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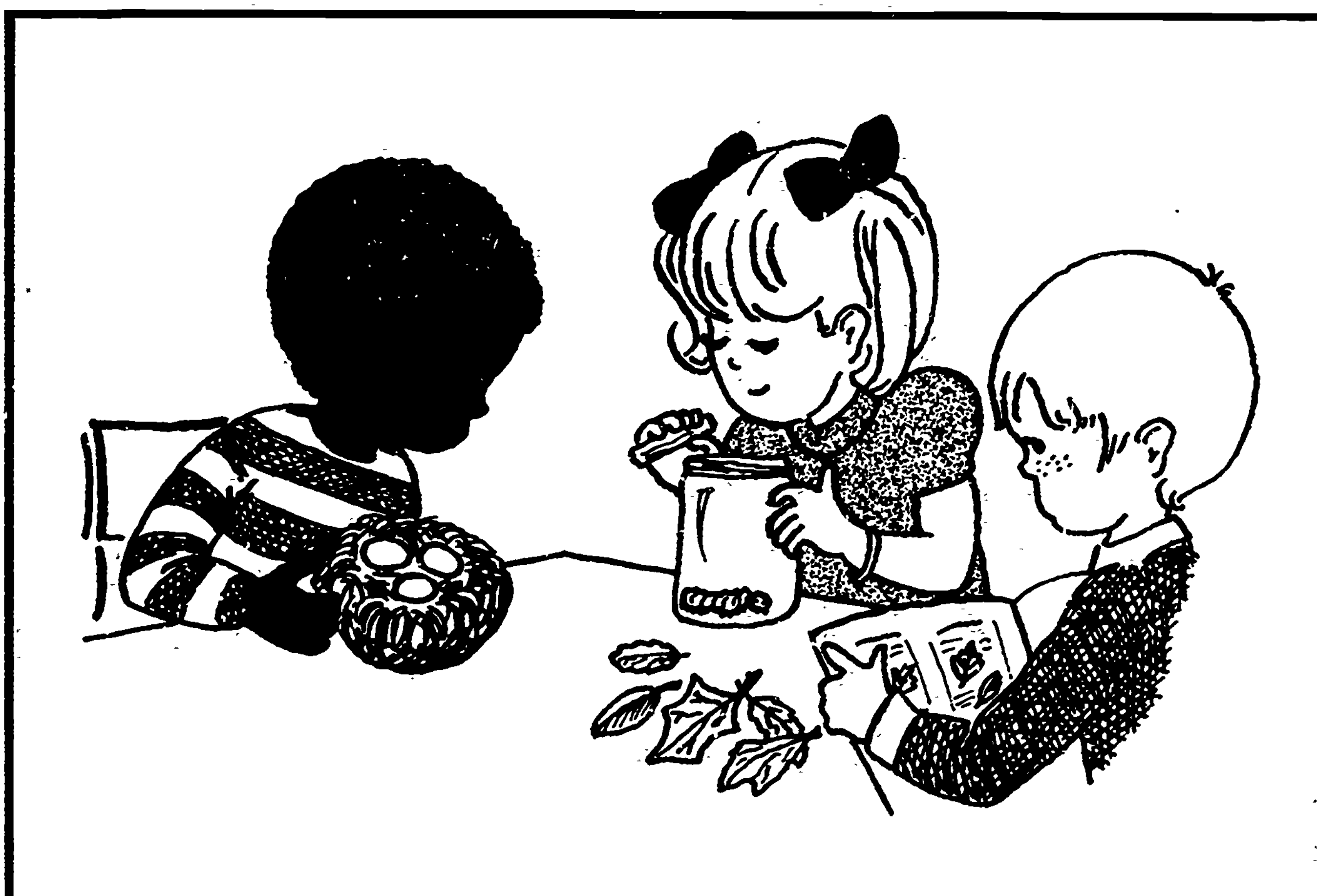
ABSTRACT

The State Department of Education for South Carolina has prepared this publication to help administrators and curriculum planners in selecting and evaluating science instructional materials for use in their schools. The report is divided into three major parts for elementary science (K-5), middle school science (6-8), and high school science (9-12). Under each division, a brief description of rationale for teaching science at that particular age level is given. This is followed by several checklists, for each division separately, to evaluate curriculum materials before or after their selection. These checklists are designed to provide listings of significant points to consider in terms of curriculum materials, role of teacher, role of administrator, physical facilities, and academic offerings. A list of some recommended commercially available curriculum materials is provided for each section. Special attention is given in the high school section on an interdisciplinary approach to curriculum planning. Two separate sections on preparation of science teachers and curriculum development are included, to provide further guidelines to administrators. Bibliographies, conceptual schemes and other useful information are included in appendices. (PS)

SCIENCE EDUCATION K-12

administrator's planning guide



SCIENCE EDUCATION K-12

administrator's planning guide

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Cyril B. Busbee
State Superintendent of Education

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USE OF THIS GUIDE

With the current emphasis on assessment and public concern for the learning accomplishments of children, school administrators are faced with the task of evaluating their educational programs in terms of specific objectives. Recognizing the need for constant reappraisal and development of suitable curricula, a committee was selected to design an instrument to assist administrators with their science program. It is hoped that the individual principal will use the checklists as an inservice activity with his faculty.

This guide is designed:

1. To provide suggestions which administrators may use in developing effective science programs.
2. To establish guidelines (checklists of facilities and equipment) for evaluation of a school's science program.
3. To identify some inquiry-oriented curriculum models.
4. To offer directions for effective use of textbook materials in an inquiry-oriented school curriculum.

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PHILOSOPHY

In a world where the rate of change is accelerating, the educational system must help young people develop the competencies that will enable them to achieve self-fulfillment.

Science education should be concerned with fostering the attitudes, values, skills and concepts that will help students to think rationally and act reasonably.

Science (K-12) should be considered as part of a continuum along which the individual may progress as he interacts with other people and his environment. In order to create a climate in which students can experience the excitement of discovery, a wide range of investigations and activities must be provided.

OBJECTIVES

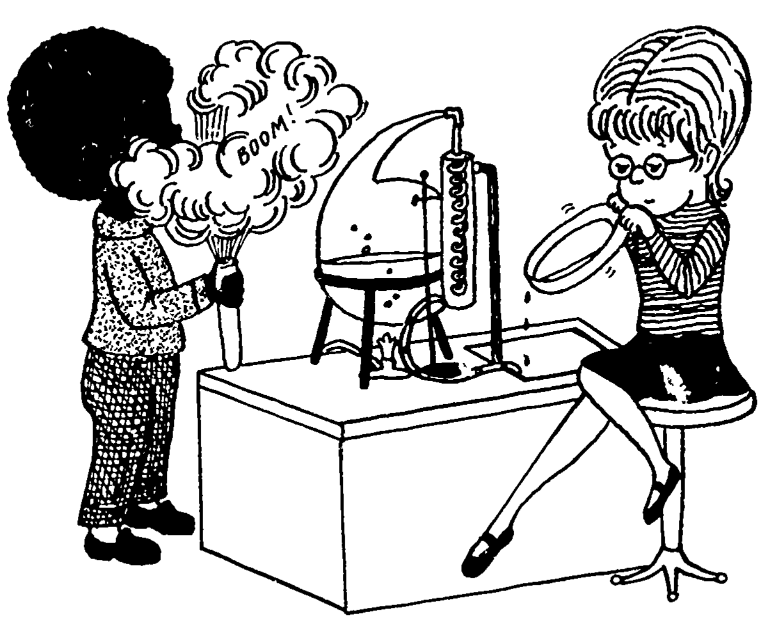
The science program should provide opportunities for a student to:

1. Develop a positive attitude toward himself, toward other people and toward his environment.
2. Grow in understanding of scientific concepts and in problem-solving abilities.
3. Grow in understanding that scientific knowledge is unlimited. Knowledge should be examined, analyzed, and related meaningful to life without prejudice or superstition.
4. Develop and use science processes and skills, simple tools, and multiple resources.
5. Experience direct involvement with structured and unstructured activities.
6. Develop the ability to learn under his own initiative according to his individual needs, interests, and abilities.
7. Participate in science taught as a unified discipline or coordinated with other disciplines, such as mathematics, social science, economics, political science, and others.
8. Share a continuing program of self-evaluation.

CURRENT TRENDS

Interest in improved and more effective learning has created an awakening to a broader and more appealing science curriculum. Trends which have emerged during the past few years include the following:

1. Behavorial change is a basic consideration in curriculum planning.
2. Emphasis is being placed on understanding broad conceptual schemes and processes of science, rather than memorizing facts, thus reducing amount of course content.
3. An interdisciplinary approach with well-articulated science involvement (as opposed to testbook, one-discipline approach) is expanding.
4. The textbook-centered approach, emphasizing accumulation of knowledge, is being replaced by the laboratory-centered approach which emphasizes problem solving and learning skills.
5. Multi-media materials are utilized to meet stated educational objectives.
6. Individual, independent, and small group instruction comprises a greater portion of the teaching day. This presupposes that individuals differ in learning rates and learning styles and that students will be motivated primarily by the materials or processes of instruction themselves.
7. Short courses (modules) are built around conceptual schemes.
8. The classroom is being extended to make more effective use of the outdoors and the special interests and skills of parents and other people in the community.
9. Flexible scheduling is providing for extended use of materials and facilities by greater numbers of students.
10. Differentiated staffing is facilitating more effective use of teachers' special competencies.
11. Emphasis is being placed on science experiences to develop basic scientific literary for all students rather than merely preparation for higher education or college.
12. Humanization of the curriculum with emphasis on openness, trust, and the needs and concerns of individual children.



INTRODUCTION

In an educational continuum K-12, the elementary child should have opportunities to develop the intellectual processes essential to learning and to understanding science. In the process of skill development, children will acquire an understanding of the basic science concepts necessary for the interpretation and explanation of observations and natural events. The children will also have experience in using these science processes and become more independent and self-sustaining in their learning.

The middle school program, primarily concerned with students between the ages of 11 and 15, should provide those educational experiences most suitable to their stage of development, concerns, needs, interests, and social responsibilities. The program should not revolve around a single text, medium, or preparation for high school; instead, it should include those materials that are best able to communicate with these children and most consistent with their educational needs.

The high school curriculum should provide opportunities for each student to explore many areas of science. The science program should be designed to help each student attain his own highest potential, to experience success, to become more independent, and to accept greater responsibility for his own education. Recently chemistry and physics enrollments have dropped alarmingly. New programs and short courses which would provide greater options more relevant to the needs and concerns of the students should be considered, so that all students may attain some degree of scientific literacy. (See Appendix III.)

Provision for diverse needs of children through a variety of learning media and class structure is essential at all grade levels. Most school philosophies attest to a belief in the value of the individual and the desirability of a program designed to meet individual needs. Yet, in school, one finds formal classrooms and no effort to determine individual needs, or make provisions for them.

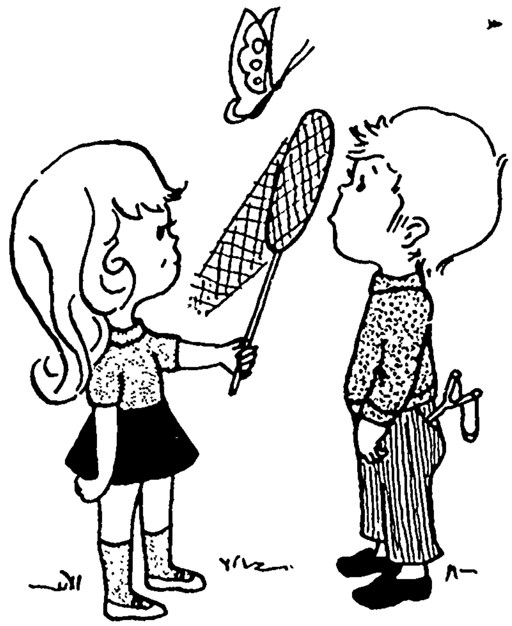
There must be a change in emphasis from teaching to learning, from memorizing to understanding, and from a threatening environment to one characterized by freedom to explore, discover, and pursue knowledge that has real meaning. School programs which have been developed with these aims should be examined carefully and chosen on the basis of the needs of the children and the community.

At present, many school systems have no clear goals for their science program; therefore, each teacher works independently within the monetary and educational limit of the school. To provide the best opportunities for the children, it is essential that each community have a science advisory committee who will assess the needs of students, will examine available programs, and will then plan for implementation within their school systems. Without a local science consultant, it's especially important that representative teachers from each school should work together to develop a coordinated science curriculum.

Few elementary and middle school teachers are prepared by their education to teach science. Most educators will follow the example of their own teachers. Few have been exposed to processes of science and inquiry techniques essential to many new science programs. Even with the best preparation, it is unlikely that teachers can do an effective job with the inadequate financial backing, the inadequate physical facilities, and the excessive work load under which many struggle. If any science program is to be successful, teachers must have the psychological, professional and monetary support of the administration and the school district.

This guide is not intended to be the "final word" in science education. As we continue to learn more about different modes of learning and as newer and better materials are developed, we must change. We must change because what we do today is based on what we now are aware of. What we do next year should therefore be different. This means continued reassessment and updating of instruction and retraining of teachers. It is hoped that this guide will serve as an instrument which will assist administrators and their staffs to assess and improve their science programs.

RECOMMENDED SCIENCE PROGRAMS



Three possible programs have been designed to meet the needs of students having different learning styles and of teachers who feel more comfortable in different methods of instruction.

The highly structured program emphasizes consecutive development of concepts and skills in grades K-6 and provides for an annual division by subject in grades 7-12.

The moderately structured program tends to be more interdisciplinary and laboratory oriented. This program requires a student oriented philosophy rather than subject oriented.

The loosely structured program provides for more student orientation and greater freedom for teacher and student to develop a course best suited to student concerns and interests. This program is especially suitable for children who learn best from concrete rather than theoretical materials and in an atmosphere free from threat and structural requirements. The poor reader and potential dropout would be more apt to succeed in this type of program.

Some examples of commercial programs which may be used are shown. These and other materials are described in the chart of curriculum models.

Recommended Science Programs

Highly Structured	Moderately Structured	Loosely Structured	
Science a Process Approach (AAAS) K-6 State Adopted Text Series (with emphasis on concept and information) 1-6	Science Curriculum Improvement Projects (SCIS) K-6 State Adopted Text Series (with emphasis on discovery through laboratory investigations) 1-6	Elementary Science Study (ESS) K-9	
	Human Science (being developed) 6-8	Me Now 6-8	ES K-12 Selected units from ESS ex. Pond Water Mosquitoes Microgardening Small Things
Life Science ERC IMB	ISCS 7-9		
Earth Science I E & T ESCP			Rocks & Charts Stream Tables Mapping
Physical Science IPS IME	Investigations in Science - 9 IIS - Physical Science	IIS Physical Science	Kitchen Physics Pendulums Batteries and Bulbs II
Biology BSCS	IIS - Biology	IIS Biology Patterns and Processes	ISCS
Chemistry Chem Study	Mini or Interdisciplinary courses such as: Geology Astronomy Ecology Genetics Chem bonding	ERC TSM	
Physics PSSC HPP	IPS		

ELEMENTARY SCIENCE K-5

Rationale

Educators have found that the learning which occurs during the first five years of life probably exceeds the learning that occurs thereafter. Independent, self-actualized learning is characteristic of preschool children.

Preschoolers naturally identify problems and engage in problem-solving activities. When they go to school, this natural tendency to continue learning through the process of problem-solving is changed. "Problems" are determined by the teacher in advance for the child. However, imposing problems on children does not insure that the children perceive them as problems. Science educators use the natural modes of learning to increase the development of problem solving skills.

Piaget's work suggests that children of formal elementary school age are at a "concrete operational" level of intellectual development and must interact with concrete objects during problem-solving situations. Science has great potential for providing the necessary manipulative materials required by the young child in such a way that a child may engage in meaningful problem-solving situations.

