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ABSTRACT

This curriculum guide provides a laboratory approach to teaching elementary school science. A set of both cognitive and affective objectives is presented. Beginning with grade level 4, conceptual schemes for each level, with accompanying subconcepts, are presented, and a complete list of behavioral objectives associated with the conceptual schemes is included. A list of suggested activities relating to the specific schemes is also included for each grade level. The program for grades 4, 5, and 6 is referred to as Experimental Science Program. For seventh grade, it is the Life Science Program. In this program emphasis is placed on the cognitive level of the learners. The program is planned on a modular basis, allowing different children to engage in different activities at the same time. Objectives and activities are cited, as well as reference resources. Desirable outcomes of the program are itemized. The guide includes special teaching hints, general safety practices, an exportability report, and an itemized implementation report. (EB)

ED 093641

CURRICULUM GUIDE

GRADES 4 - 7

LABORATORY SCIENCE IN CLOVER

CLOVER SCHOOL DISTRICT TWO

CLOVER, SOUTH CAROLINA

Martin A. Ramsey, Superintendent

SE 017 329

CONTENTS

FORWORD

To keep pace in a highly technological, changing society, the science curriculum for the children of today has been and is being changed extensively. New methods which will arouse the curiosities and cultivate the natural interests of students must be developed. Novel approaches with an element of joy and surprise must be utilized. Students must be helped to learn how to solve problems, to think, to become involved so that they can become active, more alert, less complacent citizens.

A basic set of facts can no longer be acceptable as a goal in science curricula. Facts change too quickly. The child must be able to experiment, to discover for himself, to awaken his sense of excitement in the physical universe and the biological world.

Realizing the need for a new science curriculum in our area, approximately fifteen teachers representing nine school districts met with members of the South Carolina Region V Educational Services Center, a Title III operational project, to discuss the proposed program. The resulting suggestion for establishing a pilot program was then submitted to the Advisory Control Board of Region V. The Advisory Control Board, with the help of the Region V Center, selected the Clover School District to conduct this activity. Generally, schools with professional personnel currently employed having special training to conduct a specific activity are selected to operate a field testing program.

A special study group was then organized in the Clover School District to further explore pupils' needs in providing a laboratory approach to teaching elementary school science.

Mr. Lane Trantham, Science Supervisor for the South Carolina State Department of Education, assisted teachers of the Kinard Elementary School in the development of the proposed exemplary program. Mrs. Sara Dillard of the Kinard Elementary School served as chairman and teacher-coordinator of the project.

A well-equipped laboratory was set up during the summer of 1969 at Kinard Elementary School in Clover, South Carolina. A cross-section of fourth, fifth and sixth grade students, two sections on each grade level, comprised the laboratory group. Remaining sections made up the control group.

In 1970 the laboratory was moved to Clover Middle School where fifth, sixth and seventh grade students were involved. Classes were kept intact as far as possible with new students added to the program. Classes met five days weekly and were of average size.

Attitudinal and science achievement tests were given regularly throughout the pilot years. During this time a teacher aide assisted the teacher-coordinator.

Under the direction of the teacher-project director six sixth grade classes have comprised the laboratory group during the 1972-73 term.

The project is now being carried on as a Clover School District Project at Clover Middle School.

The program has been validated through efforts of the United States Office of Education. In June, 1973, an Educational Pacesetter's Award was received from the President's National Advisory Council, ESEA Title III, for success in experimentation, creativity and innovation. The project has been featured at the Southern States Work Conference at Daytona Beach, the Educational Fair in Columbia, South Carolina and State Administrators' Conference at Myrtle Beach, S. C. It has twice been selected as an on-site visitation center for "Invitation to Innovation", a Title III project in conjunction with the State Department of Education.

The project has been termed highly exportable. However, this guide is only a guide. Teachers should add to, change, and delete parts as they incorporate their own ideas.

