern State Teachers College.-- In the two year teacher training program students study characteristics of children as part of the science education course:

[This study] results in an understanding of the traits or characteristics of children of the various age groups as these apply to classroom teaching. This understanding is acquired more through study and discussion than through observation and participation experience. More emphasis is placed on this subject with our students who are enrolled in the two year teaching program than with those in the four year program (who are required to take a separate course in "Human Growth and Development").

Fort Hays Kansas State College.-- In the respondent's classes students prepare oral reports on such topics as children's science interests, Piaget's studies, and their own field studies. Duplicated material is distributed which emphasizes individual differences of children; "The Poor Scholar's Soliloquy" is a seriocomic essay demonstrating how a child may fail school work which is not related to his life, while the teacher remains unaware of how school work can be designed to draw from life experience. A second handout, "The Fable of the Animal School," by G. H. Reavis, is reproduce in Appendix B, Item 19.

University of Louisville.-- Means of identifying and teaching intellectually gifted children are discussed. Duplicated sheets are

distributed which list characteristics of the gifted child in several areas, to be used by the teacher in identifying such children.15

University of Kentucky.— There is emphasis on children's experiential background:

At some time each semester a class discussion focuses on culturally deprived children, with particular reference to the experiences of these children and consequent implications for teaching them science. Discussion is initiated by calling attention to a current article dealing with culturally deprived children and drawing upon experience of class members with such children. The relationship of experience and concept formation is again emphasized.

National College of Education.— One of the two respondents reporting from this institution conducts a discussion with his students concerning how to influence the children's home-viewing of television. Discussions also focus on the "over" and "under" achiever in science.

University of Texas.— The emphasis in the science education course is on development of the "autonomous investigator" (p.125).

There are three specific developments which are prerequisites for autonomy in investigation. These are (a) a broad base of manipulative experience, (b) a broad base of conceptual understanding, and (c) ability to ask productive questions.

In helping the child become an autonomous investigator the respondent asserts that the satisfaction of children's needs are an "auxiliary outgrowth." The respondent adds, "Satisfying children's needs as a goal for science education is not part of our course."

Edinboro State College.— The respondent writes:

Our attempts are first to convince the prospective teacher of the values of scientific methodology, in the hope that he will then wish to develop these understandings in his children (p.126).

Students consider individual needs in unit preparation and lesson planning

Brigham Young University.-- In the process of developing a resource unit, students must identify suggestions they will make to students who express interest in hobby activities, or wish to continue a study of the topic at home.

New Mexico State University.-- In planning science lessons students are encouraged to develop "open-ended experiments" to provide for individual differences:

  Boredom thresholds are reached after varying periods of time. Those children who have the greatest curiosity are encouraged to go on as long as [they choose]. The artistically oriented child draws or paints his observations, the mechanically oriented child builds working models with common materials....Personal satisfaction to the child comes if his results are accepted by the teacher, whether or not they fit the expected outcome. Creative children are important, and creative children think up interesting variations and come up with delightfully unorthodox results.

San Diego State College.-- The respondent writes:

  With individual needs, we try to develop an open-ended curriculum. When we develop our units, we try to vary the complexity of the activities, and vary the complexity of the sub-ideas that are related to each generalization. However, this is hard to do, and I'm not sure we succeed as well as we would like.

Marshall University.-- The respondent writes:

  Cooperative unit planning is used here. Children are likely to see some of the aspects of science which affects them.

Duquesne University.-- The respondent writes:

  Students must learn how interest plays an important role in teaching -- what age level is most likely to enjoy what -- how to make a topic more challenging as students ask for more.

University of the Pacific.-- The respondent urges his students to encourage pupils to ask questions, feeling that these help to individualize instruction.
University of Southwestern Louisiana.— Unit plans are so constructed that they consist of (1) activities required of all pupils, (2) a variety of elective activities. Excerpts from a sample unit distributed to students are included in the Appendix B, Item 20.

Colorado State College.— The respondent writes:

In the organization of learning activities, curriculum planning, and unit organization, the growth and development patterns of children serve as guide lines. Teachers are assisted in understanding the types of questions children ask, the nature of scientific inquiry that may be expected at various age levels, and the skills which are essential if boys and girls are to become effective self-seekers of knowledge.

Florence State College.— The respondent writes:

When a prospective teacher develops demonstrations and experiments for any unit, it is understood that these materials must reflect a wide range of experiences. The materials should include something for the best student to be challenged by as well as something for those less able. Selection of materials becomes an important part of their study.

Harris Teachers College.— The science education course is taken after the "apprentice" term in which background for understanding of individual differences in science interests is provided.

University of Tennessee.— Inclusion of "direct laboratory experiences" in unit plans is designed to provide for individual needs of children, to some extent.

(The respondent at the University of Wisconsin made a similar observation.)

Pennsylvania State University.— Individual needs of children are considered when students prepare science lessons which they teach to children (p. 177).
Individual needs considered in preparation of teaching aids and planning of enrichment activities

Ball State Teachers College.-- The respondent writes:

Aesthetic enrichment is emphasized in the elementary science methods course...through preparation of audio-visual materials emphasizing a sensory approach to science learning.

The respondent also notes with regard to aesthetic enrichment that a study of trees, birds, rocks, etc. is provided in required science courses.

State University College at Oswego.-- In the use of the school planetarium and taking of field trips, students are acquainted with the idea that science has an aesthetic function in the curriculum. The respondent also refers to nature study in this respect.

University of Louisville.-- A member of the Junior Astronomical Society addresses the science education class about telescopes, and activities of the society. There is a visit to the campus planetarium. A class discussion considers "science interest corners" (Appendix B, Item 13).

Lewis and Clark College.-- The respondent writes:

[With respect to individualization of instruction] one class developed materials that could be used by individual students as independent activities in a classroom. Self-contained kits were devised to include a direction card and necessary (simple) materials for answering a basic question; for example, "Are all materials magnetic?"

Mississippi College.-- Similar to the activity described above:

Shoe box demonstrations or experiments are developed with the idea that exceptional children or highly motivated children can advance at their particular rate. Each shoe box has equipment and directions necessary to complete a simple discovery.

St. Cloud State College.-- The respondent writes:
By having the teacher prepare bird skins, human teeth cutaways, tanned animal hides, insect collections, etc., they should discover the personal satisfaction of doing something, developing a skill -- which can be admired by themselves and others. Possible avenues for selection of a hobby are very evident and mentioned in these skill experiences.

**University of Southwestern Louisiana.** Students prepare science exhibits. The "project" is to be appropriate for the grade level the student expects to teach: "This should help the students see possibilities of reaching some of the children."

(Administration of science fairs is discussed at National College of Education.)

**Maryland State College at Towson.** The respondent writes:

We promote the idea that science can be fun by actually "playing" the game rather than talking about it....Every student prepares some sort of display once during the term. This may be a bulletin board, a show case or a table exhibit. Everybody makes comments on these which are turned over to the exhibitor after I have added mine. These displays uncover artistic talent, ingenuity and pride in accomplishment in students who never knew they had it in them and add a valuable scientific atmosphere to the classroom. Hobby interests relating to science often come out of these.

**University of Denver.** In an elective "children's laboratory" course students may observe children participating in experiments and demonstrations and a science fair. There is also a required science education course:

The course involves field work -- trip to Chamberlain observatory, mountains and industry to study those aspects of science which appeal to children.

Reference to contribution of professional courses other than elementary science education and student teaching

**University of Southwestern Louisiana.** In one course (Presumably a child growth and development course) students study an individual child for three weeks, making use of school records.
In the required children's literature class, one of the areas treated is children's science books. The instructor stresses how teachers may guide children in a variety of readings.

(Other than the above, respondents mentioned only that such matters as suggested on item 5 are given attention in other courses. Various "methods" courses were cited in this regard by respondents from Appalachian State Teachers College, Goucher College, Moorhead State College, Northern State Teachers College, State University College at Buffalo, University of Idaho and University of Kansas. Psychology and Child Development courses were cited by respondents from Bowling Green State University, Eastern Kentucky State College and University of Idaho.)

Summary and Discussion of Practices Corresponding to the Thirteenth and Fourteenth Criteria

Criterion 13 concerns the future teacher's understanding of individual differences, their causes, and the implications of these for science teaching. Criterion 14 deals with how teachers are to individualize science teaching on several broad fronts, collectively termed the "needs of the child": health and safety, making a healthy adjustment to the physical world, aesthetic enrichment and personal benefit from learning the use of scientific method.

Some general observations can be made relative to respondents' treatment of questionnaire item 5:

1. Of some 90 returned questionnaires which were usable in most other respects, 25 had no comment on this item.

2. Many discussions on item 5 were too brief to be very meaningful. (Wherever possible, however, reported practices were tabulated.)
3. A number of respondents indicated that they feel these areas are inadequately treated at their institutions, or that they were uncertain as to the effectiveness of existing practices. A typical comment: "We do only the conventional things here, probably because we don't know how to do them any better."

4. Responses were not evenly divided over the several aspects of the two criteria. Most educators who responded to item 5 neglected reference to practices corresponding to criterion 13, dealing with criterion 14 at an operational ("how to do it") level.

On an operational level some of the most promising practices are related to unit and lesson planning, in which students may be expected to emphasize such aspects as the following:

1. Inclusion of activities permitting individualization of pupil response (open-ended activities)

2. Inclusion of a variety of activities of different kinds permitting children some choice

3. Provision for cooperative teacher-pupil planning -- motivating children to make contributions and ask questions

4. Appealing to children's interests or develop interest with attractive activities and materials

5. Helping the child apply what is learned in school to his personal circumstances

The most widely utilized practice in dealing with differences and needs of children with respect to science education is, as might be anticipated, through lectures, discussions and readings. Educators report development of topics such as the following:

1. Characteristics of children in different age groups

2. The implications of children's out-of-school interests for the science curriculum

3. Identification of academically talented children and "slow" children

4. Problems of culturally-deprived children

5. Helping children to develop ability in use of scientific method
As important as these matters are, the science educator should consider the extent to which merely lecturing about such matters will affect substantial change in the behavior of future teachers. One respondent, although commenting at length on item 5, was prompted to observe that he knew of no practice he would consider "satisfactory" in this respect. He continues:

We find that most teacher-in-training have a problem. They must exist in a highly competitive college situation where most grades are based upon the number of items that are...recalled. We suddenly then ask these people to forget that they have been able to remain in college because they have achieved success in the memorization-regurgitation processes.

Understanding and dealing with children as individuals with respect to their science education (or with respect to any other aspect of the curriculum) involves more than a transmission of information -- it often necessitates a transformation of the future teacher's attitude. There is evidence that this may be particularly true with respect to the teacher's relationship to "culturally-deprived" children.

From the point of view of the educator who is responsible for the education of elementary teachers, means must be found to facilitate the development of the future teacher's attitude toward children with respect to understanding the nature of individual differences and providing for these differences with a positive emotional response. How this program is to be constituted may require considerable research; it is possible that among other things, lectures, discussions and readings should be closely associated with field experiences. The student should have opportunities to study individual differences through first hand contact with children, to discuss these experiences
with classmates and instructor, and to consider how science may contribute to the personal development of children.

Collectively, then, completed questionnaires reflected inadequate attention given to helping students understand the differences existing among children. Respondents, generally, omitted reference to practices which help future teachers identify the science needs of children, and made few references as to how the experiential levels of children can be ascertained by teachers. There was virtually no discussion of the influence of socio-economic background. Many science educators apparently assume only two "simple" causes for individual differences among children: differences in intellectual ability and motivation.

Few respondents commented on aesthetic enrichment, or helping the child develop a "world-view." Comments on the latter were restricted largely to helping the child understand and use scientific methodology.

The responses on item 5 suggests again that in many institutions there should be a greater degree of coordination between the instructors of professional courses required for certification.

Typically, there appears to be a sharp division of responsibility in teacher-education programs. Matters pertaining to needs of children and their individual differences are considered in the educational psychology (or child growth and development) class, while what is to be done about these differences is the special province of the methods courses. One respondent sums up the situation as follows:

All of our introductory classes stress individual differences and ways to adapt to them; not specifically for science, however, and these points of view to not always carry over to the specifics.
While the educational psychology course should devote relative emphasis to the nature of children, and the methods course to the operational aspects of such matters, a complete separation of functions is unrealistic. There are occasions when the consultation of the child-growth specialist would be useful in the science education course, particularly when students have encountered "unusual" cases in their observation-participation. On the other hand, at such times as the child growth specialist is discussing characteristics of children, it seems appropriate that the methods specialist be called in to share his understanding of methodology and materials.

Instructors in both areas, therefore, should learn to draw upon the resources of the other. More important, where applicable, each instructor should be cognizant of his personal limitations. Science educators cannot afford to hide behind a veil of ignorance with respect to child growth using the lame excuse that this is not a valid concern of elementary science education.

The need for coordination of the science education course and the student teaching experience is again indicated. A relatively small number of respondents — smaller than might be expected — reported that students learn to provide for needs of individual children (with respect to science) during student teaching. The manner in which this was reported, moreover, was far from encouraging.

According to respondents, the single variable which determines the success or failure of the student teaching experience with respect to the present consideration is the quality of the supervising teacher. Undoubtedly the supervising teacher occupies a highly strategic
position. Among the criteria used in selection of supervising teachers should be their understanding of the individual differences and needs of children.

It is inevitable that this competency will not be highly developed in all supervising teachers. When this is the case the experience of the student teacher should be supplemented by various college personnel. It is here recommended that the college supervisor should have working relationships with child growth specialists and, among other personnel, the science educator.

Recommendations Evolving from a Study of Current Practices

27. Students, in their introductory educational psychology or child growth classes should begin to develop an understanding of individual differences in children, the causes of these differences, and the environmental circumstances which affect them. Observation and participation experiences with children in and out of school situations should be arranged for students wherever possible. The science educator should be aware of how these matters are handled.

28. Students in introductory professional courses should begin to develop concepts of pupil needs with particular reference to those for which the school may accept some degree of responsibility. Needs with respect to all curriculum areas, including science, should be identified and, at an introductory level, there should be some consideration given to what procedures may be followed by the classroom teacher in providing for such needs.

The science educator should not only be aware of this activity, but should be prepared to serve as a resource person in the teaching of the introductory courses.

29. In the science education course, the science educator should help the student further develop his concepts of the nature and needs of children, specifically as they are related to science education. The student should be able to recognize and understand pupil differences which are significant for the science curriculum. Developing such understandings would certainly involve the student in reading material prepared by experienced science educators and participating in stimulating discussions, but it should also involve him with children in meaningful situations.
From first hand experience students should ascertain children's science interests, the ways children express themselves on science topics, the kinds of questions children ask, the differences in experiential background among children, the science-related attitudes expressed by children in various situations, the ability of children to discover questions and find answers, etc.

30. The science educator must help the student develop a repertoire of teaching techniques and material resources that will enable him to provide for children with different needs. The future teacher must anticipate differences in children, and in light of this be able to prepare unit and lesson plans with appropriate versatility and flexibility.

31. The science educator should contribute to the development of the student teaching program with respect to providing for individual needs of children. He may serve as a resource person for student teachers who desire consultation on materials, methods, or teaching sequence, and work with college supervisors in an advisory capacity (see also recommendation 26).

32. Educators should recognize that the attitudes of future teachers toward children (acceptance) is of prime importance in their dealing with children on an individual level. Major research on, and re-evaluation of, entire teacher education programs may be in order to identify problems in attitude development, and how the teacher education institution may foster desirable attitudes. The science educator should bear in mind that attitude development, or change, does not depend solely on acquisition of information.
Practices Reported Corresponding to the Fifteenth and Sixteenth Criteria

Criterion 15: Does the particular practice acquaint the teacher with the various ways in which science may be included in the elementary curriculum?

Criterion 16: Does the particular practice help the teacher recognize the complementarity of science content, methods and attitudes to other curriculum areas and that science should be an integral part of the curriculum?

These criteria were incorporated in the sixth questionnaire item:

Describe practices in your institution which you feel are particularly effective in helping the elementary teacher develop an understanding of the relationships of science to the entire elementary curriculum.

Criterion 16 may be compared to criteria 7 and 8, which were the basis of questionnaire item 3. The latter criteria are concerned with the future teacher's personal development, referring to his understanding of the cultural implications of scientific thought, methods, attitudes and information.

Criterion 16 deals with similar matters, but with respect to curriculum development. It is evident that certain practices may correspond to several of these criteria, and may well have been reported on both items 3 and 6. The investigator found it necessary to judge in a few cases whether a particular response should be reported with reference to the present item when it appeared on item 3, and vice versa. Because of the overlapping character of these criteria it was not felt that such transposition would risk misinterpretation of particular responses. The reader is referred to Table 14 for practices classified there which might, justifiably, appear here also.
Criterion 15 deals with the ways science learnings may be included in the curriculum structure. Criteria 15 and 16 are considered together because it is assumed that the attitude of respondents concerning interrelationships of science and other curriculum areas would be reflected in their practices relative to organization of learning activities.

Classification of Responses

Responses corresponding to criteria 15 and 16 fall into five categories, as given in Table 18. In the following pages appear some of the more complete descriptions of reported practices.

Interrelationships of science with other curriculum areas studied through development of units, lessons, projects, etc.

Harris Teachers College.-- One of the criteria used in judging science lessons presented by students to classmates (p. 172) is correlation with other curriculum areas. The rest of the class is encouraged to suggest further correlation.

New Mexico State University.-- Correlation of science with other subject areas emphasized in unit development. The respondent cites an example:

The making of a compass provides one such obvious tie up between subject matter areas. What part did the compass play in world exploration in the fifteenth century?

Northwestern State Teachers College.-- The respondent writes:

Our program combines methods for social studies and science in one course. This allows the instructor to help students see the relationships among the various areas of the school program. The students in this course prepare a resource unit as an individual project.

(Similar practices were cited by 26 other respondents.)
TABLE 18. -- Tabulation of reported practices which help teachers develop an understanding of the relationships of science to the total elementary curriculum

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<th>Institution</th>
<th>Interrelationships of science with other curriculum areas studied through plans, etc.</th>
<th>Interrelationships of science with other curriculum areas considered in lectures, discussions, readings</th>
<th>Curriculum role of science studied through emphasis on unit structure or different kinds of learning activities</th>
<th>Relationship of science to total curriculum observed through student teaching and professional experiences</th>
<th>Structuring of professional courses, cooperative enterprise, internship of members designed to promote understanding of science to total curriculum</th>
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Interrelationships of science with other curriculum areas considered in lectures, discussions, readings, etc.

University of Louisville.— The following activities pertaining to correlation of science and other curriculum areas are reported:

1. Studying social studies courses for each grade, and selection of science units which correlate with social studies units
2. Reading of professional articles dealing with integration of science and social studies
3. Preparing long range plans for science and social studies for a school year
4. Considering the relationship of reading in the science program

A duplicated sheet, "Science Units of Work" is excerpted in Appendix B, Item 21.

East Carolina College.— The respondent attempts to develop an environment in the methods class in which students recognize the potential of science learnings in a wide variety of situations—things the child observes on the way to school, opportunities for correlation in teaching units, etc. The respondent emphasizes that in most units of study there are opportunities for children to investigate and ask questions.