If "learning to learn" and problem-solving skills are to be developed further, then educators must reexamine present learning strategies in the light of new understandings of how children learn.

Present science instruction predominantly involves verbal transmission of ideas and is usually taught as a "reading" exercise about science. New programs that are gradually being adopted emphasize activities and the processes of science. However, merely shifting the emphasis from "facts" to "processes" does not insure a science program which makes sense to children. In a teacher-oriented science program where concepts and processes are given to the pupil, instead of being determined by the pupil, the child learns that science has little meaning and is merely a collection of these concepts and processes. This idea is further reinforced by repeating these concepts on tests.

The science program must involve students. It must consider their level of intellectual development and their natural modes of learning. It must provide an environment in which they may participate with their minds and with their hands in activities that make sense to them.

The most desirable learning environment for elementary science children:

1. enhances a child's abilities to think systematically and creatively; provides activities which are compatible with the various levels of operational thought, and involves investigations of the environment or the solution of problems.
2. advances a child's belief that he can interpret and manipulate his own environment and that he is a part of his environment and depends upon it.
3. facilitates the development of a positive self-concept which enhances his feeling of competency to identify and solve problems and his feelings of success.
4. provides curricular flexibility to facilitate maximum individual cognitive progress and provides for a self-determined pace from manipulation of concrete objects to abstract ideas and finally to the higher mental processes of problem solving.
5. promotes individual development of interests, attitudes, personality, and creativity.
6. facilitates a child's tendency to accept the existence of individuals who have ideas and values which are different from his own; facilitates recognition of the uniqueness of individuals and "acceptance without evaluation."
7. encourages exploration of the material universe, asking questions and seeking explanations for those things which are observed; enables children to investigate, collect data, verify and interpret data, and make predictions on the basis of knowledge gained.
8. stimulates development of understanding of basic concepts and the applications of these concepts to the child's expanding world through discovery and exploration.
9. helps children learn to respect the tentative nature of scientific information and learn that change is a fundamental phenomenon in the universe.
10. provides opportunities for children to practice critical thinking through problem-solving activities and to recognize the applications and limitations of these procedures.

Science should be an essential part of the elementary school curriculum. Not only does it provide for development of creative and systematic thought processes, but it also increases the self-awareness of the individual and relieves some of the failure-causing pressures of the predominantly verbal classroom.

Checklists for Elementary Science

These checklists are intended to provide the administrator with an instrument which will enable him to evaluate the science program of his school in terms of the characteristics of a good program. From the results of this evaluation, appropriate actions to remedy any deficiencies should be planned and carried out. If the checklists serve in this capacity, they will fulfill their function.

The Elementary Science Program

1. To what degree is there a sequential K-12 science program which provides for variations of pupil growth and development?
   - ☐ We have been thinking about it.
   - ☐ We follow our basal text series but don't know what other grade levels are doing.
   - ☐ We determine the level at which children can achieve successfully and provide the necessary opportunities for continued growth and development of a positive self-concept.
2. Does the program provide opportunities for student exploration and discovery?
   - ☐ We only talk about this.
   - ☐ We have only teacher or individual demonstrations.
   - ☐ Individual and small group investigations are frequent.
3. Does the program provide for the development of varying student abilities and skills?
   - ☐ We use only a basal program providing identical learning on an identical schedule. sary opportunities for continued growth de-
   - ☐ We supplement the textbook with some additional materials.
   - ☐ We use a wide range of multi-level materials and enrichment activities, such as guest speakers, manipulative materials, audio-visuals.
4. To what extent does the program utilize community resources?
   - ☐ We limit our program to the immediate classroom.
   - ☐ We allow children to examine the outdoors during fire drills and P.E.
   - ☐ We take meaningful field trips and frequently call upon local resource persons.
5. To what degree are the present school facilities and equipment being used?
   - ☐ No science interest centers are evident; science equipment is inaccessible.
   - ☐ Most teachers are using some equipment. The others are learning.
   - ☐ Equipment is available and in constant use by students.
6. Is there a media center in the school which includes current science materials?
   - ☐ Some science books and film strips are available.
   - ☐ Books, periodicals, and various audio-visual materials are available on all levels.
   - ☐ Students constantly use a variety of media in and out of the media center.
7. Does the school have a procedure for original purchases and re-stocking of consumable science supplies?
   - ☐ Never thought of doing it. We have no inventory.
   - ☐ Only when requested by a teacher. Teachers and children bring most of the materials from home.
   - ☐ Maintain inventory. Science program included in annual budget. Lead teacher responsible for inventory and purchase request.
8. Is science a regular part of the school program throughout the entire school year?
   - ☐ We teach science one semester, alternating with health or social studies.
   - ☐ We teach science all year—when children bring things in and when it relates to other subjects.
   - ☐ We set aside time each day for science activities and provide additional time for work on special projects interrelated with other subjects.
9. Is there a science advisory committee in the school district?
   - ☐ No. Each school sets up its own curricular program.
   - ☐ Teachers work together on book adoption committees when needed.
   - ☐ We have a district advisory committee which is composed of a lead science teacher from each school. This committee provides articulation within the K-12 program, examines new programs, and works toward continued implementation of better science curricula.
10. Does the school have a science chairman?
    - ☐ Each teacher plans her own science program.
    - ☐ Teachers of each grade level meet periodically to discuss the science program.
    - ☐ The school has a science chairman who meets periodically with the lead teachers of each grade level to review the program, plan for changes, inventory, order and store equipment.
11. Is central storage provided?
    - ☐ Teachers bring materials from home. A few materials are in the library, office, and any available closets.
    - ☐ A closet is designated for storage of equipment which must be shared.
    - ☐ A central storage area is provided. One person is in charge and responsible for maintenance, replacement and checkouts.

Role of the Administrator

In all schools the administrator is the curriculum leader. He is responsible for program development, evaluation and financing, teacher assignments, and the morale and professional growth of the faculty. All program activities are influenced by administrative initiative.

1. I know that a "good" science program is in operation in my school because:
   - ☐ The teachers assure me of this fact in our staff meetings.
   - ☐ I occasionally visit the classrooms on a scheduled basis.
   - ☐ I am frequently asked by students to visit their rooms and see what they are planning, studying, building, etc.

2. How are teaching responsibilities delegated to members of the staff?
   - ☐ We are trying to fill all vacancies. Beginning teachers are given low ability groups.
   - ☐ Some consideration is given to teacher ability and interest.
   - ☐ Special abilities of teachers are given high priority in class assignments and in appointments of persons to serve as lead teacher.

3. To what extent do we provide for cooperative teacher planning and other professional activities?
   - ☐ No released time is provided. Teachers are expected to be with children at all times.
   - ☐ Some released time is available when P.E., art or music teachers are in charge of class.
   - ☐ Released time is scheduled for each teacher every day, and special provision is made for professional activities outside of school.

4. What provision is made for professional growth of teachers?
   - ☐ Left strictly up to teachers.
   - ☐ Science oriented inservice programs and workshops provided.
   - ☐ Local funds budgeted to support supplementary study in science or science education. Aid is provided to teachers who seek NSF or other scholarships.

5. Do we provide for a professional shelf in the library where teachers may examine up-to-date teacher aids, resource books and journals that might stimulate better science teaching?
   - ☐ Never thought of doing it.
   - ☐ Some attention, interest and funds are provided.
   - ☐ A good professional selection is present in a comfortable and attractive location. Teachers are encouraged to make use of the materials.

6. Are audiovisual materials wisely purchased and wisely used?
   - ☐ Large purchases are made without consulting teachers.
   - ☐ Equipment and materials are available but used infrequently. Often A.V. material is only used with large class instruction.
   - ☐ Teachers share in the selection of materials. Inservice workshops are provided to train teachers in production of materials, operation of equipment and creative use and participation by individuals and small groups.

7. To what extent are resource institutions, agencies (colleges, universities and State Department of Education, etc.) and personnel being utilized in the development of evaluation of your science program?
   - ☐ No help has been sought. The principal evaluates the program.
   - ☐ District personnel make program and evaluation decisions.
   - ☐ Cooperative College-School Science program implemented. Science educators and other resource persons are being utilized.

Role of the Teacher

This checklist is designed to facilitate self-evaluation by the teacher and cooperative evaluation of the teacher's role in the science program

1. Does the teacher have a good professional attitude?
   - ☐ Often casts disparaging remarks about the school situation.
   - ☐ Trying to be optomistic.
   - ☐ Cooperates, keeps smiling, takes full adadvantage of educational opportunities.

2. Does the teacher generally view all students as being capable of working and learning?
   - ☐ Most students from disadvantaged backgrounds are considered capable of only very limited learning.
   - ☐ Progress is being made to provide for individual differences in children.
   - ☐ This attitude is present and evident in the classroom environment.

3. Does the teacher realize that different learning styles exist among children?
   - ☐ Apparently not. All are taught the same way.
   - ☐ Uses audiovisual as well as reading materials (seeing and hearing).
   - ☐ Manipulative materials, audio materials, a variety of visual, and large group, small group and indiviaual activities are provided.

     Emphasis on total sensory development.

4. Does the science teacher attempt to discover how much a student may already know about a topic or concept prior to initiating learning activities?
   - ☐ We assume that all students have retained nothing from previous experiences and start from "scratch" with the entire group.
   - ☐ We ask the class a few questions about what they have studied in previous science classes.
   - ☐ Pre-assessment is made of all students to determine individual levels of comprehension. Subsequent teaching activities are based upon the information gained.

5. Is there evidence of good teacher planning?
   - ☐ There is little planning for classwork, too much "busy work", routine covering of textbook materials.
   - ☐ Some planning has been done. A few constructive activities are seen in classroom.
   - ☐ Careful planning is done with students; there is evidence of a planned but flexible procedure; student needs are anticipated.

6. Are the purposes of the science lessons clear to the children?
   - ☐ We play guessing games. Students must guess what they are trying to accomplish.
   - ☐ The teacher tells the goals and objectives and what must be learned.
   - ☐ Teachers and pupils cooperatively plan, carry out, and evaluate learning activities.

7. Is the teacher skillful as a questioner?
   - ☐ Only questions in the teacher's manual are utilized.
   - ☐ Children are asked questions to "keep them on their toes."
   - ☐ Questions which stimulate creative thinking processes are often used. (Compare, summarize, observe, classify, interpret, criticize, make assumption, collect and organize data, evaluate, apply, etc.)

8. Does the teacher emphasize the specialized reading skills which are unique to the area of science?
   - ☐ Reading teachers teach reading. Science teachers teach science.
   - ☐ New vocabulary words are introduced and looked up in the glossary.
   - ☐ Emphasis is given to interpretation of graphic data, preciseness of scientific vocabulary, and appropriate reading levels for science.

9. Are processes, conceptual schemes and values emphasized?
   - ☐ Facts in the text are memorized.
   - ☐ Concepts and main ideas are discovered and stated by pupils after reading and discussion.
   - ☐ Through numerous investigations and discussions, the pupil develops scientific skills, discovers and states basic concepts of science, and shows awareness of the value of science to himself and to his society.

10. Does the teacher interact with the children?
    - ☐ Provides information to the whole class from behind her desk.
    - ☐ Works with a small group while the remainder of the class is occupied with pencil and paper work.
    - ☐ Interacts verbally with individuals and small groups, continually moving from one group or child to another.

11. What determines the content and processes of learning?
    - ☐ The adopted text or TV program.
    - ☐ The teacher prescribes activities.
    - ☐ The teacher responds to the child's activity and cooperates with children in making educational decisions and plans.

12. The teacher rewards children for their activities.
    - ☐ Grades are given on all student work. Mistakes are pointed out and misbehavior is reprimanded.
    - ☐ Children are rewarded equally and frequently. Punishment and reprimand are infrequent.
    - ☐ The child's "erroneous" statements are accepted (but not reinforced). Encouragement and support are common.

13. Does the teacher provide time for inquiry and discovery?
    - ☐ Math and reading take most of the time.
    - ☐ Some time (30-40 minutes) is set aside for teacher or pupil demonstrations and discussions.
    - ☐ Pupils continually experiment and sometimes "just mess around."

14. How does the teacher choose activities?
    - ☐ We do those things that we can bring from home.
    - ☐ We do the activities in the textbook if equipment is available and pupils show interest.
    - ☐ After listening, observing mannerisms, voice inflections and other indications of pupil need, attitude, concern and interest, activities are selected to meet these needs. Activities are challenging and provocative.

15. Does the teacher involve pupils in problem-solving?
    - ☐ Problems are discussed in class.
    - ☐ The teacher designs problems for pupils to solve and explains the techniques involved. When she asks what he thinks, she really is asking him to "Guess what I think."
    - ☐ Materials are varied and accessible for observing and handling. Pupils can work on problems long enough to satisfy curiosity and to increase comprehension.

16. Is evaluation a part of every phase of an experience?
    - ☐ Grading is done by the teacher only at the end of written work.
    - ☐ Tests and class activity are evaluated.
    - ☐ Teacher and student cooperatively evaluate growth as needed.
      1. Pupil behavior records are kept which indicate changes noted in the course of an experience.
      2. Products of pupil work are judged on the basis of individual capacity.
      3. Teacher-pupil interviews, inventories and questionnaires are used.
      4. Problem situation and multiple choice tests are used.

17. Does the teacher maintain a room conducive to enthusiastic discovery?
    - ☐ There is no space to display materials.
    - ☐ Informative charts and models and some pupil work is on the wall.
    - ☐ To relieve drabness, splashes of color and bright displays decorate the room. Pupil work is evident. Displays cause pupils to ask questions and seek their own answers.

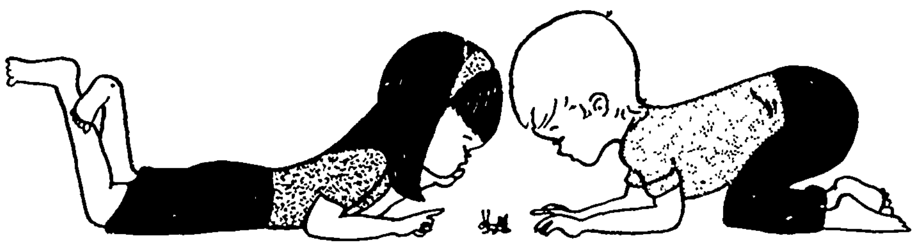
18. Does the science teacher make an effort to interrelate science with other curriculum areas?
    - ☐ No time for this activity.
    - ☐ Departmentalization without team teaching makes this difficult.
    - ☐ We have developed interdisciplinary units and techniques.

19. Does the teacher ever offer any suggestions to the administrator regarding the science program?
    - ☐ Never makes such suggestions; the administrator never asks for any.
    - ☐ Only when given a blank to fill out, or a textbook to look through and evaluate.
    - ☐ Constructively critical of our science program; feels free to discuss with principal any changes believed needed.

20. Does the teacher participate in science workshops and other opportunities for professional growth?
    - ☐ Most workshops are too far away and scheduled at inconvenient times.
    - ☐ Attends only required meetings.
    - ☐ Makes every effort to attend all meetings.

Role of the Student

Many children have difficulty with school experiences which depend upon verbal communication. But even these children can manipulate science materials successfully with little verbal direction from the teacher. A child's verbalization often develops spontaneously from interaction with concrete materials. Science may often be a unique stimulus for learning to read, but reading ability is not essential for science. John Holt has said that children fail because they are afraid, bored, and confused. Instead, if success is built into the science program, the following student behaviors should be evident:



	Yes	No
1. Students make decisions.		
2. Students ask questions and use their own creative methods of inquiry.		
3. Students learn from their mistakes.		
4. Students are involved in activities without teacher direction.		
5. Students evaluate their own progress.		
6. Students develop greater responsibility for their own learning.		
7. Students use varied resource materials and scientific equipment effectively.		
8. Students share information and learn from other students.		
9. Students show respect for logical reasoning and demand verification.		
10. Students have direct experience with living and non-living objects.		
11. Students display products of their work.		
12. Students show a positive attitude toward themselves and others, increased independence and confidence.		