Mrs. Sara G. Dillard
Teacher-Project Director

ACKNOWLEDGEMENTS

Mr. Lane Trantham

Dr. Charles Matthews

Dr. Herbert Tyler

Mrs. Jane Robinson

The Dillards

PHILOSOPHY

The first task and central purpose of science education is to develop perceptions which affect the behavior of the learner. Science education must result in a citizenry who can utilize the language and methods of science, who can keep abreast with our evergrowing body of scientific knowledge.

> Science affects the life of every contemporary man every day. It conditions decisions that need to be made by his government.... It affects the decisions made by individuals on business problems, on selecting a community in which to live.....If an individual is ignorant of science, he must guess what to do or else believe what he is told. Even if he is told what to do by an expert, he has no way to check on this advice or even to understand it. This unhappy predicament is precisely that of most citizens of the United States today. Their fate in important matters and in trivial matters may thus be decided without their participation. And it will not be otherwise so long as they remain illiterate about science and technology. [1]

An adequate science program must be one that has continuity and is planned as an integral part of the total curriculum. Science instruction must assure the education of every citizen, in addition to providing the necessary basis for the education of the future professional scientist, engineer, and technologist. [2]

Educators cannot foresee all of the problems a student will encounter nor can they present the child with each new discovery. Skills in the use of the scientific process must be developed. The curriculum should help the student to realize that the universe is orderly and that it is governed by natural laws. He must further understand that those laws are continually being refined. revised, and tested.

The student must participate; he must become actively involved in the process of inquiry. He must have the joy of success through discovery activities that are appropriate to him as an individual. He can then become a better observer, a more alert student who doesn't "jump to conclusions", a better citizen. His learning will then go beyond the classroom walls.

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1 President's Science Advisory Committee, EDUCATION FOR THE AGE OF SCIENCE, Washington, D. C., May 24, 1958, p. 4

2 President's Science Advisory Committee, p. 6

By discovering through experimentation, the child will.....
feel more at home in the world whose laws he is able to fathom. With each new discovery, large or small, he (will understand) the nature of his environment more clearly and (achieve) a more rewarding relationship to those things about him. [1]

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[1] Glenn T. Seaborg, "What It Means to Be A Scientist", Address to the National Science Fair, Baltimore, Maryland, May 5, 1964. mimeographed, p. 10

OBJECTIVES

I. Cognitive

The student should be aware that

.....science is a man-made system that is always in a state of change as new observations are noted.

.....science is systematic and creative and that to develop the ability to think creatively and systematically is more basic to learning than perhaps any other one ability.

.....orderly thinking can help to solve self-perceived problems.

.....he can design activities independently and do activities without instruction.

.....he can manipulate objects, identify relationships, and test the usefulness of the relationships he has identified.

.....he can make predictions, formulate hypotheses, and apply scientific principles.

II. Affective

The child should

.....identify himself as a person who can be successful in science.

.....be aware that science is useful.

.....describe science in terms of activities which make sense to him.

.....develop his own explanations for natural phenomena.

.....make modifications only when his explanations cease to be compatible with his own interpretation of his environment.

.....be entitled to a sequential science program which enhances his self-esteem.

.....approach new problems with an open mind.

.....recognize and respect the rights of others to express their ideas.

CONCEPTUAL SCHEMES
GRADE LEVEL FOUR

EXPERIMENTAL SCIENCE PROGRAM
GRADE LEVEL: 4

CONCEPTUAL SCHEME: The Relationships of Organism to Environment

Sub-concepts:

* Organisms are interdependent upon and interact with their environment in carrying on the processes of life.
  - —The habitats of organisms
  - —The effect of organism upon environment
    - Changes brought about: Example — man
  - —The effect of a changed environment upon the organism
    - Reduction in number of species
    - Changes in life habits

* The number of organisms which can survive is regulated by the various environmental factors which are in operation.
  - —Study of the conditions necessary for life

  (Any organism)

  Example — What conditions are necessary for life in an aquarium? Are some conditions more suited for life than others?
* The basic unit of life is the cell.
  - —Study of various organisms—single celled to multicellular. Study of the process of life. Where performed?