Edinboro State College.— A science course of study developed by the state department of education is studied. The material is correlated with mathematics. Sample material appears in Appendix B, Item 22.

Rutgers University.— The respondent emphasizes science content in his methods course which includes quantitative tools such as graphs, charts and appropriate calculations.

Northern State Teachers College.— The respondent writes:

One of our requirements in the classes in methods in social
studies and science is the selection of enrichment materials such as poetry, music, current news items, etc. that help bring about a better understanding of the topic being studied and which help meet needs and interests for individuals and groups. The basic textbook used for the methods course points out that integration of subject matter is important when it contributes to the topic under study or when it helps motivate the study. Preparing a file of materials ... also helps point out the interrelationship among the various areas of the curriculum.

Pennsylvania State University. The respondent writes:

The science methods course is taught before student teaching but after most of the other methods courses, or concurrently with them. Thus it is possible to show the students the relationships of the scientific approach to problem solving in several areas of the elementary curriculum and also to point out the areas where other content areas make natural contributions to science activities in the elementary school. Mathematics is an obvious example. Correlation with literature, reading and social studies also comes out in the course.

In a letter the respondent describes an informal relationship in which instructors of the several methods courses keep each other informed to some extent as to activities in each other's classes. There is occasional class inter-visitation by instructors.

San Diego State College. The respondent writes:

We have taped Blough's article in the Science and Social Studies yearbook of NCSS\(^{16}\) [which] helps in correlation. We mention incidental teaching. We concentrate on science as a basic, however. Some slides are shown on science corners -- which can be maintained to help in incidental and correlated science when [science is] not being taught [as a separate subject].

Moorhead State College. Readings on the ways of organizing science in the curriculum are required. The respondent attempts to show interrelationships between science and other curriculum areas, but adds:

I do not over-stress this, however, because I think science in the elementary school has suffered more from trying to mix it up with everything else and teach it (many times poorly) the same way, than it has from isolation.

For an elective course in special methods in elementary science the respondent has developed a description of how a science program can be improved, which considers correlation with other curriculum areas. Excerpts from this document are included in Appendix B, Item 23.

University of Southern Mississippi.— The respondent writes:

Through lecture, discussion and assignment of special problems such as ... "How do you plan to use Elementary Science in your school program?" the students have an opportunity to survey the subject matter of [science] and review other subjects and see to what extent they can be correlated. Through this process it becomes evident to the prospective teacher that science can be used to enrich and stimulate interest in every subject.

University of Pittsburgh.— During the science methods course students have an experience in use of scientific methodology (p. 120). Toward the end of the course similar techniques and methods are used with respect to problems in subject fields other than science.

The student has opportunities to attend seminars which deal with curriculum problems from an interdisciplinary point of view. There is further effort to interrelate curriculum areas at the level of attitudes. The respondent writes:

We try to make the prospective elementary teacher aware of attitude changes in pupils. I have particular reference to such things as treatment of the property of the school with respect to shrubbery and walking across lawns, etc. We attempt to relate this information directly to science by explaining the growth process and the damage done by youngsters when they tear off a piece of shrub, tramp across newly seeded lawns, etc.

Maryland State College at Towson.— The respondent writes:

Through many illustrations both in lecture and discussions I try to show that science is a way of thinking which cannot be separated from the total human experience. The same rational
approach fits all life's problems from economics to ecology. The same attitudes which the scientist values are found in man's best philosophies and religions. Science should therefore be integrated with all elementary school subjects. For instance, social studies are really nothing more than what the biologist might consider as human ecology.

**Indiana State College** (Indiana).-- Films used in the elementary science education class point out relationships of science to other curriculum areas.

(Films used at Wisconsin State College at Oshkosh serve a similar function.)

**Troy State College.**-- With reference to a science content-oriented science education course the respondent writes:

Science is taught as an integral part of the total curriculum and is never separated into segments of special interest. Science is, however, often emphasized more in certain units than others. For example, a unit on transportation...or a unit on energy.... We make an effort to help our elementary school teachers view the total school curriculum in broader terms than "school subjects."

**Sam Houston State Teachers College.**-- The respondent describes how correlation of subject areas is emphasized in a science and social studies methods course:

Students are made aware of the relationship between science and math through [such activities as] measuring the surface of the aquarium to find the ratio between water and fish. They can also measure the contents of the aquarium by liquid measurement, leading to an understanding and study of the tables studies in arithmetic.

Art is then used in chart work and in lettering, and careful use of English emphasizes clear expression of thoughts. Spelling and vocabulary words are used in science as it relates to teaching of reading in the primary grades.

During the social studies experiences, students are urged to find cause and effect of living conditions in the countries being studied. They are urged to plan their units on such problems as why do the Swiss people build sturdy homes with steep roofs or why do they pursue many inside hobbies and crafts and the like.

**University of Bridgeport.**-- Panel discussions deal with inter-
relationships among different subject areas as found within socially significant problems. (See excerpts from Bridgeport course syllabus in Appendix B, Item 7.)

St. Cloud State College.—The respondent notes that some of the instructors involved in the teaching of a professionalized biology course are trained in science education, adding:

Their frequent references to how instruction in [science] improves pupil performance in other curriculum areas certainly makes the teacher aware of the total elementary program.

Role of science in total curriculum studied through emphasis on unit structure: different kinds of science learning activities

National College of Education.—The respondent writes:

The science education course...devotes from four to six class hours to a discussion and general treatment of the various "science in the total curriculum" programs. We treat of the incidental kinds of science and their inadequacies as sole bases for good elementary science, the various kinds of correlated programs, and the need for some genuine science-centered work in every grade -- at least above the primary level.

Another respondent from National College mentions use of the film Near Home, described as follows:

Shows a group of English school children using the field trip to study their community's history, industries, public utilities, government, geography and other important factors.17

University of Kentucky.—The relative values of different approaches to the teaching of science are compared:

Teaching science through a "subject-matter approach" is described as (1) best for helping children develop understandings of selected science concepts and generalizations, and (2) offering an assurance (when there is grade to grade coordination of topics) that children will be introduced to a wide range of science information.

A "broad unit approach" has the relative advantages of (1) placing science information in a context in which its relationships with other fields of knowledge are more readily perceived by children, (2) providing children with a greater opportunity for discovery of problems of personal concern, and (3) providing a social atmosphere in which development of certain attitudes is more likely to accrue.

In either approach problem-solving ability can be nurtured. Incidental science activities are described as valuable for the opportunity they provide to capitalize on current interests and to maintain contact with a changing world.

Students become acquainted with the nature of the subject-matter approach to science teaching through lectures, discussions, assigned readings and development of a science unit. Major emphasis in unit development is on helping children to develop understandings of principles and concepts. Students are helped to "program" activities in a sequence from relatively simple to more complex understandings.

University of Southwestern Louisiana.-- An emphasis is placed on (1) incidental science teaching, (2) organized science teaching in grades 1-12, and (3) flexible programs incorporating both of these approaches.

Moorhead State College.-- Students study science texts for suggestions on different ways of organizing science units. Units are subsequently prepared.

Lewis and Clark College.-- The respondent writes:

One of the course requirements is a development of a resource unit at a primary, intermediate, or upper grade level in an area commonly taught at that level. The unit focuses on scientific principles or concepts to be covered with procedures to be used in helping children discover these principles. Singly, or by groups, the unit is presented to the class with appropriate demonstrations and experiments involving all class members.

The respondent adds that students are requested to develop related activities in social studies, language, arithmetic, art, etc.
University of Texas.-- The respondent expresses his conviction that science in the elementary school should not be integrated with other curriculum areas. Accordingly, students design units according to this format:

1. The intellectual problems of the unit
2. The design of experiences -- activities through which students will gather information needed to solve the problems listed above
3. Generalizations -- ideas growing out of designed experiences, including answers to the intellectual problems but not limited to them
4. Materials

Fort Hays Kansas State College.-- Students develop a unit according to a format provided by the instructor. (Appendix B, Item 24).

Kansas State College at Pittsburg.-- The respondent distributes to his students an example of a structured unit which serves as a model for units students develop. The subdivisions of the model unit: Purpose, Principles, Objectives (stated as objectives for the entire class and for individuals), Vocabulary, Motivation, Activities, Projects, Lessons, Culminating activities, Evaluation, References, Enrichment material (for bright children), Ability grouping, Minimum material (for slow children), Supplementary materials and Teacher's bibliography.

Relationship of science to total curriculum studied through observation and student teaching experiences

Colorado State College.-- Elementary education majors observe children working in all curriculum areas in the laboratory school, including basic skills essential for learning in science; reading, arithmetic and written and oral work. Students observe how art is correlated
with science and how methods of inquiry are used in the social studies. Field trips often occur which unify science and social studies learnings.

**Pennsylvania State University.** -- During student teaching, students are introduced to the following examples of science correlations:

1. Frequent integration of mathematics; graph work, measuring, development of understanding of ratio, concepts of volume, area, and linear measurement. The latter two are frequently included in astronomy study.
2. In consideration of the compass, work is usually related to map work and globe work.
3. Writing of reports, descriptions, etc. are regarded as both a language arts experience and a science experience.
5. Difference between "creative art" and "scientific illustration" is considered.

**Appalachian State Teachers College.** -- The respondent writes:

A common practice in remedial reading is for the college participating student to try to assess the science interest as a catalyst for reading as well as the handling of "science props" for oral expression. The science resource materials are selected with other curricular areas in mind. An example: the teaching of geography and plant distribution at the same time.

**Bowling Green State University.** -- The respondent writes:

The observation assignments of students expose them to actual teaching situations in which science is integrated with other areas of the elementary curriculum.

(A similar statement was made by the respondent from Wisconsin State College at Oshkosh.)

**University of Nevada.** -- A relatively small department of elementary education which works in close teamwork attempts to help the teacher be fully aware of the interrelationship of all common areas. "This is quite forcefully accomplished during student teaching under the guidance and supervision of the cooperating teacher."

**Indiana State College (Pennsylvania).** -- The respondent writes:

Students are able to participate with or observe the instructor
as he works with teachers in-service, as he demonstrates a lesson to children, or as he works with teachers in a construction of a curriculum. At all times it is emphasized that reading and writing are important in science.

**Southern State Teachers College.**—Following a study of curriculum practices in the college classroom, students observe and discuss with teachers in a cooperating public school about different arrangements of the science curriculum.

**State University College at Oswego.**—The respondent writes that beginning in Fall 1964, an eight semester-hour block will combine methods courses in elementary social studies, language arts, math and science. Correlation among these fields will be an objective of the new arrangement.

(Methods course blocks are found also at Glassboro State College, Maryland State College at Salisbury, State College of Iowa, University of Georgia and Wisconsin State College at Eau Claire.)

**Maryland State College at Towson.**—The respondent writes:

We require that all elementary education students take the course entitled "Science Education in the Elementary School" which carries one and a half semester hours credit and meets for one and a half hours once each week. A parallel course in social science in the Elementary School meets immediately following the science education. Teachers in the two courses often work closely in coordinating the two. These courses are taken during the semester in which student teaching occurs in the last half, which makes them rich with motivation and illustrative material.
Fort Hays Kansas State College.-- During the student teaching term students enroll in a course titled "The Elementary School." This course is designed to integrate the concepts learned in the separate methods courses.

(Similar integrative curriculum courses are required of students at Arizona State College and the University of Tennessee.)

University of Oklahoma.-- The instructor of the social studies methods course and the science education instructor coordinate their activities: "We try to utilize the same methods and types of assignments."

University of Alabama.-- Informal accord among the staff was noted in the respondent's statement:

Most of the instructors our students meet in their professional courses agree on basic issues. I try to relate science to other areas; I know they try to relate their areas, in appropriate ways, to science.

(Informal arrangements among instructors of the various methods courses was noted at Pennsylvania State University (p.124), and at the University of Nevada (pps. 188 and 232).

Auburn University.-- Science and social learnings are combined in a methods course. Future teachers plan units in each area and are encouraged to relate these units to other curriculum areas.
Summary and Discussion of Practices Corresponding to Criteria 15 and 16

A study of responses to questionnaire item 6 to classify reported practices into a manageable number of categories necessarily involved some arbitrary discriminations. The categories set up in Table 18 are not mutually exclusive, and many practices in each of the five categories correspond to both criteria 15 and 16.

With these limitations acknowledged, it must be observed that the majority of practices tabulated on Table 18 correspond more nearly to criterion 16 (dealing with the complementarity of science and other curriculum areas) than with criterion 15 (concerned with ways science may be included in the elementary curriculum).

The third category on Table 18 (emphasis on unit structure and different kinds of science learning activities) is more directly related to criterion 15 than are the other four categories. There are only 14 tabulations here, less than 12 percent of the tabulations on the entire table.

The apparent neglect of criterion 15 requires comment. A majority of respondents referred to unit preparation as assigned activity in science education courses. Practices associated with unit construction are classified in several places in Chapter 4, corresponding to different emphases of science educators. Table 18 includes only those practices related to correlation of subject fields and to study of unit structure.

It was anticipated that respondents would discuss organization of science learning experiences on item 6 with particular reference, in
many cases, to unit structure. A total of only seven responses specific to unit structure was surprising.

A unit is more than a compilation of resources. It should be structured in the sense that a more-or-less definite sequence of experiences (with allowances for flexibility) are designed to help children accomplish desired objectives. The structure may be intricate, taking into consideration many aspects of learning theory relative to science education. The structuring of a unit to help children develop relatively complex understanding, for example, may demand considerable resourcefulness on the part of future teachers.

Granting that a number of respondents may have considered matters such as these to be implicit in their discussions, the infrequency of specific reference to practices dealing with structuring of learning activities suggests that this is a matter of low priority in many science education courses.

The majority of educators who discussed "interrelationships of science and other curriculum areas" favor correlating science with other areas, although some respondents expressed qualifications. One respondent observed, for example, "In general we focus entirely on science. Of course, whenever it is pertinent, we discuss how the activities that we undertake could be related to reading, arithmetic and social studies."

Another respondent expressed his conviction that correlation is desirable to some extent, but added that science in the elementary school has suffered by "trying to mix it up with everything else."

A minority of respondents reacted to the matter of "interrelationships." The respondent from the University of Texas, who
wrote at some length on unit structuring, commented:

We believe that the practice and understanding of science is a worthwhile goal to educational objectives — that is, some wise choices and worthy decisions. For this reason, we question the need for integrating science with other areas of the curriculum.

The attitude expressed by these educators may be based on an assumption that correlation of science with other curriculum areas will be at the level of superficial information only, and that over-emphasis on this may undermine efforts to develop scientific thinking and habits, and understanding of science principles.

Indeed, the majority of reported practices dealing with "interrelationships" emphasize relating of informational content among the several subject matter fields. The practice most frequently reported in this respect involves preparation of science units which include appropriate references to other curriculum areas.

Some clarification of this matter of relative values may result through reference to some generally accepted objectives of elementary science education. Discussed in Chapter 2 at length, the objectives may be abbreviated as follows:

1. The child should develop knowledge, including:
   a. a fund of reliable and useful information
   b. an understanding of important concepts and principles.
2. The child should develop skills, including:
   a. the ability to think scientifically (use scientific method)
   b. facility in selected manipulative tasks.
3. The child should develop scientific attitudes.

These objectives are quite broad. It seems advisable that future teachers should have insight into several approaches to science teaching, understanding the possible advantages and disadvantages of each with respect to the different objectives. The view that only one approach to science teaching in the elementary school is THE correct approach is
here rejected, although it is conceded that a teacher with unusual understanding and ability might have considerable success utilizing a single approach.

The view that science is a subject worth its own time in the curriculum and is not to be fused with other subjects (expressed by one respondent) is a half-truth and must be challenged. Even if this policy were taken to refer only to separate treatment of "factual content," it runs counter to psychological theory. "Facts" assume significance and are more likely to be remembered when they are in a context -- a situation in which the learner can perceive the fact as related to other facts. The facts of science should not always be confined to the science lesson, nor should there be bars to introducing "non-science" information into the science lesson.

Possibly of a more fundamental nature, science should function in a child's life: he should develop his ability to observe carefully, ask appropriate questions, draw inferences from evidence, apply understandings, etc. He should be inclined to weigh evidence, look for causes, have respect for the opinions of others -- and possess other attitudes associated with scientific method. These are products of an imaginatively conceived and executed science program.

The comment, "Science is a subject worth its own time" implies something other than the development of such characteristics. It suggests that mastery of science subject-matter is an end in itself. Educators should help future teachers comprehend not only the full range of objectives of the science program but the various strategies through which they may be realized, which, of course, may include teaching of
science in period of time specifically allocated to science instruction.

On questionnaire item 6, as elsewhere, there are references to student teaching and classroom participation. Respondents who refer to student teaching on this item are, in most instances, those who mention student teaching in other connections. It is evident that most science educators do not capitalize on the potential of student teaching, but those who do utilize it to accomplish several objectives.

Practices, however, are but loosely structured—usually described simply as an "opportunity for students to observe and participate in science teaching situations in which science is correlated with other curriculum areas."

The last category on Table 18, referring to various formal and informal arrangements whereby students may gain perspective on relationships of science to other curriculum areas, is less homogeneous than are the other categories. By "formal arrangements" is meant courses which, at least by implication of course title, devote attention to such interrelationships. Several kinds of courses are mentioned:

1. course in which science methodology is combined with methodology of one or two other curriculum areas (the most frequent combination is "Science and Social Studies")
2. courses in which science methods are taught in a "block" along with all other methods
3. a separate non-methods course (offered in addition to methods courses and usually taken after them) which considers the elementary curriculum in its entirety.

One respondent who teaches a combined course indicates that when he teaches the course the emphasis is on science, while his colleagues who teach it do so from the point of view of their special interests. Extrapolating from this admission, this might be the case elsewhere where individuals are responsible for the teaching of block-type or
combined methods courses.

The great activity in curriculum development in all fields at the present time makes it difficult to keep up with a single field, much less several. In instructor in charge of a "multiple" methods course may be faced with the choice of keeping abreast of one field adequately, or taking half-measures in several.

There are, undoubtedly, sound theoretical arguments for the merger of methods courses. It appears advisable, however, that the teaching of such a course should not be the responsibility of an individual whose interests and background -- however rich they may be in one area -- tend to skew the orientation of the course. There may be considerable merit in a team approach to the teaching of methods blocks.

Informal arrangements usually consist of interchange of information among persons who teach various professional courses and coordination of course activities. In one of the cases reported the elementary education department is relatively small; in another case it is a large department in one of the nation's largest universities. Size of the institution, while undoubtedly complicating problems of communication and coordination, should not constitute an excuse for not attempting informal relationships.

Where informal relationships are reported, questionnaire discussions suggest the presence of one or both of two influencing conditions: (1) an accepted departmental philosophy which guides the efforts of all concerned, and (2) the efforts of individuals to be in contact with their colleagues and the inclination to work cooperatively in a total enterprise.
Recommendations Evolving from a Study of Current Practices

33. Future teachers should develop understanding of the several ways science may be included in the elementary curriculum, with particular reference to accepted objectives of elementary science education.

