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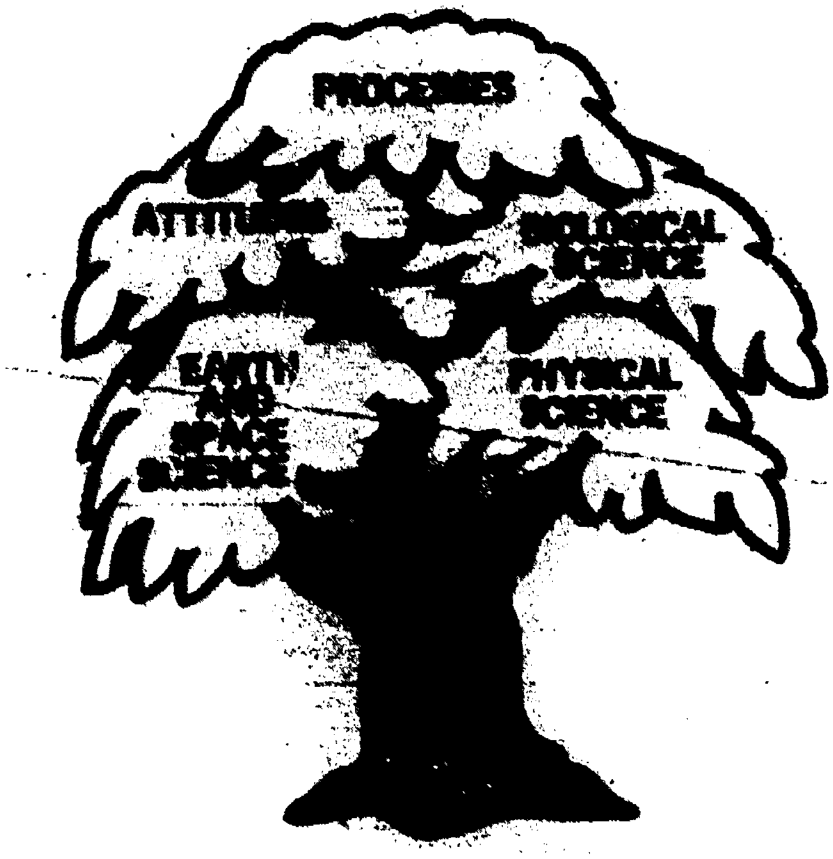
ABSTRACT

This document provides information about Science Unlimited (SU), the elementary school science effort of the Pennsylvania Department of Education. (The philosophy and characteristics of SU continue the earlier Pennsylvania science program effort entitled Investigative Science in Elementary Education.) The document includes: (1) a list of SU activities (indicating that 30 weeks of televised science instruction are available for primary and intermediate grades); (2) a list of 12 SU aims, accompanied by a description of the assumption that produced the choice of that aim for the instructional program; (3) a discussion of reading and relationship of textbooks to SU; (4) examples of how science relates to reading, language arts, mathematics, social studies, self-concept, creativity, career awareness, and women in science; (5) characteristics of highly desirable and less desirable science programs; (6) examples of science taught using living things, with learning centers, and outside the classroom; (7) examples of evaluation methods in science; (8) sources of science materials; (9) safety considerations; and (10) a summary (in chart format) of selected information about children and their thinking derived from the contributions of Jean Piaget and his co-workers. (JN)



SCIENCE UNLIMITED

Pennsylvania's Resource Guide for Elementary Science

Pennsylvania Department of Education 1984
Commonwealth Institute for the Improvement of Science and Mathematics Education

COMMONWEALTH OF PENNSYLVANIA
Dick Thornburgh, Governor

DEPARTMENT OF EDUCATION
Robert C. Wilburn, Secretary

OFFICE OF BASIC EDUCATION
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June 1984

Preface

The elementary school science effort of the Pennsylvania Department of Education has been named SCIENCE UNLIMITED. The intent of this effort is to aid teachers in teaching science.

Improving science programs in Pennsylvania's Elementary Schools is one of three priorities of the Commonwealth Institute for the Improvement of Science and Mathematics Education, established by Governor Dick Thornburgh on March 1984 to develop and coordinate programs and training opportunities which support and upgrade the skills of the state's mathematics and science teachers.

The Institute is one component of Pennsylvania's Comprehensive Plan for the Improvement of Science and Mathematics Education, prepared in response to the Governor's blueprint for educational reform, "Turning the Tide: An Agenda for Excellence in Pennsylvania Public Schools."

The philosophy and characteristics of SCIENCE UNLIMITED continue the earlier Pennsylvania science program effort entitled Investigative Science in Elementary Education (ISEE). This earlier effort has been greatly expanded to include:

- A K-6 Student Competency Continuum.
- A Competency Matrix which matches the given competencies with (1) appropriate video programs, (2) the processes, attitudes and content involved, (3) the written hands-on lessons, (4) the textbook content list, and (5) appropriate computer software.
- Thirty weeks of televised instruction for primary and intermediate grades.
- A detailed teachers manual for primary grades and another for the intermediate grades.
- A source of instant help and/or direct assistance to teachers by calling the toll-free SCIENCE UNLIMITED Hotline, 1-800-TELESCI between the hours of 9:00 a.m. and 4:00 p.m.
- A diagnostic/prescriptive review of your existing science program to pinpoint its strengths and weaknesses and to provide recommendations for remedial steps.
- A low cost method of teaching science without the need to purchase expensive equipment. SCIENCE UNLIMITED makes use of everyday, inexpensive items which are easily obtainable to teach inquiry science.
- An articulated teacher training program to provide in-service training at many levels and locations.

We feel that it is especially important for teachers to understand that while students are learning science today, they are in fact preparing for a world of tomorrow. If we are to be successful in educating students for the future, we will need to develop in students critical thinking skills and, equally important, an understanding of the basic concepts of science through experiences that guide students through interactions with materials and ideas. A world of rapid change requires continuous learning and the ability to learn independently -- the two main goals of the SCIENCE UNLIMITED resources.

Student study of science should contribute to the development of wholesome attitudes and a sense of responsibility for behavior. The objectivity of science does not preclude concern for living things, nor should students be allowed to interpret scientists as devoid of concern for the potential impact of their work on the world around them. Student experimentation must not lack feeling if it is to contribute to a better understanding of the work of scientists and the nature of scientific study. In addition, teachers should not abandon sensitive and humane behavior in the study of science if it is their desire to portray scientific behavior as it really occurs.

Science and scientific behavior should be portrayed as normal, and inquiry behavior as characteristic of human curiosity. Except for the careful attention to evidence and replicability, the study of science is essentially the same as the study of other academic fields.

In summary, this guide is designed to provide information about the goals, philosophy and resources that are part of the ISEE effort. The sections of the guide are arranged to answer questions which are expected to arise in the minds of teachers. Additional resources, including other guides, separate classroom lessons and instructional television materials, are described in another section. In every instance, these resources are correlated to the aims of the program and designed to help teachers teach science effectively.

SCIENCE UNLIMITED AIMS

SCIENCE UNLIMITED is committed to instruction which recognizes that learning is gradual and cumulative. Concepts are not taught to children; they are evolved by children as they broaden and deepen their experiences. For example, a person's concept of magnetism is a dynamic one, changing, growing, deepening through each new purposeful experience with magnets and through each thoughtful consideration of reading material related to the topic. So too, a person's understanding, appreciation and skill in each of the various science processes evolves bit by bit in a cumulative pattern through sequential opportunities to use these skills in a wide variety of investigations.

Eleven aims were developed in recognition of this important and dynamic aspect of learning. Each lesson provides experiences which help children grow in the direction of the aims identified for that lesson. Thus, over a period of time, teachers should be able to observe evidences of student growth in the categories identified in the list of aims.

The list of aims is not all-inclusive. Teachers and schools are encouraged to expand this list to reflect their own value system and long-term instructional goals. Further, each aim presented below is accompanied by a description of the assumption that produced the choice of that aim for the instructional program.

Assumption	Aim
1. Assuming that skill in the use of science processes is essential to the scientific literacy of citizens in a democracy...	...students will demonstrate competency in the use of the processes by (a) observing, (b) classifying, (c) communicating, (d) measuring, (e) inferring, (f) formulating hypotheses, (g) interpreting data, (h) controlling variables, (i) experimenting and (j) predicting.
2. Assuming that the ability to solve problems will always be a skill required of our citizenry...	...students will solve problems by gathering data, using equipment and materials, observing purposefully and drawing appropriate conclusions based on their findings.
3. Assuming that is important for students to improve their skill in asking questions and that students are motivated to learn more when they pursue answers to their own questions...	...students will develop and ask questions of their environment. They will also use answers to questions to describe, clarify, and analyze problems.
4. Assuming that quantification and the correlation of measurement are integral to the study of science...	...students will measure (with English and metric units), gather data and use this data to solve problems.

5. Assuming that investigative evidence through observations is a foundation for generating knowledge.	...the students will observe and record data in a form that is convenient for interpretation.
6. Assuming that the result of any scientific investigation is limited by its nature...	...the students will identify examples of scientific hypotheses and theories as evidence that our interpretation of truth changes as our knowledge increases.
7. Assuming that scientific evidence is an effective means of solving problems...	...the students will defend points of view by making use of supporting scientific evidence.
8. Assuming that the ultimate goal of formal education is to guide students toward the goal of self-education...	...the students will demonstrate a desire to learn and a curiosity for the unknown by formulating and performing self-motivated science investigations and readings of their own outside the formal confines of science classes.
9. Assuming that critical thinking is part of science study and integral to basic education...	...the student will discriminate between (a) observation and inference (b) fact and theory (c) evidence and proof (d) summation and analysis
10. Assuming that some legitimate science topics lend themselves better to exploration of printed sources than hands on investigation...	...the students will demonstrate a competent use of textbooks, reference books, tables of contents, indexes and glossaries to obtain information.
11. Assuming that as students grow to adulthood they need to continually reevaluate and interpret their environment so that they may become responsible citizens who base their political and economic decisions on democratic values...	...the students will reach increasingly sophisticated, scientific explanations as they mature.
12. Assuming that an adequate supply of both trained scientists and technicians is essential to the future well-being of our society...	...the student will identify the role of both pure and applied science in our society and the role of science in helping to solve current problems.