CONCEPTUAL SCHEME: Time and Space as Factors Affecting Both Living Organisms and Material Universe (Change)

Sub-concepts:

* There are seasonal and annual changes on the earth.
  - —Motions of the earth as it orbits the sun
  - —Daily changes — night and day
  - —Amount (length of day) and intensity of light received from the sun

* Weather changes are caused by the interaction of air and water and the resulting energy transfer.
  - —Movements of air masses
  - —Effect of gravity upon air masses

* Changes upon the earth are brought about by combined physical and biological forces.

CONCEPTUAL SCHEME: The Relationships of Matter and Energy

Sub-concepts: * All matter in the universe is organized into units which vary in size and complexity.

—The variety of different substances found on the earth

—Characteristics of this variety of matter. (Likenesses and differences) — to build toward the concept of necessity for a classification system, SO THAT MAN may organize and thus better understand his accumulated knowledge of nature.

Many ACTIVITIES should be developed which stress the skills of classification.

Example: Living and non-living organism
Classification by size
Classification by shape
Classification by texture
Classification by two or more characteristics: Example—
Shape and size, etc.

—The unit nature of matter found in the universe:

In the solar system
Sun
Planets
Moon
Etc.

* THESE BODIES CONSTITUTE UNITS OF A LARGER BODY

* The primary source of all the earth's energy is the sun.

—Study of the 'secondary' sources found on the earth

—Energy may be both transferred from one place to another and transformed from one form to another.

* Energy is required to produce motion.

—Study of all types of forces

The effect of heat on various substances, i. e. solids, liquids, gases

—Properties of solids, liquids, gases

—Study of sound — how the ear functions

* The energy received from a system cannot exceed the total amount of energy put into the system.

—Study of the simple machines

Lever	Wheel and axle
Pulley	Screw
Inclined plane	Gear

BEHAVIORAL OUTCOMES

GRADE LEVEL FOUR

I. At the end of Conceptual Scheme The Relationships of Organism to Environment

The child should be able to:

...recognize various environments.

...explain how specialized adaptations enable living things to survive in different environments as he considers moisture, temperature, available food, etc.

...name some animals in South Carolina that migrate.

...group animals in local environment as meat or plant eaters.

...observe how nature protects animals.

...be familiar with animals that help or harm man.

...identify certain specialized structures such as fins, beaks, feet, feathers, eyes and fur which help the animal to live in his particular environment.

...relate plant growth to climate, hours of daylight, soil, topography of local area.

...show that plant seeds produce plants like those from which the seed came.

...identify places in Clover where erosive forces such as wind, water, and temperature are at work.

...assist in setting up a balanced aquarium.

...perform experiments to determine how the growth rate of plants and animals is affected by varying conditions.

II. At the conclusion of Conceptual Scheme Time and Space as Factors Affecting Both Living Organisms and Material Universe

The child should be able to:

...demonstrate path of earth around the sun, using a tilted globe and central light.

...show with flashlight and glove that the day and night cycle is a result of the earth's rotation.

...observe, to measure, to record weather changes using bar graphs.

...to perform experiments to demonstrate the water cycle.

...make simple weather maps.

...observe changes in clouds and relate these changes to weather.

...note that changes of weather in Piedmont Section can occur suddenly.

III. At the conclusion of Conceptual Scheme The Relationship of Matter and Energy

The child should be able to:

...identify some common elements such as copper, mercury, iron,

aluminum.
...identify elements in local area.
...classify objects into living and non-living groups.
...recognize and group fish, amphibians, birds, reptiles, insects and mammals.
...use model of solar system and planetarium.
...identify Big Dipper and locate North Star.
...take measurements of length, width, time, and distance.
...use metric units gradually.
...demonstrate that force affects the direction of objects in motion.
...predict the effect of a magnet on certain objects.
...separate magnetic and non-magnetic objects.
...perform experiments showing relation of force needed to mass of object.
...to construct a simple electromagnet.
...to perform experiments to show effects of heat on solids, liquids and gases.
...perform experiments to show that light travels in a straight line.
...demonstrate that sound waves can travel through various media.
...demonstrate that a wave is a path of energy.
...demonstrate characteristics of sound.
...identify some objects by the sounds they produce.
...use a model of the human ear to show the function of each part.
...construct some simple machines and to demonstrate work they can do.