Instructors of science education courses should develop imaginative ways of helping students in this respect since the implications of the several approaches may be subtle from the undergraduate point of view. Conventional activities such as observation and participation in elementary classrooms, readings, lectures and discussions may be useful in this respect, but they should be further developed. The simulation technique may be attempted after observation of a film or tape recording in which a particular approach to science teaching is illustrated, future teachers can consider, "What goals of science education can be realized through such a program -- what are the limitations of this approach?"

34. Future teachers should develop an understanding of unit structure. The purposes (objectives) of the plan should be clearly defined with respect to knowledge, skills and attitudes and the proposed teaching methods and pupil activities should be consistent with these objectives. The unit should be sequentially organized in consideration of the nature of hypothetical learners, yet have provisions for flexibility.

35. The future teacher should be helped to understand the broad meaning of "integration," with respect to integrating science into the total curriculum. While this may involve teaching of science different ways to accomplish different objectives and liberal cross-enrichment of science and non-science fields, it means still more. Where science is fully integrated children will use scientific methodology in attacking problems in many curriculum areas and scientific attitudes will be developed through a wide range of experiences.

36. It is again recommended that the science educator develop a cooperative approach with other staff members since it is unlikely that the student can develop a full understanding of integration of science into the total curriculum in the science education course alone. Liaison with instructors of other methods courses is clearly indicated as well as with college supervisors of student teaching and the instructors of courses in elementary curriculum.
Practices Reported Corresponding to the Seventeenth and Eighteenth Criteria

Criterion 17: Does the particular practice help the teacher understand that evaluation of outcomes of science instruction is a matter in which children should be treated as individuals as well as members of a group, and that different techniques and instruments are appropriate for different outcomes of instruction?

Criterion 18: Does the particular practice help the teacher develop a critical attitude toward all methods and materials employed in or suggested for science teaching and to evaluate these with respect to all accepted goals of science education?

These criteria were incorporated in questionnaire item 7:

Describe practices in your institution which you feel are particularly effective in helping the elementary teacher understand the need for and nature of evaluation.

Classification of Reported Practices

Inasmuch as criterion 17 deals with evaluation of children's progress in science while criterion 18 focusses on evaluation of methods and materials of instruction, practices corresponding to these criteria are classified separately in this section. The section ends with a summary and discussion, and a series of recommendations.

Reported practices corresponding to criterion 17 are tabulated on Table 19. Practices are classified into eight categories. In the following pages appear some of the more complete descriptions.

Nature of evaluation considered as students observe children and the products of their work

Duquesne University.-- The reaction of children to different situations is observed. Students are reminded that proper evaluation of some matters (not specified) requires longer periods of time than a semester or a year.
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<th>Evaluation Excluded in Professional Education</th>
<th>Evaluation Excluded in Course in Teaching</th>
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\*required course
Eastern Kentucky State College.-- Students examine science projects prepared by children in the model school.

(Consideration of the products of children's science work as a part of the evaluation procedure is emphasized also at the University of Louisville.)

Mississippi College.-- Students conduct case studies on individual children (detailed procedure was not described).

(Anecdotal records and records of performance of individual children are kept by students also at the University of Tennessee.)

Teachers College, Columbia University.-- Anecdotal records of children kept by graduate students attempt to appraise conceptual growth (Detailed procedure was not described).

Wisconsin State College at Eau Claire.-- Students observe laboratory school pupils being evaluated by devices which the respondent terms "opportunities." These devices, as described by the respondent, include demonstrations which the children must carefully observe and interpret.

Readings, lectures, etc. consider nature of evaluation

Edinboro State College.-- Subjective evaluation, using instruments described by Navarra and Zaffaroni,\textsuperscript{18} is emphasized and future teachers are urged to consider written and oral reporting in evaluating students.

Distributed to students is a list of competencies in science which children should be helped to develop in grades Kindergarten through three, and a second list for grades four through six. Examples

\textsuperscript{18}Navarra and Zaffaroni, op. cit.
of these competencies, or "behavioral characteristics," are "Ability to ask appropriate questions," and "Ability to weight and measure simple objects." Also included are appreciations, such as, "The ability to understand and appreciate that the plants and animals in our environment depend on each other." The teacher is urged to be alert to behavior which indicates growth in such competencies.

(Reference to the evaluation methods of Navarra and Zaffaroni was made also by the respondent from Indiana University.)

**National College of Education.**—The respondent writes:

We give time to the flexible approach to children's creative science learning and point out how the teacher daily sensitizes himself to bit-evaluations, and also reinforces certain behaviors in his children.

**New Mexico State University.**—The respondent writes:

Evaluation involves some testing for the acquisition of facts and the mastery of scientific principles. The principle purpose in science teaching is [however] to develop the child's power of observation, to encourage open-mindedness toward facts, to draw conclusions from facts rather than guesses. It is the attitudes we are concerned about, and attitudes defy accurate measurement.

**San Diego State College.**—The respondent writes:

We develop behavioral objectives. Idea being that behavior can be observed for (evaluation) purposes. Also, behavior can be built into tests. For example, "Student selects the most plausible hypothesis from among several hypothesis."

**University of Pittsburgh.**—The respondent writes:

Various techniques are emphasized....For instance, the observation process during a demonstration. In addition to this the problem solving techniques in use of library materials is also emphasized. The collection and interpretation of data at all levels of the elementary curriculum is constantly emphasized.... We place a tremendous amount of emphasis upon the student's ability to arrive and/or perhaps cope with problems along a generalized pattern that may be considered a logical approach to scientific thinking.
University of Alabama.-- The respondent writes:

One chapter in our text is devoted to evaluation in science [name of text not provided]. I try to get them to see that evaluation is more than testing; that evaluation should be done in terms of objectives, and that the objectives of science are more than the accumulation of facts.

Bowling Green State University.-- The respondent writes:

Students in the methods courses, as well as in their practice teaching assignments, are given practice in both subjective and objective evaluation procedures.

Winona State College.-- The respondent writes:

I stress the need for subjective evaluation and the fact that all evaluation cannot be objective: that careful observation of students and anecdotal records of their behavior is important.

(The role of observation in evaluation is considered also at the University of Bridgeport, East Carolina College, University of Oregon, University of Arizona and the University of Kentucky.)

Sam Houston State Teachers College.-- The respondent writes:

We teach that evaluation is summarizing. It should be done at the end of every science lesson, either orally, but the use of charts, or by a written review. Often in the primary grades the summary is done by the use of charts, such as writing the names of objects which react to magnetic force [on one side of the chart] and on the other side writing [names of] objects which will not react to magnetic force.

Evaluation procedures demonstrated by instructor

National College of Education.-- Through demonstrations, students are familiarized with the concept of "continuous evaluation" and involvement of the learner in the evaluative process. The respondent writes:

[Once monthly] students communicate on worksheets what they have learned -- how their behavior has changed -- this is difficult since they cannot limit their definition of learning as the acquisition of knowledge.
Maryland State College at Towson. -- The respondent writes:

Every session starts with a ten-minute quiz on previous session's work. Papers are exchanged and marked by class....What constitutes an acceptable answer elicits much discussion. Partial credit brings some hot arguments and defences. I get a chance to show (1) how I can handle emotionalism, and (2) my respect for accuracy, truth and justice. Matters of fairness and cheating get close scientific scrutiny from the class.

University of Miami. -- The science education course emphasizes science content. The respondent writes:

My tests are designed to be models of the kinds of evaluation students should use in the elementary school....I try, especially in essay type questions to emphasize transfer of learning. Students must apply, synthesize, and organize previously acquired knowledge in light of a new situation.

(Examples of some of these test items appear in Appendix B, Item 25).

Sam Houston State Teachers College. -- The respondent writes:

In working with our own college students, we like to administer a take home type objective test which is in reality a resume of the principles stressed during a study of some particular area of science. This practice acts as a stimulant to the student to see the area as a whole, to clarify his understandings, and to see the outstanding science principles that should be developed during the child's school experience.

(Take home texts are administered also at the University of Louisville.)

Indiana State College (Penna.). -- Concerning a science content-oriented science education course the respondent writes:

Exams and quizzes are based strictly on observation and applications of previously learned materials, rather than facts. Each question is centered around an actual situation.

Florence State College. -- The respondent writes:

Methods of evaluation in science are discussed and a variety of evaluation procedures are attempted using the class as an experimental group.
Austin Peay State College. The respondent uses a teacher-pupil planning procedure in conducting his "General Science for Elementary Teachers" course (p. 54). Evaluation is an integral part of the procedure.

Evaluation procedure included in units developed by students

Northwestern State College. Students must select means for evaluating the outcomes of the resource unit they prepare in the social studies and science methods course. The respondent adds:

Whenever possible, this unit is prepared for the class in which they will do their student teaching. Many of the students are therefore able to use the evaluative techniques they have selected.

Kansas State College at Pittsburg. Duplicated material ("Example of a structured unit") is distributed to students to illustrate what is expected of them in unit planning. The model unit stresses evaluative procedure.

Moorhead State College. Before preparing a unit students receive an extensive sample unit, which contains two pages of suggested evaluative activities.

University of Louisville. Sample tests are to be included in student-prepared units. The instructor lectures on testing and preparation of tests and other ways of evaluating science achievement.

University of Miami. In preparation of units students determine objectives (content objectives and concomitant learnings) as well as choose materials and procedures. An evaluation scheme is developed which is based upon and interrelated to all other parts of the unit plan.
Winona State College.— The respondent writes:

[In development of lesson plans] attention is always drawn
to this question: "What will you accept as evidence that your ob­
jectives were reached?" If in their objectives [students] mention
"development of interests," then they must think in terms of how
they could determine if in fact this was achieved....This is very
difficult for inexperienced people but I'm told by cooperating
teachers in the student teaching program that I am successful -- in
part.

Ohio University.— Students must list pupil behaviors which are
to be achieved in given lessons and methods of evaluating these behaviors.

Bowling Green State University.— The respondent writes:

As students [develop] units in science, special attention is
given to the need for stating objectives (content and behavioral)
in definitive form. The students develop pre-tests and post-tests
for these objectives, and are offered practice in applying the tests
through classroom teaching of their units.

Moorhead State College.— Seven pages of material developed by
the respondent is distributed to students, which describes several kinds
of tests: tests which accompany textbooks, teacher-made tests, standard­
ized tests, oral tests and performance tests.

Advantages and disadvantages of different types of test items
are considered, and suggestions given to avoid construction of faulty
items. Examples of both acceptable and unacceptable items are provided.
Excerpts from this document are included in Appendix B, Item 26.

University of Maryland.— Examinations administered to students
during the science education course are designed to illustrate various
types and purposes of tests. Students are required to construct various
kinds of evaluation instruments.
Mississippi College. -- Students examine standardized tests concerned with intelligence, reading readiness and achievement.

San Diego State College. -- Students compare Stanford, STEP, and Metropolitan tests for content agreement and objectives.

(Students examine different types of tests also at Pennsylvania State University, National College of Education and the University of Louisville.)

Colorado State College. -- In a professionalized science course students are exposed to different testing techniques and develop many types of exercises.

Maryland State College at Towson. -- The respondent writes:

I discuss evaluation of progress toward established goals and the types of written evaluation.... I let the class contribute questions for the final examination and I used many of these. After it is turned in, I go over the examinations and they see how ambiguities, truisms, and cloudy phrasing have reduced the value of much they have submitted.

Western Washington State College. -- In the professionalized biology course students develop what the respondent refers to as "Aunt Jane" tests. These are performance tests, about which the respondent writes:

The "Aunt Jane" test asks students who have just completed a unit on insects (for example) to accurately construct an insect of paper, stones, clay, etc. The product reveals to the tester whether the student perceives insects as six-legged, having three body parts, etc.

Evaluation emphasized during student teaching or participation experience

East Carolina College. -- The respondent writes:

Testing receives major emphasis here. Validation of items, test construction, and application of results occupy a prominent role. To a large degree, the theoretical aspects considered in the classroom are integrated into student teaching.
The respondent adds that attention is given also to observation of the whole child "in a macrocosm."

**University of Nevada.** In the science education class students develop evaluative criteria which are used later, during student teaching, for appraising outcomes of instruction.

**Rhode Island College.** Science teaching opportunities prior to student teaching have been noted previously (p. 176). The respondent notes:

Upon completion of units, tests are prepared and administered to the elementary child by the college student. The materials found in Blough's *Elementary School Science and How to Teach It* are used in evaluation.

**Course in testing required or recommended**

A number of respondents indicated on item 7 that a course in testing is required of elementary majors, or highly recommended. Where such a course is required is indicated on Table 19. The required course at Arizona State College is titled "Evaluation of Learning." The testing course at the University of Bridgeport is organized as a workshop.

**Evaluation treated in educational psychology courses or other professional courses**

**Troy State College.** The respondent writes:

The psychology staff assists us with evaluation and we assist them with the content for evaluation. The techniques of evaluation are learned in the psychology and evaluation classes under more competent teachers of that subject.

(Evaluation is considered in educational psychology courses at Oregon State University, State College of Iowa, Goucher College, and the University of Georgia.)
("Testing" is studied in the "Introduction to Education"
course at Loyola University, in "The Teaching Process" at the University
of Maine, and in the senior-methods block at the University of
Georgia.)

* * *

A tabulation of reported practices through which future
teachers learn to evaluate methods and materials used in science teaching
appears in Table 20. Practices were classified into six categories.

Students evaluate lesson plans and
units developed by themselves or
by classmates.

Ohio University.-- Students teach demonstration lessons to
classmates. The respondent writes:

Each student is asked to evaluate his own demonstration in
terms of materials used and probable effectiveness in the class-
room. Each student participates in the evaluation of the demon-
strations of the other members of his class.

University of Arizona.-- The respondent describes a formula
for evaluating demonstrations given by students:

[Evaluation is] on a point basis: preparation 20 points,
execution 30 points, follow-up 20 points, creativity 20, criticism
10; all evaluation is tied in with broad objectives of education.

Ball State Teachers College.-- The respondent writes:

A student has the opportunity of considering the effective-
ness of his teaching methods compared to that of his classmates,
as well as giving consideration to the possible ways of presenting
a concept.

Marshall University.-- The respondent writes:

We consider each activity to be evaluated in terms of its
appropriateness, its flexibility, its worth (in the scientific
sense), and as to whether it shows what it was intended to show.
TABLE 20.—Practices reported in which elementary education majors evaluate methods and materials used in science teaching

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<th>Auburn University</th>
<th>X²</th>
<th>Ball State Teachers College</th>
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²When the practice is not reported, a question mark (?) is shown.
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<td>Winona State College</td>
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<tr>
<td>Wisconsin State College (Oshkosh)</td>
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</table>

^a Indicates the activity is practiced during student teaching.
Pennsylvania State University. The respondent writes:

Special effort is made to have class understand goals and objectives and to help them see how evaluation of their work is made in terms of these objectives.

Each teaching experience includes some form of evaluation. During the sharing of these experiences a wide variety of methods of evaluation are thus considered. Also, some time later in the course methods of evaluation are considered.

Because of time limitations, curriculum evaluation, per se, is somewhat neglected. It does get in through discussions centered on importance of objectives and goals which one believes in and sincerely works toward.

Auburn University. In addition to evaluation of demonstrations and reports given in class, evaluation of science teaching occurs during student teaching. The respondent comments:

The most realistic evaluation of science teaching comes as part of student teaching. Here the student actually teaches a unit and evaluates the learning of pupils as well as his teaching.

University of Texas. Units are evaluated with respect to stated objectives (p. 231). The respondent adds:

If the experiences provided for the children are adequate for the securing of answers to the intellectual problems, then the unit holds together.

Northwestern State College. Students select means for evaluating units which they prepare. Whenever possible, the unit is prepared for the class the student will teach during student teaching, making it possible for students to evaluate their techniques.

Cornell University. Students doing in-service work in science education do a rigorous evaluation of their science teaching efforts (p. 178).

Students evaluate lessons taught by instructor.

University of Oklahoma. The respondent conducts demonstrations during laboratory periods of his science education course (p. 121).
Students later analyze behavior of instructor during the lesson.

Harris Teachers College. -- The respondent, who teaches a science education course, comments:

Actually, every lesson given by professor or students is criticized severely if it lacks opportunity for inductive thinking, weighing evidence, and leaving some questions open.

Students evaluate science textbooks, courses of study

University of Southwestern Louisiana. -- The respondent writes:

Through examining approximately eight series of textbooks students learn that not one textbook has all the answers and to understand that today a unit should be developed in depth.

Indiana State College (Pennsylvania). -- Student committees are assigned to evaluate a textbook series. The evaluation report is shared with other class members.

University of Oregon. -- The respondent writes:

Teachers are asked to evaluate three textbook series using a set of criteria which we have developed here at the University of Oregon.

(Procedures similar to those described above are practices at Ball State Teachers College, Northern State Teachers College, University of Oklahoma, and Moorhead State College.)

(Several respondents reported that students evaluate city or state courses of study but provided no further details. Examination of courses of study was reported on questionnaire item 8 by some respondents.)

Students develop, or use prepared criteria, for evaluating science teaching

University of Oregon. -- The respondent writes:

Criteria for evaluating science curricula are developed as a culminating activity for the course.
Harris Teachers College.—Students evaluate their own teaching on the basis of a list of criteria which is developed cooperatively by students at the beginning of the semester.

Wisconsin State College at Oshkosh.—A form (Appendix B, Item 27) is utilized in evaluation of teaching procedures.

Teachers College, Columbia University.—Characteristics of a good elementary science program are discussed. Duplicated material distributed to students list important criteria (excerpted in Appendix B, Item 28).

Evaluation of elementary science programs is considered also in a graduate level administrative course. A checklist includes such items as the following:

1. Do you provide a climate in which elementary teachers feel free to experiment and make mistakes? YES____ NO____

2. Do your elementary classroom teachers participate in ordering science materials, equipment, supplies? YES____ NO____

(Evaluation checklists are distributed to students also at Colorado State College and the University of Louisville.)

Students evaluate films, television, other materials

University of Bridgeport.—The course syllabus indicates that specific class meetings are devoted to evaluation and use of films and filmstrips (Appendix B, Item 7).

Maryland State College at Salisbury.—The respondent notes that when student teachers come into contact with science instruction by television there are subsequent evaluation discussions.

University of Kentucky.—Television science instruction is analyzed;
Students view a science telecast* and in small groups list "strengths" and "weaknesses" which they perceive. This activity is done early in the course at a time when students are just becoming acquainted with objectives of science teaching in the elementary school. Students often focus these first criticisms on such matters as the personality of the TV teacher*, accuracy of science content and whether or not the material treated would be interesting to children of a given age. Students are then guided to develop a broader base for evaluation -- to consider criteria such as "What opportunity would the child have to think inductively? to discover through personal manipulation? to ask questions?"

(Science telecasts and manuals which accompany them are evaluated also at the University of Louisville.)

University of Nevada.-- The respondent writes;

[During the elementary science education course] each student works out a special project aimed at...appraising materials of instruction.

Students study, evaluate recent science curriculum programs

University of Oregon.-- The respondent writes:

Several science projects at the elementary school level are being implemented in the public schools in neighboring communities. Resource people involved with these projects are invited to the class to discuss them.