Reading and the Relationship of Textbooks to SCIENCE UNLIMITED

SCIENCE UNLIMITED recognizes the potential of using textbooks to help children learn about science. However, so that science does not become merely an adjunct to the daily reading program, some discretion in the use of science textbooks is necessary.

First, children not old enough to read, and those who have just begun to read benefit little from exploring science through the printed word. This means that reading should play a minor role in the primary science program.

Second, it is probably wiser to sequence science activities from direct, hands-on investigations to reading, rather than the reverse - even at the intermediate level. Accumulating firsthand perceptions through the senses during many of the SCIENCE UNLIMITED activities serves as a foundation for the child, who then turns to reading to progress well beyond the immediate environment.

Third, there are science topics, such as prehistoric life, nuclear energy, earthquakes and eclipses, which have only limited potential to involve children in direct investigations. If we believe the exploration of such topics is important, it is quite obvious that less direct means, such as reading, films and models, will play a major role in learning We could further assume that topics of this nature might best be reserved for older children who handle the skill of reading adequately.

Ideally, teachers might have on their classroom bookshelves 25 or 30 recently written textbooks, four or five from each of five or six publishing companies representing several reading (grade) levels. These, added to conventional reference books, serve as a science reference library for children. Children can then build on the knowledge they derived from firsthand investigations, thus making a particular science concept or principle more complete.

In the past, science textbooks dictated what the child and teacher should do. Instead, it is advisable that children and teachers determine what the textbook should do for them.

Science, Basic Skills, and the Overall School Curriculum

Despite the demonstrated success of the national elementary science programs (Elementary Science Study, Science Curriculum Improvement Study, Science - A Process Approach), and despite state mandates that science be taught in all elementary grades, studies show that many children receive little or no science instruction in elementary school. Of those who do, too few experience the kind of contemporary science learning represented by SCIENCE UNLIMITED.

This circumstance will change only when both teachers and administrators believe that quality science instruction is an important, if not essential, means to accomplish those goals to which their overall elementary school program is committed. Most elementary schools build curriculum around a set of broad, student-oriented goals, including:

. Achieving individual growth potential in reading, language.

. Arts and mathematics.

. Developing positive self concept.

. Acquiring skills for self-motivated lifetime learning.

. Developing desirable interests and attitudes important to the role of a member of society (i.e., citizen, family member, worker).

SCIENCE UNLIMITED type science encourages teachers to break down arbitrary barriers between subject matter instruction. Basic skills are taught because they are important to success in living. Too often children think that reading is "what you do during reading class" rather than a tool for pleasure and for obtaining needed information. Mathematics skills are gained vicariously whenever children learn them as isolated exercises from a book. Mathematical skills become functional when they are used and refined in a variety of curricular and personal-living situations. Thinking, creativity and self-concepts, for instance, are best developed in students when school experiences encourage such growth.

The kind of science instruction advocated by SCIENCE UNLIMITED leads to the achievement of long-range goals of elementary education for today's children. Elementary science, with its high interest level, its experience approach and its emphasis on process skills and communication, is a power-packed means of helping teachers accomplish what they are trying to do for their children. Budgeting time to assure that science will be taught, providing resources for a hands-on science program, encouraging in-service growth for contemporary science teaching and providing encouragement and recognition for good science teaching can do much for children's growth. The following are examples of how science relates to other subjects in the elementary school program:

<u>READING</u>. Both formal and informal research has shown that elementary science can stimulate and generate growth in reading skills.

1. The science skills of observing, inferring, identifying characteristics, classifying, and serial ordering are basic to beginning and early stages of learning to read.

2. Experience charts resulting from science activities are useful for both reading and science learning.

3. Many science experiences can lead to "reading with a purpose." Children may want to find out more about something they are investigating and seek additional activities from books: they might want to compare their investigation outcomes with what has been written; they may need help from books to successfully care for new plants or animals brought into the classroom; or they may seek directions for making a piece of equipment. Most school and community libraries have useful tradebooks and reference sources to answer student questions as: "I want to know" or "I want to find out" or "I (we) want to know more about." Such questions are outgrowths of contemporary science-learning experiences. As schools develop their own science programs, they can add pertinent library resource materials which can serve the dual purpose of science and reading.

When used wisely, science textbooks can provide the resources to integrate learning activities of both science and reading. Experiences should precede reading. Then, after children have been exposed to new vocabulary words in the context of experiences and after they have acquired insight into concepts, they are ready to read related materials with individual help as needed. Several textbook series, each spanning more than one grade, best meet individual needs. In this way, children who develop interests during science investigations can choose from books catering to a variety of reading levels.

By helping children use assorted science textbooks and relevant library sources, a teacher can allocate some reading time to science. Through this approach, children learn and use library skills -- not as isolated skill exercises, but as a means to an end which is important and useful to them. Such an approach helps pupils develop their vocabulary, increases their enjoyment of reading and stimulates in them a desire for reading for information. Contemporary science helps change "learning to read" into "reading to learn".

LANGUAGE ARTS. Science instruction is inevitably language arts instruction. In science, the basic skill of communication is continually developed in terms of both listening and the ability to communicate ideas to others. Useful science vocabulary offers students many opportunities to develop word-analysis skills. Record-keeping, graphing, making charts and drawing and interpreting diagrams frequently are part of investigative science.

All children can have an opportunity to make written and oral reports with the help of the teacher. Some science experiences lend themselves to creative writing and some science studies offer children a potential to produce bulletin boards, school exhibits and newspaper articles. When children find little or no library material on a topic they have been investigating, they may even enjoy, and learn much from, producing a book for others to use. Language arts instruction will be most successful when it is a natural component of something children want or need to do.

MATHEMATICS. Science is strongly based on mathematics. Many elementary science teachers have negative feelings toward science as a result of having been required to struggle earlier in their life with complicated mathematics formulas for which they did not have the necessary experience.

Simple mathematics, an integral part of many elementary science activities, can replace, supplement or strengthen parts of the existing elementary mathematics curriculum. The skills, processes and facts of the elementary mathematics program should be put to work whenever they are useful to any learning or living situation. Practical use is more effective than an isolated task completed to pass a test or earn a grade.

Elementary science offers opportunities for mathematics readiness experiences. Shapes, symmetry, experiences with area and volume concepts, observation and discussion of acceleration, simple graphing, averaging, measuring, balancing, identifying and stating relationships are examples of ways in which science experiences can enhance the mathematics curriculum.

A timely contribution of science to mathematics is the functional teaching of the metric system. Children can and should measure and work with length, area, volume, weight and temperature in metric units whenever opportunities arise in their investigations.

SOCIAL STUDIES. Many elementary teachers already integrate science and social studies in creative ways. The current concern for environmental education provides abundant opportunities to blend science and social science.

Many skills emphasized in science are also basic to contemporary social studies, i.e., observing, inferring, seeking and evaluating evidence; open-mindedness, critical thinking; using reference materials; organizing and interpreting data; developing or sustaining interest in learning.

These goals are basic to education for one's role as a citizen, a consumer, or an individual in society. It is not surprising that these goals reappear in several curricular areas. They are transferable, but the likelihood of transfer depends upon instruction which encourages learners to apply their skills in new learning situations. Science instruction can provide students many direct opportunities to introduce and apply a variety of basic skills for living.

SELF-CONCEPT. The importance of building and maintaining a child's self-concept is widely recognized. Inasmuch as science instruction allows acceptance of answers limited by what a child has experienced and can mentally interpret, children with a wide range of ability can succeed in science. Science advocates internal rather than external motivation of students. Science encourages self-correction and emphasizes that ideas are subject to reexamination when new information becomes available. Science further emphasizes using communication skills, helps learners minimize the chance of their being misinterpreted, allows them to contribute to what is under discussion and helps them express their thoughts.

CREATIVITY. Investigative science thrives on creativity. Creative thinking is important in observing and inferring, in raising questions for further study, in reorganizing data and in planning ways to seek answers to questions. The opportunity and the need for creativity are often associated with improving and designing equipment in elementary science programs just as in the design of equipment for science research laboratories. Much of science deals with mental images, built from limited, direct evidence used to infer the possible structure or relationships of that which we cannot observe directly. Creative thinking, which yields a variety of models to fit existing evidence, is important because it leads to the gathering of additional evidence needed to select the most fitting mental model. Drawing diagrams to explain what has happened often calls for creativity. Creativity develops and thrives as children are encouraged to go their own way to find "best" answers rather than follow the "beaten path" to a right answer. Teachers are encouraged to avoid short-circuiting students' creative thinking when such thinking goes counter to the teacher's own ideas.

CAREER AWARENESS. A quality elementary science program cannot, and should not, be justified primarily for its importance in launching children on their way to science and science-related careers. Only a small percentage of elementary children will eventually enter professional or related nonprofessional science work.

However, the career guidance aspect of the elementary science program is important. Research shows that science-related career decisions are strongly influenced, or often made, during early school years. As we help children develop basic science skills, discover the spirit of investigation, recognize the mathematical nature of science and deal with content from the various science fields, we make them develop possible interests and aptitudes for science-related careers.

Early explorations in science are also important for children who will not pursue science-related careers. Science and technology depend on a scientifically literate society: people who understand layman-level reports on the work of scientists who influence research; people who can use and evaluate the products of science and technology; resolving problems in their work, hobbies, human relations, citizenship and more.