SUGGESTED ACTIVITIES

GRADE LEVEL FOUR

INTRODUCTION

It would be highly desirable for the instructor to become thoroughly familiar with the spirit of AAAS materials if they are available. Activities for measuring, interpreting data, controlling variables, defining operationally, classifying, using space-time relationships, predicting, inferring, and communicating are explained. If the ability and interest of the pupils indicate that suitable activities are included, choose parts accordingly.

The major emphasis of this program is on the development of the child's skills in using processes of science rather than on the learning of "bits and places" of content. The process approach is a current reaction to the belief that the elementary school child was learning only scientific facts and that he was learning these by reading and was thus receiving a distorted view of the scientific enterprise.

If students have not worked through Parts A-D, Part E of AAAS will probably be more suitable for fifth or sixth grade students.

Conceptual Scheme: The Relationship of Organism and Environment

1. Set up a balanced aquarium noting conditions necessary for life.

2. Allow students to bring small animals to class for one day. Keep and care for gerbils (from local pet shop) in classroom.

3. Make a class chart of animals found in local environment. Show natural habitat, special structures which help animal to adapt to its environment, ways in which students can conserve natural habitats.

4. Group animals in local environment as carnivorous and those which are herbivorous.

5. List kinds of snakes in local environment. Classify as poisonous-non-poisonous; helpful-harmful.

6. Use transparencies on reptiles. Allow children to point out observations.

7. Do research on reptiles. Formulate a brief summary in class.

8. Allow those who wish to do art work to illustrate findings.

9. Observe prepared slides of animal and plant cells under a microscope.

10. Plan a field trip on the school grounds or to an interesting area in the community in order to observe and record characteristics of living things.

11. To observe seed growth, place a variety of seeds between a piece of glass and a piece of blotting paper. Do not overwater. Sand, oil, or sawdust may be used between the glass and blotting paper.

12. Make dish gardens.

13. Experiment with the effects of light, water, fertilizer, on single plants. Omit only one of these in each planting.

14. Record plant growth by use of chart or bar graph. Use metric measure.

15. Include following processes in study:

food-getting	transpiration	excretion
photosynthesis	respiration	growth
reproduction	stimuli	digestion

16. Use transparencies of human digestive and respiratory systems.

Conceptual Scheme: Time and Space as Factors Affecting Both Living Organisms and Material Universe (Change)

1. Allow students to use planetarium model to observe:
   a. motion of earth as it orbits sun.
   b. causes of night and day.

2. Have students to place themselves in the position of the sun, moon and earth. Let them "rotate" and "revolve."

3. Using a basketball for the sun, select other balls which would be suitable in size for moon and earth.

4. Observe cloud formations on clear, windy, and rainy days.

5. Show "Our Mr. Sun" (Bell Telephone free film). Narrate any parts in which vocabulary might be too advanced. Be certain to preview film.

6. Learn how to read C.° and F.° thermometers. Make bar graph of readings for five consecutive days.
7. Make shadow boxes for eclipses if there are any to be observed.

8. Bring newspaper clippings of weather-caused disasters.

9. Show "Unchained Goddess" (Bell Telephone free film).

10. Locate areas of erosion in local environment.
11. Emphasize man's responsibility to conserve resources.

Conceptual Scheme: The Relationship of Matter and Energy

1. Make a list of the examples of matter (anything that takes up space) in the classroom.

2. Allow students to decide whether these examples are living or non-living. Use chalkboard and compile decisions in chart form.

3. Have students to bring seeds, yarn, buttons, etc. from home. Make classification "packs." Note the number of ways buttons, etc. may be grouped. (size, color, texture). Enclose in sandwich bags for future use.