Maryland State College at Towson.-- The respondent writes:

Curricula are evaluated with respect to how useful they are in giving children a chance to grow in the use of the scientific method.

(Practices involving examination of recently developed science curricula were tabulated on Table 20 and described on p. 127.)

Summary and Discussion of Practices Corresponding to Criteria 17 and 18

Respondents from 55 institutions reported practices designed to help future teachers evaluate the growth of children in science (Table 19). Many of these respondents indicated concern for broadening the student's conception of evaluation.
Some 24 respondents reported that evaluation of children is considered in discussions and reading assignments. The emphasis in virtually all cases is that evaluation of children should include subjective as well as objective procedures. Students in many cases are urged to develop a systematic procedure for observing behavior of children.

It is not clear in every case, however, that students are helped to understand what it is they should look for, and how their observations are to be used in the continuing teaching process. Students in some courses study evaluation devices which specify observation of such pupil behavior as "asking appropriate questions," etc. In other courses students may develop their own devices.

At several institutions students consider the nature of evaluation as they engage in observation of children or in student teaching. At these times students are sensitized to observe children's reactions in different situations, the products of children's work, and -- over longer periods of time -- evidence of growth in understanding of concepts.

An attitude implied by many respondents in reporting these practices may be stated in this way:

The student has survived in an educational system to this point because he has adapted himself to a system in which recognition and advancement is based largely on testing. These tests, on the whole, measure only the student's capacity for recalling information. Our job is to convince the student that the system in which he has been successful -- particularly the methods of evaluation in this system -- leaves much to be desired. The student must be helped to understand that some of the important objectives of science education can be evaluated best, or only, through non-traditional methods.19

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19 Portions of this statement are adapted after the discussion by the respondent from Fort Hays Kansas State College on item 3 of the questionnaire.
An apparent manifestation of this attitude is that few respondents devote attention to conventional testing devices. Those who do usually emphasize that testing is but one aspect of evaluation.

This point of view is acceptable, but testing, nevertheless, is an important aspect (or, a nearly universally practiced aspect) of teaching and should not be neglected in undergraduate teacher education. Future teachers should know how to construct unambiguous and significant test items. Practices at Moorhead State College (p. 251), Maryland State College at Towson (p. 252), and Western Washington State College (p. 252) appear particularly appropriate in this respect. Nine respondents, in addition, reported that courses in testing (or evaluation) are required of future teachers at their institutions. In five other cases it is recommended.

Another function of unit and lesson planning is developing understanding of evaluation procedures. Seventeen respondents reported that students are required to build into their plans means for assessing growth of children with respect to stated objectives of the plan.

A practice reported by nine science educators is "example setting:" students are evaluated by means which the instructor believes can be used in elementary school settings. Practices include administering tests composed of model test items, involving students in teacher-pupil planning in which evaluation procedures are integrated, evaluation of student's classroom behavior in certain situations, and involving students in self-evaluation exercises.

Responses from 40 institutions dealt with evaluation of methods and materials of science teaching. The most frequently reported prac-
tice involves students in evaluating lessons taught by themselves or by classmates.

Several respondents indicate, in effect, that they believe it is valuable for a student who has just presented a lesson to hear the comments of classmates, or be evaluated by classmates on prepared forms. The value of this type of activity would probably depend on the following conditions:

1. The teaching situation should be as realistic as possible. Where students simulate the behavior of children, the role-playing should be entered into with enthusiasm and insight.
2. The atmosphere of the evaluation session should be such that the student demonstrator can receive comments of fellow students without loss of face, or undue fear that his grade in the course will be affected adversely.
3. The atmosphere is such that students can express their opinions frankly and constructively.

No respondent referred to such conditions as these, nor implied any limitations to activities in which students evaluate each other. A number of subtle factors, however, can influence classroom process. Some observers believe, for instance, that there are sub-cultural differences in student characteristics. The southern student may feel a greater degree of inhibition in expressing his opinions in the classroom than his northern counterpart.

In any event, it seems quite possible that under some circumstances practices such as some of those reported would evoke considerable embarrassment on the part of shy students, although in other settings these same methods might be very effective. The crux of the matter, however, is that future teachers should be able to engage in self-evaluation. What methods might the science educator employ to achieve this goal? It is unlikely that self-evaluation will occur in the presence of an audience.
There may be merit in requiring the student to follow up his demonstration teaching with a self-evaluation, or with a small-group evaluation session. Ample time, of course, should first be devoted to development of unit or lesson objectives and establishment of evaluative criteria.

A practice infrequently reported — but one which may have considerable potential — is student evaluation of demonstration lessons taught by the instructor. Similar, the student could view filmed models, listen to tape recordings, or read anecdotes describing a science teaching procedure. Since the student does not ordinarily perceive personality involvement in these situations, he should be able to examine the "simulant" objectively. At the same time he may "project" himself into the situation.

Inasmuch as a recurrent criticism of science teaching is the charge that teachers abuse the use of textbooks, it was surprising that textbook evaluation was reported by only seven respondents. Also, in view of the increasing availability of films and television in elementary science education — particularly the latter — it is surprising that only seven respondents reported that their students evaluate these materials. The use of these resources should be thoroughly explored in undergraduate science education courses.

Recommendations Evolving from a Study of Current Practices

37. The development of understanding of the objectives of an elementary science program should be a major objective of the science education course. Reference to these objectives should be made throughout the course in a variety of contexts.

38. Educators should continue to emphasize that evaluation of children with respect to accepted objectives requires different methods appropriate to different objectives. In situations which are as
meaningful as possible, future teachers should be helped to understand the role of observation in the evaluation process. Attention should be given to what behavior should be looked for, and how this may be used in guiding the child's growth.

39. Future teachers need to understand the role and versatility of testing in the evaluation process. Through either a special course in testing, or a series of exercises in the science education course, students should develop skill in composing significant and valid test items of different kinds, and understand how these may be used in effective teaching. The use of published tests may also be considered.

40. The science educator, as well as other members of the instructional staff who have a role in the education of future elementary teachers, may demonstrate through personal example that evaluation involves more than factual recall. College teachers may help the students develop their concept of evaluation by establishing behavioral objectives for college courses and involving students in situations in which they are evaluated on the basis of growth in such behavior.

College students, furthermore, should have some role in planning course activities and evaluating their achievement with respect to these plans (see recommendation 22).

41. The science educator should develop improved methods through which future teachers can learn to evaluate their own teaching efforts. Future teachers, for instance, may assume responsibility in development of lesson and unit plans and engage in evaluation of such plans with reference to carefully developed criteria. The more realistic the circumstances in which this, or some other responsibility, is undertaken, the more meaningful should be the evaluation.

The future teacher may be involved in demonstration teaching before classmates or, preferably, before children, which is subsequently evaluated. While involvement of classmates in this evaluation may be helpful, primary emphasis should be placed on self-evaluation.

The most meaningful setting in which the undergraduate student may engage in self-evaluation is his student-teaching experience. It is again recommended that science educators seek to use student-teaching as effectively as possible (recommendations 26 and 31).

42. Prior to self-evaluation the future teacher may be involved in vicarious exercises. There may be merit in having the student contemplate the effectiveness of various teaching models (recommendation 33).

43. Future teachers should be involved in thoughtful evaluation of a variety of teaching materials and resources, including courses of study, textbooks, and audio-visual devices. Science educators cannot risk the possibility that future elementary teachers might come to accept materials uncritically.
Practices Reported Corresponding to the Nineteenth, Twentieth and Twenty-first Criteria

Criterion 19: Does the particular practice help the teacher understand the bases of scope and sequence organizations for the elementary science program, and how such programs may be made operational?

Criterion 20: Does the particular practice help the teacher understand the relationships between himself and various kinds of elementary science specialists and to evaluate the contributions of all such persons to the total science program?

Criterion 21: Does the particular practice help the teacher recognize that curriculum development is a matter of continuous evolution, requiring that the teacher participate in such in-service activities as exchanging ideas, working in committees, membership in professional organizations, graduate study and classroom experimentation?

These criteria were the basis of questionnaire item 8:

Describe practices in your institution which you feel are particularly effective in helping the elementary teacher understand the bases for continuity and coordination in the science curriculum, and his future role in curriculum implementation and development.

Classification of Practices

Reported practices corresponding to these criteria can be classified in three sub-sections. Practices corresponding to criterion 19 are tabulated on Table 21 in six categories. More complete descriptions of reported practices follow in order of these categories:

Scope and sequence designs studied in elementary curriculum guides and courses of study

University of Southern Mississippi.— Students examine course-of-study outlines and elementary science text series, including publishers' scope and sequence charts. A major point emphasized is that continuity cannot be achieved unless a teacher is aware of children's background when they reach a particular grade level, and what background
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<th>collegiate institution</th>
<th>scope and sequence design studied in elementary curriculum</th>
<th>textbook series/ charts published</th>
<th>new and experimental curricula examined</th>
<th>unit preparation emphasizes scope and sequence organization</th>
<th>scope and sequence problems considered in teaching, participation experience</th>
<th>scope and sequence problems considered in lectures, discussions, etc.</th>
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<th>Textbook series examined</th>
<th>New and experimental curricula examined</th>
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<td>Textbook series publishers' charts examined</td>
<td>New and experimental curricula examined</td>
<td>Unit preparation emphasizes scope and sequence organization</td>
<td>Scope and sequence problems considered during participation in lectures, discussions, etc.</td>
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they need for higher grades. It is observed that science curricula are usually in states of transition:

One of the major concepts is Change and all prospective teachers have this called to their attention repeatedly through mention of the change in subject-matter in textbooks. Old textbooks are used for comparison.

Northern State College.-- Continual change in science curriculum is stressed. The respondent writes:

The interests of children and in science information itself are pointed out and students are led to see the need to keep informed. Much reading of current science periodicals is urged.

University of Colorado.-- The respondent writes:

Students are required to study five courses of study or curriculum guides from various cities as well as five sets of elementary science textbooks in order to acquaint them with the role of the development of the science curriculum areas.

Cornell University.-- The respondent reports:

The teachers are exposed to many scope and sequence charts to curricula developed and published by many cities and states, and to the current curriculum studies of which I as instructor of the course am also listed as a consultant. They get both a formal, external glimpse of continuity and coordination, and also an inside glimpse via the instructor of the course in which these studies are discussed.

Textbook series; publishers' charts examined by students

See University of Southern Mississippi, University of Colorado, and Cornell University, above. There was no significant elaboration of this practice, reported by 27 respondents.

New or experimental curricula examined

Several respondents reported that students have an opportunity to examine experimental elementary science programs or materials such as those developed by Science Curriculum Improvement Study (Department of Physics, University of California), Elementary School Science Project
(Department of Astronomy, University of Illinois) and Elementary Science Study (Educational Services, Inc., Watertown, Massachusetts). Two respondents reported use of the "Science in Action" materials developed by the Pennsylvania State Department of Education.

Unit preparation emphasizes scope and sequence organization

San Diego State College.-- The respondent states:

Each person makes a teaching resource unit. It is based on generalizations, with problem solving the approach in at least several of the generalizations. Using process as the base, (i.e., isolating skills and teaching these longitudinally) is also shown, but not followed through because it doesn't seem too useful yet.

The respondent at San Diego observes that matters pertaining to scope and sequence are treated as open issues.

University of Kentucky.-- Student committees prepare teaching units based on grade-placed topics suggested by Jacobson and Tannenbaum.

Emphasis is placed on (1) the several areas of science which should be included in a rounded elementary science curriculum, and (2) important generalizations which may serve as a framework for sequential organization. Although the Jacobson and Tannenbaum plan is used, no one scheme for topic placement is endorsed -- the point being made that curricula are under constant revision. Further, such schemes are intended to be only a minimum foundation for a complete science program, not the entire program.

Scope and sequence problems considered during student teaching; participation experience

Northern State Teachers College.-- The respondent writes:

Three one-hour observations are assigned at different grade levels of the elementary school so that students may have some idea of the over-all school program.

Wisconsin State College at Eau Claire.-- The respondent writes:

The emphasis on observation, problem solving and vocabulary

20 Jacobson and Tannenbaum, op. cit.
building is a strain running through our entire K-9 science curriculum in the campus school. College students are aware of this consistency.

**Scope and sequence problems considered in lectures, discussions, etc.**

**Colorado State College**.— Students become acquainted with "trends" in elementary science education which are influencing evolving science curricula.

**New Mexico State University**.— The respondent writes:

Ideally there ought to be a ladder of growth in science concepts. In a mobile population this ideal cannot be attained. The more science experiences that enter the elementary school, the greater the difficulty of building a ladder of growth will become....The future teacher is told that a science-specialist attempts to provide clean cut areas of science to be taught in each grade, but that skips and duplication will develop in spite of all attempts to curb them.

**Edinboro State College**.— On item 8 the respondent writes,

"Our program definitely does not fit the scope and sequence mold. It is ungraded, non-textbook oriented."

On item 7, however, the respondent referred to his use of evaluation techniques described by Navarra and Zaffaroni, (p. 246); this emphasis on helping children develop greater and greater competence in science skills would constitute one kind of scope and sequence organization.

**University of Arizona**.— The respondent writes:

No one has clearly determined, in a rational sense, what ought to be the scope and sequence of a good elementary school science program. All the emphasis recently has been on process and method.

**Pennsylvania State University**.— The respondent writes:

An attempt is made to leave each content area open to suggest that the elementary school science program does not complete the understanding of content in area. Science is process and the individual's developmental patterns are constantly emphasized in the methods course.
Winona State Teachers College. -- The respondent writes:

In lecture I stress spiraling curricula and strongly support the extended spiral in which a topic is not repeated each year but perhaps every third year. We discuss the advantages and disadvantages of both types of spirals.

University of Southwestern Louisiana. -- The respondent writes:

Major generalizations applicable to the six broad areas of elementary science are brought together. Students form "faculty groups" where many grade levels are represented. Overlapping of content is checked; gaps in content are noted.

Eastern Michigan University. -- Students develop a plan of subjects which may be taught at different grade levels and support their allocation of topics to the different grades with a rationale.

Practices corresponding to criterion 20 are summarized in Table 22. Inasmuch as these practices were described very briefly by respondents, further elaboration in the text is unnecessary.

Practices corresponding to criterion 21 are summarized in Table 23. Some practices are given below in further detail:

University of Colorado. -- There is an institutional commitment to in-service education of which undergraduate students are aware.

The respondent continues:

I think every student faces a rather strong sensitivity to their responsibilities for curriculum improvement and inservice education when they start teaching science to boys and girls, after having been exposed to it in college very recently.

University of Pittsburgh. -- Students have a first hand opportunity to observe a continuing curriculum improvement program. The respondent adds:

We have, in the last three years or so in the Pittsburgh area, been developing a continuous curriculum program in the area of science, which will follow from Kindergarten through college. In
TABLE 22.— Summary of reported practices in which the future teacher is helped to understand the relationship between himself and science specialists

<table>
<thead>
<tr>
<th>Institution</th>
<th>Summary of practice</th>
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<tbody>
<tr>
<td>Colorado State University</td>
<td>In lectures, the responsibility of various persons (teachers, superintendents, science specialists, supervisors and parents) in curriculum building is discussed.</td>
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<tr>
<td>Eastern Kentucky State College</td>
<td>Students have interviews with science specialists.</td>
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<tr>
<td>Lewis and Clark College</td>
<td>Science resource people are invited to the college classroom.</td>
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<tr>
<td>National College of Education</td>
<td>&quot;We discuss the role of a science consultant and how one can best use him.&quot;</td>
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<tr>
<td>New Mexico State University</td>
<td>Function of the science specialist is considered in lectures, discussion.</td>
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<tr>
<td>State Univ. College at Oswego</td>
<td>&quot;We try to show that the elementary science specialist... is just one more highly specialized [person] in that particular area of curriculum.</td>
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<tr>
<td>University of Kansas</td>
<td>&quot;Part of the methods course is devoted to the role of the science specialist and how the teacher should work with him.&quot;</td>
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<td>University of Oregon</td>
<td>&quot;The curriculum consultant in science from the local public schools is asked [to] explain the inservice education and curriculum improvement projects. The issue of departmentalization vs. self-contained classroom vs. science consultant vs. special room for science is explored.&quot;</td>
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<tr>
<td>Univ. of Southwestern Louisiana</td>
<td>Science specialists are invited to class. Visits are made to the working area of the specialist.</td>
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<td>Institution</td>
<td>Summary of practice or emphasis</td>
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<td>Appalachian State Teachers College</td>
<td>Elementary majors given contact with professionally-minded public school teachers.</td>
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<td>Ball State Teachers College</td>
<td>By the time he completes the course the elementary major understands the responsibility of keeping informed.</td>
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<td>Bowling Green State University</td>
<td>The work in the methods course brings about general recognition of the need for curriculum development.</td>
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<td>Colorado State College</td>
<td>The nature of current research in curriculum is considered.</td>
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<td>Duquesne University</td>
<td>The students are helped in their reading and become aware of current literature and changes in curriculum.</td>
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<td>Goucher College</td>
<td>The leadership within a particular school during the student teaching experience can influence the degree to which students feel they will have any voice in the matter of curriculum improvement in the future.</td>
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<td>Harris Teachers College</td>
<td>Students are required to attend professional science education meetings held locally; reports from the conferences are heard in class.</td>
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<td>Marshall University</td>
<td>We sensitize the future teacher to his responsibility in curriculum development through in-service institutes involving experienced teachers.</td>
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<td>Moorhead State College</td>
<td>The role of the teacher to his responsibility in curriculum improvement is discussed.</td>
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<tr>
<td>National College of Education</td>
<td>A lecture considers the involvement of new teachers in professional science education organizations and publications of these organizations.</td>
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<td>Institution</td>
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| New Mexico State University              | "Each teacher is told that cooperative ventures in building a sequential science program may well fall within his responsibilities."
| Northern State Teachers College          | "Changes in the interests of children and in science information itself point to the need to keep informed. Much reading of current science is urged."
| Ohio University                          | "Each student is required to suggest ways he will utilize possible in-service programs to improve his science deficiencies."
<p>| Pennsylvania State University            | Students are urged to continue study through personal reading programs.                                                                                                                                                  |
| University of Colorado                   | Undergraduates are made aware of institutional commitment to in-service education.                                                                                                                                       |
| University of Iowa                       | Undergraduates observe aspects of the developing elementary science program in the campus school.                                                                                                                        |
| University of Kentucky                   | Committee work on science units is designed that it may be successful and satisfying to its members. The value of pooling effort on curriculum projects is thus emphasized. |
| University of Miami                      | The instructor sets himself as an example that teachers must be learners and that in-service education is imperative.                                                                                                     |
| University of Oregon                     | A science curriculum consultant from the local school system explains in-service curriculum improvement projects. The instructor emphasizes, &quot;We have much to learn.&quot;                                                   |
| University of Pittsburgh                 | Students are exposed to curriculum improvement projects in the Pittsburgh area.                                                                                                                                         |</p>
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<tr>
<td>University of Wisconsin</td>
<td>&quot;The need for a continuous developmental program is discussed in the methods class.&quot;</td>
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<td>Western Kentucky State College</td>
<td>&quot;I feel that [my role] in certain experimental programs helps [students] see how they can contribute.&quot;</td>
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<tr>
<td>Wisconsin State College at Eau Claire</td>
<td>The instructor attempts to communicate the idea that attitude is conditioned by one's reaction to the unexpected and his desire to experiment. Teachers should experiment and not be afraid of mistakes.&quot;</td>
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the development of the science teacher I expose all the students to the process of curriculum development, materials that are required, and down to a development of units and specific lessons to be taught.