WOMEN IN SCIENCE. There is considerable information and research to show that most girls are turned away from science and science interests in school, particularly at the intermediate elementary level and again in the junior high school. It has been further documented that the choice of becoming a scientist is frequently made by students before the end of their eighth year in school; therefore it is the responsibility of the elementary school to encourage a positive view of scientists and their work.

Elementary teachers need to be aware of how much their teaching influences students in choosing careers and behavior models. It is also important for teachers to emphasize activities that highlight the nature of science without characterizing it as a male enterprise dominated by middle-class values.

Elementary teachers can help alleviate this problem in part by being aware of it when they plan their science curriculum. The following classroom activities are suggest to help encourage girls to view science in a more positive way:

1. Encourage girls as well as boys to manipulate materials and equipment in science.

2. Enlist the help of girls in "scrounging" needed science materials, equipment, and supplies for the classroom.

3. Designate girls as leaders in science groups as often as possible.

4. Use girls as laboratory assistants.

5. Call on girls to talk and write about the "experiments" or "research" at least as often as boys.

6. Serve as a personal role model by teaching science and being a "scientist" yourself if you are a woman.

7. Invite from your community females who are working in science.

8. Use every opportunity to highlight both present and past activities of women scientists.

Further information about women in science can be obtained from the Department of Education posters, Women in Science.

THE LEARNING ENVIRONMENT

The learning environment is more than "things." It's the way children, materials and the teacher interact. Both the youngsters and the teachers should derive satisfaction from what goes on in the classroom most of the time. Some of the characteristics of a healthy learning framework for science are unique to science but much of what constitutes successful learning experiences can be equally applicable to other curriculums.

If investigative processes are the focus of a lesson, the spirit of investigation will prevail. There will be no right or wrong answers, but rather a sequence of progression toward conclusions about which an individual feels increasingly more confident. The teacher should not be the only authority, nor should books be the final authorities. Rather these should all be resources to aid in investigation. Scientists turn to library materials or to colleagues for facts, ideas or techniques; but, the experiment, the behavior of the materials which they are investigating, is a source of dependable answers. The "goodness" of these answers depends on how skillfully questions were asked and how well investigative procedures were conducted.

If subject-matter learning is the main focus, the teacher might well take a little time to examine his/her own perception of the value of the material and continually try to strengthen his/her own understanding. Teachers should use each question (their own or their students') which they can't honestly answer as an opportunity to extend learning rather than as an embarrassment. They should share enthusiasm for learning something new with children, knowing that this is how learning is most contagious.

This means the teacher and students should feel successful when they derive answers (tentative or limited though they be) obtained from and justified by the evidence of, their investigation. Children (and teachers) must still feel challenged rather than defeated when a new fact suggests further modifications, rejections or extension of their answers (conclusions).

During any science lesson one can identify indicators or the philosophy and value system behind the instruction. The observations described below reflect the value system of SCIENCE UNLIMITED. Teachers might use this section to improve their instructional planning or to constructively evaluate a science lesson in progress, or in retrospect.

<u>Evidences of a Highly Desirable Science Program</u>	<u>Evidences of a Less Desirable Science Program</u>
1. Children are engaged in direct experiences with learning materials.	1. Children talk or read about science ideas without direct, "hands-on" experiences.
2. The science investigations in which children are engaged are efforts to identify questions, or to pursue answers to questions, which they have clearly identified.	2. The science activities are basically those of children following a procedure whose outcome is predetermined and prestated by a book or the teacher.

3. Children discuss, defend and modify ideas together, with the teacher participating and guiding influence rather than controlling. Discussion pattern might be student-student-student-teacher-student-student-student-etc.	3. Class discussion consists of student responses to the teacher's questions. Discussion patterns, almost exclusively, are teacher-student-teacher-student-etc., with little time allows for students to answer or thinking divergently.
4. Class discussions reflect an effort to arrive at tentative conclusions (and perhaps further questions) based on the evidence of experience (manipulation of material or investigation, reference work, past experiences of group).	4. Class discussions reflect a drill-type verbalization based on text reading or teacher statements.
5. Children have some opportunity and responsibility for identifying and planning investigations, usually after an initiating experience such as reading in a text, a demonstration presented in class or a timely question-stimulating event.	5. Children follow a prescribed sequence of steps in an activity, draw a predetermined conclusion and move on to the text topic.
6. The science investigation is continued long enough to enable children to understand the ideas with which they are working. Provision is made for individual differences by allowing some children to go further than the basic class project or to follow a different line of investigation.	6. Investigation or topic study is brought to a close at a predetermined time to enable the class to "cover" all topics included in the book or in the curriculum guide.
7. The study of a science topic reflects an attitude on the part of the teacher that development of the skills of science investigation is at least as important as the mastery of science subject matter.	7. Both the teaching and the testing reflect only a concern for the learning of factual science information.
8. The use, practice and extension of basic skills in mathematics and language arts are integral components of the science program.	8. The mathematical aspects of science investigations are avoided; new vocabulary words are introduced without structural analysis; and children are rarely given opportunity or responsibility for anything but one word answers in class discussion or tests.

9. Children are involved mentally in what they are doing: making decisions, asking questions, contributing ideas in terms of what has meaning for them and seems important or significant.	9. Children's behavior suggests that they are mainly concerned with the "right" answers if the teacher calls on them.
10. Children discuss what they are doing and what they have learned in their own words.	10. Children use mainly a set of "pat" phrases, which suggest verbalization rather than meaningful experience to describe what they are doing and to review what they have learned.
11. Most of the science program is investigative in nature. The topics chosen for study are those which can be (and are) studies through direct experiences.	11. Most of the topics chosen for study can only be studied through vicarious experiences such as reading, viewing films and teacher talk.

The Classroom

In many ways, the classroom environment can be managed so that it assumes an appreciable share of the science teaching load. The following illustrate ways in which science learning can take place throughout the day in an incidental way.

Living Things

The natural enthusiasm of children to bring plants and animals to school involves both opportunity and responsibility. A classroom environment of living things must reflect and foster a respect for life. The greater the variety of plants and animals children come to know well as they move through elementary school, the richer the background they bring to later experiences in biological studies, in plant and animal hobbies and in environmental attitudes. By encouraging practices of observation, questioning, description, cause-and-effect thinking, recordkeeping and humane experimentation with controlling variables (such as temperature, light, air), teachers can guide children so that the uses of these investigative skills become a meaningful part of the child's behavior. The children come to know the plants and animals in their classroom environment when the teacher is as curious and interested in them as the teacher wants the children to be.

The few examples listed below may suggest or lead teachers in search of some possibilities. Ideas for using plants and animals in the classroom are almost endless:

. Courtship, reproduction, and care of young -- mice, hamsters, gerbils, guinea pigs, fish (tropical and goldfish).

. Food chains and balance of nature -- aquariums and terrariums.

. Ecology -- varying environmental interrelationships of woodland, desert, bog and various types of plant and animal terrariums.

. Life histories, metamorphosis -- mealworms, grasshoppers, dragonflies, mosquitoes, praying mantis, moths, butterflies, fruit flies.

Children are encouraged to add to a terrarium as many new kinds of mosses, ferns, and other woodland plants as they can find, examining each new contribution and describing or drawing its characteristics; children are building a background of classification skills. Hopefully, spore producing structures will appear on some of the ferns and mosses. As these ripen the spore can be examined. As a result of this direct experience reading about the life cycle of these plant groups becomes meaningful. The class might even try to germinate the spores.

A Disney film is not the only way to come "eye to eye" with a creature such as a crayfish. Two crayfish fighting over a mealworm provides quite a show. Then there's the day when someone excitedly reports that "there's an extra crayfish in the jar" or "one of the crayfish died," though more careful investigation reveals that the crayfish shed its exoskeleton. This leads to an examination of this shed "skin" and to speculate on how it split and where the crayfish worked its way out of it. Someone notices how soft the crayfish is now, perhaps leading to a discussion of soft-shelled crabs or an examination of a batch of shrimp from a store to see the varying degree of hardness of their ...ter "coats." Perhaps the class will start keeping records of how often the ...ish sheds and try to find out whether food supply, season or temperature ...ts the frequency of shedding.

Plants add beauty to many classrooms and many teachers can use their own know-how or that of some "green thumb" house plant enthusiast (perhaps a senior citizen) to launch a plant study, such as vegetable propagation. Children can compare the relative virtues of water, soil and vermiculite as rooting mediums for cuttings. What plants and what parts of plants can root successfully? Are there certain times for successful cuttings? These and other questions gradually emerge in such a study, and the answers are best obtained by experimenting with plant cuttings. An open-minded, curious teacher will probably learn as much as the children.

Learning Centers

One or more centers should be established in the classroom so materials for science learning can be used freely by the children whenever they have time to work with them. These need not be elaborate displays nor highly structured centers. In fact, the simpler the better. A corner or table where science materials can be placed and simple directions, either written or oral, will do nicely. The following are examples:

a. The class is studying electromagnets during their science period. Several devices which use electromagnets are placed on a science table by the teacher, who also displays some books which show children how to make a homemade telegraph set, electromagnetic crane and motor. In a week or two some of the students will have made some of the apparatus, and all will have studied the equipment on the table. Two additional pieces of equipment such as a small electric motor or a toy that uses electromagnets can be brought from home. There have been many discussions at the science table and the teacher feels the class is now ready to share what they have found out and to answer some of their own questions.

b. A first grade class is about to investigate floating and sinking objects. To initiate the activity and to promote class discussion, the teacher has two students try to float several objects in an aquarium or dishpan filled with water. After the discussion, the dishpan of water and materials are moved to the science corner to permit other members of the class to investigate them at their leisure. The teacher adds a few items every day or so, and of course, the children bring in many items of their own to investigate.

c. Children had been reading about molds in their textbook. They brought in a few examples of moldy foods from home and grew some bread molds according to suggestions from their textbook. Questions began to arise as children use a magnifying glass to examine their growing collection. Under the guidance of the teacher, they planned some experiments which might answer some of their questions.

d. A collage is a creative way of developing classification skills in younger students. Magazines, newspapers and catalogs are placed on a table in a corner of the room for the activity. More than one collage can be made by having students choose examples of living and nonliving things.