	Yes	*No*
13. Students participate in large group activity, small group activity, or individual inquiry.		
14. Students demonstrate enthusiasm and interest which extends outside the classroom.		
15. Students demonstrate various skills of problem-solving and of inquiry (observing, recording data accurately, proposing hypotheses, developing experiments to test hypotheses).		
16. Students apply understanding of concepts to new problems and to daily life.		
17. Students demonstrate appreciation for and knowledge of their individual responsibilities for their environment.		
18. Students show awareness that intellectual honesty is essential to the scientific enterprise.		

Curricular Programs

From numerous national curriculum studies, elementary science programs have been developed that have ideas and procedures which could improve local science programs. These programs should be studied and considered as a source of supplementary materials to upgrade your present program or to adopt as a total science curriculum. In order to be successful, it is recommended that teachers who will be using these new materials have special training. Most programs provide consultants for this purpose.

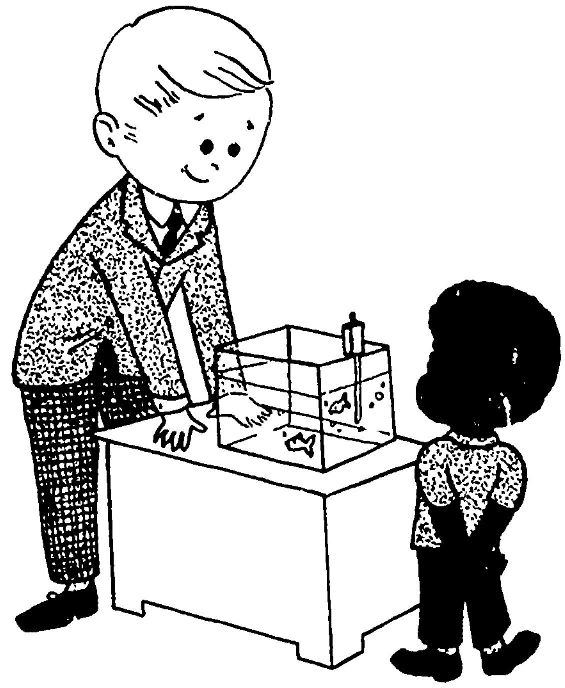
Three projects which may be used to implement the inquiry approach are described here.

Elementary Science Study (ESS) (K-8)

This is designed to serve as supplementary material or as a complete program. It is probably the least structured national curriculum project in science. The ESS units are non-sequential and goals are intentionally not specified. They are designed to lead pupils and teachers to set their own goals and initiate activities to reach these goals.

All units encourage children to explore, invent, discover, and examine the world around them. Content is not neglected but processes and problem-solving are emphasized. Problems are of interest to children and are designed so that they can be investigated. Children can ask their own questions and find answers for themselves.

The materials and activities resemble those common to children's environment and are centered around open-ended investigations. The 56 units consist of text material, equipment, activity suggestions, teachers' guides, films, and filmloops. These are available from Webster Division of McGraw-Hill Book Co.



Unit	Suggested Grade Level
Animal Activity	4-6
Animals in the Classroom	K-up
Attribute Games & Problems	K-3
Balloons and Gases	5-8
Batteries and Bulbs	4-6
Batteries and Bulbs II	5-up
Behavior of Mealworms	4-8
Bones	4-6
Brine Shrimp	K-4
Budding Twigs	4-6
Butterflies	4-6
Changes	1-4
Clay Boats	2-6
Colored Solutions	3-8
Crayfish	4-6
Daytime Astronomy	1-8
Drops, Streams, and Containers	2-3
Earthworms	4-6
Eggs and Tadpoles	K-9
Gases and "Airs"	5-8
Geo Blocks	K-7
Growing Seeds	K-3
Heating and Cooling	5-7
Ice Cubes	3-5
Kitchen Physics	5-8
Life of Beans & Peas	K-3
Light and Shadows	K-3
Mapping	5-7
Match and Measure	K-3
Microgardening	4-7
Mirror Cards	1-7
Mobiles	2-3
Mosquitoes	3-up
Musical Instruments Recipe Book	K-Adult
Mystery Powders	3-4
Optics	4-6
Pattern Blocks	K-5
Peas and Particles	3-8
Pendulums	4-6
Pond Water	4-6
Primary Balancing	K-3
Printing Press	3-6
Rocks and Charts	3-6
Sand	2-3
Senior Balancing	4-6
Sink or Float	2-7
Small Things	4-6
Spinning Tables	1-2
Starting from Seeds	3-7
Stream Tables	4-9
Structures	2-6
Tangrams	K-8
Tracks	4-6

Science—A Process Approach (K-6)

Developed by the American Association for the Advancement of Science, this project provides the most highly structured total program.

Its major aim is the development of basic skills needed for scientific investigation. A sequential pattern is designed to guide and predict student achievement. Teachers guides and student materials are part of a package which has built-in behavioral objectives and competency measures for each exercise. Success is defined in terms of the percentage of pupils who can exhibit the required behaviors.

Because of its structure and emphasis on skill development, this program could be used to individualize a science program. This interdisciplinary program involves a wide variety of science concepts as well as mathematical skills.

Part	Level	Process	Title of Exercise
A	Kindergarten	Observing	Observing Temperature
		Classifying	Classifying Animals
B	Grade 1	Observing	Observing the Weather
C	Grade 2	Measuring	Measuring Forces with Springs
		Classifying	The Solid Liquid and Gaseous States of Matter
		Communicating	Using a Sundial to Describe Shadow Changes
		Observing	Observing Animal Responses to Stimuli
		Predicting	Surveying Opinion
D	Grade 3	Predicting	Describing the Motion of a Bouncing Ball
		Measuring	Measuring Rate of Evaporating of Water
		Inferring	Loss of Water from Plants
E	Grade 4	Controlling Variables	Liquid Movement in Materials
		Interpreting Data	Guinea Pig Learning in a Maze
		Inferring	Inferring Connection Patterns in Electric Circuits
		Classifying	Classifying Minerals
		Communicating	Force and Motion
F	Grade 5	Defining Operationally	Determining the Direction of True North
		Controlling Variables	Effect of Practice on Memorization
		Interpreting Data	Effect of Temperature on Reaction Time
G	Grade 6	Experimenting	Temperature and Heat
		Experimenting	The Growth of a Root

Commercial materials may be obtained from several companies. Xerox was the initial producer.

Science Curriculum Improvement Study (1-6)

This is a complete program designed to increase growth of inquiry attitudes and skills in investigation while developing a functional understanding of basic physical and biological concepts. Units in biological science and physical science are provided for each year, giving the program some structure and continuity.

Emphasis is on guided discovery with many opportunities for pupils to explore and experience the wonders in their environment. Content has been selected for systematic understanding of a few major broad ideas. The use of many live materials, varied books and texts for reference is encouraged.

The teachers' guides, student lab manuals and materials may be obtained from Rand McNally & Company.

Level	Physical Science Units	Life Science Units
1	Material Objects	Organisms
2	Interaction and Systems	Life Cycles
3	Subsystems and Variables	Populations
4	Relative Position and Motion	Environments
5	Energy Sources	Communities
6	Models: Electric and Magnetic Interactions	Ecosystems

A Textbook Model

The textbook has been used so inappropriately in science education that children and teachers have become intimidated by the idea that "you can't learn if you can't read." Yet educators still do not know at what point in a child's development he will turn to the recorded data and ideas of others. The common practice of purchasing textbooks and little or no manipulative materials can no longer be justified.

Primary children need manipulative materials for problem-solving activities. Symbols acquire meaning only after children have interacted with the concrete objects indicated by the symbols. For this reason science textbooks have limited possibilities as learning aids to children. The actions that children perform upon objects in their environment gradually build up mental structures that can eventually be used for abstract thinking without use of the objects themselves. During this time books in the classroom should provide reference material. They may also provide some assistance to teachers who need encouragement.

The following model is designed for teachers who use the textbook as their main source of lesson planning. These suggestions, questions and examples are designed to encourage the teacher to move toward a more creative and activity-oriented program.

Getting started with an inquiry technique

There are many advantages to using an "Invitation to Inquiry" as an introduction to a topic. Children are asked to suggest solutions to problems, devise experiments and discuss their reasoning as they face an event or situation. The teacher is able to find out how much children already know about a topic.

In an "Invitation to Inquiry" the children respond to information or events and suggest possible reasons or solutions. In most inquiry situations the teacher needs materials so that students can carry out their experiments. A good teacher anticipates what the children might suggest and has materials available.

There are many sources for "Invitations to Inquiry" in elementary science source books and in periodicals such as *Science and Children* and *Science Activities*. Often incidental classroom events lead to further inquiry.

Here are some examples:

1. Teacher: Do you think you could boil water in a paper cup held over a candle? (Get the students to decide "yes" or "no.")

Teacher: How could we find out?

Let some of the students devise an experiment, carry it out, and then discuss the result with the class.

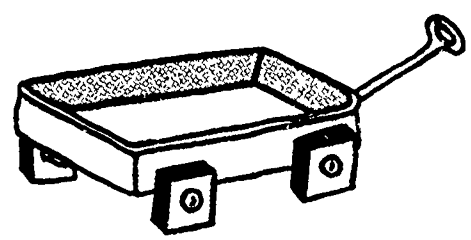
Information for the teacher:

The water in the cup prevents the paper from reaching the kindling point. When the water boils away completely, the paper will ignite because its kindling point has been reached.

2. Using a pictorial riddle:

A picture that depicts an event or situation that defies reality often prompts responses from a wide range of students.

Here is an example that might be used with an overhead projector or drawn on newsprint paper:



The teacher asks the children: "Do you see anything wrong with this picture?"

Children might respond by indicating the wheels are square. This could lead to fruitful discussion on the function of wheels, their characteristics, and a search to find examples around the room and outside. A follow-up activity might lead to constructing wheel toys with different kinds of wheels.

3. An Inquiry Starter:

There are also advantages to presenting the children with a closed shoe box that has been sealed with tape. Inside the box the teacher has placed some object. The children are asked to try to find out as much about the contents of the box as possible without opening the box. The children tilt the box, listen, and devise an idea of what is inside. This offers the opportunity for the teacher to discuss the way a scientist sometimes works out a possible solution to a problem. The boxes are usually not opened but may be returned to some area of the room and used again later. This type of inquiry sharpens the students' abilities to observe, listen, and reason.

4. Using a counter-intuitive event:

A counter-intuitive event is usually a demonstration or event that upsets our concept of what we think will happen.

Here is an example:

The teacher has two clear glass tumblers filled with clear liquid. She tells the pupils that she is going to place an ice cube in each glass. When she does this, one ice cube floats, one sinks to the bottom and remains there. This perplexing event should arouse the pupils' curiosity and lead them to suggest possible reasons for what they have seen. The teacher may suggest that questions be stated so that they can be answered with a "yes" or "no" by the teacher. As the children explore and gain information through their questioninng, the teacher may suggest they devise experiments to test their hypotheses.

Information for the teacher: One glass contained clear water, one glass contained a mixture of alcohol and water.

The following questions might lead a teacher to vary her approach in teaching science:

1. Have you considered dramatization by pupils? The study of animals lends itself easily to dramatization. The children guess which animal is being depicted.

2. If a demonstration is planned, how could you involve as many pupils as possible? You might work with several small groups of children who would share their procedures and findings with the class.

3. Have you asked the children to predict possible outcomes for a demonstration before it is performed? This technique provides useful information on how the children are able to think critically.

4. What is the point of the experiment in the textbook? Could you substitute one just as effective?

5. How could an experiment from the textbook be extended? You could often vary factors in the original experiment. What might happen? Why?

6. Are you using a variety of media as you plan a science lesson?

7. Have you thought about setting up a learning center (science interest area) in the classroom? A good activity area draws pupils into problem-solving situations where they respond to events or questions provided by the teacher. Books on many levels, equipment, filmstrips, and other materials could be used. Mere observation in an interest area is not enough to draw pupils into problem-solving situations.

8. Have you asked the librarian to subscribe to periodicals such as *Science and Children* and other sources of information?

9. Have you thought about a unit approach to teaching science as a substitute for a chapter-by chapter sequence through the textbook?

10. Have you taken advantage of children's interests and incidental learning that might occur on a day-to-day basis? Interest in what some child has brought to class or mentions in class often leads to many new sources of information.

11. Have you considered hobbies, guest speakers, other teachers, or community resources that might help?

12. When equipment is in short supply, why not ask a junior high or senior high teacher if you might borrow?

13. Have you considered using textbooks on several levels or from several publishers? You might trade books with another teacher and find books on varying reading levels.

14. Have you asked about subscribing to a weekly science newsletter or science reader? These frequently contain current topics and have improved their formats.

MIDDLE SCHOOL SCIENCE 6-8

Rationale

The student advances into his "mid-years" of education at the age of ten or eleven. He is a changing individual. He is a social individual. And he is a highly active individual. He is maturing in his ability to exercise judgment and make significant decisions. The environment, which surrounds him, has become increasingly intriguing. He now is cognizant of the usefulness of technology. He seeks to learn if school objectives are compatible with his world. He needs and wants to achieve success. He seems to have an exceptional need to understand himself and his society.

The most important component of the science program at the middle school level is the student. The "subject" of science is a nonentity; the textbook is only a tool which serves the teacher and student. Outcomes and goals should be formulated then activities should be used which will enable the student to progress toward his individual objectives.

An administrator, as the instructional leader, will need to evaluate the program to determine what planning or improvements may be meaningful. He may find that a cooperative interdisciplinary team pattern is effective. He may find a need for greater individualization and increased exploratory experiences. He may find that greater balance in the curriculum with more emphasis on personal development and learning skills is advantageous. He may find a need for greater flexibility and improved physical facilities. He may also find ways of helping teachers through special workshops and training programs.

Checklist for Middle School Science

Administrators, teachers and students are partners in the learning process. Each has his own responsibility to assure that the science program produces expectations commensurate with projected outcomes. Educational objectives, some of which are difficult to measure, are designated for the consideration of those individuals involved in evaluation of the science program.

Checklists have been developed so that all persons involved in the instructional program may consider students' present behaviors and the behaviors desired and make efforts for continual improvement.

The Middle School Science Program

	Yes	No
1. Have criteria, based on long-range goals, been established for the selection and organization of course content?		
2. Does the program provide for student differences in abilities and interests? (by provision of special learning activities, enrichment materials, and references on varied reading levels)		
3. Are there opportunities for each student to engage in laboratory work and other first-hand experiences?		
4. Is science compatible with reality? Is it combined with math, reading, social studies and fine arts or is it compartmentalized into an artificial "subject" field?		
5. Does the student participate in evaluations that measure his growth in the processes of scientific inquiry?		
6. Does the evaluation program include use of student records which indicate changes in behavior, their work products evaluated on the basis of individual capacity, teacher-student interviews, inventories and questionnaires, problem situation tests, observations of laboratory procedures and rating scales?		
7. Is there variety in grouping structure and freedom to change group size and composition?		
8. Are self-discipline and self-control encouraged without strict rules and regulations?		
9. Does the program emphasize strengths rather than weaknesses, success rather than failure, and individuality rather than conformity?		
10. Are instructional and laboratory materials provided in such quantity and quality to facilitate extensive individual participation in the adopted curricula?		