**Pennsylvania State University.** The respondent writes:

This year each student is required to read one book — may be popular in nature (but acceptable to instructor) — and these are discussed in class in hopes that further reading will be stimulated. Usually at the beginning and the end of the course the importance of continuing growth on the part of the teacher is stressed. I clearly state that I can only hope to do a good job of launching the students on their way to becoming good teachers of science to children. The rest is up to them and we discuss how they can organize and utilize the course opportunities to this end and how they can work after they leave the course.

**Ball State Teachers College.** The respondent states:

I believe that by the time they have completed our required courses the elementary education student has the idea that science is so large a field that no single person has all the answers, and that each teacher has the responsibility of keeping informed as much as possible and flexible enough to make changes in the curriculum where it is needed. In general I believe they are made aware of a need for some coordinating authority such as a specialist.

**Wisconsin State College at Eau Claire.** The respondent attempts to anticipate fears of future elementary teachers and to develop the attitude that self-improvement is conditioned by one’s reaction to the unexpected and his desire to experiment:

The great fear of not having the proper answer [or a pupil having unusual knowledge of some science subject area] may frighten some college students. However, we try to eliminate certain fears by trying out mistakes on each other with the end result: the science teacher may not always be a Paragon of Virtue and that many experiences have teaching or learning values.

**University of Kentucky.** Students develop units in committees (p. 271):

At the time the unit-development assignment is made the instructor leads a class discussion on the role of individuals in committees, leadership is committees, human relations, etc. Measures are taken to ensure that the committee work is successful with respect to developing a sound unit and that committee work is a source of satisfaction to individual members. I meet with each committee after
its members have had some opportunity for some exploratory reading. Committee objectives are defined in this meeting. In most cases the results of committee effort greatly surpass what could be accomplished by persons working alone. It is observed that practicing teachers can work together in this way to effect curriculum improvement.

Discussion of Practices Corresponding to Criteria 19, 20 and 21

Respondents from 56 institutions reported practices corresponding to criterion 19 (bases of scope and sequence...). In 27 cases at least one of the practices reported is examination of elementary science textbook series. At 19 institutions students refer to elementary science curriculum guides from one or more school systems. One or both of these practices account for the reported activity relative to scope and sequence problems at 39 institutions.

Respondents generally provided little elaboration of such practices. Two educators emphasize the change in curricula and textbooks over the years. Publishers' scope and sequence charts are studied in many courses.

A parenthetical question under questionnaire item 8 was, "How are future teachers acquainted with various scope and sequence plans, or other arrangements designed to maintain continuity of the science program?" (Italics added).

Responses to this question were not all assuring. The absence of reference to this aspect by at least 32 respondents, the brevity of nearly all responses and the relatively common practice of textbook, scope and sequence chart and curriculum guide examination suggest two inferences: (1) in many elementary science education courses there is little concern for helping students understand the bases for scope
and sequence (continuity) in the science curriculum, and (2) scope
and sequence problems are usually resolved as matter of grade-placement
of subjects or topics.

Undoubtedly, there is uncertainty in this area. This is
reflected in the comments of many respondents who write, in effect,
"No one sequence of topics can be considered best -- students must keep
an open mind."

A few respondents who evidently equate "scope and sequence"
with "grade placement of topics" reacted rather strongly. One educator
wrote:

A regimented "program" for science in the elementary school
will in my estimation tend to lead to the expounding of facts rather
than the teaching of rational scientific thinking. The new teacher,
feeling insecure, wants a pattern upon which to lean and pattern
becomes a habit in the older ones. Granted there must be crutches
for our poor teachers who have been made mental cripples by past
generations of inflexible programs or by teachers who let self-
expression lead their classes on will-of-the-wisp chases in which
the blind lead the blind. However, high school would seem soon
enough for a curriculum with an organization of scientific knowl-
edge on a basis which has continuity.

This respondent would probably advocate some form of organi-
ation, objectives, or scheme for continuity if the alternative is a
laissez-faire policy of "let each teacher do as he deems fit, or as he
pleases." He continues:

The teacher should inspire children with curiosity and enthusiasm
for exploration, and then urge them to stress close observation in
the lower grades and more and more reasoning with the older children.
Let the teacher use whatever topic proves most stimulating, most
current or regionally appropriate, and most profitable from the
standpoint of the children in their particular classes.

There is an emotional appeal to this declaration, and a logic-
also. One important basis for continuity should be systematic develop-
ment of scientific habits, including, among other things, development of
curiosity and ability to observe and reason. In addition, children should study topics which are stimulating, current and regionally appropriate.

The respondent's statement implies, however, that some topics are intrinsically non-stimulating, lack currency, or are regionally inappropriate. It could be argued that this is true, within limits, but that an imaginative teacher can make virtually any general topic stimulating, current and appropriate for his pupils.

While many elementary science programs may be grievously inadequate because "expounding of facts" crowds out other legitimate objectives, science educators should exercise caution in urging approaches which depart greatly from present practices. Providing continuity within the science program is not a simple problem solved by accepting a panacea inspired by disenchantment with the worst of contemporary practice.

"Scope and sequence" may have referred traditionally to grade-level placement of topics, but in the modern curriculum it should involve other considerations. The future teacher should learn through meaningful experiences that he will be in partnership with teachers at all grade levels. Skills, attitudes and knowledge to be developed over the years should be identified. A tentative, vertical and horizontal placement of topics may then be designated as the vehicle through which the skills, attitudes and knowledge may be developed. The resulting program must make the obligation of teachers at each grade level clear, but grant the teacher the necessary flexibility to work effectively with a particular group of children. There must be, of course, continual evaluation of the program and periodic adjustments.
Because the practicing teacher should accept responsibility in fulfilling his role in a scope and sequence scheme, and because he will be called upon to engage in in-service curriculum development, deliberate attention should be given the matter of continuity in the undergraduate science education program. Granted that understanding in this area is in a state of evolution, educators are equipped, nevertheless, with working hypotheses which should be shared with future teachers.

Again, the most promising practices appear to be those which involve the student in meaningful situations. Examination of textbooks and sources of study are supplemented in some institutions by unit development which emphasizes scope and sequence concepts. Students at several institutions are guided to perceive possible scope and sequence relationships between the unit on which they are working and other units suggested for the same grade level and for different grade levels.

Several respondents report also that observation and participation experiences in the elementary classroom contribute to the student's understanding of the nature of scope and sequence.

The foregoing notwithstanding, the science educator should take into consideration that in many cases beginning teachers will not enter a teaching situation in which there is a well-developed rationale for scope and sequence. The teacher may be expected to act as a free agent in determining what, if any, science experiences his pupils are to have, or his science program may be rigidly circumscribed. The beginning teacher should enter any situation with a well-developed understanding of the objectives of science education and a commitment
to the concept of continuity. Where a plan exists, however imperfect, he should work with enthusiasm and imagination. His commitment should be to support his colleagues in developing and improving the science curriculum.

Respondents from only nine institutions replied positively with respect to criterion 20, represented on item 8 by the parenthetical question, "How does the future teacher develop a perception of the relationship between himself and the elementary science specialist?"

A practice in three science education courses is to invite a local science specialist to the college classroom to discuss the in-service work he directs and his other functions as a specialist. In one institution students conduct an interview with a science specialist and in five other schools the instructor of the methods course discusses the functions of science specialists with his students. There was virtually no elaboration of these practices.

The fact that over ninety percent of educators completing the questionnaire made no comment with respect to science specialists indicates clearly that this consideration rates low priority in most elementary science education courses. Do educators believe there is but remote possibility that future teachers will work with consultants or other specialists? There is mounting evidence to the contrary.

Two respondents expressed negative sentiments with respect to consultant help and science specialists. One person commented, "The student generally expects to do his own science teaching without help from a specialist or resource person." Another respondent wrote:
The "elementary science specialist" may be another crutch we should fear, because the ordinary classroom teacher may feel inferior to him in this area and hence hesitate to tackle any science unless in consultation with this "authority." Science is not something to be set apart from the rest of the curriculum, so why permit specialization to permit fragmentation?"

Whether or not the actual teaching of science by a specialist will become a reality in a significant proportion of elementary schools, it appear to be certain that in the years immediately ahead teachers may expect to work more closely with supervisors (consultants) than did teachers in the past.

The association of classroom teacher with a curriculum specialist does not negate the regular teacher's responsibility to be prepared to teach science in a competent manner. The consultant should be a person whose objective is to improve the competence of the teacher to teach science through providing various services.

The relationship should be one in which the classroom teacher understands the role of the specialist, welcomes his help and suggestions and is able to go to him for assistance when it is required. A human relationship should be developed in which information and ideas can flow freely between both parties. It seems apparent that the role of the teacher in this association should be explored to some extent in the undergraduate science education course.

Twenty-three respondents commented on criterion 21, represented on the questionnaire item 8 by the question, "What experiences sensitize future teachers to their future responsibilities for curriculum improvement and in-service education?" A positive response from only 25 percent of respondents who completed the questionnaire is again somewhat surprising. Reported practices are rather varied.
In five cases the effort on the part of the science educator is an encouragement, or appeal to the student to "keep informed" -- to continue reading habits begun in the science education course. Students are urged to read science content articles as well as material pertaining to developments in science education.

At five institutions instructors attempt in various ways to acquaint future teachers with the nature of in-service study. In several cases the respondent is himself a director of in-service projects and students may gain some perspective through sharing in this experience.

Three respondents report that they develop class discussions concerning responsibilities of the future teacher in curriculum development.

At four schools future teachers have an opportunity to observe directly and to participate to some extent in continuing curriculum evaluation and development programs. At Appalachian State Teachers College the practice is the provision of opportunities for students to associate with professionally-minded public school teachers. At Goucher College the respondent attempts to place students in situations where they may observe and be influenced by excellent public school leadership. In the other two institutions students have an opportunity to observe in schools where curriculum development projects are in progress.

Two respondents urge their students to affiliate with professional science education associations.
At two institutions respondents indicate efforts to work with students at a somewhat more personal level. At Wisconsin State College at Eau Claire, the science educator attempts to develop in his students an experimental attitude with respect to curriculum development. Students are assured that they should not be discouraged by the unexpected or by minor setbacks.

At the University of Kentucky effort is made to help students be successful in a group curriculum development (unit planning) project. It is desired that the human association in successful group work will be highly satisfying to as many students as possible, and serve as a model for future group enterprise.

The ability to work well with others is essential for an effective relationship with science consultants as well as for successful curriculum development projects with colleagues. Educators should accept this responsibility in preparing future teachers to work harmoniously in group situations as well as informing them of various in-service and curriculum development opportunities.

Recommendations Evolving from a Study of Current Practices

44. Science educators should prepare future teachers to fulfill their partnership obligation in the total elementary school science education program by helping them develop an understanding of scope and sequence. Attention should be given to possible grade-topic allocation through textbook and curriculum guide examination, but scope and sequence must be based on more fundamental considerations than this -- namely, systematic development of skills (scientific method, or process), knowledge and attitudes.

45. The future teacher should develop understanding of scope and sequence through meaningful course activity. Two of the most promising practices appear to be taking these matters into consideration during participation in elementary school classrooms and during unit planning.
46. Students should consider their future teaching role with respect to the science specialist; particularly with respect to science consultants. When students prepare units, the science educator may simulate the role of a consultant.

47. Students should be prepared to accept their future obligation for self-improvement and curriculum development. Some practices which can be developed include:

   a. Helping the student develop habits and skills in self-directed study
   b. Acquainting the student with the nature of professional science education organizations and their publications
   c. Acquainting the student with opportunities for in-service education
   d. Arranging for the student to observe in schools where there is good leadership and active in-service projects.

48. With particular reference to future curriculum development, the science educator -- as well as other educators involved in the professional education of elementary teachers -- should prepare the future teacher to work harmoniously in group situations. Future teachers should learn how to contribute to group enterprises and develop skill in human relations. Educators should seek effective means to develop latent leadership potential.
CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Practices reported by 104 respondents relative to the preparation of elementary teachers to teach science are summarized or tabulated on 23 tables in the ten sections of Chapter IV. The order in which data is presented parallels the organization of the 8-item questionnaire used in the study. Many of the more completely described practices are recorded in some detail in the text. In addition, Appendix B includes 28 items which, for the most part, are excerpts from duplicated material distributed by educators to their students.

Following the presentation of data in each of the ten sections is a summary and discussion of reported practices which includes observations on the apparent strengths and weaknesses of existing practices and programs. Concluding each section is a series of recommendations to science educators evolving from a study of current practices. These recommendations reflect value positions taken by various respondents and the writer which appear consistent with a democratic philosophy of elementary education. There are a total of 48 recommendations which may by classified as follows, with some degree of overlap:

A. Recommendations pertaining to institutional arrangements (courses which should be available to elementary majors and/or the nature of these courses)  Recommendations 1, 2, 6, 18, 19, 21, 22, 39
B. Recommendations pertaining to appropriate activities in science education courses, or professional courses in which science teaching methods and philosophy are considered

C. Recommendations pertaining to content of professional courses other than science education

D. Recommendations pertaining to appropriate activities or emphasis in science courses

E. Recommendations pertaining to cooperative arrangements between science educators and other personnel whose areas of responsibility have a relationship to the preparation of teachers to teach science

F. Recommendations pertaining to counseling of students

Conclusions

The design of this study did not include a mechanism for evaluating the effectiveness of reported practices. It is possible, however, to generalize on the attitudes and values of respondents, and on the role perception of elementary science educators. The basis for such generalization lies not only in what respondents report but in what they omit.

Role Perception of Science Educators

Different educators perceive their roles differently. Many science educators express concern about the absence of appropriate science courses for elementary majors at their institutions. Some educators, consequently, perceive their role as compensatory. In their courses, designed to provide remedial or supplemental work in science, students devote much time to manipulation of science materials,
conducting exercises, and observing the instructor's demonstrations. Lectures, films and required reading emphasize science content.

Some respondents reflect a "how-to-do-it" orientation. The role they accept is one of preparing future teachers by arming them with specific ideas for classroom practice. The apparent rationale is that since many future teachers have weak science backgrounds and are apprehensive about teaching it, their confidence is to be bolstered by providing them a course which is as "practical" as possible. The future teacher is thus involved in many activities which are similar or identical to those which might be conducted in elementary classrooms. Students may be required to develop an extensive file of such exercises.

This orientation differs from the first described although they are not mutually exclusive. In the first case, the science educator is attempting to develop or supplement the future teacher's fund of information and understanding. In the second case the relative emphasis is on preparing the teacher by having him rehearse specific activities.

A few respondents place particular -- or nearly exclusive -- emphasis on the intellectual function of elementary science. The science education courses they teach deal heavily with the nature of scientific method. Laboratory exercises are designed to provide experience in drawing conclusions from various kinds of evidence.

The view is narrow, however, in that science is conceived as limited to the effort of individuals to comprehend their physical environment. Application of science to social problems and correlation of science content to other curriculum areas is flatly rejected. Scientific thinking is evidently regarded as a "faculty" to be developed through intellectual exercise, but little attention is devoted to a
consideration of children's experiential level, their motivation, and their personal and social needs.

Isolationism in Elementary Science Education

There are indications that a number of respondents consider their areas of responsibility in the education of teachers to be more or less rigidly circumscribed. These individuals accept responsibility for designing their courses and leave to other instructors the responsibility for designing theirs. Whether or not overlap is considered desirable, there is a boundary for each individual beyond which he accepts no responsibility and within which others should not trespass. There may be an attitude of indifference to the content of other courses, suggested by such comments as, "That is done in course X, if it is done at all."

Some individuals who might acknowledge the possible benefits accruing from understanding the nature of other courses and attempting some form of coordination evidently resign themselves to the status quo. The factors which make cooperative effort appear futile or excessively demanding in energy include changeover in personnel, departmental and interdepartmental politics and alleged indifference on the part of others.

Whatever the particular causes of the "isolationist posture," it is apparent that many science educators do not conceive their role as a member of a team. They have staked out their territories and are performing their functions in accordance with their personal values and assumptions. From their limited point of vantage they are only vaguely aware of what transpires elsewhere, but they are known to indulge occasionally in carping criticism of the ways others perform their duties.
Variations of "We wish we could do something about this situation" are not uncommon and are as likely to come from persons of high prestige as from science educators in small institutions.

The isolationist posture assumes another dimension in the attitudes of future teachers. A scant 9 percent of respondents replied positively with respect to the student's future relationships with science supervisors or consultants, and virtually none referred to the teacher's role in relatively informal cooperative situations (the writer includes team-teaching in this category). As expressed by one respondent, "The future teacher expects to teach science without help."

Another educator fears that specialists may be an undesirable "crutch."

The value communicated to students either directly or by default in the great majority of science education courses is, evidently, that one is better off working alone. Cooperative arrangements are inefficient at best, and betray one's weakness at worst.

Need for and Conditions Requisite to a Dialogue

The position taken here is that neither college-level personnel associated with the education of future teachers nor the future teachers themselves can afford to be isolationists. Breakdown in communication can result in a destructive alienation which in one case undermines the effectiveness of a teacher-education program and in the second case could prevent the fullest development of a science program for children. The problem is one of how a dialogue may be established and maintained between the personnel at these levels.

A "dialogue," as used in this context, refers to a continuing discussion between two or more individuals who have some common concern, which has as its objective the development of a mutually satisfactory
course of action to improve the conditions which gave rise to the con-
cern.

Requisite to development of a dialogue, individuals must have a
respect for other personalities which involves, in particular, a
willingness to perceive and respect the value positions of others.

There must be a basis for the dialogue, such as recognition of a common
problem which is perceived as one best solved or alleviated through a
cooperative effort. There must also be an expectation of success.

All of these conditions are intimately related to the philo-
sophical position of individuals (whether or not the position is artic-
ulated) as well as their self-concept. It must be conceded that a
dialogue between unperceiving and unyielding parties is impossible.

Assuming the philosophical and psychological disposition of
individuals to engage in dialogue, the common grounds should be identi-
fied.

With college-level personnel whose area of responsibility
impinges on the preparation of elementary teachers to teach science,
the basis for dialogue may be among such ideas as;

1. Science in the elementary school -- like other aspects of the
curriculum -- should be an integral part of the curriculum.
(Our present organization of the teacher-education program does
not emphasize this integral relationship as it should.)

2. Effective teaching of science -- like effective teaching in other
areas -- requires that teachers understand the nature of the child
and that they possess an operational knowledge of the teaching-
learning process. (Our present program appears to isolate practi-
cal experience, study of educational psychology, and child growth
from science teaching methodology.)