Science Outside the Classroom

When within the confines of a school children often have little contact with the reality of nature. Their attention becomes focused upon the printed page, and many of their activities are limited to what can be accomplished within the walls of the classroom.

Education must be aimed at helping children learn to face reality. They need to learn about nature, people and the ways in which they interact and become interdependent. To accomplish these aims the students and teachers must spend time outdoors in their environment.

The curriculum regulations of Pennsylvania require that environmental education be taught in every school as a special course or part of another course throughout the elementary school.

There is an ever-increasing need to understand the relationships between people and their environment, the value of natural resources and the part all people play in the use and control of these resources. The urgency of these considerations is currently reflected in the energy crisis and in the multitude of pollution problems the country faces.

Unfortunately, many teachers are more at home in the classroom than outdoors. The usual choice is to provide students vicarious experiences in spite of the excitement the real experiences would provide. All schools, even those in the heart of a city, have a natural environment which students can use to bring learning outdoors. Plants grow along sidewalks, backyards and alleys. Rain produces puddles, deltas and gullies on playgrounds; snow becomes dirtied by pollution; and streets accumulate litter. It is possible to use the outdoors all year to observe the natural environment, whether schools are in rural, urban or suburban locations.

If at all possible, special areas should be established for outdoor activities. Schools and communities should cooperate in the selection and planning of these outdoor education sites. Where the areas available to schools are rather limited the planning should involve businesses and other community agencies interested in education in locating suitable sites for outdoor study.

Wholesome attitudes towards the environment can be developed best through the use of outdoor areas. The teacher will need to identify the resources available in the local community, plan trips, design investigations and ensure that students will be able to understand the many interrelationships that exist between people and nature. The real problems in our society today should provide the focus for learning.

Much of what is being done in the classroom could be done more effectively outdoors, and much of what is collected outdoors can be taken into the classroom for study and observation. In the final analysis, the success of an outdoor educational program depends on strong, continued support from school administrations and communities through the provision of resources and scheduled permitting field trips.

EVALUATION IN SCIENCE

Evaluation in science is treated as the measure of progress of an individual student, a class or a technique of instruction. The role of evaluation in each of these three areas is the same: to measure success. Success criteria for each area may differ.

The individual student is considered successful when observable evidence indicates that the student can complete science tasks that the student could not previously complete, or that the student can do these tasks in a more mature manner. The "task" as herein defined may include such characteristics as interest and aptitude.

A class is successful when the individual members participate actively in the learning process, and from this participation show a satisfactory degree of progress as described for an individual student. Although it is desirable that all students progress to the limit of their individual capabilities, the present "institutional" atmosphere of our schools make such a goal impractical. If 80 percent of the students in a class are making good progress and the remainder are improving, the class could be considered successful.

The technique of instruction in the school science curriculum can be measured according to its success in creating science classes where each individual student has the opportunity and encouragement to progress. A program for a school, class or individual must be tailor-made by the teacher. A curriculum produced by a textbook or a national committee does not guarantee instant success. The learning environment differs across the state in terms of school size, organization, local needs and potential for development. Hence, a program must be measured within the area it is used, not by comparison with districts outside this area.

Since evaluation at any level begins with the evaluation of the individual student, teachers need to understand that evaluating a student demands more than objectivity. Teachers must draw on their professional skills to determine any differences between students with identical test scores. A teacher, from training and experience, calls upon many subjective elements for adequate diagnosis and evaluation of student progress.

THE STEPS IN EVALUATION

DIMENSIONS

Evaluation begins with deciding what areas are to be evaluated. The items about which science instruction should be concerned need to be complementary to the goals of the teacher and the school district. The three areas of concern in science instruction are included in the diagram:

1. <u>The development of scientific skills</u>. This area deals with the processes and techniques that scientists use in problem-solving. Such skills as measuring, record-keeping, reporting and using instruments are considered. Also considered is a large group of skills, important but somewhat elusive, such as critical observation, questioning techniques, making value judgments and selecting from alternatives.

2. <u>Fostering scientific attitudes</u>. A much neglected area of science instruction, "scientific attitudes" can be identified behaviorally. Proper attitudes, an imperative prerequisite to problem-solving, are developed as a student sees, understands and interprets reasons for experiences that are presented.

   Lessons presented as teacher-dictates or curricular-dictates do not spontaneously provide "reason" to the student. Attitudes, of course, are concerned with motivation and discipline. Motivation must be effective at the individual student level; hence, it must be created by the student. Certain attitudes that can be fostered and recognized through behaviors are:

   a) Seeking reasons for phenomena (curiosity, skepticism, demand for proof).

   b) Evaluating the extent of reason (inquiry, willingness to participate, acceptance of evidence).

   c) Reconsidering evidence and conclusions (withholding judgment, recognizing that "truth" is relative, accepting change, maintaining open-mindedness).

   d) Interpreting applications of science to society.

3. <u>Conceptualizing</u>. Formulating, organizing and constituting usable generalizations are important goals of science. This is not a package that can be transferred from teacher to student. The ability to conceptualize is a result of an interplay between the student and the environment. Inductive teaching techniques are imperative in this.

   A child makes specific contacts with the environment through the senses. The child beings to these contacts previous experiences and background. The information the child draws from these contacts are perceptions, i.e., the chair is hard, the ice cream is cold, the sunlight is warm and bright.

   As the child begins to draw relationships between perceptions, he or she forms concepts according to some quality or quantity, i.e., hardness, smoothness, form, weight, few, many and so forth. This process of development we call conceptualization. When concepts from one group of experiences are connected with another set of concepts a larger relationship is developed. This we call a generalization. At any level of experience children may draw upon all of their developed concepts and generalizations for action.

THE COMPETENCY MEASURE

Objectives for instruction, measured in terms of behaviors produced, give the teacher an estimate of student progress. The competency measure contains elements designed to specifically evaluate the behaviors learned during a classroom activity. Learning is reflected in the quantity and quality of behaviors produced. A competency measure is an instrument used to determine if a specific behavior pattern is followed by a student who is faced with a set of choices. Such a measuring instrument is used in conjunction with behavioral objectives.

Behavioral objectives are unit or lesson goals written in terms of measurable, observable student performance. They contain three key ingredients: (1) the expected performance - single underscore in the example below - that describes the behavior, (2) the conditions - double underscore - that describe the setting under which the activity will be performed; and (3) a criterion - triple underscore - that sets the level of acceptable performance.

For example, consider these two objectives:

1. Selects the metallic objects from the objects on the table with but one error in judgment.

2. Order in two ways the ten objects on the table.

A competency measure can be administered in numerous ways. The best approach is on a one-to-one basis (teacher-student), when a student is asked to perform a task and the teacher observes and records the student behavior. Teacher observation of student behavior is the key to the use of this tool. This measure can also be accomplished through direct observation during classroom activities.

Pencil-and-paper tests can be used to determine some behavioral competencies, but the teacher is cautioned to examine the manner in which the objectives are stated. For example, consider the second objective above: "Order in two ways the ten objects on the table." A teacher who asks the students to classify ten objects in two different ways and then to write their answers on paper is not testing this objective, since a student may be able to perform the behavior but be handicapped by insufficient writing skills.

SCALAR PROFILE

Letter grades A, B, C, D, F, Pass-Fail notations, and citizenship marks are a few of the methods used by schools to rate, compare and/or evaluate student competence in achieving desired goals of learning. The intent of SCIENCE UNLIMITED is to produce an individualized program that encourages students to achieve within their level of capabilities; hence, evaluation should not circumvent this objective.

Evaluation is approached as a tool to help the teacher analyze individual students. Such an analysis provides information the teacher can use to prescribe future learning activities. The Scalar Profile is a device that allows a teacher to pictorially describe a perception of student performance at a particular time. At some later date a comparative profile is made to show growth. Since the profile is shown to the student, is compliments a student in those areas where he or she shows progress and encourages the student to improve in other areas. In the final analysis, the profile is no more than a pictorial view of the teacher's subjective evaluation of a student.

SCIENCE UNLIMITED presents the Scalar Profile as one way to improve the techniques of evaluation. The format of the profile was developed from principles and in ungraded school programs. It is basically a subjective, individualized approach to evaluation. Since the intent of evaluation is to determine the extent of individual student growth, the prelearning ability of the student must be known. This provides a control for measuring progress at some later period. It is also important that all postevaluative activities reflect the types of measures used in the "control" or preevaluation. Once the area of concern has been selected, a teacher can use numerous tools to determine a student's level of competence. Diagnostic testing, personal counseling, examination of past records and family history may serve as interpretive tools to construct profiles at time intervals and thereby to record the changing status of the student. These profiles should reflect in a scalar manner the competence of the student within the dimensions defined. An example of a scalar profile follows:

Scalar-Profile* (Sample)

Subject	Science	Student	Mary Jones
Date		Age	10
Evaluator	Ms. Smith	Grade	4

Area 1. The Development of Scientific Skills

ELEMENT	ACCEPTABLE LEVEL OF DEVELOPMENT	
	MINIMAL	MAXIMAL
1. Measurement		
2. Record Keeping		
3. Using Instruments		
4. Observational Skills		
5. Selects Alternatives		
6. Investigative Techniques		
Other: Reporting		
Questions		

_____ March 9

_____ April 23

_________ *Scalar-Profile developed by T. V. Come, professor of Science Educa tion, Edinboro State College.

The parts of a Scalar Profile are (1) the level of development, (2) the elements and (3) the profile.