	Yes	*No*
11. Does each room where science is taught have the following characteristics:		
flexibility		
proper heat and ventilation		
good lighting		
movable flat-top tables and chairs		
sufficient electrical circuits and outlets		
gas supply and outlets where needed		
sinks with running water		
facilities for proper use of audio-visual equipment		
exhibit and display areas		
space for individual and small group projects		
suitable areas for maintaining living plants and animals		
acid-resistant table tops and floor coverings where needed		
preparation area for teachers		
ample storage with cabinets, shelves filing cabinets (some with locks)		
safety devices (first-aid kit, goggles, fire extinguisher)		
12. Are equipment and supplies stored and organized for effective use?		
13. Are suitable types of basic equipment (such as overhead projectors) and instructional aids (periodicals, reference books) easily accessible?		
14. Are supplies simple, easily obtained and common to the child's environment (jars, cans, mud)?		
15. Are adequate inventory records and controls maintained for equipment and materials?		
16. Do teachers seek to improve their professional and scientific backgrounds by attending meetings, participating in in-service programs, working with consultants, reading journals?		
17. Have the board of education and the school administration taken specific action to enable and encourage teachers to update their professional and academic qualifications?		
18. Has a plan been developed to make effective use of the outdoors and areas of interest in the community?		
19. Have the scientific skills of parents and other community residents been explored and utilized?		

Role of the Administrator

An effective developmental program that extends the total school experience of young people cannot be left to chance. To insure such a program, does the administrator:

	Yes	No
Provide the impetus for classroom change which is educationally significant?		
Work out lines of communication (including teachers, students, and parents) for continuous science curriculum study and revision?		
Facilitate the acquisition of necessary equipment and materials to accommodate the wide range of learning styles and abilities of students?		
Encourage innovative approaches to meet the needs of science teachers through science workshops, and schedule time for exchange of ideas and planning?		

Role of the Teacher

The most important person in implementing a good science program is the teacher. The teacher's knowledge, behavior and strategies in responding to students and handling their responses, questions and ideas are determining factors in learning experiences. The science teacher is perceived as one who:

	Yes	No
1. Develops goals and objectives to implement and promote desirable task involvement and positive behavioral change.		
2. Matches objectives with various activities designed to help students attain these goals.		
3. Places emphasis on science processes, conceptual schemes and values, with less emphasis on actual information.		
4. Identifies activities which require group work and establishes working groups appropriate for the activity and students involved.		
5. Provides time and opportunities for students to try their own suggestions, for inquiry and for discovery.		
6. Works with teachers of other disciplines and with resource personnel to provide more meaningful learning experiences.		
7. Communicates desirable attitudes and behaviors in all relationships with students and has a positive self-image himself.		
8. Understands and recognizes the various developmental levels of students (physical, intellectual, social and emotional) and provides appropriate educational experiences.		
9. Cooperates with students in making decisions concerning their education and does not make all the decisions for them or permit a fixed curriculum to determine the content and processes of learning.		
10. Guides students to resources, books, people and equipment. Provides only that assistance that is necessary, helping children become independent learners.		
11. Encourages students' self-awareness and self-actualization rather than merely preparation for future educational activities.		
12. Interacts verbally with individuals or small groups rather than with an entire class, asks good questions and is an expert listener.		
13. Gets involved with student concerns, has flexibility, openness to change, and can admit his errors; is not overly protective of his dignity, but is approachable, responsive, supportive, sympathetic (rarely reprimands or punishes).		
14. Creates a learning environment compatible with reality, an environment of trust and acceptance where the dignity and worth of the individual is respected, where the child feels free to be curious, to make mistakes, to learn from his environment and from his fellow students.		
15. Grows in professional competence.		

Role of the Student

The student is an actively involved individual; therefore, he should be able to:

	Yes	No
1. Exhibit enthusiasm and excitement for learning.		
2. Experience the joy of investigation on his own and for his own reasons.		
3. Explore objects, events or data so that new relationships become evident to him.		
4. Initiate activity and make significant decisions about what he studies, how he completes activities, and when, how, and by whom his learning is to be evaluated.		
5. Explore concepts using his everyday environment rather than meaningless examples in books.		
6. Recognize the usefulness of science and technology.		
7. Learn from mistakes without penalty.		
8. Share information and skills with others.		
9. Exhibit a positive self-concept.		
10. Laugh, play and interact with others.		

	Yes	No
11. Demonstrate development of science attitudes by:		
. . . showing willingness to have his ideas questioned and showing respect for the ideas of others		
. . . attempting to validate information and observations		
. . . recognizing the tentative nature of scientific information and the pervading phenomena of change throughout the universe		
. . . showing awareness of the necessity of intellectual honesty		
12. Demonstrate skill development in the processes of science by: 1. observing and communicating observations of scientific phenomenon		
2. interpreting a given set of scientific data		
3. stating a hypothesis in terms that can be tested by investigation		
4. making an inference based on observed events or data		
5. making necessary measurements of a given object or phenomenon		
6. classifying a group of objects according to certain criteria		
7. constructing a scientific model		
8. devising an investigation to test a scientific hypothesis		
9. predicting the occcurrence of an event based on a set of data		
10. keep accurate records.		

Curricular Programs

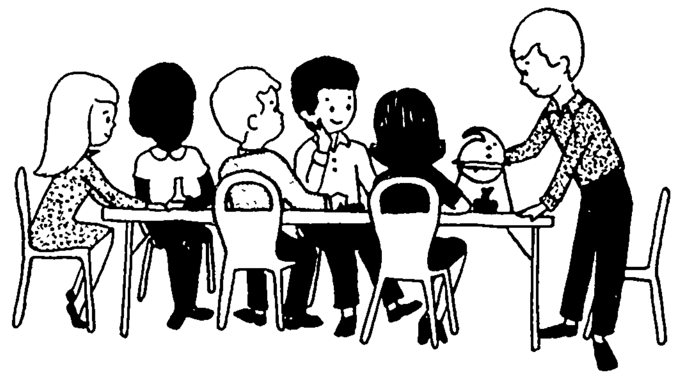
The following programs are among those which meet major objectives for students of science. Special teacher training is highly desirable.

Name of Program	Content	Level	Source	Necessary Space
Science A Process Approach (S-APA)	Wide coverage, various fields of science, some math & social studies—process skills	K-6	Xerox Ed.Group—Distribution Center 555 Gotham Parkway, Carlstadt, N. J. 07072	Regular Classroom
Science Curriculum Improvement Study (SCIS)	Ungraded, sequential physical & life science	K-6	Rand McNally P. O. Box 7600 Chicago, Ill. 60680	Regular Classroom
Elementary Science Study (ESS)	Ungraded, modular, non-sequential units of wide range could be used with non-readers	K up	Webster McGraw Hill-Manchester Rd. Manchester, Missouri 63011	Regular Classroom
Intermediate Science Curriculum Study (ISCS)	Energy, Matter, process skills for heterogeneous groups & special activities for scientifically talented	7-9	Silver Burdette General Learning Laboratory 250 James St. Morristown, N. J. 07960	Classroom Lab
Interaction Science Curriculum Project (ISCP)	Lab oriented program for heterogeneous groups & special activities for scientifically talented	7-9	Rand McNally P. O. Box 7600 Chicago, Ill. 60680	Classroom Lab
Interaction of Man and the Biosphere	Life Science	7		
Interaction of Earth & Time	Earth Science	8		
Interaction of Matter & Energy	Physical Science (see description in S. C. Adopted Textbooks)	9		
Investigating the Earth—Earth Science Curriculum Project (ESCP)	The Earth Sciences for scientifically talented. If Activities stressed, Heterogeneous classes can use this lab approach.	8-9	Houghton Mifflin 666 Miami Circle, N.E. Atlanta, Ga. 30325	Classroom Lab
Life Science Investigations Man & The Environment (ERC-Life Sci.)	Life science with ecological emphasis—useful for heterogeneous groups	7-8	Houghton Mifflin Co. 110 Tremont St. Boston, Mass. 02107	Classroom Lab
Me Now	Life Science for non-reader	Mentally handicapped (M.A. 6-9)	Hubbard Scientific Co. Box 105, Northbrook, Ill. 60062	Classroom lab

Necessary Materials	Basic Teacher Training	Approximate Initial Cost (Class of 30)	Type of Structure
Instructional materials for teachers, commentary for teachers, extra kits of teaching aids	Inservice training necessary consultant training available—Guide for inservice training	$500	Highly structured Sequential
2 kits of instructional materials each level (1 life, 1 physical)	Inservice training necessary consultant help, conferences,. workshops	$125 - $200	Moderately structured
Choice by units-teacher manuals available (extra)	Consultant & workshops	$12 - $150	Loosely structured
Student texts, Teachers' guide Master set for students section sets	Consultant services Conferences, institutes	Master set for 5 sections of 30 students each $788	Moderately structured
Text Teachers' guide Lab materials	Consultant service, workshop	$375 if kit puchased. Most material can be obtained locally.	Highly structured
Teacher instructional materials Laboratory equip. Package separate kits	Consultant services—inservice training desirable	Complete class asst. $789 minimum $450	Highly structured as written but adaptable
No kits-learning games-basic life-science equip. needed	Life science background helpful	Class set including printed materials and learning games $42.15	Moderately structured
4 units instructors guide daylight slides, film loops	Life science background	$400 - $500	Loosely structured

ADDITIONAL MATERIALS

Name of Program	Content	Level	Source	Necessary Space
People and Their Environment	Environmental education (interdisciplinary) useful for heterogeneous groups	1-12	Copies distributed to all S. C. schools additional copies J. G. Ferguson Pub. Co. 6 N. Michigan Ave. Chicago, Ill. 60602	Classroom & outdoor
Addison-Wesley Environmental Studies Series	Air, water, noise pollution	Open	Addison-Wesley Pub. Co. Menlo Park Reading, Mass.	Classroom & outdoor
Pathways in Science	Modular biology, earth science, chemistry, physics	7 up Written on lower 5 and 6 grade level	Globe Book Co. Dept. B-20 175 Fifth Ave. New York, N. Y. 10010	
Middle School Life Science Proj. of BSCS	Multi-disciplinary	6-8 integrated program designed specifically for middle school students for heterogeneous groups	BSCS P. O. Box 930 Boulder, Colo. 80302	Being developed to be tested in classroom Sept. 1972
Time, Space and Matter	Physical science geology, astronomy, physics, chemistry, math. Interdisciplinary, could be used with non-readers and heterogeneous groups; 9 sequential investigations	8, 9, 10	Webster McGraw Hill, Manchester Rd. Manchester, Mo. 63011	Classroom Lab
Environmental Studies Packets (ES)	Suggestions for exploring the environment, useful with non-readers, heterogeneous groups, and interdisciplinary programs	K-12	Environmental Studies Project Box 1559 Boulder, Colorado 80302	Outdoor classroom



Necessary Materials	Basic Prog. Teacher Tr.	Initial Cost (Class of 30)	Type of Structure
Natural basic science equipment		Minimal	Loosely structured
Easily obtainable		Minimal	Moderately structured
Soft & hardback texts, lab books		Minimal	Moderately structured
Modules		Minimal	Moderately structured
Student, class teacher equip. packages (No text) Science Reading Series	Training program recommended Consultant services	$409 (for 30) Does not include printed materials	Loosely structured
Natural		Pks. 1 and 2 $10 Teaching non-guide	Open—supplementary—not a total program

HIGH SCHOOL SCIENCE 9-12

Rationale

Science education, having a history of change, is in the midst of another revision in emphasis; this time toward a more "humanistic" and pragmatic approach. No longer is the thrust to turn out more scientists and students who think like scientists. No longer are courses to be so pure, theoretical, and mathematical that only the brightest students can comprehend them.

On the contrary, the aim of science education today is "scientific literacy" for the masses. Everyone is affected by scientific research and technology and should have opportunities to learn what science really is, how it got that way, and how to cope with the conditions which science creates. The National Science Teachers Association has described the purpose of science education in a "Position Statement On School Science Education for the 70's" as follows:

"The major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action. This choice of goals is based on the belief that achieving scientific literacy involves the development of attitudes, process skills, and concepts, necessary to meet the more general goals of all education, such as:

- learning how to learn, how to attack new problems, how to acquire new knowledge
- using rational processes
- building competence in basic skills
- developing intellectual and vocational competence
- exploring values in new experiences
- understanding concepts and generalizations
- learning to live harmoniously within the biosphere

Above all, the school must develop in the individual an ability to learn under his own initiative and an abiding interest in doing so." (NSTA, **The Science Teacher**, Vol. 38, Nov. 1971.)

A scientifically literate person has an understanding of the conceptual schemes and processes of science and can apply this understanding. The conceptual schemes provide the organizational framework for a science course. Students of varied ability levels and backgrounds can work together within a given conceptual scheme although involved in activities of diverse complexity. Slow learners can concentrate on a few essential ideas, while the more able students maintain their interest as they learn to see the interrelationships of the schemes in diverse scientific disciplines.

Processes of science involve numerous skills, modes of inquiry, and inductive and deductive reasoning. Of necessity, many activities must be provided if students are to develop skills and apply them to everyday situations. Since processes are behavioral in nature, they may form a basis for assessing student growth.

Instruction that does not relate to living and does not provide the learner with standards by which he can weigh his own behavior is of little worth to him. Although mastery of the processes of science and comprehension of the concepts can provide the student with valuable tools for critically evaluating his actions, desirable attitudes and standards of behavior should emerge from scientific learning experiences which can give direction to the student's present and future life.

Checklist Instructions

The following checklists are designed to assist the administrator in his evaluation of the science program. They should be used for each room where science is taught. Three categories have been described for most items:

1. designate minimum rating,
2. designate recommended rating,
3. is considered exceptional.

This will enable administrators to get the total numerical rating of their program. If the rating is below minimum, put an X in the box provided.

While the checklists are devised for the traditional

A Tabulation Sheet for these checklists is found on Page 37.

secondary science program, the format may be used for experimental courses, interdisciplinary courses, mini-courses, and other innovative science programs.

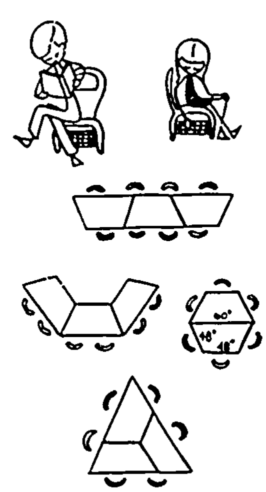
Facilities and Supplies

Facilities and supplies should be flexible enough to accommodate a variety of students, learning styles, interests and abilities. Without adequate materials and equipment children do not study science but study about science.

A. Furniture

X	1	2	3

1. flat, horizontal working surface (library or cafeteria-type tables. Every student must have working space.
2. movable tables to accommodate 2-4 students (trapezoidal shaped tables provide flexibility.) book storage so that books need not be on tables.
3. student tables with acid resistant surface, each supplied with gas, electricity and water accommodating 2-4 students. Facilities available at all times and may be used in a class-lab setting.



B. Accessory Furniture

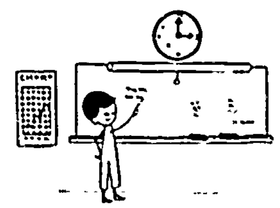
X	1	2	3

1. demonstration table, storage, at least one water source, sink, display areas and surfaces for collections and projects, bookcase, locked file cabinet, and teacher's desk.
2. demonstration table with gas, electricity and water and locked storage, appropriate storage (some locked, some ventilated for special chemicals, some special for microscopes.) fume hood, bookcases and display case, display and project area, 6 sinks with running water.
3. (2.) and space for independent student work such as student carrels or an adjoining room for preparation and conference.

C. Room Accessories

X	1	2	3

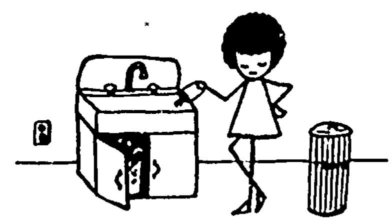
1. chalkboard visible to all areas of the room, 1 cork board, wall clock with second hand, room darkening facilities, chart holder.
2. (1) and corkboard or pegboard on all wall surfaces that do not have cabinets, permanent provision for projection screen, and other hanging objects, window ledges or shelves about 10 inches deep for display. The room should be colorful and not drab.
3. (2) and pegboard.