3. Future teachers need substantial background in each of several areas
of science. (Our present program appears to be wanting in several
respects.)
These ideas appear to be relatively non-controversial. The parenthetical statements following them represent the admission of a weakness, which in turn implies the desirability of cooperative corrective action.

With respect to the last-cited idea, personnel in the departments of education and the various sciences may proceed to identify issues more specifically. The following questions might arise:

1. How much science does the elementary teacher need to know?

2. To what extent should science courses for future teachers involve laboratory experience? What kind of laboratory experience?

3. What should be the responsibility of the science instructor? Of the science-education instructor?

4. To what extent should the science course emphasize scientific methodology and involve the student in problem-solving activities?

5. What arrangements are made in other institutions?

The first three issues might arise very early in a dialogue, while the fourth probably requires some ground work. In answering the last question (which is not, of course, a matter of value judgment as are the preceding questions) it is hoped that this study might be useful.

The values of some science educators, as identified earlier in this discussion, are considered constrictive by the investigator. Certain aspects of these value positions would be highly desirable if placed in proper perspective, but if permitted to dominate the science education program at a given institution would expose the student to an unnecessarily narrow view of science education. If educators generally can engage in a dialogue with their colleagues, better balanced positions should emerge.

A recommendation for an open dialogue is not a plea for
concensus, as valuable as this might be. It is submitted that various personnel involved in teacher education should know and have respect for each other, understand each other's values, and coordinate their efforts -- wherever possible -- to the end that the student's program will be more meaningful. The science education program is no place for dogmatic and closed-minded individuals. The student should be spared being caught in a destructive cross-fire of conflicting values.

Recommendations classified under "A," "C," "D" and particularly "E" (pp. 288 and 289) should be undertaken in a spirit of open dialogue.

The ideal of the dialogue should also be developed in students in anticipation of interpersonal relationships during their teaching enterprise. The requisites would be the same, generally, as those pertaining to dialogue between college staff members. Specifically, however, elementary teachers should recognize that development of an excellent science program can, in most cases, be realized only through cooperative arrangements with such persons as science consultants and fellow teachers.

The common concern may be as uncomplicated as "How can we develop a good unit in electricity for our fourth graders?" or may involve teachers with more sophisticated issues as "What kinds of behavior do we wish to develop in children, and through what experiences will we attempt to develop them?"

Development of Values in Elementary Science Education

The majority of respondents (there are vigorous exceptions) claims allegiance to such values as "Science should be an integral part of the total curriculum," "Scientific understandings and skills have important social implications," "Evaluation of a child's growth in
science should be made with respect to changes in the child's behavior in various situations," "Certain needs of children are satisfied best, or only, through a carefully designed science program," and "The future teacher should accept the obligation to continually evaluate his teaching efforts and participate in self-improvement projects."

There appears to be some degree of embarrassment here, however, which may be rooted in a sub-verbal assumption. The embarrassment is inferred from brief questionnaire responses in which educators assert that such values are indeed held, and frequently asserted in class discussions and assignments, but the tone of these discussion often suggests that there is no great confidence in the effectiveness of reported procedures. In some cases respondents express this uncertainty quite specifically.

The assumption is that such values are directly transmitted to students through the media of lectures, readings and discussions. While matters such as those itemized above involve certain concepts and information which can be imparted by relatively direct methods, it is submitted here that there is also an emotional or attitudinal component which requires longer periods of time for development.

Attitudes and associated skills can be developed best -- perhaps only -- through involving the learner in meaningful activities. Involvement as used here refers not only to active participation but to acceptance of some degree of responsibility in situations which the learner regards as "significant."

An apparent weakness of many science education courses is that future teachers are not involved in a sufficient variety of meaningful situations. While much developmental work needs to be done in this
respect, there are many practices reported in this study which appear to have considerable potential for attitude development.

An Assessment of the Current State of the Art

The quality of elementary science education programs varies greatly from institution to institution, and any attempt to generalize on the current state of affairs risks offending those who have worked diligently in developing excellent programs. Some attempt at generalization is useful, however, to indicate where we are and in what direction we should be moving.

Many science education courses do not appear to be designed to develop on the part of the future teacher a depth of understanding of why science should be included in the elementary curriculum. It is as though the science educator, through an emphasis on the "how" of matters, is attempting to convince his students that (1) science is not so abstract and incomprehensible as it often appears in poorly designed high school and introductory college courses, and (2) children enjoy involvement in "science activities."

Although the science educator may be committed to a wider range of values than these, and may succeed in getting student to verbalize such concepts, there is quite definitely the possibility that only the two ideas cited above may be grasped, while the student is denied an opportunity to develop a more sophisticated point of view. The danger is that when the new teacher faces his heavy first-year responsibility, other subject areas, perceived as "essential," achieve priority over science. Science -- aside from requiring considerable effort on the part of the teacher -- is considered more recreational than educational.
Further, the first year of teaching often sets a pattern for the years which follow.

Final Recommendations

One direction in which science educators should move, then, to devote greater energy to helping future teachers develop an intellectually defensible commitment to teach science, coupled with an understanding of how science may be taught to achieve desired educational objectives.

When the science educator considers such recommendations as those classified under "B" (p. 289) he should not overlook the critical importance of developing this commitment. It may well be that the educator should begin by examining his own values relative to the role of science in the elementary curriculum, and to identify his assumptions relative to how students develop values of their own.
Appendix A

Item 1: Criteria Developed to Serve as a Basis for Construction of a Questionnaire and as an Instrument for Evaluation of Reported Practices

Does the particular practice...

1) ...introduce the teacher to content in the several fields of science which should be represented in a balanced elementary science curriculum (biology, chemistry, physics, geology, astronomy, meteorology)?

2) ...help the teacher understand some of the major principles of science, to arrive at understanding by inductive experiences in classrooms, to understand phenomena in the "everyday environment" with respect to these principles, and to apply them deductively?

3) ...provide the teacher with an opportunity to develop skill in use of common laboratory materials and techniques?

4) ...familiarize the teacher with a variety of materials and their appropriate use which, in addition to science materials and facilities, includes science literature, films, tape recorders, television, still pictures, maps, community resources and teaching machines?

      ★ ★ ★ ★

5) ...develop the concept of science as a human enterprise -- an effort on the part of man to interpret phenomena in the environment?

6) ...provide opportunity for the teacher to develop skill in scientific method, or reflective thinking, and associated attitudes including experiences in such activities as identification of problems, suggesting hypotheses, designing experiments, gathering data, arriving at conclusions consistent with data, willingness to listen to opinions of others, desire to withhold judgment until sufficient evidence is in, etc.?

      ★ ★ ★ ★

7) ...help the teacher put science into the perspective of total human experience including realization of the role of scientific method and associated attitudes in many life situations, consideration of the history of lines of scientific inquiry, the impact of scientific inquiry and its application in our culture, the role of scientific inquiry in our future, its limitations, etc.?
Appendix A, Item 1 (contd.)

8) ...help the teacher understand the possible contributions of science education to development of citizenship and the relationship of science to democracy including the citizen's need to think reflectively in individual and group situations and have his behavior influenced by scientific attitudes, the citizen's need to have a general background of science information, the responsibility of citizens in formulation of public policy in matters relating to science -- while recognizing the role of the expert in such matters -- and the citizen's need for certain social skills which might be developed concomitantly with the science program?

       * * * * * *

9) ...help the teacher apply to science teaching-learning situations principles of educational psychology, including what is known about the processes by which children develop concepts and generalizations?

10) ...acquaint the teacher with the characteristic responsiveness of children toward phenomena in their environment (curiosity, experimental-mindedness, initiative, etc.)?

11) ...help the teacher understand that the spirit of inquiry is greatly affected by the atmosphere created in the classroom?

12) ...help the teacher understand the value and techniques of teaching in which problems are discovered and solved by children and to distinguish this type of teaching from that in which primary emphasis is given to presentation and recalling of information?

       * * * * * *

13) ...help the teacher understand the differences which exist among children in such factors as general intelligence, age (maturity), socio-economic background and experiential background and the implications of these differences for teaching science?

14) ...help the teacher understand the possible contributions of science education in helping children satisfy personal needs including the need for information relative to health and safety, for aesthetic enrichment through introduction to new ideas and things, and personal benefit from ability to think scientifically?

       * * * * * *

15) ...acquaint the teacher with the various ways in which science may be included in the elementary curriculum?

16) ...help the teacher recognize the complementarity of science content, methods and attitudes with curriculum areas and that science should be an integral part of the curriculum?
Appendix A, Item 1 (contd.)

17) ...help the teacher understand that evaluation of outcomes of science instruction is a matter in which children should be treated as individuals as well as members of a group, and that different techniques and instruments are appropriate for evaluation of different outcomes of instruction?

18) ...help the teacher develop a critical attitude toward all methods and materials employed in or suggested for science teaching and to evaluate these with respect to all accepted goals of science education?

19) ...help the teacher understand the bases of scope and sequence organization for the elementary science programs and how such programs may be made operational?

20) ...help the teacher understand the relationship between himself and various kinds of elementary science specialists and to evaluate the contributions of all such persons to the total science program?

21) ...help the teacher recognize that curriculum development is a matter of continuous evolution, requiring that the teacher participate in such in-service activities as exchanging ideas, working in committees, membership in professional organizations, graduate study and classroom experimentation?
Appendix A, Item 23: Items Appearing on the Questionnaire

Describe practices in your institution which you feel are particularly effective in...

1) ...providing the elementary teacher with an appropriate background of science information?

(For example, do you have courses in science especially appropriate for elementary education majors? If so, what special characteristics make these courses appropriate? What unique types of experience make science principles meaningful to future teachers? How are future teachers helped to develop skill in the selection and use of simple science equipment? What experiences acquaint students with science teaching resources? What courses in science are required to provide a general background considered adequate for teachers? What courses are recommended? Please explain.)

2) ...helping the elementary teacher understand and appreciate the nature of science?

(For example, what types of activity are designed to acquaint future teachers with scientific methodology? What opportunities are provided for identification and solving of problems? What types of experience do future teachers have in developing their ability to think inductively, to interpret observation of phenomena, to develop scientific attitudes, to become increasingly critical in weighing evidence?)

3) ...helping the elementary teacher understand the relationship of science education to social living and to total human experience?

(For example, what experiences are designed to help future teachers realize the social values which may accrue from science teaching? How is an understanding of the relationship of science to democratic society developed? How are future teachers helped to appreciate the impact of scientific inquiry and its applications on our culture — what examples or activities are provided to help students understand the role which science may play in life situations?)

4) ...helping the elementary teacher understand and apply learning theory to science teaching situations?

(For example, what special activities sensitize future teachers to children and their responsiveness to phenomena in their environment? What activities are designed to help them understand the relationship of experience to conceptualization? What experiences

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1A single item, followed by a series of questions in parentheses, appeared on each of the eight pages. The remainder of the page was left blank for use by the respondents.
Appendix A, Item 2 (contd.)

illustrate the effect of classroom atmosphere on the spirit of inquiry? What opportunities are provided to develop skill in a "problem-solving" approach to science teaching?

5) ...preparing the elementary teacher for teaching science in such a way that it contributes to the satisfaction of personal needs of children?

(For example, what kinds of experience are designed to help future teachers adapt science instruction to needs of individual children? Through what experiences do future teachers develop an understanding of the relationship of science to the personal life and habits of children -- to their aesthetic enrichment -- to the development of their world-view?)

6) ...helping the elementary teacher develop an understanding of the relationships of science to the entire elementary curriculum?

(For example, what kinds of activity are designed to help a future teacher gain insight into the several ways science may be included in the curriculum structure? What experiences demonstrate the interrelationship of science with other curriculum areas?)

7) ...helping the elementary teacher understand the need for and nature of evaluation?

(For example, what experiences do future teachers have with various evaluation procedures and instruments? Through what activities do they develop an understanding of the relationship of evaluation to methodology? ... that evaluation should be concerned with the child as an individual as well as a group member? What kinds of experience prepare the future teacher to evaluate his science teaching and the materials he used? How is he prepared to evaluate science curricula and proposals for future innovations?)

8) ...helping the elementary teacher understand the bases for continuity and coordination in the science curriculum, and his future role in curriculum implementation and development?

(For example, how are future teachers acquainted with various scope and sequence plans, or other arrangements designed to maintain continuity of the science program? How does the future teacher develop a perception of the relationship between himself and the elementary science specialist? What experiences sensitize future teachers to their future responsibilities for curriculum improvement and in-service education?)
Dear Science Educators:

I am undertaking a doctoral study titled *Promising Practices in the Preparation of Elementary Teachers for the Teaching of Science*. The work is under the direction of Dr. John S. Richardson of the Ohio State University.

The study is intended to be of use to persons involved in improvement of elementary science education programs. The instrument to be employed will permit a free response to eight general questions. With the assistance of my advisers I have attempted to design an instrument which will secure information otherwise difficult to compile and at the same time be as economical as possible of your time.

Because completing the instrument may require more time than do check-list questionnaires, I am requesting permission in advance to send it to you. I will be most grateful for your assistance.

Will you return the enclosed card, and also indicate other elementary science educators in your state whom you feel would contribute to this endeavor? Thank you.

Sincerely,

William H. Banks, Jr.
Assistant Professor
I would like to express my appreciation for your willingness to assist in this study. As you will recall, my investigation deals with promising practices in the preparation of elementary teachers for the teaching of science. The following suggestions are made to help you in completing this instrument.

1. On each page you are asked to describe practices at your institution which you feel are particularly effective in achieving certain objectives. If you feel you have no outstanding practice corresponding to a particular item, leave the page blank.

2. By "practices" is meant either (a) curriculum arrangements, or (b) classroom procedures used by yourself or others.

3. Do not discuss practices employed at institutions other than yours. I would appreciate, however, your suggesting persons at other institutions whom I might contact.

4. If you have a syllabus or other materials which you distribute to your science education classes, I would appreciate receiving them. Costs will be refunded where requested.

5. This instrument is designed to elicit your free response, thereby revealing practices which a more structured questionnaire might not bring out. It would be helpful to have enough detail in your response to make it possible to give others a clear account.

6. It will be assumed that practices described are in the undergraduate program unless specified otherwise.

7. Should you have any practice which you highly regard but which does not correspond to one of the eight items, please discuss it on the back of any page under the heading "miscellaneous". This might include unique assignments, special activities, etc.

Please indicate on the questionnaire if you wish to receive a summary of my study. You can expect it late in the year.

Sincerely,

William H. Banks, Jr.
Appendix B

Item 1: Excerpts from Proposal to Modify Existing General Education Physics Course for the Benefit of Elementary Education Majors --

Indiana State College (Indiana)

Synopsis: At present the Physics Department does not have enough equipment to offer a laboratory in association with the course Physics III, "Introduction to the Physical Sciences." Such a laboratory is highly desirable for future elementary teachers.

Proposal: ...The responsibility for training these future teachers has motivated a re-evaluation of the goals of the Physics III course...(which is the only physical science course offered for elementary education majors)...The laboratory now becomes a necessity for the future elementary teachers.

Of the 350 students enrolled in Physics III, 250 have been elementary majors, for which Physics III is a required course.

Assuming the necessity for a laboratory, one looks for the most desirable program...(The general view shared by many physics teachers is)... that the individualized laboratory has great merit. Such a program allows each student to puzzle through a series of observations and hopefully discover a general principle. The future teacher needs to develop this ability to think independently, for she will be required to do much individual planning during her career. The concept of the open-ended, individualized, discovery-type laboratory is energetically supported by many Science Education Departments, including our own.

The following laboratory program is proposed: ...Each student will attend a laboratory period one day per week for two hours. Ten of these sessions will be devoted to experimentation and five will be devoted to the activities generally designated as recitation. ...The laboratory will consist of twenty stations and, therefore, will be capable of handling 240 students in the 12 (sections scheduled)...

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4 Original proposal prepared by Howard T. Black, Associate Professor of Physics, Indiana State College.
Appendix B, Item 2: Excerpts from a Laboratory Sheet Distributed to Students in Elementary Science Education Course -- Albany State College

"Tiny Plants and Animals"

Station 1

1. (Examination of organisms in a hay infusion.)
3. Collect samples of filamentous algae from a pond or pool and examine them under a waterdrop microscope or compound microscope...

Station 2

2. (Collecting water from pond; examination for Cyclops)
4. (Examination of stagnant water for Infusoria) "...Now dip the point of a glass rod or pencil into some substance such as salt water, iodine, vinegar or other dilute acid. Transfer a drop to the slide so that the two liquids are brought into contact and observe the effect on the Infusoria"

Station 3

1. (Examination of microscopic crustaceans using hollow ground slides).
4. (Collecting and observing behavior of Ameba).

Station 4

2. (Examining fresh mounts of Elodea leaves under microscope, identifying cell structure).
4. (Observation of yeast fermentation).

Station 5

3. (Examination of filamentous structure of molds with hand lens).
4. (Examination of green mold on orange peel).
Appendix B, Item 3: Excerpts from Course Prospectus, "Science in Childhood Education" -- Teachers College, Columbia University

SCIENCE IN CHILDHOOD EDUCATION is a professional course in elementary school science. The purpose of the course is to help teachers and others concerned with the elementary school develop and improve their work with children in science. A point of view for science in the elementary school is developed; science information is presented; there are demonstrations, construction of various kinds of simple equipment, and some of the professional problems that are encountered in elementary school will be discussed.

Several areas of science are considered in the course:

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<tr>
<th>TK3300</th>
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<tr>
<td>The earth and earth’s surface</td>
<td>Electricity</td>
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<td>Rocks and minerals</td>
<td>The universe in which we live</td>
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<td>Human body and its care</td>
<td>The atmosphere, weather, climate</td>
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<td>Heat and temperature</td>
<td>Plants</td>
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<td>Light and seeing</td>
<td>Ecology</td>
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<td>Sound and hearing</td>
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<td>Water and water supply</td>
<td>Machines and how they work</td>
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<td>Food and Nutrition</td>
<td>Energy</td>
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<td>Animals</td>
<td>Chemical changes</td>
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<tr>
<td>Principles of flight</td>
<td>Atomic energy</td>
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<tr>
<td>Organization of living things</td>
<td>Exploration of space</td>
</tr>
<tr>
<td>The ocean and the hydrosphere</td>
<td>Preventing spread of disease</td>
</tr>
</tbody>
</table>

Course requirements: attendance at class sessions, assignments and preparation of a resource unit in some area of elementary science. The resource unit may contain the following kinds of materials:

1. Suggested projects, demonstrations, field experiences, etc.

2. Suggested experiences in other areas of the curriculum such as music, literature, social studies, reading, arithmetic, etc. that would help in the development of the area.