1. The level of development evaluates student competence at a specific period of growth. The rates vary from minimal to maximal competence. This points out an important concern of evaluation in science. All beginning student competencies are satisfactory; no student is a failure because of a lack of ability. Only degrees of satisfactory progress are recorded.

2. The elements, determined within the school district, depend on the type of program in use or contemplated, the basic educational philosophy of the school, the teachers of science and student involvement in evaluation. The more specific the elements, the more meaningful they are to students. "Measure length" is better than just "measurement." "Quantifies observations" is better than "observes."

Suggested items that can be used in a Scalar Profile are the following:

Skills

Measure Length	Classifies Objects	Forms Hypotheses
Determines Area	Identifies	Makes Interences
Determines Volume	Communication Skill-Verbal	Predicts
Counts Numbers to 10	Communication Skill-Written	Experiments
Makes Records	Gathers Information	

Attitudes

Curious	Delays Judgment	Selects Alternatives
Self-motivated	Weighs Evidence	Questions Conclusions

Conceptualization

States Relationships	Applies Rules	Forms Generalizations

3. The profile records performance strengths and weaknesses of the student at a specific time. Comparisons can be made at a later period by superimposing the profiles.

GRADING

This section is placed at the end of this series of topics because it represents a paradox. One the one hand grading is possibly the most abused and misused practice in education. At the same time it has great potential as an instructional tool.

The system of grading chosen by the teacher determines, to a large degree, the type of teaching-learning situation that will be established in the classroom. An evaluation process in which students have some responsibility for defining the criteria by which they are to be evaluated, as well as the opportunity to establish and defend their progress along the evaluation continuum, provides for students involvement and self-evaluation opportunities. An evaluation process based on fixed standards of material to be "learned" or "covered" and then measured by recall of factual information provides little opportunity for student involvement. The first process fosters the major objectives while the latter tends to defeat these objectives.

The committee developing this publication recommends that no student fail science for lack of ability. Reports to the child and to the child's parents should indicate the progress of the individual student on the basis of the child's own capabilities.

Evaluation can be a valuable tool in the education of children, but it should hot occupy a major portion of science study. Instead, evaluation should be an integral part of the student's science experiences.

The examples in this guide are not to be construed as exclusive procedures for evaluation. The procedures presented here have been used successfully by individuals who share the underlying philosophy of SCIENCE UNLIMITED. In any case, evaluation is not an activity that requires a prescribed time period for completion and repetition; instead, it grows out of the immediate need for judgment of the growth of an individual. Teachers must be willing to accept the responsibility for determining a student's grade without referring to a large collection of written test results or similar quasi-objective records. No one is better placed or qualified than the teacher for evaluation and grading of students; and it is the teacher who must accept this final responsibility rather than withdraw from this task under the guise of need for sufficient objective data.

Equipment and Supplies for Elementary Science

The hands-on, investigation-centered approach to science advocated by SCIENCE UNLIMITED necessitates adequate amounts of supplies and equipment. Much of what is needed has little or no cost and is locally available. However, some basic commercial science items are essential.

Most of the items needed for the hands-on science program fail under three categories:

1. Scroungeables.
2. Inexpensive equipment or supplies which can be purchased locally. Most supplies are expendable and must be replaced periodically.
3. Purchases from science supply houses.

Scroungeables

Some things may be borrowed when needed and then returned.

Examples are: bicycle pump, bicycle, mechanical toys, flashlights, magnifying lenses, roller skates, tradebooks from local or school library, models and collections from resource people and a wide variety of pets.

Many useful things can be rescued from the neighborhood discards and retained for future use.

Containers: squeeze bottles; assorted jars and glasses with or without lids which can be calibrated for volumes, flower pots, pyrex baby bottles, paper or styrofoam cups, bottles, jugs, egg cartons, tin cans with smooth edges, boxes, aluminum foil dishes or plates, film cans, milk containers, fancy shaped jars that magnify, plastic stackable food containers and trays, baggies, etc.

Action Tools: string, yarn, rulers, wire, plastic knives, forks and spoons, popsicle sticks, tongue depressors, twist ties, paper clips, nails, screws, needles, pins, fishing sinkers.

Stuff to work on: scrap lumber, rubber balls, marbles, candles, discarded tops (wheeled, windup or other), corks, modeling clay, soap bubble blowers, towel rods, buttons, waxed paper, aluminum foil, Christmas wrapping paper, garden seeds (refrigerate to keep viable), soil, scrap glass, mailing tubes, soap dishes, etc., metal rods, pieces of aluminum, other scrap metal, old bricks, tile, paint, wire screen, hinges, sand, old erector set.

How to make scrounging easier:

People to contact: parents, neighbors, school parent groups, school custodian, high school science teachers, civic groups and business people.

People to visit: grocery store, film processing laboratory, drug store, state store, shoe store, school cafeteria, garages, plumbing and roofing shops, lumber yards, contractors, local manufacturers.

Justifications for solicitations: recycling waste materials saves the environment, helps students be creative, furthers science experiences, teaches students about real things, keeps school costs low.

How to contact: notes to parents, children talk to neighbors and relatives, phone calls, notes to local news media.

Extra help or alternatives to scrounging.

A petty cash fund could be established by the school for small, urgent needs such as dry cells or perishables such as pet foods. A parent group could set up such a fund for things not included in the school budget or sponsor fund-raising activities for specific things (aquarium pumps, tools, etc)

Supplies and Equipment from Commercial Science Supply Houses

Commercial supplies and equipment should be replaced, even expanded, each year as needed. A committee of science teachers should identify proper needs and prepare supply and equipment orders. If a school starts with little in the way of science equipment, the task for building a good base of supplies and equipment will probably have to be spread over several years. But, get started and keep working on it each year!

Urge parents and the local school board to set an amount per child per year for commercial supplies.

If you are alone or one of a small group of teachers concerned about improving the science program for your children, make realistic requests to the administration at budget time. You may be surprised at the cooperation you receive! Show specifically how the requested equipment will be used. Nothing will strengthen your request like providing evidence that you've been doing good things in spite of equipment handicaps.

School administrators may have catalogues from science supply companies or may borrow them from junior high or high school science departments. Some of our equipment and supply needs can be met through such catalogues. However, suppliers for upper-level science courses may not have the appropriate stock for elementary science programs:

> Young children need large, heavy-duty pulleys so they can feel differences in forces as they use pulleys in various arrangements that alter the effect of the pulling force applied. The small, bakelite pulleys sold for high school physics are not appropriate. Clothesline pulleys and nylon rope are far superior and can be purchased in hardware stores.

Several companies specialize in equipment and supplies for elementary science. Use their catalogues when making up orders. Commercial exhibits at science education conventions offer an important opportunity for teachers to obtain catalogs to identify and evaluate new equipment as well as sources of equipment.

Much-needed equipment can be purchased locally for less than the cost from suppliers of science equipment for schools. Check with your administration to find out whether the procedures mandated for purchase of school supplies encourage or discourage local purchasing.

Examples of Items For Purchase From Science Supply Houses	Examples of Items which may be more easily or inexpensively purchased locally
Equipment	
thermometers	tools
barometers	thermometers
medicine droppers	rulers
light sockets	wire
dry cell holders	hardware

magnets
iron filings
lenses
prisms
microscopes
microprojector
meter sticks
terrarium cages
pan balances
spring balances
pyrex beakers
hot plates with heat controls
graduated cylinders
clear plastic tubing (for siphon)
D.C. voltage supplies

electrical connections
pots and pans
flashlights
door bells, buzzers
small toy electrical motors
aquarium

Expendable Supplies

Supply houses	Local
wire gauze for hot plate to keep glass from touching burner	salt, sugar, food coloring, liquid soap, cooking oil, vinegar
some chemicals	aluminum foil, wax paper, baking soda
	flashlight bulbs, dry cells
	safe drug store chemicals, patching plaster, modeling clay, aquarium supplies, plants

General Hints for Equipment

Careful use of dry cells extends their usable life. Put switches in circuits; avoid short circuits. Dry cells age quickly but are essential for early electrical experiences; older children might profit from DC Voltage supplies used on some model slot cars or trains. These items are inexpensive, safe and long-lasting.

Time Versus Money

There is a dilemma concerning the relative value of buying supplies and equipment and scrounging them. Collecting needed supplies and equipment requires time on the part of the teacher. In some cases, if money is available,.it may be more desirable to purchase needed materials.

Magnets:

Bar magnets should always be stored in pairs with opposite poles facing each other. They can be held together with rubber bands.

All magnets will retain their magnetism better if "keepers" are used. Often keepers are included with magnets purchased. If keepers are lost or not included, iron nails or other iron or steel objects can be used as improved keepers. "Keepers" should be placed across the ends of the opposite poles of magnets.

-- Keepers	iron nail or screw used as keeper

Improperly stored magnets lose their magnetism and provide very unsatisfactory learning experiences. It is often a better investment to buy stronger, better magnets (if they are stored properly) than less expensive ones.

In some communities, certain industries which use magnets will remagnetize magnets for schools. This is worth investigating. Some high schools will have a remagnetizing apparatus which is quite inexpensive.

Slide Projectors:

Slide projectors, overhead projectors, gooseneck lamps and microscope lamps provide much better light for study of such things as phases of the moon, seasons, reflection of light, refraction of light, etc. than flashlights. (See "Investigating Reflection of Light Beams", for directions for making slit slides when narrow beams are needed in reflection and refraction investigations.)

Microprojectors, available to elementary schools, are microscopes which project magnified images on a screen or a white surface so they can be observed simultaneously by a group of children. Thus, children are sure to see what they are magnifying, can make observations and discuss in a group the characteristics and behaviors of these items. Higher-power magnifications require a darkened room. Microprojectors are manufactured by several companies and sold under such names as Bioscope, Trisimplex and Kenevision. Microprojectors are easy to use, and although they are costly compared to single elementary microscopes, upper elementary children can become quite skillful in their use.