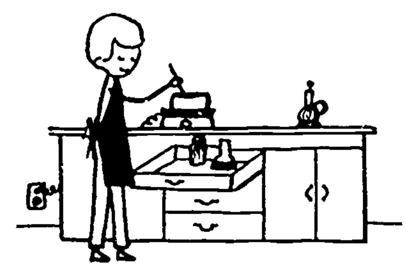


D. Utilities

X	1	2	3

1. Any building must comply with state building code specifications. Master cut off valves for gas, electricity and water should be placed in each room (preferably near or in teacher demonstration table). In school with septic tanks, sink drains should lead to a separate drain field. Sinks with cold water—sinks and pipes of corrosion and chemically resistant material, 1 outlet and 1 heat source for every 4-5 students, 1 electric hot plate, 1 separate hot plate, 1 separate waste container, strainers over drain opening.
2. (1) and fume hood, 5 sinks with running water, gas jet for each student station, outlet for every 2 students, 25 foot drop cord, 2 sinks should be deep and should have hot water. 2-20 amp. 110 v. circuits for general service, 1-30 amp. 110 v. circuit for refrigerator, heater, hot plate, etc., 1-220 v. circuit for ovens, stoves, etc., with outlets in appropriate positions.
3. (2) and hot and cold water at each sink, distilled water in preparation room, water, gas and electricity for each team of 2-4 students.





E. Safety

X	1	2	3

1. Fire extinguisher, instruction sheet for accident procedures prominantly displayed and discussed by teacher, safety glasses, first-aid kit, 1 fire blanket, flooring that is not slippery, protective aprons.
2. (1) and safety charts displayed, locked storage, eye wash and shower facility.
3. Annual inservice for teacher training in classrom safety procedures. The NSTA publication "How to Provide for Safety" may be used.

F. Equipment and Supplies—Audiovisual

X	1	2	3

1. Overhead projector, filmstrip projector, 16 mm projector, 2" x 2" slide projector, 8 mm film projector, tape recorder and duplicating machine available to the teacher but not housed in the room. Charts and models appropriate to the subject taught. At least 25 science filmstrips, a set of transparencies and tapes.
2. (1) and an overhead projector assigned to the room. Micro-projector available in the department. Large number of charts and models (torso, eye, ear, leaf, root, heart, molecules)
3. (2) and equipment for videotaping available, 8 mm projector and film loops in the department, 16 mm projector assigned to the department, T. V. facilities available.

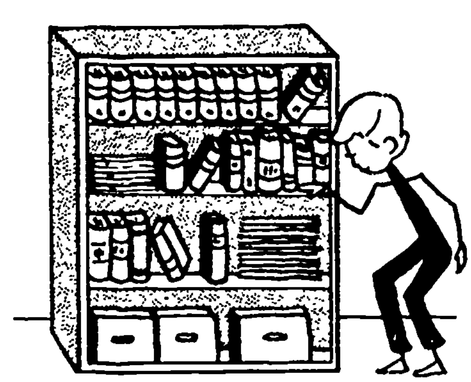
G. Equipment and Supplies

X	1	2	3

1. The teacher can demonstrate that enough science supplies are available either in this room or in a storage area to cover a minimum listing of activities to be performed by students during the year. Recommended lists may be found in the teachers guide being used. Tool kit. Equipment should be adequate for at least one set per team of 4 students. An inventory of materials has been made and a copy distributed to each science teacher and their principal.
2. (1) and 75% of the necessary supplies and equipment available in the room where it will be used.
3. (1) and 95% of the supplies and materials permanently assigned to the room where it will be used. Equipment adequate for teams of 2 students, materials for special studies.

H. Resource Materials

X	1	2	3



1. Biennial review of library holdings and use. Teachers should recommend new books and periodicals to the librarian for purchase. The teacher should have guides to current text and lab books, guides and handbooks, test item reference books, standardized tests.
2. Classroom library for student use including other science textbooks, and manuals, pamphlets, current science catalogs, locally relevant resources,
3. Additional handbooks and mechanical guides and handbooks, additional publications in greater depth and variety. Materials on varied reading levels and directed to varied student interest.

I. Space

X	1	2	3

1. Rooms are for one science only. When enrollment is less than 500 students the chemistry classroom may be shared with physical science or physics. Where less than 200 students are enrolled in school, a multi-purpose science room may be used.
   Storage area specifically designed for the science to be taught. Minimum of 45 sq. ft. per pupil in the science room.
2. All science rooms on the same wing.
   Laboratory and/or work roms located on ground floor with direct access to outside.
   School room nature study area provided.
   Separate room for storage and preparation.
3. Additional space for animal and plant growth areas, office or conference space adjacent to the science room. Special area for faculty and for student research.

Note: Locked storage space or cabinets for all hazardous reagents and potentially explosive or flammable materials with adequate ventilation is essential in all science departments or rooms.

J. Outdoor Use

X	1	2	3

1. Science teachers are encouraged to use the outside for first hand science observation and experience.

2. (1) plus the school property provides opportunities for students to study most of the following:

Plant growth	Noise pollution
Drainage patterns	Water quality
Erosion	Population density
Soil types	Ecological difference
Plant succession	Ecological similarities
Air pollution	Ecological variety
Wind currents	Change
Micro climates	Interdependance
Clouds	Heredity as well as environmental influences
Solid waste disposal problems	

3. (2) plus science and social studies teachers work together on environmental studies and projects.

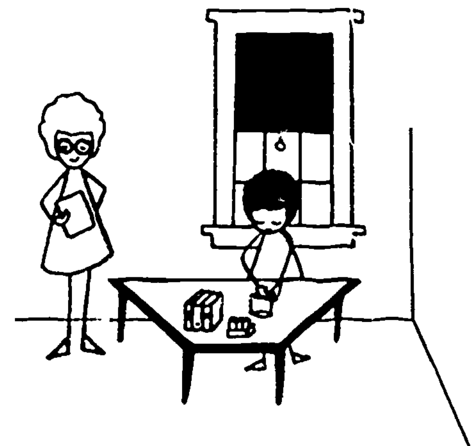
Curriculum Checklists

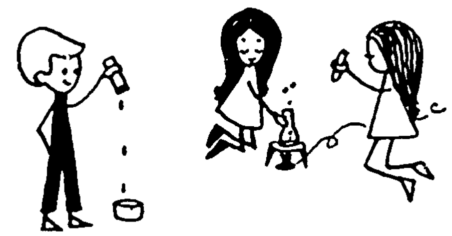
This guide does not provide a recipe for a perfect science curriculum. Each school, after careful study of its own situation, must develop its own curriculum to meet the needs of its own students. The following components should be considered:

A. General Program

X	1	2	3

1. The program stresses both processes of science and scientific concepts. Science is presented as a process of solving problems through laboratory investigations and class discussion. Conceptual schemes provide the basic framework of the program. At least one period per week is devoted to laboratory investigation by the students. Students demonstrate acquisition of scientific understandings and skills in their performance of certain tasks as well as through tests, laboratory reports and special projects. Classes should last 60 minutes to provide adequate lab time.
2. (1) and the curriculum has been designed and performance objectives established to meet the needs of a given group of students. Laboratory investigations twice a week, using an inquiry oriented program (such as IPS, BSCS, CHEM STUDY, PSSC, HPP), one or two double periods for lab activities are provided.
3. (2) and the curriculum is designed and periodically modified to meet individual needs and concerns of the students. Open-ended investigations are emphasized rather than step-by-step directed experiments. Laboratory sessions are provided at least three times per week. Emphasis is on latest and most significant developments in science and their relationship to society.





B. Course Offerings

X	1	2	3

1. Physical science, a laboratory oriented course, is provided which includes concepts from the areas of chemistry and physics for students who do not elect these courses or as background for them.
   Biology, a laboratory oriented course, is provided with emphasis on those areas of greatest concern to students including health, homeostasis, heredity, ecology, behavior.
   Physics and chemistry—both laboratory oriented, are offered each year or they may be offered on alternating years.
2. (1) and special courses to meet individual needs (ex. advanced courses in biology or chemistry emphasizing research and using at least 50% of the time in laboratory study. Special programs for the non-reader and slow to learn; special programs for the potential drop-out). Special vocational oriented courses such as horticulture, floriculture, forestry, etc.)
3. (2) and independent study programs and mini courses to provide increased options for students.

Teacher

A. Educational Qualifications

X	1	2	3

1. South Carolina certification with undergraduate degree and minimum of 18 hours in the subject being taught.
2. Certification in the subject being taught and an undergraduate major or equivalent hours in the subject being taught. At least 6 hours in each of two other science areas.
3. (2) and a MA, MS, or MAT degree with major emphasis in science.

B. Experience

X	1	2	3

1. Inservice training program emphasizing natural science at least 2 days per year.
2. Has attended summer institute or major inservice training in the area of science being taught, science hobbies.
3. (2) and science research experience or work experience in the field of science such as a related industry or hospital lab. Summer institute or other college science courses at least once every three years.

C. Professional Activities

X	1	2	3

1. Membership in one national and one state wide science organization.
2. (1) and attendance at a state level meeting at least once a year.
3. (2) and active membership and subscription to several science journals.

D. Performance Criterion

X	1	2	3

1. Provides regular laboratory experiences.
   Communicates well with students.
   Provides variety of learning materials, methods, and student experiences—laboratory, audiovisual, discussion, etc.
2. (1) and flexible and innovative program using inquiry approach effectively.
   Uses community resources successfully—including field trips and outside speakers.
3. (2) and develops some original materials and methods. Encourages students in individual research and science fairs and junior academy participation. Works with a science club.

E. Skills

X	1	2	3

The following statements are associated with classroom behaviors of teachers. The teacher will be able to:

1. identify student behaviors which are appropriate for a given exercise.
2. match behavioral objectives with the various activities in the exercise.
3. encourage the student to demonstrate ideas.
4. match instructional activities to student progress.
5. probe students to extend their responses.
6. establish classroom working groups appropriate to given activities.
7. identify activities which require group work.
8. identify specific procedures that assist in preparation for teaching a science exercise.
9. identify student behaviors related to processes of science.
10. identify and demonstrate the use of teaching strategies which are compatible with the philosophy developed for the teaching of science. (Accreditation Standards, Florida Public Schools, 1969-70).

Administration

Success of any program depends on teamwork. Cooperation, consideration and good communication are essentials.

X	1	2	3

A. Department Chairman

1. A science department with more than three teachers has a department chairman who will coordinate the program, consider the curriculum and equipment, recognize needs, and suggest changes.
   The department chairman meets with the principal after departmental meetings to discuss budgeting needs, in-service training programs, and new curricula.
2. The science department chairman has one free period for department work in addition to the regular planning period.
3. The chairman is paid a supplement for additional duties.

X	1	2	3

B. Guidance Personnel

1. Guidance personnel are familiar with the various programs of the science department so that they may help students in their selection of courses.
2. Guidance personnel are aware of specific skills and background necessary for a particular course to insure proper student placement.
3. Guidance personnel work with individual students and the science teachers to help them develop their interests, skills, and special abilities.

C. Principal—Teacher

X	1	2	3

1. Teacher qualifications are considered in making assignments.
2. (1) and reviews teacher assignment annually in terms of academic and related qualifications and teacher preference. Provides time for professional growth and training and to attend professional meetings.
3. (2) and provides time and pay for teachers to attend professional meetings. Encourages professional growth by promotional pay credits for inservice, institutes, graduate work and visits to other schools where innovative programs are being conducted.

D. Principal—Scheduling

X	1	2	3

1. A planning or preparation period is provided.
2. (1) and in scheduling teacher classes course sequence is considered so that a teacher will not be required to follow a chemistry class with a physical science class and then reassemble chemistry materials for another chemistry class.
3. (2) and in scheduling students the principal considers double periods for lab courses and makes special arrangements for mini courses.

E. Principal—Policies

X	1	2	3

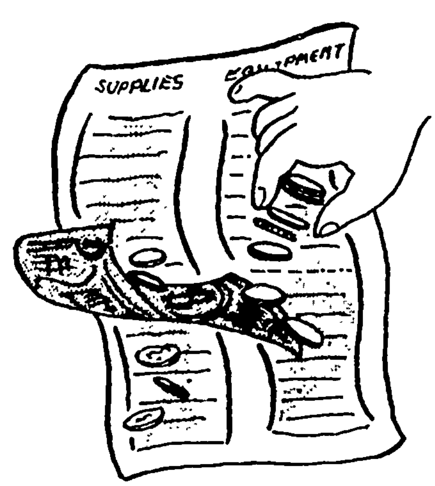
1. Policies are provided for use of outside speakers.
2. (1) and a student assistant program is established for selected students. Provision is made for field trips and outdoor study.
3. (2) and provision is made for free transportation for field trips of 1 or more days duration. Experimental programs and curriculum projects are encouraged.

Financing and Purchasing

X	1	2	3

Wise planning and budgeting can result in a good program without excessive cost to the school.

1. Each teacher should have identified what activities will be performed during the year and what equipment will be necessary. Materials should be ordered in such quantity that students may participate in teams of 2-4.
2. (1) and petty cash fund should be provided for the department to be used for local purchases.
   The science department meets to discuss needs for the coming year and propose an approximate budgetary requirement. This is submitted to principal and superintendent for approval. Members of the department are consulted if changes are necessary.
3. (2) and the department discusses and plans for instituting new curricular programs.



Date ______________ Room No.______________

(Tear out this page and use with checklists on pages 28-35)

SECONDARY SCIENCE ANALYSIS TABULATION SHEET

	Unacceptable X	Minimum 1	Recommended 2	Exceptional 3
Facilities and Supplies				
A. Furniture				
B. Accessory furniture				
C. Room accessories				
D. Utilities				
E. Safety				
F. Equipment and supplies—Audio-visual				
G. Equipment and supplies				
H. Resource Materials				
I. Space				
J. Outdoor use				
Curriculum				
A. General Program				
B. Course Offerings				
Teacher				
A. Educational qualifications				
B. Experiences				
C. Professional Activities				
D. Performance criterion				
E. Skills				
Administration				
A. Department Chairman				
B. Guidance Personnel				
C. Principal—Teacher				
D. Principal—Scheduling				
E. Principal—Policies				
Financing and Purchasing				
Column totals				

0 - 21 = unacceptable
22 - 33 = marginal
34 - 45 = fair
46 - 55 = good
56 - 66 = excellent

TOTAL SCORE ______________

Curricular Programs

If the purpose of the high school science program is to be scientific literacy for all, then each student must have the opportunity to acquire basic understandings and skills necessary to:

1. understand himself
2. understand his changing environment
3. use the processes of inquiry to continue his learning and evaluation of information
4. appreciate science and its contributions to his life and society.

Curriculum content designed to achieve the objectives listed must provide sufficient variation to meet the diverse needs and interests of the students. Several types of programs are possible.

Structured program

In this program emphasis is placed on understanding and a sequence of concepts derived largely from commercial texts.

Physical science (9th) and biological science (10th) should be provided for all students. Materials are available in both areas for non-academic students. In programs such as Project Succeed where only one year of science is scheduled, a selection of concepts from both areas should be included. At least 20% of the students time should be devoted to laboratory investigations (*Standards for Accredited High Schools of South Carolina*). In courses for the non-academic, students should be involved in laboratory investigations almost every day.

Both chemistry (11th) and physics (12th) must be provided each year or, if enrollment is 300 or less; offered on alternate years.

Advanced courses are provided for the academically talented who have special interests in science; but not for students who take vocational and technical courses. Students taking advanced courses have had Biology I and Chemistry I, and it is recommended that they be currently enrolled in physics. These courses should provide the students with a working knowledge of the scientific processes of investigation, and an opportunity to investigate problems, using science reference materials and statistical evaluation of data. Students should be encouraged to engage in an independent study of scientific problems that interest them. At least 35% of the time should be devoted to laboratory investigation (*S. C. Standards*). A double period is almost mandatory for these advanced courses.