3. Children's books and other materials useful in developing this area of science.

4. Teacher's bibliography.
Appendix B, Item 4: Excerpts from Sample Material Distributed in "Science and Childhood Education" Relative to Science Topics Considered in Class -- Teachers College, Columbia University

"The Earth and Its Surface"

I. How we study the earth and how it was formed
   A. The principle of uniformitarianism
   B. Fossils and how they were formed

II. How the earth was formed
   A. The dust cloud hypothesis (etc.)

III. The shape of the earth

IV. Rocks and how we study them
   A. What are rocks? How do we classify them? (etc.)

V. Minerals and how we study them
   A. What are minerals? How do we classify them?
   E. Rock and mineral collections

VI. Soil and how we study them
   A. What is soil? How is soil formed?
   F. Conserving the soil

VII. Changes that take place in the surface of the earth
   A. Erosion by wind and water
   E. Earthquakes

VIII. The interior of the earth
   A. How we study the interior of the earth
   B. The nature of the interior of the earth

Some Important Science Generalizations

1. All rocks are composed of one or more minerals.

(etc.)
Appendix B, Item 5: Excerpts from One of Several Sheets Distributed to Students in Elementary Science Education Course -- University of Louisville

"The Story of the Earth"

A. Major concepts to be developed: primary grades

The sun is very important to the earth.
Plants and animals need sunlight in order to live and grow.
Shadows caused by the sun help us to tell time.

etc.

B. Major basic concepts to be developed: intermediate grades

The earth is very old.
Many forces have been and still are changing our earth.
The earth is part of the solar system.
Conservation is the wise use of natural resources and the restoration of renewable resources.

etc.

C. Guide questions -- science problems

Why is the sun so important to the earth?
How was the earth formed?
How does moving water change the earth?
Of what is soil made?
How can our soil be saved and improved?
How have fossils helped us to learn about life long ago?

etc.

E. The story of the earth -- main suptopics

The forces which change the earth's surface
The formation of rocks and soil
The development of life through the ages
The earth a part of the solar system
Conservation of natural resources

etc.
Appendix B, Item 6: Excerpts from Course Outline, "The Teaching of Elementary Science"—University of Louisville

A. Objectives of the course (selected)

1. To acquaint students with the objectives of science education in the elementary school
2. To develop an understanding of the scientific method of problem solving, skills, and scientific attitudes to be developed in the elementary school
3. To demonstrate methods of teaching science in the elementary school
4. To give students an opportunity to perform simple experiments with simple equipment
5. To develop the ability to carry out an effective demonstration
6. To help students prepare lesson plans, units of work, and plan science programs which correlate with social studies, safety and health
7. To survey materials for teaching elementary science...
8. To help students learn the value of field trips...
9. To help students become acquainted with resource persons in the community
10. Enlarge student's subject matter backgrounds in the areas of earth and biological sciences, weather, climate, etc.
11. To teach students how to prepare effective tests and evaluate pupil progress in science
12. To acquaint students with professional organizations and professional literature in the field of elementary science education

B. Required activities include reading of professional literature, preparation of picture file, study of children's science books, preparation of lesson plans and units of work, reading of science material in current newspapers and magazines, etc.

C. Student achievement is evaluated by:

1. Objective tests given on each area of science studies.
3. Reviews of professional reading.
4. Science demonstration by student for class.
Appendix B, Item 7: Excerpts from Course Outline, "Methods and Materials in Elementary Education" -- University of Bridgeport

A. Organizational components of the class:

The class
Entire class enrollment. Meets as a group for presentations of general interest.

The section group
Those members of the class whose interests lie either in the primary or the intermediate level of elementary school. Topics of relevance to their level will be discussed.

The learning team
A group of about five students who will develop a resource unit. Learning teams meet individually to discuss their problems and develop materials. Instructor guidance available.

B. Procedures:

1. Each student is assigned to a section group and a learning group according to his interests and judgment of the instructor.

2. Each section group is assigned a room for a base of operations. Class meetings in large lecture rooms, team meetings in various locations.

3. A weekly schedule is distributed to students which outlines activities, locations and other information for the week.

C. Course requirements:

1. Team requirements

   a. Development of a resource unit which focuses on a socially significant problem and contains provisions for teaching appropriate social and scientific concepts, generalizations, skills, attitudes and appreciations...

   b. A log of team meetings and accomplishments is submitted to the instructor. An analysis of the human relations dynamics observed within the group is included.

   c. Presentation of units to section groups near end of course.

   d. Development of a bulletin board display.
Appendix B, Item 7 (contd.)

2. Individual requirements:

Includes attendance at meetings, assigned readings, taking examinations and completion of four activities related to team resource unit. The activities are to be chosen from a list, which includes a collection of pictures, a script and worksheet for use with a tape recorder, a series of evaluation devices, preparation of charts, graphs or models.

3. Course topics (selected)

Introduction to social studies and science, developing a perspective

The unit method: resource and teaching units

Integrating social and scientific learning in unit teaching

Curriculum content and organization: science and social studies

Characteristics of children, learning, and content areas

Measurement and appraisal in science and social studies

Lesson planning: block planning and individual lessons

Children's books in science and social studies

Study skills in the content areas

New trends in science and social studies

Maps, globes and teaching models

Programmed learning

Films and filmstrips: selection, use and evaluation

Tapes and transparencies as teaching devices

Bulletin boards, pictures and dioramas

Planning and executing the field trip

Methods of inquiry in science

5. Resource unit format: includes title, statement of significance, suggested problems and questions, statement of anticipated outcomes, analysis of content, suggested pupil activities, suggested evaluation techniques and instruments, teachers' and children's bibliography.
Appendix B, Item 8: Excerpts from Assignment Sheet of Elementary Science Education Course -- Utah State University

1. Read a current article from any appropriate periodical on each of the following five topics and write a report on a 4" x 6" card including the reference, a summary in your own words, and your critique or personal reaction to the article.
   a. Current philosophy of elementary science teaching (may include goals and trends)
   b. Methodology (may be on any specific method)
   c. Curriculum
   d. Teaching aids and materials for science
   e. Co-curricular activities in science (science fairs, clubs, excursions, seminars, etc.)

2. Build a teaching model appropriate for your chosen level of instruction and be prepared to display it and explain:
   a. how it was constructed.
   b. principles that it could teach (several).
   c. how to teach one of the above principles (demonstrate as though the class were elementary students).

3. Plan an activity for the teaching of any concept in an elementary science lesson. Bring necessary materials and supplies and conduct the activity as you would in actual teaching. A student worksheet is recommended.
   
or
   Plan a bulletin board or display on a science topic for your grade level. Bulletin board chairmen will assign dates.

4. Compose a teaching unit, "core type," to cover one week for your chosen grade level. Details of this are explained on a separate sheet.
   
or
   Do a simple research project or experiment in any branch of science and write it up describing the procedure, results and conclusions. Be prepared to display the apparatus and describe the project and its conclusions to the class. Show data in tabular and graph form.
Appendix B, Item 9: Selected Investigations and Activities Suggested for Students in Elementary Science Education Course -- Teachers

College, Columbia University
College, Columbia University

1. On what kinds of substances can bread mold be grown? Where do they grow best?

2. What color and angle roof will keep the interior of a house coolest under intense sunlight conditions?

3. How is the rate at which water flows out of a bottle related to the size of the opening?

4. What are some of the variations in microclimates to be found in a playground? (Temperature, wind direction, relative humidity, dew, frost, fog, etc.) How do the microclimates change during the day? How can the microclimates be explained?

5. How much does the radiant energy absorbed by a surface vary with the angle at which the radiant energy strikes the surface?

6. What kind of stimulus is most likely to make a mealworm (or other worm) reverse its direction of movement?

7. What is the distance between the nerve endings for pressure on various parts of the body?

8. What is the effect of bleaching liquid on different colors of cloth?

Some activities in the study of animals:

1. The care of pets, mice, rats, hamsters, guinea pigs

2. The story of cocoons and the changes that take place as butterflies and moths emerge

3. Maintaining a bird feeding station

4. Setting up a vivarium

5. Making a collection of local insects

6. Discovering and studying the major problems of conservation in the community
Appendix B, Item 10: Description of "Original Research Paper"

Required of Students in Elementary Education Course -- The Ohio State University

A. Field trip

This will be very short and will be taken on the campus between Arps Hall and the University School. This is for demonstration only as you are to make a similar study for one-half hour on your own lawn, school lot or some spot you may wish to explore.

The idea is to study some interesting microclimates that exist around us -- climates we pass every day but do not see because we do not stop to observe. We will locate:

1. Micro-deserts: footpaths, sidewalks, driveways, road shoulders, etc.


3. Radiation ceiling: trees, bushes, tall plant growth as weeds, rose bushes and high grasses.

4. Micro-mountains and valleys: small ridges on lawns, excavations, a deep footprint, etc.

5. Mirages -- pavement looks wet far ahead of you as you drive along the road.

B. Short research paper

When you have finished your microclimate observation you are to write a short research paper (one to two pages) describing the climate you saw and note the plants and animals that lived there. Explain how you could use such a field trip with your students in helping them observe, describe and develop concepts about the world in which they live.
Appendix B, Item II: A Selected Laboratory Exercise from "Biology III"

Kansas State College at Pittsburg

"Osmosis and Diffusion"

Diffusion:

400 or 500 m. clear-glass container of tap-water and potassium permanganate crystals (2 or 3 to each container). Allow currents to subside before gently dropping the crystals into the water. Do not disturb the system after the crystals are dropped in. Iodine crystals may be substituted for the potassium permanganate.

Osmosis:

Chicken egg (the yolk is the cell) should be separated from the albumen in three instances. These should be placed into fingerbowls in:

a. Ringer's solution
b. 10% saline solution
c. distilled water

A fourth should be removed from the shell, but left in its albumen envelop and placed in a 50 or 100 m. beaker.

The students should be encouraged to observe these periodically during the laboratory period, to make notes and write up the results as an experiment.

Blood cells (from any mammal) should be placed on concave slides as drops. Care should be taken that the blood is not oxidized before the procedure is begun. To one drop of blood the students should add one drop of:

a. Ringer's solution
b. 10% saline solution
c. distilled water
Appendix B, Item 12: Excerpts from a Form Used by Students When They Observe a Lesson Taught in an Elementary Classroom — University of Southwestern Louisiana

A. What were the aims of the lesson?
   1. Were the aims determined by the teacher? \underline{\text{the teacher}}\underline{\text{the pupils}}\underline{\text{the teacher and the pupils}}
   2. What indications were there that the aims were accomplished?

B. What materials were used by the teacher and pupils?

C. Could you suggest other materials which might have been helpful?

D. How was the lesson introduced?

E. Was there any indication of a connection between this lesson and the previous one in this subject? If so, what was it?

F. How interested were the pupils in this lesson? Give examples.

G. What activities were included?

H. How was the lesson summarized?

I. Was the lesson evaluated? If so, how?

J. Was an assignment given?
   1. Do you consider it a reasonable assignment?
   2. Were directions clearly given?
   3. Did the assignment provide for individual differences? If so, how?

K. Give your general reaction to this class observation.
Appendix B, Item 13: Excerpts from Duplicated Material Distributed
in Science Education Class -- University of Louisville

"The Classroom Science Corner"

The setting up of a science center in one corner of the classroom is a stimulating and worthwhile undertaking if the children do it with the help of the teacher. In this corner there should be many of the following materials for children to observe and study:

- **Living things**: plants, bulbs, seeds, terraria, aquaria, etc.
- **Collections** belonging to the children
- **A table** for demonstration and experimentation by children
- **Shelves** for exhibits and equipment
- **A bulletin board** for pictures, charts, children's work, etc.
- **Science books**

**Purposes of the classroom science corner:**

...The science corner should be a spot in the elementary classroom where children feel free to go for any of the following purposes:

a. To perform an experiment (or repeat one)
b. To observe results of experiments
c. To contribute new materials to collections, exhibits, library and bulletin boards

Etc.

**Values of the science corner:**

If materials are changed frequently, and an air of orderliness, attractiveness and informality... are maintained, the science corner will give every child the opportunity of contributing and participating in class interests and activities. The corner will be a stimulus for:

a. Going to authorities for information
b. A critical approach to problems
c. Working with others
d. Use of previous learnings in new situations

Etc.
Appendix B, Item 14: Excerpts from Course Syllabus, "Methods and Materials in Science Education for the Elementary Grades" -- Rhode Island University

The Elementary School Child: The characteristics of children in grades kindergarten through six will be considered, with emphasis on those characteristics which should be recognized in planning and teaching the science program, e.g.:  

Elementary school children usually enjoy and readily learn scientific concepts from

1. Observing, perceiving, listening....
2. Questioning (to learn to interpret observations, to increase understanding of the world, and to find answers).
3. Reading (to differentiate fact and fiction, fact and opinion and to challenge authenticity of data.
4. Problem solving (to learn to collect, organize, relate, interpret, generalize from data...)
5. Evaluating (to generalize from what has been observed in two or more similar and related situations).

Course Outline:

1. Study and exploration of these questions:
   a. What is science in the elementary school?
   b. What are the goals of science instruction? (How does science contribute to aims of education in our society?)
   c. What are some major trends in the science curriculum?
   d. How should science topics be selected for each grade level?
   e. How should the program for the elementary school be organized?

2. Develop some of these related activities:
   a. Individual and group demonstrations....
   b. Experimenting with simple equipment found in the home or that which is readily available to the student.
   c. Examination and analysis of elementary science textbooks.
   d. Learn when and how to use audio-visual aids.
   e. Demonstrate teaching techniques using Henry Barnard School when and if feasible.
Appendix B, Item 15: Excerpts from 'Course Syllabus, "Science Education 273"—Wisconsin State College at Oshkosh

The following list of questions has been prepared to help you think about lecture and reading material pertaining to the course. In many instances the questions call for opinions. As prospective elementary school science teachers it is important that you develop some attitudes with regard to these....

Uns in science teaching and unit construction:

Is there a necessity for unit organization of science subject matter? Why or why not?

In preparing units for different grade levels, what factors should be considered in selecting content? determining learning experiences? obtaining materials? evaluating progress?

What are some other mechanisms or bases for formulating or organizing subject matter in science? Advantages and disadvantages?

Objectives:

List at least four valid objectives for teaching science which cannot be attained in a satisfactory manner in some other subject area.

Philosophic and psychological considerations:

What individual differences must you consider in selecting content and learning experiences for your students in science classes?

Children need practice in critical thinking. How can you promote this in your science teaching? Consider types of questions, responses of students, and your own attitudes.

Organization of the science curriculum:

(Referring to state elementary science guide) What is your opinion regarding the grade placement of various areas, duplication of areas from one grade to the next, and deletion or minimizing of other areas?

Science can be readily correlated with other areas of learning. Be able to explain, using specific examples, how you could correlate science with language arts, social studies, mathematics, art and music.

What problems... will arise if there is not adequate coordination in the teaching of science in your school or district?
Appendix B, Item 15 (contd.)

**Science text and workbooks, assignments, projects, demonstrations:**

What are significant advantages and disadvantages to having children use a science workbook?

...List six or more outstanding factors needing consideration in selection of textbooks and six of lesser importance.

What are some of the principal failings in many science assignments?

What values accrue to the teacher or science program and to the student from completing a project?

Should all students be required to complete a science project?

Explain the essential differences between an inductive and deductive demonstration. Give advantages and disadvantages of each type.

**Teacher-pupil planning:**

Teacher-pupil planning can be effective under a variety of conditions. As a new teacher, how do you plan to use the technique even on a limited scale?

**Field trips, laboratory work:**

...Be able to discuss... advisability of field trips, necessary preparation, possible alternatives to field trips.

What values accrue from laboratory work? At what grade level would you consider introducing such procedures? How can laboratory work be accomplished by all members of the class and still not have them doing the same thing at the same time?

**Evaluation:**

What types of science learnings do you consider significant enough for objective measurement? What other techniques would you use?

What factors would you consider if you were going to evaluate yourself with regard to your effectiveness in teaching science?
Appendix B, Item 16: Reproduction of Evaluation Form Used in Conjunction with Student-taught Lessons -- San Diego State College

(Lessons are taught to small groups of students. Each student in the group completes one of the forms, below.)

<table>
<thead>
<tr>
<th>(Your name)</th>
<th>(Experimenter's name)</th>
</tr>
</thead>
</table>

Skill in raising the problem:

Skill in developing the best hypothesis:

Skill in designing and stimulating thinking in the experiments:

Skill in drawing the conclusions and applying the problem:

General reactions:
Appendix B, Item 17: Excerpts from Duplicated Material Describing Development of Science Lessons -- Maryland State College at Towson

Select a science generalization which you feel is very important for children to understand. State the generalization clearly and list at least three reasons why you feel it is important.

Think of some question or problem which might arise in the classroom spontaneously or through teacher stimulation, the solving of which would lead children to a better understanding of the generalization you have selected. State exactly what the circumstances are under which the question or problem might arise.

Plan how you and a class might possibly attack this problem using scientific procedure. Outline the phases of scientific method to be applied to your problem.

A. State and define problem

Do this clearly and on what you feel is the level of the children you will be teaching.

B. Research

1. What knowledge relevant to the problem would you expect the children to have already?
2. How much would you tell them of what you know?

C. Hypothesis

List all the possible hypotheses you think the children and you might want to develop cooperatively.

D. Experimentation and observation

Develop some simple procedures to test one of these hypotheses. List materials. Record the possible steps in your experiment and parallel each with a statement of the expected student observations.

E. Conclusions

What conclusions do you expect the children to reach

Outline the checks, controls and precautions you would need to consider in order to make this experiment truly scientific and develop in the children a scientific attitude. What applications of it would you expect your students to recognize? Build a list of possible applications, considering integration of this generalization with school subjects other than science and all life situations.
Appendix B, Item 18: Excerpts from Questionnaire Administered to Students at the End of Their Student Teaching Experience -- Moorhead State College

1. During your student teaching quarter, what science or health units have you (a) taught? (b) observed or assisted in teaching?

2. What incidental science or health topics have you taught or observed being taught this quarter? (examples: identification of an insect a child brought to school, etc.)

3. With what science laboratory equipment have you worked this quarter?

6. In teaching or assisting in teaching science or health, which of the following activities did you take part in?

   _____ assisting pupils in setting up experiments
   _____ handling discussion of science or health current events
   _____ preparing a science display (either pupil or teacher materials)
   _____ assisting girls in doing science laboratory work
   _____ assisting some of the more gifted people in the room in doing science laboratory work
   etc.

9. Which of the following visual or auditory aids (other than textbooks or laboratory materials) were used in connection with science or health teaching?

<table>
<thead>
<tr>
<th>aid</th>
<th>used by student teacher</th>
<th>observed use</th>
</tr>
</thead>
<tbody>
<tr>
<td>films</td>
<td></td>
<td></td>
</tr>
<tr>
<td>filmstrips</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bulletin board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>charts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>live animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Once upon a time, the animals decided that they must do something heroic to meet the problems of a "new world," so they organized a school. They adopted an activity curriculum consisting of running, climbing, swimming and flying. To make it easier to administer, all the animals took all the subjects.

The duck was excellent in swimming -- better, in fact, than his instructor -- and made passing grades in flying, but he was very poor in running. Since he was slow in running, he had to stay after school and also drop swimming to practice running. This was kept up until his webbed feet were badly worn and he was only average in swimming. But average was acceptable in school, so nobody worried about that except the duck.

The rabbit started at the top of the class in running, but had a nervous breakdown because of so much makeup work in swimming.

The squirrel was excellent in climbing until he developed frustration in the flying class where his teacher made him start from the ground up instead of from the tree-top down. He also developed charlie horses from overexertion and then got a C in climbing and a D in running.