A caution is necessary concerning this piece of equipment. Some microprojectors heat up rapidly to the point where students could be burned if they touch them near the heating element.

Elementary School Microscopes

Elementary microscopes may be used with transparent materials placed on slides and illuminated from below either by a built-in light or an external light source reflected upward through the slide by the adjustable mirror in the base. These microscopes are useful in the 40-to-100 power range of magnification. A few good microscopes can be found in the $50 price range, allowing for the purchase of sufficient quantities. Higher powers are seldom used and are harder for children to manipulate (hand lenses are sufficient up to 10X magnification).

Useful for observing dimensions, items such as flower parts, insects, soil samples, crystals and small aquatic life in dishes is an elementary stereomicroscope. A specimen being studies is lighted from the top with the light reflected from the specimen to the stereo eyepieces. On the average, steromicroscopes cost approximately twice as much as elementary microscopes.

A science equipment and supply checklist

You r   eed to discuss some of these questions with your principal, and you may   , need to spend some time finding out what science supplies and equipmen are available.

Does your school have a budget for elementary science materials? ________

If so, how much? ________

If not, can funds be made available? ________

Is money available (i.e., petty cash) for local purchase of materials as needed? ________

If so, how much? ________

If not, can such a fund be made available? ________

Is there a central storage location for elementary science equipment and supplies? ________

In your building? ________

In a separate building? ________

If so, is it well organized so materials can be easily found? ________

Is an up-to-date inventory maintained? ________

Do you know what is available? ________

Are teachers asked to identify their science needs when it is time to order equipment and supplies? ________

If not, can they initiate requests for inclusion in the annual order? ________

Can elementary teachers occasionally borrow needed items from junior and/or senior high science departments? ________

Is there a system for distributing and maintaining supplies and equipment? ________

Storage for Science Supplies and Equipment

Ideally, each classroom should have storage space for (a) equipment checked out of cental supply for several days' use, and (b) permanent storage for those materials and equipment that are unique to the teacher's science program and are frequently used throughout the school year. There should also be a well-organized, adequate science materials storage area in each elementary school building. The storage area should be inventoried and restocked at least once a year. Necessary repairs to equipment should be made before the equipment deteriorates to uselessness. An individual or a committee should be responsible for organizing materials so that they are easily found, easily returned and properly located.

Safety and Science

In a vital hands-on investigativ(elementary science program there is limited need for equipment or activities which potentially threaten the safety or health of students. Elementary science lessons sh(uld be as safe as other things children do in school.

To make science activities safe:

- Wipe up water spills on floor.
- Use plastic containers rather than glass when possible.
- Avoid sharp objects and missile-type objects unless safety is assured.
- Use flames, hotplates, hot water, etc., only under close supervisions or as a demonstration.
- Be sure that electric cord arrangements are safely out of paths of children.
- Try to anticipate problems which result from over-enthusiasm or problem behaviors.

Helpful hints for safe science experiments:

1. Establish a rule of no tasting unless specifically instructed to do so. Remind children of the rule when it is relevant to a given lesson.
2. Never heat water in, or pour hot water or other hot liquids into, glassware that is not pyrex.
3. Do not use materials that are cracked (i.e., glass or china) or have sharp, rough edges (i.e., tin cans, glassware).
4. If using a hand pump to increase or decrease pressure in a container, be sure the container is not cracked; and pump only enough to achieve observable results. Too much pressure or too great a vacuum can make a missile out of the stopper or cause the container to break explorively.
5. Never use or mix chemicals for which you do not have full assurance of safety. Even certain household products which are safe to use by themselves can produce unsafe reactions when mixed (i.e., clorox and ammonia produce poisonous gas).
6. Be sure children do not look directly at the sun or a strong light (i.e., projector) and that they do not reflect such lift into other children's eyes.

If Using Hotplates

1. Be sure the surface beneath them is protected by asbestos or heat-proof material.

2. Asbestos disc or heavy wire screening should be placed between the heating element and any glass or ceramic containers.

3. Arrange electric cords to be sure they will not trip anyone or be pulled.

4. Use only heavy-duty extension cords.

5. Turn off a hot plate as soon as it has served its purpose. If such things as sticks, beans, marbles and water fall to the floor, clean them up immediately so that children will not fall on them.

6. Select a hot plate with a temperature control so liquids can be heated and kept warm without the need for constant plugging and unplugging of the hot plate.

If candles or other flames are used:

1. Have a pail of water handy in case of trouble.

2. Plan ahead to avoid problems due to long hair, loose clothing, etc.

3. Use alcohol burners cautiously to avoid igniting unseen fumes and spills.

The 110-120 volt current at home and in the classroom is not safe for elementary school activities related to the study of electric current and circuits. Current from a dry cell is safe for electric circuit activities and there is no shock. Caution children not to use household current to repeat activities done with dry cells.

Consider safety when planning and conducting field trips. Terrain should be safe for active children. If children are going to explore a pond or stream, they should wear boots or sneakers to protect their feet against glass, metal objects, sharp rocks, etc.

Use demonstrations rather than individual or group activity when safety precautions indicate children should be at a safe distance. Keep children at a safe distance during the demonstration.

Know your children. Individual differences in dependability and maturity should influence decisions on how to conduct activities.

Secondary science teachers are useful resource people when you have questions about the safety of what you plan to use and the manner in which you will use it.

Some Special Cautions:

Never use mercury or carbon tetrachloride. Both substances are known to cause serious internal injury; both release gases which are harmful when inhaled.

Mercury thermometers should be avoided, if possible. If a mercury thermometer should break, do not allow children to play with the mercury droplets. Clean up the mercury droplets immediately and thoroughly, avoiding contact with the mercury as well as the broken glass.

Rubbing alcohol should be used only for activities requiring very small quantities. Be sure that the children do not taste it. In cases where larger quantities or other forms of alcohol are called for, use a teacher demonstration.

Alcohol should never be heated directly over a heat source since it flames at a comparatively low temperature. For the rare occasions when heated alcohol is needed, place alcohol (small quantity) in a container and set the container in a pan of water on a hot plate. The alcohol is thus heated by the water which, even when boiling, never reaches a temperature at which alcohol bursts into flame.

Dry Ice should be used in small quantities only; and be handled only with heavy insulating gloves or tongs. Direct contact with dry ice can result in skin injury.

Some references direct you to use diluted hydrochloric acid as a test for limestone. This acid is strong and corrosive and should not be used in the elementary school. Use warm vinegar as a substitute. Small pieces of limestone rock or powdered limestone rock cause bubbles and wear away at the surface when left in vinegar for a few days.

Do not make a demonstration volcano using ammonium dichromate. This chemical is unsafe, is occasionally subject to explosive action and produces a fine dust which should not be inhaled.

Be certain any food coloring used to color liquids is pure and nonpoisonous.

Children should not dissect animals whose cause of death is not known. Animals found dead are those likely to be weakened by disease or chemical poisons; some of these can be harmful if handled without proper precautions.

Inserting glass tubing into stoppers and removing glass tubing from stoppers can be hazardous. Children should not do this. Always protect hands against possible breakage with heavy gloves or cloth. A coating of glycerin on the tubing helps it to slide into the stopper hole more easily and makes removal easier. An alternative is to hold the stopper under running water or to use Vaseline or a similar lubricant. Tubing should not be left in the stopper for long periods since it becomes increasingly difficult to remove.

Several portable compressed gas burners are available on the market and through science supply companies. The propane type often used by campers is an example. They should be used only if hot plates or candles are not adequate for the activity and only for demonstration activities. Before using them, check to be sure that the connections are free of leaks. When turning them off, be sure they are completely off so that gas does not leak gradually. Users of gas burners should thoroughly read instructions for their use and disposal, or obtain instruction from an experienced person.

The precautions mentioned here cannot, of course, meet all of the potential problems that might arise in an activity-oriented elementary science program. Good planning with safety in mind and alertness on the part of the teacher during the activities should assure a safe science program. A good general rule is -- "When in doubt about the safety of an activity, don't do it!"

Many science activity books have been published for use by teachers. Publications of an activity is not guarantee of its safety. Even elementary science textbooks occasionally include unsafe activities. The cautions listed in this safety section should help teachers recognize potentially hazardous activities found in published materials.

Safety Glasses for the Science Laboratory

Act 116 of the General Assembly requires that in a science classroom every person who is in an area where hot liquids, solids or gases or caustic or explosive materials are being used must wear industrial-quality eye protection devices.

In the elementary classroom this would require the teacher and students to wear safety goggles whenever they use open flames, hot materials or chemicals. Safety goggles are available from most science supply houses.

Descriptions of Current Science Programs For Young Children

The contemporary approaches to teaching sciences are providing a learning environment rich in material stimuli. Children are given the opportunity to explore their world through sensory responses, feeling, seeing, smelling, touching and manipulating the elements presented to them. But most of all, in the modern science classroom a child participates in decision-making processes. Students pose questions, consider alternatives, organize materials, measure objects and take part in many other ways that contribute to their learning process. Children are not taught by traditional instructional procedures. Learning takes place when the child makes an individual response to selected learning-environment stimuli.

The teacher's role in this classroom setting is to provide an appropriate environment that will motivate the children to actively respond. The teacher serves as a guide and stimulant for student discovery and invention.

Some common denominators exist among new programs. In addition, each new program has a unique quality of its own, providing educators with many avenues for achieving a sound, functional science program.

The major similarities among the new science programs are:

1. The students participate in the activities.

2. New and different materials are used.

3. Goals are reflected as changes in behavior.

4. The processes of science are examined in a variety of ways.

5. Mathematics skills are used in many activities.

6. Textbooks and other reading materials are not the central focus for activity.

7. The programs are based on modern learning theories.

PIAGET AND CLASSROOM PRACTICE

Jean Piaget, a Swiss psychologist, was intrigued with the question of why children are includes to be more comfortable with "wrong" answers than they are with "right" answers. His research into children's thinking have provided important information about their mental abilities and inabilities and has led to his theory of human mental development.