Moderately structured program

The moderately structured program is more interdisciplinary and less sequential. It provides more options for the students in the form of semester, quarterly or "mini-courses." In this type of program greater emphasis is placed on problem solving, laboratory research, seminars and independent study. Numerous materials are available to schools interested in this approach, including:

1. BSCS Laboratory Blocks (13 paperbacks) developed and tested by the Biological Sciences Curriculum Study and published by D. C. Heath and Co. They include the following titles:

   Animal Behavior
   Animal Growth and Development
   Evolution
   Field Ecology
   Genetic Continuity
   Life in the Soil
   Microbes: Their Growth, Nutrition and Interaction
   Physiological Adaption
   Plant Growth and Development
   Radiation and its Use in Biology
   Regulation in Plants by Hormones
   The Complementary of Structure and Function
   The Molecular Basis of Metabolism

2. *Ideas and Investigations in Science* by Wong and Dolmetz, published by Prentice Hall, consists of 10 paperbacks including the following topics in physical science and biology:

Predicting	*Inquiry*
Matter	*Evolution*
Energy	*Genetics*
Interaction	*Homeostasis*
Technology	*Ecology*

3. *Terms, Tables and Skills*, published by Silver Burdett, could be used as a basis to develop a mini-course in scientific computations. It covers subjects such as systems, standards, scientific notation, significant figures, dimensional anal-

ysis, logarithms, slide rule, error analysis and many other useful skills.

4. *Project Physics*, published by Holt Co., could also be broken down into short courses. It would probably be necessary to have some sequencial scheduling. (For example the section on the nucleus should be preceded by the section on the atom.) Unit 2 of the Project Physics course could be used as a short course in Astronomy. Other possible sources for astronomy include: *Modern Space Science* by Trunklein and Huffer, published by Holt. The University of Illinois Astronomy Program, published by Harper and Roe, is composed of numerous paperback booklets which could be the basis of a short course in Astronomy.

5. *Modules, The Use of Modules in College Biology Teaching*, published by the Commission on Undergraduate Education in the Biological Sciences, offers much help to the teacher or school who is developing a curriculum of short courses.

6. Okemos High School, Okemos, Michigan, has developed a program composed of short courses which are described in their curriculum publication.

7. Eight modules have been developed by high school teachers and teachers in the Chemistry Department at the University of Maryland. Experimental copies of the following modules may be obtained from Harper and Row:

   Reactions and Reason, an Introductory Chemistry Module

   Diversity and Periodicity, an Inorganic Chemistry Module

   Form and Function, an Organic Chemistry Module

   Molecules in Living Systems, a Biochemistry Module

   The Heart of the Matter, a Nuclear Chemistry Module

   Earth and its Neighbors, a Geochemistry Module

   The Delicate Balance, an Environmental Chemistry Module

   Communities of Molecules, a Physical Chemistry Module

8. District 40, Moline, Illinois has printed a series of modules for their program called, "Toward Humanization and Individualization of Science." They may be purchased from the staff at the school district for $2 per module. The modules are initial drafts which are being used in pilot classes. Revisions and corrections are planned for the summer of 1973. A few titles from this program include:

   Is It True Blonds Have More Fun?

   Should You Throw Away the Box Before You Eat the Cracker Jack?

   The Answer Table—a more detailed study of the uses of the Periodic Table

   Bonding and Structure

   Flying Saucers

   Do You "Dig" Dolphins?

9. A module called *Science Problems* could include a study of drugs, pollution, medical advances, population problems. A program based on "problems" is available from McGraw-Hill Co. It was developed by the Engineering Concepts Curriculum Project and is called *The Man Made World*. This interdisciplinary approach involves mathematics, social problems, and science, providing a one year program.

10. Another program called *ERC Science Problems* has been developed by the educational Research Council of America. It involves independent study using student guide cards and resource books. Titles in this program for non-science 11th and 12th graders include:

Behavioral Science	*Measuring Stars*
Chemical Analysis	*Photography*
Chromatography	*Plant Growth*
Electricity	*Slotcar Science*
Map Making	*Survival*

Many other paperbacks and programmed materials are available to schools who are considering changes in their curricular structure. However, teachers may wish to develop their own courses based on their special interests and on student interests. Nature study, for example, may have as its goal the development of student appreciation for the world of living things. It could include macro and microscopic studies, studies of birds, populations, ecosystems, photography and field work.

Loosely Structured Program

The present practice of providing instruction in science by separate and distinct disciplines has not succeeded in producing a scientifically literate society. Therefore a unified approach is a possible alternative.

A scientific investigation is usually not thought of in terms of its biology parts, its chemistry parts, or its physics parts; it is considered a procedure for solving the problem or for answering the question. It is for these reasons that this guide recommends interdisciplinary mini-courses, based on societal problems and using the processes and concepts of science, to explore solutions to the problems.

There is no way that students can know all that there is to know in any one small area of science. However, he can learn much of the nature of science and the concepts and processes of science as he studies situations of concern to him. Mastering a little at this level will provide the tools for greater mastery at the college level and for greater use in everyday life for those who do not continue their science education.

A flexible class-lab including a variety of A-V materials as well as science equipment is essential to provide for differences among students. Field trips should be frequent with an extensive use of the out-of-doors and the community as the classroom. The student should cooperate with the teacher in the choice of activities best suited to his schedule, interest and level of performance ability. It must be remembered that we do not individualize instruction to produce uniform products all behaving in the same way. The individuality of learners must be fostered and the ends of our educational program must be as unique as ability, interest and personality warrant.

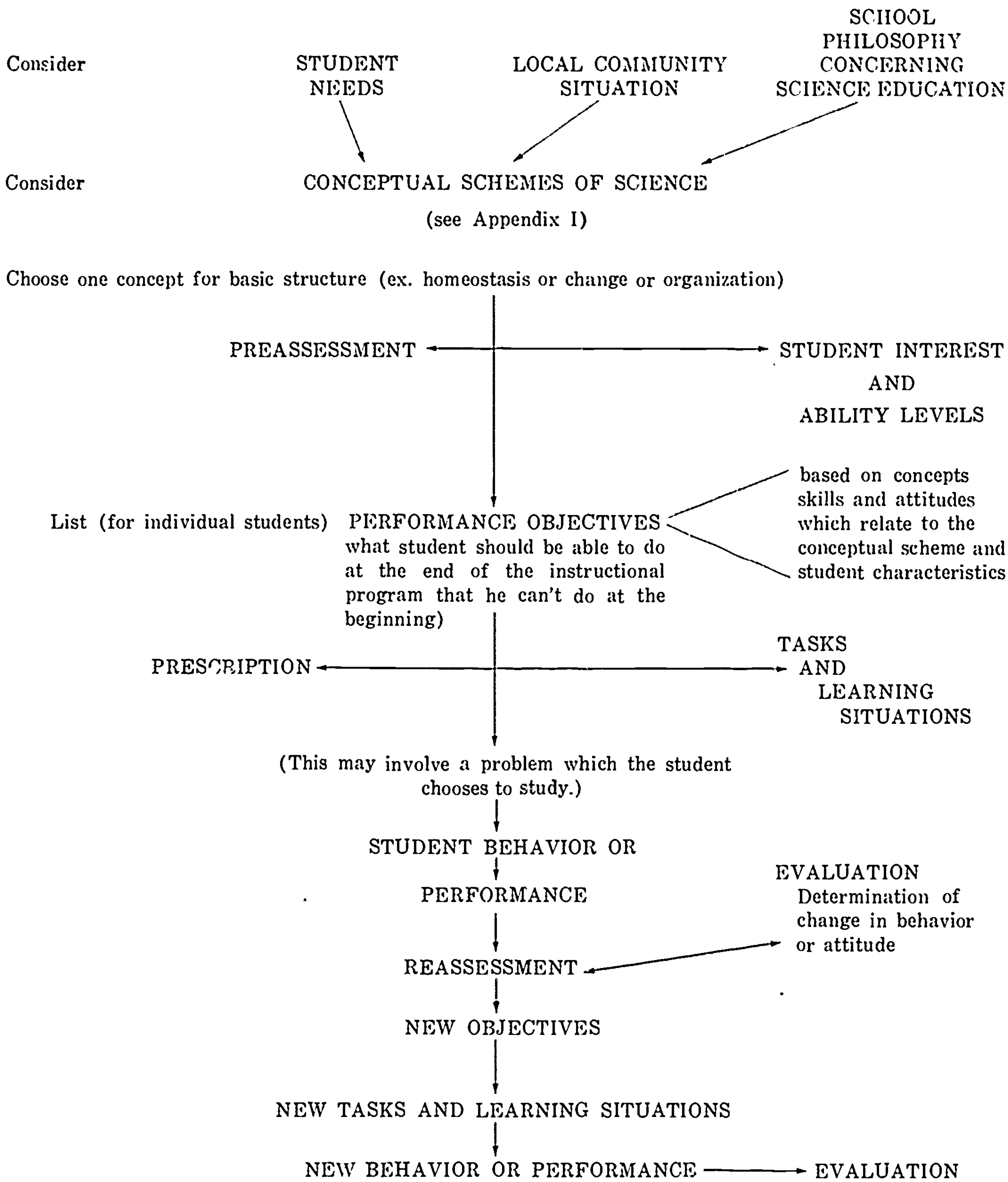
A diagram and sample showing a possible procedure for structuring a program which is not only interdisciplinary but also may be used with individualized instruction or class instruction may be found on page 44.

Name of Program	Content	Level	Source
The Man-Made World Engineering Concepts Curriculum Project (ECCP)	based on a "Systems" approach to solving social and environmental problems interdisciplinary emphasizes technological literacy	11–12	Webster-McGraw-Hill
Chemistry: An Investigative Approach (Chem Study)	emphasis on experimentation, observation and measurement leading to understanding of concepts. Opportunity for discovery (see State Adopted Text)	11	Houghton Mifflin
Chemistry Experimental Foundation	Same as above	11	Prentice-Hall
Ideas and Investigations in Science Physical Science	5 major ideas taught using a lab approach. predicting, matter, energy, interaction, technology, designed for the "educationally uninvolved" poor reader, potential drop-out; stress success	9–10	Prentice-Hall
Biology	5 major ideas: inquiry, evolution, genetics, homeostasis, ecology		
Introductory Physical Science (IPS)	lab approach to Physical Science—lab activities are part of text (see State Adopted Text description)	9	Prentice-Hall
Biological Science, An Inquiry Into Life (BSCS Yellow)	emphasis on cell and organismic levels of Biology for average and above (see State Adopted Text)	10	Harcourt, Brace & Javanovich
Biological Science: Molecules to Man (BSCS Blue)	for above average (see State Text Adoption) Biochemical evolutionary approach	10	Houghton Mifflin
High School Biology (BSCS Green)	for average and above (see State Text Adoption) Ecological approach	10	Rand McNally
Biological Science: Patterns and Processes	for below average (see State Text Adoption)	10	Holt, Rinehart, Winston
Physics (PSSC)	average and above (see State Text Adoption)	12	Heath
The Project Physics Course (HPP)	broad, humanistic, lab oriented approach	12 9th grade reading level	Holt, Rinehart Winston
Sets of cards for each problem Teacher's guide	Consultant services available	$466.40 and lab materials usually found in high school	

Necessary Training	Teacher Training	Approximate Initial Cost
Text Lab manual Teacher's manual Lab equipment	Methods of instruction include: independent study, lab investigations, seminars & discussion groups, computer simulations. Training is recommended and available.	$1,000 - $4,000 depending on present inventory of equipment
Text and lab in a single volume Teacher's guide	Consultants and institutes for training are available but not essential	Basic chemical equipment and supplies only
Text Lab manual Teacher's guide	Same as above	Same as above
5 paperbacks (1 for each idea) or 1 text and student lab book Teacher's guide Lab materials	Consultant available	May use local materials if package is purchased cost range is per package
Same as above	Same as above	Same as above
Text Teacher's guide Specially designed materials	Consultant services available	$678 highly structured
Text Teacher's guide Lab book	Consultant available	Basic biology materials no special equipment
Text (lab included in text) Teacher's guide	Same as above	Same as above
Same as above	Same as above	Same as above
Same as above	Same as above	Same as above
Text Lab manual Teacher's guide Films available	Consultant available	
Text Handbook, Teachers' Resource Books, Readers, Programmed instruction booklets, (Average materials available)		

Science Problems (ERC Sci Problems)	lab science course for those who do not take chemistry and physics; individualized, interdisciplinary, problem centered, modules. Titles include: *Plant Growth, Slot Car Science, Survival, Behavioral Science, Chemical Analysis, Electricity, Photography*	11 & 12	Not commercially published

CONSTRUCTION OF INTERDISCIPLINARY MODULES



This continuum should involve concept, skill and attitude development.

SAMPLE INTERDISCIPLINARY MODULE

Conceptual Scheme—Matter is subject to change with time. Such changes occur at various rates and in various patterns.

The student and teacher, together, consider the interests and needs and determine the medium which may be used to develop understanding of this concept. They may consider the following:

- changes in soil, water, air
- changes in earth's structure
- changes in chemicals
- changes due to pollution or to natural causes
- changes in biological systems — succession, growth, development
- changes due to man's intervention—herbicides, plant growth hormones, etc.

With a study of any of these areas, the student will gain an understanding of the concept and be able to develop those skills which he needs most. Some students will need to develop measuring skills, some interpreting data, some need skills in graphing, etc. Tasks should be chosen which will help each child with his special needs. A variety of learning activities are described in commercial texts and other materials. Frequently, children of similar interests may wish to work together, so that the teacher may spend most of the class time involved with small groups.

PREPARATION FOR TEACHERS OF SCIENCE

Elementary and Middle School Science Preparation

Science in grades K through eight plays a very significant role in modern education. More students study science in these grades than in all senior high science courses combined. In addition, students within this grade range encounter science during a time when they are particularly impressionable. At this time their science interests can be easily developed or destroyed. Therefore, in order to assure adequate science education, teacher training programs must provide emphasis not only on content but also on instructional techniques.

Teachers need courses based upon broad ideas common to most science disciplines rather than memorization of facts. The courses should be taught using the inquiry techniques that they are expected to teach, with materials that they will be expected to use. For teachers of science in the elementary and middle school, science preparation should include at least 24% of their undergraduate program.

Study in the area of science should include biology, chemistry, earth science, and physics. The total preparation should include mathematics as it applies to a functional understanding of science.

If our emphasis is on "learning" rather than on "teaching", teachers need less training in the dispensing of information and more experience in appropriate methods of interacting with children. They must have an understanding of intellectual levels of development and of various learning styles. They should be able to use this information in the development of curricula, methods, and materials.

Teacher education programs, both preservice and inservice, should be oriented toward performance rather than lecture. Inservice programs should include the skills which are necessary to optimal functioning of the classroom teacher. This would include skills in:

1. helping students to develop concepts
2. helping students to develop inquiry and process abilities
3. designing and maintaining appropriate laboratory activities
4. working with a team of teachers to provide a more relevant and interdisciplinary approach to learning
5. maintaining the facilities, equipment, learning materials, and time for an effective science program (including organization, storage, distribution and ordering of materials and equipment)
6. group dynamics and varied grouping practices, thus maintaining flexibility of class structure
7. identifying individual student needs, providing experiences appropriate to these needs and assessment techniques to determine level of success
8. use of multi-media materials and equipment
9. counseling and other student-teacher interactions
10. use of "inquiry" methods

Most of the new science programs available are designed for active student participation which requires special teaching skills and techniques. Teachers should no longer rely solely on a textbook, but must develop sufficient confidence to come out from behind their desks and work with their children.

Some schools have purchased packages which are not used due to lack of teacher training. All elementary and middle school science teachers should be required to participate in a course emphasizing the methods of teaching science, especially methods needed to teach the new programs.