The eagle was a problem child and was disciplined severely. In the climbing class he beat all the others to the top of the tree, but insisted on using his own way to get there.

At the end of the year, an abnormal eel that could swim exceedingly well, and also run, climb and fly a little had the highest average and was valedictorian.

The prairie dogs stayed out of school and fought the tax levy because the administration would not add digging and burrowing to the curriculum. They apprenticed their child to a badger and later joined the groundhogs and gophers to start a successful private school.

Does the fable have a moral????????????

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5 Dr. G. H. Reavis, Assistant Superintendent of Schools, Cincinnati, Ohio.
Appendix B, Item 20: Excerpts from a Model Unit Plan Distributed to Students -- University of Southwestern Louisiana

"Science unit -- Water"

I. List of activities

A. Required activities -- everyone will do each of the following:

1. Read Unit IV, pps. 137-178 in your text.
2. Keep a vocabulary chart.
3. Locate a small pool of water...note all forms of life.
4. Prepare a written report on one of the following topics:
   a. Why are many of the largest and most important cities in the world located on the shores of an ocean, large lake or river?
   b. The importance of water to man from earliest time to the present.

   etc.

B. Elective activities -- each student will select four of the following activities:

1. You can test various kinds of cloth to see which dries fastest.
2. Keep a record of the various ways in which water is used during one day in the kitchen of your house.
3. Make an oral report to the class on an epidemic which was caused by impure or polluted water.
4. If we could use water from the oceans, we would have plenty of water. What research for doing this is underway?
5. Four students make a model of the TVA project.
6. Four students prepare a debate on "Resolved: Fluorides should be added to our drinking water."
7. Make a graph showing number of floods in the United States in the last ten years.
8. Construct a map of a particular state showing its major water supplies.

   etc.

(Following this is a sample lesson plan, organized to include objectives, procedure, evaluation and assignment.)
Appendix B, Item 21: Excerpts from "Science Units of Work"

University of Louisville

1. Organized science units of work begin in the upper primary grades. These units are organized studies of major problems in the environment of children. They consist of activities directed toward understanding that will function in intelligent living.

2. Values of organized science units are:
   a. They constitute a balanced program which provides experiences with the physical as well as the biological world.
   b. They proceed from units with simple concepts to those with more complex concepts.
   c. They include great emphasis on the social significance of the science understandings.
   
3. Organized science units -- how to plan a unit of work:
   a. Introduction or survey of unit
   b. List of the purposes, or aims, of the unit of work...
      (1) Basic concepts...to be developed
      (2) Scientific attitudes to be developed
      (3) Skills to be developed
   c. Science problems
   d. Approaches or ways to initiate...the unit of work
   e. Experiments
      (1) Experiments for teacher demonstration
      (2) Experiments for individual pupils
      (3) Experiments for group participation
   f. Activities which include other ways for learning science
      (1) Reading
      (2) Discussions
      (3) Field trips
      (4) Visual aids

   (Also listed here are teacher references, pupil references, lists of visual aids, list of equipment needed, practical applications, etc.)

4. Criteria for evaluation of science units:
   a. Does the unit originate from something in the children's experience?
   b. Does the unit afford opportunity for first-hand experiences with science materials and phenomena?

   etc.
Appendix B, Item 22: Excerpts from "Investigation -- A Drop"

Edinboro State College

Introduction:
.....News agencies spend much time explaining the many major advances in science, such as space travel, transplant of human organs, and atomic power. From publicity of this type it is difficult to realize that most major findings in science are the result of many very small, insignificant studies. Most scientists are content to move the threshold of knowledge an inch at a time.

This study is designed to explore the characteristics of an insignificant particle of matter, a drop....

The problem:

What is a drop?

Methods and Materials:

An eyedropper is provided -- this will be your major research item. The methods described will help you interpret the drops from this one dropper.

1. Find the volume of one drop of water by averaging the volume of 100 drops. Repeat this same operation until you are personally convinced. Have sufficient data to support your findings.

2. Find the weight of a drop of water by similar techniques.

3. Drop ten drops of water on a blotter. Measure the area of each spot and find the mean. Repeat and compare. Is the eyedropper dependable? Have evidence to support your answer.

4. Repeat the same tests using water at room temperature and boiling water. Record and explain your results.

6. Using your present findings, further investigation and/or logical deductions, seek answers to the following:

a. Does the inclusion of detergents at a constant temperature affect the drop of water? (at variable temperatures?)

b. How does the eyedropper react when other materials are used, such as oil?

c. Give a complete calibrated description of your eyedropper.
Appendix B, Item 23: Excerpts from "Suggestions for Improving the Elementary Science Program in Minnesota Schools" — Moorhead State College

I. A definite, but flexible, planned program for science:

A. Provision for both planned and incidental science. ("On the one hand the plan must be flexible enough that a Sputnik or a blizzard or polio shots or a new batch of baby guppies can be considered briefly when they occur, but it must be definite enough so that barometers and levers and migrating birds don't appear time after time while simple chemistry is left out completely.")

B. Organization around important principles of chemistry, physics, biology, astronomy, and the earth sciences and their applications in safety, health, first aid, conservation, consumer science etc.

C. Provisions for developing a functional understanding of science principles, scientific attitudes, appreciation and interest as well as a variety of methods of finding answers to questions and skill in problem solving.

D. Provision for a developmental program where learning in the various areas of science are expanded systematically rather than being repeated with little change or treated exhaustively and then dropped.

II. Aids in carrying out the plans:

A. Administrative interest and support

B. Area surveys with information provided for the teachers on field trip possibilities, resource personnel, visual aids available, books, free and inexpensive materials, suggestions for experiments and projects, etc.

Appendix B, Item 23 (contd.)

C. An expanded record system, including such things as units and important principles taught, key experiments, field trips and visual aids used, and evaluation results.

D. Adequate equipment and convenient and safe places to carry on simple laboratory work...

E. Full-time science consultants in the school building or school system — either an elementary teacher with science interests and training, or a secondary science teacher with interest and knowledge in the elementary field.

F. A library well supplied with all types of science books and audio-visual aids.

G. Good evaluation instruments, both teacher-made and standardized. (See pg. 8-10 of "Evaluation of Science Instruction. A checklist of Suggested Teaching Procedures.")

III. Suggestions for carrying out plans successfully:

A. Encouraging teachers (financially and in other ways) to participate in workshops and additional science courses, to make use of in-service help of all kinds, and to practice the kinds of science activities they want pupils to learn to do.

B. Using a wide variety of classroom activities in teaching science, rather than limiting the work to reading about and talking about science. Activities could include exploratory and research reading, simple laboratory work, field trips, careful observation and recording, using scientific equipment, planning and carrying out simple problem-solving, etc.

C. Providing activities in science for pupils at all levels of ability. .

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Appendix B, Item 24: Excerpts from "The Construction of a Modified Teaching-Resource Unit" -- Fort Hays Kansas State College

A. The unit title:

The unit needs a title which is "catchy" and explains basically what will be studied.

B. The introduction to the unit:

This should be a short paragraph explaining the value of the topic, how interest is to be stimulated and, in further detail, the content.

C. Thought questions relative to study of the unit:

These questions should be complete and should be of such a nature that students are required to think out the answers rather than finding them verbatim in the textbook.

D. Subject matter to be studied:

Material should correspond to the items in "B" above. It may be presented in outline form, preferably a sentence outline.

E. Activities:

The activities are the real learning situations which are to be developed by the class or by the teacher enabling the children to acquire the necessary understanding.

F. Bibliography:

This should include a selected bibliography for teachers and one for children. Suggest sources of information suitable for use by both slow and more rapid learners.

G. Participation:

It is strongly recommended that you ask your students to assist you in formulating the contents of a unit and that you act as the resource person to guide their planning. Participation enhances learning.
Appendix B, Item 25: Selected Test Items and Laboratory Problems

University of Miami

1. Indians boil water in birch bark containers. (You can duplicate this using glazed cardboard.) Why did the birch bark or cardboard not burn? Explain....

2. If you were to touch a piece of metal and then a piece of wood, the metal would feel cooler. Why?

3. If you wanted to boil an egg on top of a mountain how would you adjust cooking time? Why?

4. If a child in your class said he could tell the temperature outside by counting the rate of a cricket's chirping, how would you react?

5. Fill three jars to the top with hot water and cover them tightly. Wipe the outside of the jars dry. Now pull a woolen sock around one jar, covering it as though it were your foot. Pull a cotton sock over the second jar. Leave the third jar as it is. Place all three jars in a cool place. After about a half hour, remove the socks and feel all the jars.

a. What are the results?
b. List the principles involved in this experiment.
c. Why was the third jar used?
Appendix B Item 26: Excerpts from "Testing in Elementary School Science" -- Moorhead State College

1. True-false questions are best used for short, factual items. It is usually not a good idea for matters of opinion, cases where bright pupils might be confused by knowing too much or questions that must be stated negatively.

What is wrong with the following T-F questions?

   a. There are no birds without feathers. T-F
   b. Fish lay eggs. T-F
   c. The best way of sending messages is by radio. T-F

2. Two-way classification questions are closely related to T-F questions because there are just two possible answers for each item. They are usable at any difficulty level.

   a. Draw a line under the names of the animals which usually hibernate for the winter:

      fish  worms  bears  cows  horses

   b. Sort a series of cards or pictures into two groups -- those which show methods of land transportation and those which show methods of water (or air) transportation.

3. Matching questions can be used to find out whether a pupil can select the two items that belong together from a number of closely related items. They can be used at different levels of difficulty, as shown below.

   a. Place the letter of the instrument in Column II in front of that instrument's job in Column I.

      Measures temperature  A. Anemometer
      Measures air pressure  B. Barometer
      Measures wind velocity  C. Humidifier
      Indicates wind direction D. Rain gauge
      Measures temperature  E. Thermometer
      Measures air pressure  F. Wind vane

   b. The words SPRING, SUMMER, WINTER and AUTUMN are printed on the board. Children are instructed to look at the words to be sure they know what each says. From a selection of pictures, children place those corresponding to the correct season on the tray under the correct word. (Typical pictures: rakes, ball and bat, sled, picnic basket, weather pictures, adults doing seasonal work, etc.)
Appendix B, Item 26 (contd.)

c. example of a poor matching question

boiling point of water A. meteorologist
used for measuring temperature B. aviator
man who studies weather C. 212 degrees F.
fluffy cloud D. thermometer
man to whom weather reports are E. barometers
very important F. Cumulus
instruments used to measure air pressure

4. Multiple choice questions, if well constructed, make excellent objective questions. They are hard to construct, but easy to correct.

a. Before they are born, human babies grow inside their mother's body for
   a. 21 days  b. 6 weeks  c. 9 months  d. two years

b. Circle the one word that does not belong in this list: feather leaf root seed stem

Suggestions for multiple choice questions: Make all choices grammatically correct, equally plausible, and about equal in length.... Examples of poor multiple choice questions:

a. Galileo was an:
   astronomer  chemist  biologist

b. Mammals eat:
   meat  plants  plants and meat  it depends on what mammal you're talking about

5. Performance tests in science might include such activities as:

a. Identifying, assembling or using science equipment correctly.

b. Sorting objects or pictures into correct classification.
   (stones, bird pictures, metals, simple machines, etc.)

c. Constructing a model of a water wheel, steam shovel, compass, etc.

d. Making a chart, poster, display, bulletin board or booklet that illustrates a science principle.
Appendix B, Item 27: Excerpts from form "Evaluation of Demonstration"

Wisconsin State College at Oshkosh

<table>
<thead>
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</table>

<table>
<thead>
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<td>class understand purpose of the demonstration</td>
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<table>
<thead>
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<th>PRESENTATION</th>
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<tr>
<td>Use of blackboard</td>
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<tr>
<td>Vocabulary suitability</td>
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<tr>
<td>Grammar</td>
</tr>
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</table>

Remarks:

1. Children’s experiences are paramount. Activities may be logically planned, cleverly developed and efficiently executed. But, the test of success or failure lies in the actual experiences that children have as they take part in these activities.

2. Children’s immediate interests and concerns are considered.

3. Science programs should be planned so that children have a chance to explore new areas of science and expand their range of interests and concerns.....

4. The teacher considers and develops a set of goals that give direction to the activities he plans. These goals may range from the development of basic attitudes to mastery of certain manipulatory skills.

5. Science is an integral part of the overall educational program of the school.....The interrelationships between various areas, including science, should be stressed.

6. ...Elementary science forms a base for subsequent science experiences. In planning science programs previous and subsequent science experiences should be kept in mind.

7. A variety of resources are utilized, including various science books, community resources, audio-visual materials, etc.

8. Activities in which materials are handled are stressed. Of course, the study of science should involve reading, listening and discussion. ......In the elementary school, however, the manipulation and handling of materials should be stressed.

9. Science experiment centers are provided...These centers may be in the classroom or in a separate room in the school.

10. The classroom teacher is interested, resourceful and enthusiastic...

11. The classroom teacher has access to consultant help and advice....
Appendix C

Alphabetical Listing of Institutions from which Information was Received and Respondents at these Institutions

1. Albany State College, Albany, Georgia (H. Thomas Hutchins).
2. Appalachian State Teachers College, Boone, North Carolina (Kent Robinson).
5. Auburn University, Auburn, Alabama (Laura Newell).
7. Ball State Teachers College, Muncie, Indiana (Margaret McElhinney).
8. Bowling Green State University, Bowling Green, Ohio (William Harris).
10. Brigham Young University, Provo, Utah (Max J. Berryessa).
11. Colorado State College, Greeley, Colorado (Louise A. Neal).
15. East Carolina College, Greenville, North Carolina (James W. Batten).
17. Eastern Michigan University, Ypsilanti, Michigan (Elizabeth V. Giles).
19. Farmington State Teachers College, Farmington, Maine (J. E. Mudge).
Appendix C. (contd.)


24. Goucher College, Baltimore, Maryland (Jane Morrell).

25. Harris Teachers College, St. Louis, Missouri (Katherine P. Chambers).


27. Indiana State College, Terre Haute, Indiana (K. W. Uhlhorn).

28. Indiana University, Bloomington, Indiana (Stanley B. Brown).


30. Lewis and Clark College, Portland, Oregon (Bernard R. Wolff).

31. Loyola University, New Orleans, Louisiana (Mary C. Fitzgerald).

32. Marshall University, Huntington, West Virginia (Harold Ward).

33. Maryland State College at Salisbury, Salisbury, Maryland (Maurice C. Fleming).

34. Maryland State College at Towson, Towson, Maryland (Lois D. Odell).

35. Mississippi College, Clinton, Mississippi (John R. Blair).

36. Montana State University, Missoula, Montana (Kenneth J. Bandelier).

37. Moorhead State College, Moorhead, Minnesota (Jane Johnston).


39. Newark State College, Union, New Jersey (Herman I. Lepp).

40. New Mexico State University, University Park, New Mexico (Kenneth Melgaard).
Appendix C. (cont'd.)

41. North Texas State University, Denton, Texas (Howard W. Smith, Jr.).
42. Northern State Teachers College, Aberdeen, South Dakota (Barbara Steele).
43. Northwestern State College, Natchitoches, Louisiana (Mary Jo Harris).
44. Ohio State University, Columbus, Ohio (Eloise McElfresh).
45. Ohio University, Athens, Ohio (Lester C. Mills).
46. Oregon State University, Corvallis, Oregon (Albert L. Leeland).
47. Pennsylvania State University, University Park, Pennsylvania (Marlin L. Languis, Dorothy Alfke).
48. Rhode Island College, Providence, Rhode Island (Renato E. Leonelli).
49. Rutgers, The State University, New Brunswick, New Jersey (Gladys S. Kleinman).
50. St. Cloud State College, St. Cloud, Minnesota (Irvamae Applegate).
51. Sam Houston State Teachers College, Huntsville, Texas (Genieve G. Alford).
52. San Diego State College, San Diego, California (Peter C. Gega).
53. San Jose State College, San Jose, California (Matthew F. Vessel).
54. Southern State Teachers College, Springfield, South Dakota (Harold S. Anderson).
55. State College of Iowa, Cedar Falls, Iowa (Clifford G. McCollum).
56. State University College at Buffalo, Buffalo, New York (Marie R. McComb).
57. State University College at Oneonta, Oneonta, New York (Emery L. Will).
58. State University College at Oswego, Oswego, New York (Harold M. Williamson).
60. Temple University, Philadelphia, Pennsylvania (Herman C. Kranzer).
Appendix C. (contd.)

61. Trenton State College, Trenton, New Jersey (Fred T. Pregger).
63. University of Alabama, University, Alabama (Charles K. Avey).
64. University of Arizona, Tucson, Arizona (Milo Blecka).
65. University of Bridgeport, Bridgeport, Connecticut (Bartlett A. Wagner).
66. University of California at Santa Barbara, Santa Barbara, California (George E. Temps).
68. University of Denver, Denver, Colorado (Harold Woolum).
69. University of Georgia, Athens, Georgia (Alex F. Perrodin).
70. University of Idaho, Moscow, Idaho (Herbert Vent).
72. University of Kansas, Lawrence, Kansas (Kenneth D. George).
73. University of Kentucky, Lexington, Kentucky (William H. Banks, Jr.).
74. University of Louisville, Louisville, Kentucky (Esther L. Bossung).
75. University of Maine, Orono, Maine (George T. Davis).
76. University of Maryland, College Park, Maryland (Glenn O. Blough).
77. University of Miami, Miami, Florida (R. E. Hendricks).
78. University of Missouri, Columbia, Missouri (Hames L. Craigmile).
79. University of Missouri at Kansas City, Kansas City, Missouri (Gary W. Nahrstedt).
80. University of Nevada, Reno, Nevada (Calvin H. Reed).
81. University of Oklahoma, Norman, Oklahoma (John W. Renner).
Appendix C. (contd.)

83. University of the Pacific, Stockton, California (John V. Schippers).

84. University of Pittsburgh, Pittsburgh, Pennsylvania (Theodore T. Polk).

85. University of Southern California, Los Angeles, California (R. C. Perry).

86. University of Southern Mississippi, Hattiesburg, Mississippi (John M. Frazier).

87. University of Southwestern Louisiana, Lafayette, Louisiana (Charles J. Faulk).


89. University of Texas, Austin, Texas (David P. Butts).

90. University of Tulsa, Tulsa, Oklahoma (Jack Evans).

91. University of Vermont, Burlington, Vermont (Margaret Petrusich).

92. University of Wisconsin, Madison, Wisconsin (Calvin W. Gale).


94. Utah State University, Logan, Utah (A. L. Braswell).

95. Western Kentucky State College, Bowling Green, Kentucky (Earl P. Murphy).

96. Western New Mexico University, Silver City, New Mexico (Jesse F. Bingaman).


98. Winona State College, Winona, Minnesota (Howard Munson).

99. Wisconsin State College at Eau Clair, Eau Clair, Wisconsin (Chester P. Olson).

100. Wisconsin State College at Oshkosh, Oshkosh, Wisconsin (Mervon L. Johnson).

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2 Respondents sent a letter or partially completed questionnaire providing some data for the study.

3 Questionnaires completed by two respondents from the institution.
BIBLIOGRAPHY