How many times have teachers decried variations of "I told them and told them, but they still don't know it?" Piaget's work provides much potential for avoiding or minimizing learning frustration for both teachers and children.

Piaget's work is so extensive and complex that it will be years before the full impact of his findings and their interpretations can be tested and applied at the grass roots level. However, some basic knowledge about the development of mental processes in children has emerged. This part of Piaget's work has been supported through further research by many investigators. Much progress has been made in translating the results into guidelines for more effective and realistic learning experiences for preschool and elementary children.

Piaget gathered his data by talking with children about common experiences. Using a basic set of topics (often incorporating manipulative experiences) and a consistent set of questions for each topic, he and his co-workers interviewed large numbers of children of various ages. He found convincing evidence that children are incapable of much of the kind of thinking and learning that many school curriculums require. Mental development is a process which depends upon physical maturity and follows an invariable sequence of stages which he has defined and which can be identified by simple testing. Different children reach each developmental level at different chronological ages, but always in the same sequence.

The following is a summary of selected information about children and their thinking derived from contributions of Piaget and his co-workers. These have been chosen for their potential for helping elementary teachers evaluate and modify their instructional goals and ways of working with children. The accompanying implications provide guidelines for such evaluation and change.

FROM PIAGET	ILLUSTRATIVE EXAMPLES	IMPLICATIONS FOR TEACHERS
1. Children have mental structures quite different from those of adults. Young children cannot conceptualize many ideas which we, adults, consider logical or right. Piaget has gathered convincing evidence that we are attempting the impossible when we try to convince children of certain truths before they have matured enough to do the kind of thinking involved.	a) Piaget found that few children below the age of seven can "converse." One example of this is the following: A child and an interviewer each have a ball of clay of equal size. The child usually states with confidence that they both have the same amount of clay. When one ball is rolled into a sausage shape, or into a pancake or broken into small pieces, most children below the age of seven confidently state that the transformed ball is not equal in amount to the unchanged ball of clay.	We must talk with children seeking insight into what they think and how they think. We'll get best results if we use a conversational manner, showing interest, respect, and acceptance for their ideas and thinking.
	b) In a one to one interview, a third grader readily stated, "Air is everywhere." She said she knew is because her teacher said so. When shown a glass and asked if there was air in there, she hesitated, then said, "Yes, air is everywhere." The interviewer then held the glass upside down and the student commented, "Now there is no air in it." The interviewer then guided her through a variety of experiences in an effort to help her appreciate that air was in the open inverted glass. Part of the time was spent pushing containers, including the glass, under water and observing the bubbles coming out. They put lids on some of the containers, taking them off under water. The student was encouraged to talk freely about what was going on. After about an hour of this, she was making statements that seemed to indicate that she was convinced that air was in an inverted glass. Later, while eating snacks, she notice a pole lamp with cup-shaped metal shades. Pointing to one turned up she said, and there's even air in there." Then pointing to one turned down she said, "But you don't mean there's air in that one?!"	We must get more open feedback from our learners to know the ideas behind the words they state, and to know what ideas they generate from the words we are saying and those they are reading. (We are in for some real surprises and disillusionment about things we thought we have taught.) We must appreciate that our logic is rarely parallel to a child's path to learning. We must therefore seek more clues from children as to their patterns of thinking and their limitations with respect to a given concept.
	c) Children in a first grade tested a great variety of objects in a bucket of water to find out if they floated or sank. They labelled their group of floating objects LIGHT THINGS and their sinking objects HEAVY THINGS. The next day, the teacher chose two objects, one from the LIGHT THINGS that weighed more than	

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one chosen from the HEAVY THINGS. Students could still identify which was heavy, which was light, which floated, and which sank. They were momentarily unable to explain why the LIGHT THINGS object was heavier than the HEAVY THINGS object and therefore continued to be satisfied with their conclusions.

2. Mental development progresses through a sequence of stages, fixed in sequence for all children but differing in the ages at which each stage develops.

Developmental stages are limiting factors for what a child can profitably attempt to learn.

Characteristics of each developmental stage have been studied and identified by Piaget. A few are listed below:

a) Second graders had studies a unit in their science books on causes of day and night and why we see different shapes of the moon. They had worked with models, using a globe, ball, and projector. The teacher had faithfully followed the directions for the activities and had explained and reviewed all the concepts she wanted the children to learn. She almost always got the right answers back and the results were gratifying when she gave a short answer test. About a month later, the children were interviewed individually. Common answers to the question, "Where does the sun (or moon) go when we can't see it?" were "Behind the mountain", "into the trees", or "The clouds hide it." Answers to other questions about the sun, earth, and moon were equally revealing, indicating a lack of understanding.

b) Preoperational children apparently cannot be taught that the amount of a solid or liquid does not change when its shape is changed. Investigators have tried but found that although they can get children to respond correctly in one situation, the concept is not lasting or transferable.

c) A second grade class was studying air. During an introductory discussion, they responded to the question, "Where do we find air?" with "Air is everywhere." in almost unanimous chorus.

The teacher distributed a straw to each child to be used in some blowing activities. She asked, "Is there air in these straws?" The majority confidently responded "No". A few uncertainly said "Yes". When asked to give reasons for their answers, the children offered none. No one expressed any relationship between their statement, "Air is everywhere" and the space inside the straw.

Most elementary school children have not reached the developmental stage at which they can deal with abstract concepts for which we cannot provide direct, concrete learning experiences (i.e., molecules and atoms).

We must be ready to accept different outcomes for different children as evidence of success from a science learning experience. Differences in interest, in developmental level and in background experiences can lead to variations.

Use science vocabulary words in context, permitting children to adopt those they find useful and pleasing. Avoid settling for one word or stock phrase responses (i.e. air pressure, vibration, direct rays of the sun, refraction, machines

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d) A first grader became very uneasy in a restaurant when he spied a sign, vividly illustrated with large, cartoon-type germs. As his parents probed his concern, he revealed that his class had seen a moving picture of those germs in school and he was scared that those monsters would be on his hands or his food. He also said he kept seeing those things when he went to sleep and they frightened him.

e) Piaget interviewed many children of many ages, questioning them about the air they breathe out. He told them to blow on their fingers and then he talked with them about it. One fairly typical pattern for 6 and 7 year olds follows:

Interviewer	Child
"What happens when you blow?"	"air"
"Where does it come from" (Note window is closed)	"outside"
"Is there air in the room?"	"no"
"How does the air come from the outside?"	"from my mouth"
"Where does the air in your mouth come from?"	"through the window. It was on the trees, and then it came."
"Now, where is the air you blew?"	"outside"

f) A five year old, riding in the car with her father said, "Look daddy, there's a bull." Curious her father asked her how she knew it was a bull. "That's easy," she answered. "If it's one it's a bull, it it's two it's horses, and if it's a whole lot, it's cows."

make work easier). Rather encourage children to express their ideas in their own words.

Sustain a readiness approach to science learning. Appreciate that elementary children can acquire a wealth of background experiences which later can be drawn upon to incorporate into logical thinking.

Use individual or small group activities whenever possible. Move among groups, encouraging children to talk with you about what they are doing/thinking. Seek to understand their reasoning. Raise appropriate questions, and suggest additional observations or activities which might be helpful or interesting. Be as interested in finding out as you want them to be in the activities.

FROM PIAGET	ILLUSTRATIVE EXAMPLES	IMPLICATIONS FOR TEACHERS

INTUITIVE THOUGHT STAGE

approximate age range
4 to 8 years

- reason and explain events on the basis of intuition rather than logic.
- poor at thinking in terms of cause and effect.
- satisfied with multiple and contradictory explanations.

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PREOPERATIONAL CHILDREN

Do not try to convince them of a truth which they signal in many ways is not meaningful to them.

Do not expect children to identify and control varibles in investigations.

Recognize that leisurely manipulation of learning materials is essential for child centered learning.

Provide science experiences in which children:

- make observations of likeness and differences,
- divide a group of objects into two subgroups according to any property they can defend
- make observations of change with time (i.e., growth in plants and animals, change in shadows in sunlight, change in their view of the moon over a period of time),
- observe and describe objects as they view them from different positions.

FROM PIAGET

CONCRETE OPERATIONAL STAGE

approximate age range
8 to 12 years old

- able to think through problems mentally but only in terms of concrete and real objects
- proceeds from step to step in thinking without relating links to each other.
- uses many words and phrases which have only vague meaning to him or her.

ILLUSTRATIVE EXAMPLES

CONCRETE OPERATIONAL

Two small groups of fourth grade children were subject to two different patterns of instruction on the development of fruit and seeds from flowers. One group was shown diagrammatic drawings and given an account of the sequence of the events involved. The teacher also showed them snapdragons and petunia plants with flowers and fruits in several stages of maturity. The teacher also stressed heavily new vocabulary words for parts of a flower and used some game type exercises to help the children learn them.

The second group was given snapdragon and petunia plants like those used for demonstration in the first group. They were asked to observe and describe the parts of the flower and other structures they noticed. They were then encouraged to infer the sequence of changes as the pistil of the flower develops into the ripened seed pod (fruit). During all this the teacher introduced the names for the flower parts, jotting them down so the children could refer to them any time they wished. They began to place stages in order, experienced some disagreement, made additional observations, and eventually arrived at an ordering which they agreed upon and which represented the actual sequence of change.

In a multiple choice test, both groups did about equally as well. They later were shown a tomato plant blossom and a ripe tomato and were asked to predict how the tomato developed. The first group gave brief statements, usually ending with question mark inflection. Their account included some confusion. The second group enthusiastically and vividly described the kinds of change that occurred, including the identification of the sepals and the scar of the style of the pistil.