In other words, a general elementary methods course should not be allowed to suffice. The science methods course should stress ways of encouraging individual, small group, and large group student participation and laboratory study, with special emphasis on development of process skills. **If teachers are not taught by inquiry, it is unlikely that they will teach that way themselves.**

Educational courses have little meaning to the student unless he is exposed to a planned sequence of experiences, including observation in elementary schools, culminating in full-time supervised teaching. These experiences should include laboratory investigations, field trips and other activities that involve the methods and processes of science. They should also include problem solving, critical thinking and methods of inquiry.

Secondary Science Preparation

The newer science courses developed for secondary schools have all emphasized an inquiry approach. However, most of our present science teachers have not experienced inquiry methods of instruction in the science or methods courses that they have taken. Science courses for preservcie or inservice education should be organized and taught using the philosophy of inquiry, using interdisciplinary themes, and providing experiences necessary to deal with this philosophy in high schools. They should include:

1. experiences that lead to incorporating understanding, knowledge and skills in science
2. experiences that lead to incorporating skills in problem solving, critical thinking and methods of inquiry
3. experiences that lead to understanding the relationships between branches of science and other areas of learning
4. awareness of historical as well as contemporary scientific developments
5. experience with children, especially laboratory and field experiences which illustrate the processes of science
6. opportunities to develop ability to inquire through designing and conducting their own laboratory experiences (individually or in groups)
7. opportunities to consider purposes, methods, materials, and evaluation procedures
8. opportunities to identify and develop teaching procedures to meet varied student needs
9. become aware of different approaches and trends in science teaching and learning styles
10. experience in analyzing and developing curricula

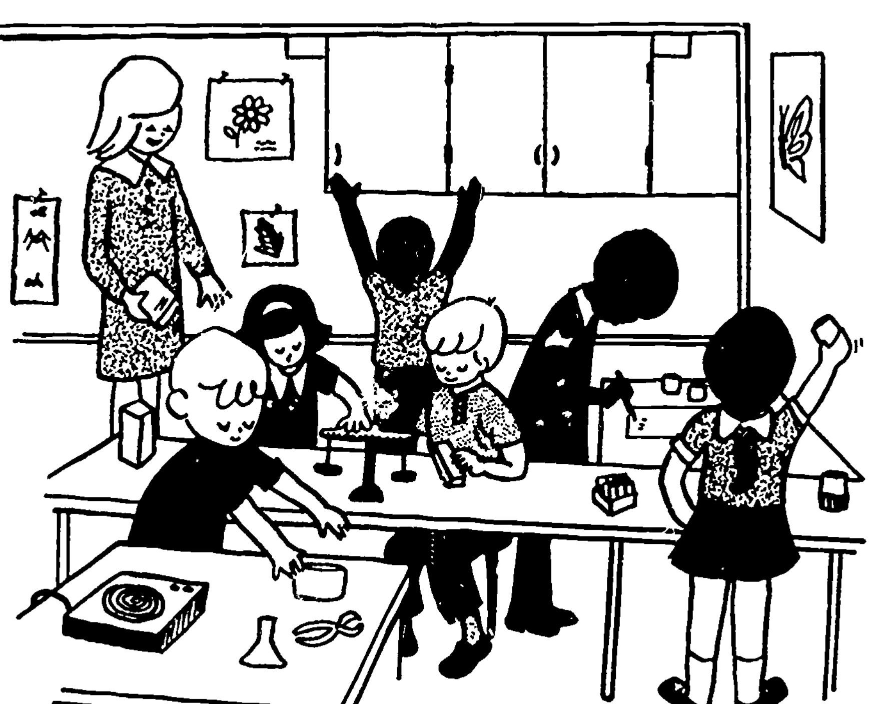
It would be advisable for teacher preparation programs to provide a laboratory course in experimental procedures and scientific techniques as they apply to the secondary school child. High school teachers should have instruction in each of the major disciplines with an emphasis in one. If they are teaching advanced placement courses or second year courses, they should have a master's degree with specialization in the area that they are teaching.

Inservice

Inservice programs are needed to facilitate the implementation of inquiry-oriented science programs. The State Department of Education, in cooperation with colleges, universities and the local school administration, should work together to develop programs that meet the needs of specific local situations. They can also work together in the development of materials, evaluation, and follow-up activities. Teachers are usually aware of their own needs and should be consulted in the planning of inservice workshops.

Some inservice work must be of a general nature, but some must deal specifically with the rationale of the science curriculum which the school district chooses to use. Many inservice programs have been designed to provide the teacher with better background in subject matter. Some teachers may need more content understanding but most have their greatest problems in areas of teacher-student interactions and science processes.

It is the responsibility of the school system to initiate and carry out the specific training necessary to implement a particular science curriculum program. Teachers must have adequate preparation if a new program is to be successful. If the teacher is expected to change teaching strategies, support of the administration is essential.



In-Service Checklist

	Yes	No
1. Is the program designed to train teachers who will be implementing a new science curriculum?		
2. Will the program give teachers increased confidence in their ability to teach science?		
3. Does the program provide guidance in the use of time, of space, and of present physical facilities?		
4. Does the program provide opportunities for the teachers to become familiar with science teaching materials and aids?		
5. Does the program provide experiences in methods of inquiry and problem solving?		
6. Does the program increase the teacher's understanding of the nature of science and its value in the educational curriculum?		
7. Does the program provide background information which the teachers may need?		
8. Does the program provide opportunities for teachers to participate in experiences and investigations that the children will be involved in?		
9. Will the teachers be taught in the same manner in which they will be expected to teach?		
10. Will the program help teachers in the identification of goals, learner characteristics and needs, learning conditions necessary to achieve the goals, and mechanisms for assessing progress?		

Use of Consultants Checklist

Another valuable part of an inservice education program is consultant help. Consultants are available from other public schools, from colleges and universities, from publishing houses, and from the State Department of Education. In order to assist schools in the use of these services, the following check list was designed from the article by W. W. Savage in the *Education Report*, University of South Carolina, vol. 14, February, 1972, Number 4.

	Yes	No
1. Do you need a consultant or a speaker?		
2. Have you defined your problem or needs with which you wish assistance?		
3. Have you discussed your needs with the personnel who will work with the consultant?		
4. Have you selected a consultant whose qualifications and procedures are appropriate to the defined needs of the group with which he will work (expert, resource person, process person)?		
5. Have you provided the consultant with adequate information for planning his work? (size and characteristics of the group with whom he will work, what has already been done toward solving the problem, what the group wishes him to do and to bring, time allotted for his visit, place and facilities where he will meet, dates and times of meetings.)		
6. Have you evaluated the consultant's experience? Was progress made? Was the consultant effective?		

PHASES OF CURRICULUM DEVELOPMENT

Evaluate present program

- Determine the philosophy
- Study current trends
- Identify special needs—strengths and weaknesses of present program

Planning for curricular changes

- Organize a science curriculum advisory committee
- Review all available programs
- Select programs that are consistent with the philosophy and educational objectives of the local school district
- pilot test the programs
- evaluate tested programs and select those best suited to the school situation.

Implementation of new programs

- Provide inservice education
- Provide additional time and pay for extra time needed to implement the program
- Provide consultants for periodic feedback and on-the-spot assistance
- Reevaluate and revise the program
- Continue inservice as new teachers are added to the program
- Provide funds for continued supply of necessary materials

Designing A Science Curriculum

Every school district has a responsibility for curriculum development. The need for change must be recognized before any progress can be made to bring the science program up to date with present trends and current research. The needs and wishes of faculty, students and community should be considered in the curriculum design and the choice of materials.

Three phases are usually involved in curriculum development: evaluation of the present program, planning for curricular change, and implementation of the new curriculum. For a detailed explanation of science curriculum development, the science advisory committee may wish to study the "Science Curriculum and the States" developed by the Council of State Science Supervisors and from which some of the following information has been obtained.

Evaluation of Present Program

In choosing or designing a curriculum for science education, consideration should be given to a philosophy, needs of the present program, and current trends in science education. Evaluation of the existing science program to determine areas of deficiency or weakness must occur before new programs are considered for adoption. The following questions may serve as a guide.

1. Is the science program directed toward certain realistic and worthy objectives?
2. Does it develop intellectual skills of scientific inquiry? (See Appendix II.)
   What skills are developed?
   What skills are ignored?
3. Is it based on pupil experiences and activities?
4. Does it develop laboratory skills?
5. Does it promote understanding of basic concepts? (See Appendix I.)
   In what way is the content adequate?
   In what way is the content inadequate?
6. Does it develop an appreciation of the scientific enterprise?
7. Is it multi-media oriented?
   Are materials available?
   Are materials appropriate to program objectives?
8. Is it a planned sequence of science instruction on a K-12 basis?
9. Is it organized but flexible and adaptable to diverse learning styles and teaching strategies?
10. Are student needs being met?
    What needs are not being met?
    What segment of the student population is not served?
11. Is it up-to-date in learning techniques as well as in scientific developments?
12. Does it emphasize interrelationships of science, technology, society, and other curriculum areas?
13. Is it understandable and appealing to the students for whom it is designed?

Planning of Curricular Change

When a program has been evaluated and need for change is recognized, there must be an organizational plan to assure effective curriculum development. This plan should include the administrator, the curriculum supervisor, the classroom teachers, interested school patrons, parents, consultants, and students. In planning for change in the science curriculum, local school districts have three options:

1. adoption of commercial programs
2. adaptation of commercial programs
3. creation of new programs

If the school district has a science consultant, this person should be responsible for the selection of a curriculum committee. If such a person is not available, a science advisory committee should be formed from the lead teachers of the school or a lead teacher from each school in the district. This committee should consider identification of desired educational objectives, local conditions and needs, recognition of socio-economic conditions and orientation to the local environment. They should also survey new science programs in accordance with national trends.

State or local textbook adoption should not inhibit experimentation and testing of new programs. In considering new science programs for adoption, the following factors should be considered:

1. Will the program use available materials to meet stated educational objectives?
2. Will it teach for behavioral change?
3. Does it use inquiry-centered experiences as opposed to a subject centered approach?
4. Is it developmental in sequence (based on levels of cognitive development rather than on topic sequence?)
6. Do the suggested methods reflect sound learning theory and recent pedegogical know how?

7. Has the program been adequately tested?
8. Is there provision for a wide range of learning abilities and styles? If not, for what type of student is it intended?
9. What will it cost to implement? Is the cost feasible in terms of obtainable funds?
10. What changes will be necessary in personnel, time, space?
11. Is special teacher training necessary and, if so, are consultants available for this?
12. Does the package include all necessary materials or must the teacher still obtain certain things locally or by order?
13. What content areas are emphasized?
14. Can the program be coordinated with existing science programs or with the proposed curriculum?

Role of the Teacher

Since the teachers are the key agents in curricular change, it is important that they have a part in the study of materials and choice of them. It is essential that they understand the rationale and techniques necessary for implementing the materials and accept the curriculum design if they are to be successful in teaching it.

Probably the greatest teacher involvement comes in the trial classroom and evaluation stages where quantitative data as well as subjective judgments must be collected and fed back to the curriculum committee for consideration. When possible, it is wise to test some materials before purchasing a major commercial program. After testing, the following questions may aid in the evaluation:

1. How were the materials used?
2. What occurred when the materials were used?
3. What did students do? What did the teacher do?
4. What can students do now that they have used the materials?
5. What attitudes and perceptions do students hold about the materials and content?

A new curriculum is not something that can be installed completely at any given time; but rather, it is to be gradually put into effect as decisions are made regarding staff and resources. Constant adaptation and evolution of the program will be accomplished by teacher feedback and team planning. No project developed is the final answer—teachers must adapt materials to their own situations and to their own students.

Role of the Community

Parents want to know what is going on in their schools, and become involved, but science has become so sophisticated that parents and other school patrons often feel left out. Members of the community may become involved by initiating curriculum change. For example, a community with a specialized industry, such as aerospace technology, may want aerospace science courses in the school. It is important that the community be informed of the nature of the experimental materials and methodology. Public schools are the people's business and involving a variety of people in the changes and decisions enhances the success of the programs.

Role of the Administrator

The administrator must know the present state of science education within his district and must help in planning for continual improvement. This is essential if the science curriculum is to effectively serve the entire range of students, from those who end their formal science study early to those who become professional scientists and engineers.

He is in a position to be able to work out lines of communication for continuous study and revision and make efficient use of available staff, facilities, and funds for the program. Cooperation and assistance of all personnel is needed for effective implementation of a new science instructional program on a district-wide basis.

Role of the Local Science Coordinator

The science coordinator is responsible for:

1. surveys on the effectiveness of current programs
2. contracts with federal and state agencies, foundations, and industries for the procurement of funds and support
3. contact with professional societies and institutions for resource people and materials
4. identification of master teachers to assist with the program
5. dissemination of information to all school personnel
6. piloting new programs
7. coordination of curriculum
8. teacher inservice education

Implementation of the Curriculum

Following the planning stages, the task remains to construct a strategy for curriculum installation, complete with distinct components and approximate implementation dates. The teachers scheduled for involvement in the curriculum installation should personally volunteer or agree to participate.

The philosophy and objectives of the new curriculum should be understood by school board members, parents and students. The program must not begin until all the required curriculum guides, other materials, equipment, and facilities are available for use.

Phases to be considered in the process of curriculum implementation include:

Phase I—Initiation of the Idea to implement New Curricula

Phase II—Exploration of Curriculum Alternatives

Phase III—Decision to Implement

Phase IV—Pre-Installation Training of Personnel

A teacher training program should be organized for the attainment of definite competencies and experience in using the program materials as they were intended. Practice in the use of the materials and thorough examination of course content, sequence, rationale and teaching strategies should be included. Participating teachers should have an opportunity to view live or filmed models of the instructional methodology as prescribe by the developers of the new curriculum.

Phase V—Post-Installation Activities (recommended by The Council of State Science Supervisors in *Science Curriculum in the States.*)

"Many new curricula, whether developed locally or on a larger scale, include radical departures from traditional teaching strategies and impose new roles upon administrators, teachers, students, and other members of the educational community. If the implementation of such curricula is to be relatively smooth and lasting, it must also include post-installation activities among its components. Such activities include:

a. Establishment of a staffed, on-site resource center to provide materials as they are needed and such other day-to-day assistance as is necessary.

b. Continuing inservice course work designed to supplement and enhance the curriculum implementation.

c. Periodic meetings of involved teaching and administrative personnel to discuss mutual observations, to share ideas and concerns, and to continually assess the curriculum implementation.

d. A regular program of maintenance of equipment and consumable supplies necessary to conduct the program.

e. Visitations to evaluate the status of the implementation process and to make recommendations for further progress."

Phase VI—Evaluation

A new curriculum is implemented to bring about a desirable educational change in the community which the curriculum serves. It is very important that a strategy be provided that will indicate the degree of success in reaching the educational goals that were established at the beginning of the curriculum project. All programs should be reevaluated and revised periodically but special studies should be made at the end of the first year's trial.

Appendix I

Conceptual Schemes For Science

From the NSTA Publication "Theory into Action"

1. All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.
2. Matter exists in the form of units which can be classified into hierarchies of organizational levels.
3. The behavior of matter in the universe can be described on a statistical basis.
4. Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.
5. All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.
6. One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, and gaseous.
7. All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

Appendix II

Science Process Skills

By the end of the 8th grade, students should have developed the following skills:

1. Observing
2. Classifying
3. Inferring
4. Predicting
5. Measuring
6. Communicating
7. Interpreting Data
8. Making Operational Definitions
9. Formulating questions and Hypotheses
10. Experimenting
11. Formulating Models

Appendix III

Characteristics of a Scientifically Literate Person

In the NSTA Position Statement on School Science Education for the 70's, the following characteristics were listed to describe the scientifically literate person. These characteristics should also be considered when looking at student behavior in science:

- *"uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and with his environment*
- *understands that scientific knowledge depends upon the inquiry process and upon conceptual theories*
- *distinguishes between scientific evidence and personal opinion*
- *identifies the relationship between facts and theory*
- *recognizes the limitations as well as the usefulness of science and technology in advancing human welfare*
- *understands the interrelationships between science technology and other facets of society, including social and economic development*
- *recognizes the human origin of science and understands that scientific knowledge is tentative, subject to change as evidence accumulates*
- *has sufficient knowledge and experience so that he can appreciate the scientific work being carried out by others*
- *has a richer and more exciting view of the world as a result of his science education*
- *has adopted values similar to those that underlie science so that he can use and enjoy science for its intellectual stimulation, its elegance of explanation, and its excitement of inquiry*
- *continues to inquire and increase his scientific knowledge through his life"*

Appendix IV

Facilities and Equipment Grades K-8

While a student-oriented science program in the elementary and middle school does not call for elaborate, sophisticated facilities and equipment, certain items are absolutely essenital to any science room. These are:

1. Sufficient space to provide flexibility of furniture arrangement is necessary for a variety of activities and learning styles. Space is also a safety factor. Crowding of actively participating children increases the chance of accidents. Space is also necessary for display and construction of student projects.
2. Each room should be provided with large sinks and running water. Each room should be provided with at least four double electrical outlets.
3. Tables or flat top desks which may be arranged in a variety of ways for a variety of activities.
4. Safety equipment should be located in any room in which science activities are conducted involving strong chemicals or open flames. This should include a first-aid kit, fire extinguisher and eye protection devices.
5. Scientific equipment and other learning materials should be provided in sufficient quantity and quality to allow active participation of all students. These materials should be varied enough to meet the diverse needs of students and should include up-to-date reference and audiovisual materials as well as scientific and household supplies. These materials should be readily accessible to students as well as teachers. Learning materials and equipment should be procured in accordance with the objectives of the science program which the school has adopted.
6. The learning environment should include the total cultural and physical environment. Schoolgrounds and other outdoor areas of the community should be utilized and, where possible, developed for increased learning opportunities.
7. Adequate storage space is essential for efficient management of a science program. Two kinds of storage are possible:

   a. Individual classroom storage—If a packaged program has been obtained, adequate storage space to maintain this material should be provided in the room where it is used. In all classrooms where science is taught, storage space should be available for the most frequently used equipment and supplies (wire, bottles, jars, cans).

   b. Central storage — where items used by many teachers may be conveniently stored (microscopes, models). This room should be accessible to all teachers and should be under the supervision of a teacher familiar with the equipment. To facilitate checkout of materials, items may be assigned a number and each teacher given a list of the items stored.

   For example:

Number	Item	Quantity
2750	Bar magnet	40
2751	Horseshoe magnet	10

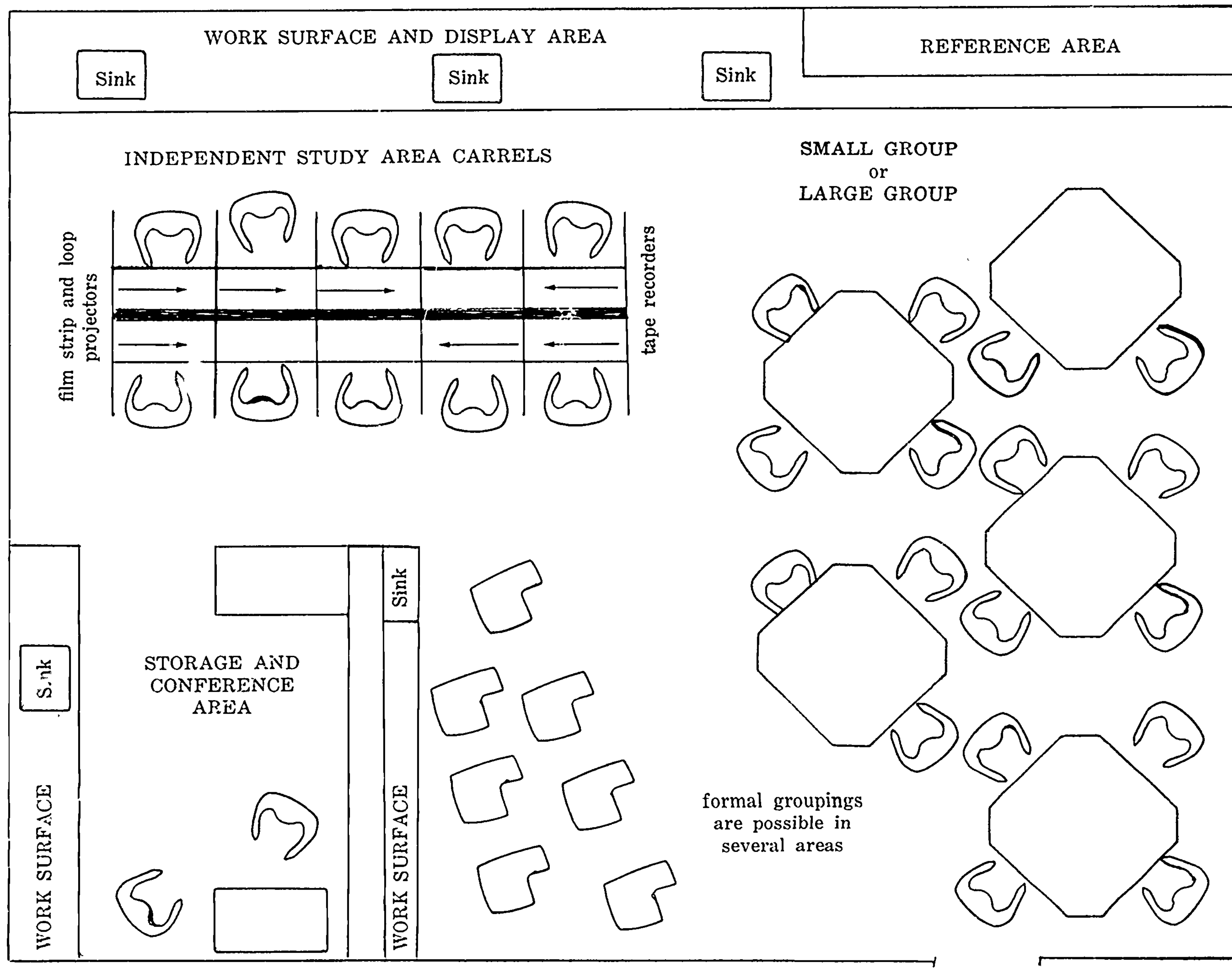
   The boxes in which items are stored should be labeled with the same information. Carts could be provided for moving materials. One basic rule for storage should be, "Always return equipment to the proper place, clean and in operating condition."

Students learn because they have the right combination of experiences at the optimum time of their receptivity. The activities, as well as the instructional design, school design, and organizational structure, should assist in the process of learning.

Each room should have areas for independent work, study, reading, and special projects; areas for small and large group discussion and activity; areas for display; areas for storage and preparation; and an area for conferences. (see figure 1)

Inadequate physical facilities should never be a legitimate reason for failure to implement an inquiry approach to learning. Working space may be any flat surface—ideally a table top but floor space is adequate. Side tables or shelves are necessary for display of materials—references, aquaria, terraria, bones, rocks, shells, etc. These materials should be accessible to students for observation, handling and investigation. A science program utilizing materials from a child's own environment can have more meaning to him than one which is built around sophisticated scientific equipment. The important thing is that he have materials to work with and that he is provided with the time, space and opportunity to use them.

AREAS PROVIDING FOR VARIED LEARNING STYLES



Appendix V

Safety in Science

The following has been adapted wi:': permission from *Children Learn Science*, A Guide for Elementary School Teachers, prepared by the Public Schools of Hammond, Indiana, by Gerald D. Spitzer, Coor'':nator of Science and Health and Anne Hopman, Director of Elementary Education.

Safety Practices for Teachers

1. If there is a question about hazards in working with the materials and equipment, the watchword is "DON'T".
2. Handle the equipment and materials prior to student usage to discover all possible hazards, and be sure that the intended experience is a reasonably safe one before proceeding.
3. Practice general safety procedures i:. relation to the use of fire and instruct children in how to take appropriate precautions. Consult with the principal regarding fire regulations.
4. At the beginning of any experience, which is hazardous, instruct the children regarding the recognition of dangers and the precautions to be taken. This includes experimentation and study trips.
5. If children are working in groups with limited amounts of equipment, limit the number in each group to prevent confusion which might result in accidents.
6. When using equipment that might present special hazards, individual and group work should be arranged in the classroom so there can be constant teacher supervision.
7. Insist that all accidents resulting from the handling of equipment be reported to the teacher.
8. Warn the children never to carry equipment through the halls when classes are passing.
9. Allow the children sufficient time to perform experiments, because haste sometimes causes accidents.
10. A child should not perform any experiments, at school and in the home, without thorough investigation by the teacher before a child proceeds.
11. Any piece of equipment that has been heated (microprojector, hot plates, A. V. devices) should not be moved until it has cooled.
12. Hazardous materials and equipment not in use should be labeled, "KEEP HANDS OFF."
13. Before permitting children to work with sharp tools, the teacher must be assured that children are competent to use these tools.
14. There is always danger when heating a liquid which is confined in a container.
15. Glass wool and steel wool should be handled with gloves.

Safety in relation to Animals and Plants

1. All mammals used in a classroom should be innoculated for rabies, unless purchased from a reliable scientific company.
2. The following animals should never be brought into the classroom: wild rabbits, snapping turtles, poisonous snakes, and insects that may be disease carriers. Teachers should not encourage children to bring their pets, such as dogs and cats, to the classroom.
3. Before a small animal is brought into the classroom for observation, plans should be made for proper habitat and food. The living quarters of animals in the classroom must be kept clean, free from contamination, and secure for the confinement of the animals. Plans should be made for animal care over the weekends and during vacation periods.
4. Handle animals only if it is necessary. This handling should be done properly according to the particular animal. Special handling is required if the animal is excited, is pregnant, or is with its young.
5. Children should wash their hands after handling turtles, snakes, fish, frogs, toads, etc. Water from the habitat should be disposed of carefully.
6. Children should be cautioned never to tease animals nor to insert their fingers or objects through an animal's wire-mesh cage.
7. Report any animal bites or scratches immediately to the school nurse.
8. After a period of animal observation is completed, return the animals to their natural environment.
9. Before taking study trips into wooded areas, identify and discuss the plants which could produce poisonous effects.
10. Use flowers and molds which have excessive spores with caution because of possible allergies of children.
11. There is great danger of contamination from bacteria cultures unless sterile techniques are used.

Safety with Chemicals

1. Label all bottles, identifying the contents, at all times.
2. Pupils should never test unknown chemicals by the senses of taste or touch.
3. Chemicals should never be mixed just to see what will happen.
4. If volatile or flammable liquids are used in a demonstration, extreme care should be taken so that hot plates or open flames are at a safe distance from the fumes.
5. Store rosin, shellac, alcohols, and charcoal in bottles with plastic tops or glass stoppers.
6. Keep combustible materials in a metal cabinet equipped with a lock.
7. Store chemicals in a cool place but not in a refrigerator.
8. Children should never experiment with rocket fuel propulsion devices.
9. Dispose of spilled volatile substances in fireproof receptacles.
10. The use of preservatives (formaldehyde and alcohol) demands protection to the skin. Wash preserved specimens in clean water and keep them in saltwater for use during the day. Use tongs and rubber gloves to remove specimens from preservatives.

Safety with Electricity

1. At the beginning of any unit on electricity, tell children not to experiment with the electric current of home and school circuits.
2. Children need to be taught safety precautions for use of electricity in all everyday situations.
3. Children should never handle electric devices immediately after use, because these devices might retain a high temperature for a period of time.
4. To remove an electric plug from a socket, the plug should be pulled and not the cord.
5. Short-circuited dry cells can produce a high temperature which can cause a serious burn.
6. Storage batteries are dangerous because of the acids used and the possibility of a short circuit.

Safety with Glassware

1. Only Pyrex or other heat-treated glassware can be heated.
2. Polish or bevel with emery paper the edges of glass tubing used with corks or stoppers.
3. Use a soap solution or glycerine on glass rods or tubing for lubrication before inserting into a cork or stopper. Wrap the tubing with several layers of cloth or use a rubber tubing holder. Hold the tubing as close to the cork as possible.
4. Remove corks from tubing to keep from adhering and "freezing." "Frozen" stoppers can be removed by splitting them with a razor blade and then reclosing them with rubber glue.
5. Dispose of broken glassware in a special containers marked "BROKEN GLASS."
6. Never pick up broken glass with the fingers. A whisk broom and dustpan can be used for large pieces, and large pieces of wet cotton can be used for small pieces.
7. Clean glassware thoroughly after use.
8. Children should never be allowed to drink from glassware used for science experimentation.
9. Children should report sharp edges on mirrors or glassware to the teacher.
10. Wrap glass objects which might break with plastic wrappers or wire screening.

Appendix VI

Periodicals for Children

My Weekly Surprise—K level—a picture magazine

My Weekly Reader—Grades 1-6, contains a science section
American Education Publications
Education Center
Columbus, Ohio 43216

Ranger Rick's Nature Magazine
National Wildlife Federation
1412-16th Street, N.W.
Washington, D. C. 20036

Curious Naturalist
National Audubon Society
1130 Fifth Avenue
New York, N. Y. 10028

Nature and Science
American Museum of Natural History
Central Park West at 79th Street
New York, N. Y. 10024

Rocks and Minerals
Rocks and Minerals Magazine
Peekskill, N. Y. 10566

Science News
Science Service, Inc.
1719 N. Street, N. W.
Washington, D. C. 20036

Aquarium
Pet Books, Inc.
53 E. Main Street
Norristown, Pa. 19404

National Parks Magazine
National Parks Magazine
1710 18th St., N. W.
Washington, D. C. 20009

Appendix VII

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Science and Children. National Science Teachers Assoc., 1201 Sixteenth St., Washington, D. C.

Appendix IX

Pertinent NSTA Publications

Annual Self-Inventory for Science Teachers in Secondary School	NSTA	$1
Bibliography of Textbooks and Courses of Study for Science Teaching—K-12	471-14362	$2
Conditions for Good Science Teaching in Secondary Schools	NSTA	$2
Environmental Education for Everyone—Bibliography of Curriculum Materials for Environmental Studies	471-14600	.75
Issues in Elementary School Science	471-14328	$1
Why Behavioral Objectives? Audiovisual Aid	NSTA, week	$4
Bibliography of Textbooks and Courses of Study for Science Teaching K-12	471-14362	$2
Behavioral Objectives in the Affective Domain	471-14582	$2
Building Curricular Structures for Science: With Special Reference to the Junior High School	471-14542	$1
Learning and Creativity: With Special Emphasis on Science	471-14544	$2
Report of a Conference on Interdisciplinary Science Education	NSTA	$2
Theory into Action in Science Curriculum Development	471-14282	$1.50
How to Care for Living Things in the Classroom	471-14288	.35
How to Teach Science Through Field Studies	471-14290	.35
How to Individualize Science Instruction in the Elementary School	471-14294	.35
How to Evaluate Science Learning in the Elementary School	471-14564	.35
How to Provide for Safety in the Science Laboratory	471-14576	.35
How to Teach Measurements in Elementary School Science	471-14580	.35
How to Plan and Organize Team Teaching in Elementary School Science	471-14594	.35
How to Use Behavioral Objectives in Science Instruction	471-14596	.35
Teaching Tips from TST (1967)		
Biological Science	471-14526	$5
Physical Science	471-14348	$5
Earth-Space Science	471-14350	$4
Ideas for Teaching Science in the Junior High School	471-14184	$4
Computers—Theory and Uses		
Student's Manual	471-14224	$1
Teacher's Guide	471-14226	$1
Helping Children Learn Science	471-14498	$3
Investigating Science With Children	478-14280	$14.95

These publications may be ordered from:
National Science Teachers Association
1201 Sixteenth Street, N. W.
Washington, D. C. 20036

Appendix X

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