IMPLICATIONS FOR TEACHERS

CONCRETE OPERATIONAL

Confine explanations to cause and effect level. Avoid theoretical and abstract explanations. This applies to explanations given by children as well as by the teacher.

Initiate investigations which depend on identifying and controlling only one or two obvious variables.

We must not be misled that a class has "learned it" when one or two children have "come up with the right answers."

Do not expect children to reason as adults and to formulate or internalize adult ideas. Accept ideas which they can explain as logical to them in terms of their limited experiences and mental maturity. Avoid imposing right explanations which are different from theirs. When possible, provide experiences which might enable children to modify their own ideas.

FROM PIAGET	ILLUSTRATIVE EXAMPLES	IMPLICATIONS FOR TEACHERS
FORMAL OPERATIONAL STAGE approximate age range 12 to 15 years old - develop ability to deal with abstractions; can think in terms of ideas, - can hypothesize and carryout experiments.		Teach science through direct and concrete experiences, guiding children to observe and act upon the materials. A good guide to appropriateness of the experiences and the learning goal is, if they can tell you in their own words, the plan is good. If you must tell them, either the activities or the goals are not right.
3. Intellectual development is influenced by four interrelated factors: MATURATION: physical maturing, especially of the central nervous system.	Research indicates that we cannot teach or train children to do the kind of thinking that is beyond their physical maturation. Certain development must first take place in their central nervous system. Average ages for children reaching the various developmental stages in certain populations which have been studies have shown a lag by as much as four years compared with the averages for U.S. children. There is evidence that mental development can be retarded by limitations related to any of the four factors.	Nutrition, health, cultural and hereditary factors may influence physical maturing and therefore mental development.
EXPERIENCE: handling, moving, and thinking about concrete objects and thinking about observations involving them.	Head start programs are, to some extent, a result of concern for providing experiences and social interaction essential for intellectual growth.	We must provide children with abundant interaction using appropriate manipulative materials and concrete learning opportunities to observe things in their environment. Lack of experiences may retard mental development.
SOCIAL INTERACTION: playing, talking, working with others, especially other children.		We must foster student growth through pupil-pupil and pupil-teacher discussion.

EQUILIBRATION: process of bring the above three together to build and rebuild structures. When children are engaged in direct experiences they often find something in conflict with what they expected. If new observations do not fit their present ideas, they try to find a way to shift from disequilibrium to equilibrium.

We must realize that it takes time to learn in science. "Cover less, but uncover more."

We must provide a variety of experiences leading to generalizations. Avoid depending on a single example which merely illustrates a generalization.

4. Knowledge cannot be given to children; it must be evolved by the learner. Thoughts grow from actions, not words.

Words are probably not a shortcut to better understanding. The level of understanding seems to modify the language that is used rather than vice versa.

Language may represent a danger if used to introduce an idea which is not yet accessible.

a) A class of sixth graders was excited about their observations as they moved "empty" pop bottles, capped with balloons, out into snowbanks, back into their room, and then into a flow of hot air from the ventilator. But class discussion became confused as children rapidly popped up with verbalizations they tried to retrieve from the past, such as "the molecules, they get bigger," "warm air rises," and "cold air contracts."

The teacher has planned on a discussion dealing first with simple cause and effect as a start toward an understanding of how temperature affects volume, weight, and pressure of gases. Many children were more intent on trying to think of science words from past experiences than they were in trying to think about the changed they had observed. That lesson deteriorated into somewhat of a guessing game rather than a science discussion.

b) A student teacher had planned an interesting lesson on investigating things that make sound. She started the lesson by asking the children what they knew about sound. Several chorused "vibrations." She panicked thinking her whole lesson was useless. But she had the presence of mind to ask what they meant

We must shift from telling children to structuring and guiding learning experiences so that children can tell us.

We must avoid premature introduction of new vocabulary and science phrases which encourage children to substitute these for concepts. When children explain something in their own words we have evidence of where they are in their understanding. If children respond with phrases from the book or state only the vocabulary words of the day, we have little evidence of what ideas they have developed.

by that. The only response was several children saying variations of "sound is caused by vibrations." No child could show her what was meant. She then launched into her lesson and the children obviously found the investigation of vibrating sound makers new and interesting.

We must recognize that premature verbalizations adopted by children tend to result in overlooked observations or to short circuit thinking. They can cause distortion of observations and inferences to fit the verbalizations.

Usually it is best to have the children carry out the activities related to a chapter in a textbook before reading the chapter. This makes for more open investigation and also helps solve some problems of reading difficulty.

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5. It is natural and inevitable that children continually experience a remaking of mental "structures" as they deal with new experiences, and as their thinking matures.

a) In a series of interviews to find out about children's ideas about space, a second grader was asked, "Which is nearer, the moon or China?" She confidently replied, "The moon." When asked why, she replied, "We can see the moon but we can't see China."

b) A three-year old told her "sitter" that she knew a lot about cats 'cause she once had one. Then she volunteered that momma cats have different daddy cats when they have babies. "That's interesting," commented the baby sitter. "You want to know why?", asked the child. The baby sitter sure did! "Because that's the peculiar thing about cats," was the child's explanation.

c) A primary grade was studying magnets. They had sorted into "Yes" and "No" boxes the things that a magnet picked up and the things it did not pick up. They concluded that magnets

Both Piagetian theory and self concept development support guiding children to correct their own ideas. Teacher corrections to what is right is usually undesirable in investigative science. Many so called wrong answers are really right answers within the limits of what a child has experienced to day.

We need to find out the ideas behind wrong answers and accept them if the child can defend them or pick up metals and do not pick up other things. The teacher checked and, according to the items in the boxes this was true. She accepted their conclusion. The next day she provided each group with an assortment of metals to test. The children enthusiastically changed their previous conclusions when they discovered that some metals were attracted and some were not.

d) In a lesson on reflection of light beams, one child stated that when a light beam hits a mirror it crosses. (The child was looking into a mirror and at the reflection at the same time.) The teacher was confused -- she had planned for them to discover that the beam of light was reflected when it hit the mirror and formed a V. She asked to child to explain what he meant. He showed her that the image of the reflected beam in the mirror looking down from above produced a clear X pattern. The teacher had not noticed this as she had prepared the lesson.

is too immature to profit from the right answer. We can then expose children to more evidence leading to modification of the idea, or let the idea rest for further modification to occur with later experiences.

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As a psychologist, Piaget is concerned with research into how children think and the construction of a theory of human intellectual development. In response to questioning by educators on the implications of his work for teaching children, Piaget stated:

> The goal in education is not to increase the amount of knowledge, but to create the possibility for a child to investigate and discover. When we teach too fast, we keep the child from investigating and discovering for himself. It does not mean transmitting structures which may be transmitted at nothing but a verbal level.*

Piaget advocates a curricular emphasis on learning how to learn and on critical thinking as opposed to stress on accumulating (at any price) ready-made verbalized knowledge. This seems most appropriate for education for the increasingly dynamic world of knowledge, employment opportunities, and culture change in which we exist. How much of what we might mandate the children learn in science can we justify as critical to their future? Could we not make a better case for the potential usefulness of such instructional goals as caring about finding out, acquiring skill in finding out, probing for understanding, refining concepts through new experiences, and open-minded communication of ideas? Instruction toward such goals inevitably results in acquisition of knowledge -- knowledge about which learners care; knowledge which has internalized meaning for the learner; knowledge which grows and becomes refined with experience. Self-motivated, open-minded learners would seem to be better equipped for a dynamic world than learners trained to regurgitate verbalizations which have little meaning for them, and trained to try to learn in school only what they must for passing tests.

* "Piaget Rediscovered" by Eleanor Duckworth, published in Journal for Research in Science Teaching, Volume 2, September, 1964.

QUESTIONS FOR EVALUATION OF A SCIENCE CURRICULUM

1. Are the students and teachers enthusiastic about the programs?

   Self-discipline and motivation for learning depend on both student and teacher enthusiasm. Also, enthusiasm for a science program often results in more time spent in the study of science and in a greater possibility that students will understand ideas of science.

2. Are the materials supplied sufficient to provide student-material interaction?

   Hands-on science programs depend on the availability of sufficient materials and equipment for more than just teacher demonstration. Students need to answer questions and formulate ideas on their own through as much individual interaction with events and materials as possible. Teachers who provide constant direction and expect uniform answers foster dependent learners.

3. To what extent do the teachers use the materials provided?

   Teacher preparation and abilities limit the use of certain materials and techniques. In-service preparation for use of new science materials and programs is essential, as is periodic in-service after the program is in operation. If materials are not being used by teachers, the program is less likely to involve hands-on, direct experiences for students.

4. To what extent are the children involved in the learning activity?

   Some materials deal only with reading about science experiences or for teacher demonstration. While both activities are useful to science learning, students should handle equipment and materials as an integral part of their science education.

5. Does the program allow for variations among students and teachers?

   The needs of students vary, as do the methods by which students learn Programs rigidly fixed by grade can lose the flexibility needed to be current and adaptable to student and teacher requirements.

6. Is the program flexible enough to permit innovations by students and teachers?

   Original and creative ideas of teachers and students are basic to a science program and should be encouraged.

7. Are teachers knowledgeable about new programs?

   Teachers need to be informed about new materials and approaches. Elementary school science journals and professional memberships are useful resources for keeping teachers and administrators informed.

8. Does the school provide consultant assistance for teachers implementing the program?

   The rate of change in education makes it desirable for school districts to utilize outside consultant services. The broader viewpoint and past experience of an appropriate consultant often result in successful implementation of programs where they may normally encounter unnecessary difficulties.

9. What new programs might produce better results?

   New programs should be evaluated according to the above criteria, which are heavily concerned with teachers and students. Selected should be programs that suit the needs of the users, while reflecting the concerns for educational outcomes of both the school and community.