4. Cut circles, triangles, squares and rectangles from different colors of paper. Use rough and smooth surfaces if possible. Manipulate these, grouping them in as many ways as possible.
5. Manipulate many groups of objects for classification schemes, allowing *each student to use all classification packs.*

6. Use mathematics sets of objects if available.

7. Do research on different substances found on the earth.

8. Construct some swinging systems, using small wooded dowels, string and clay balls. Let children discover that energy may be transferred from one swinging clay ball to another.
9. With help of a parent, have a steel ball swinging system constructed on wire or wooden frame. (action-reaction). This is available in commercial form but ours was non-commercial.

10. Simple machines: Use commercially prepared but preferably student-furnished examples of: lever; inclined plane; wheel and axle (spools, plastic straws, etc.); gear; pulley; wedge. Manipulate machines.
11. Use a filmstrip on "Simple Machines" as a review — not at the outset.

12. Have students to note likenesses and differences of solids, liquids and gases.

13. Place balloon on neck of boiling flask which contains water. Heat water on hotplate. Predict what will happen. Observe what happens when water is hot. Remove from heat. Observe what happens. Discuss reasons for inflation and deflation of balloon.

14. Put colored water into boiling flask. Insert glass rod into one-hole rubber stopper and close opening of flask with stopper. Heat on hotplate. Predict results. Observe what happens. Decide why it happened. (Effects of heat on liquid)

15. Using aluminum pans, have children (who must be closely observed) to test the effect of a candle flame on different materials such as a small piece of asbestos pad, a small wooden splint, a piece of nylon, a small piece of construction paper. Record results in a previously prepared check list.
16. Use bar magnets to demonstrate magnetic force. Experiment with many objects testing to see if magnet affects them.

17. Magnetize needles by stroking with bar magnet. Be sure to stroke in same direction.

18. Make simple electromagnets. Have 1 ½ v. batteries, insulated wire, and nails available in classroom. Allow groups of six students to work at one time. Continue this activity until each child has completed this.

Sound:

19. Make simple musical instruments. Observe piano in use.

20. Vibrate many objects such as yard sticks, rubber bands, and tuning forks.

21. Place vibrating tuning fork to surface of a container of water. Note results.

22. Dancing pith balls: Attach string to pith ball and hold ball in between prongs of vibrating tuning fork. Observe results.

23. Study model of human car. Do not emphasize technical explanation. Do compile a brief summary of the care of the ears.

24. Demonstrate wave generation in a variety of materials, showing that a wave is a path of energy.

CONCEPTUAL SCHEMES

GRADE LEVEL FIVE

EXPERIMENTAL SCIENCE PROGRAM
GRADE LEVEL: 5

CONCEPTUAL SCHEME: Time and Space as Factors Affecting Both Living Organisms and Material Universe

Sub-concepts:

* *Many cycles of change are in evidence on the earth.
  - —Nitrogen cycle
  - —Oxygen cycle
  - —Carbon cycle
  - —Water cycle
  - —All of the above are essential for the process of life, which in turn causes further change.
* *Our concept of time is based upon the motions of certain heavenly bodies.
  - —Earth movements
  - —Earth movements in relation to the sun
  - —Moon movements in relation to the earth
* *Of all the living organisms, man is most able to adapt to varying environments.
  - —Powers of reasoning
  - —Man's widespread habitation of the earth's surface from equator to poles
  - —Man's current ventures into space and the depths of the oceans

CONCEPTUAL SCHEME: The Relationships of Matter and Energy

Sub-concepts:

* *All matter in the universe is organized into units which vary in size and complexity.
  - —Continue characteristics of variety of matter. Classification schemes should now be of a higher level, i. e., involving several characteristics. Students should be able to use a 'simple key'.
  - — The unit nature of matter found in the universe:
    In the universe
    Stars
    Star systems
    Etc.

* This will involve the skill of "model" formation by the student. (abstraction)

On the earth

Living things (large and small)

Rocks and minerals — composition

Bodies of water (ponds, lakes, oceans)

The properties of matter are determined by the manner in which the units of matter are joined together.

Units of matter interact under the influence of a few kinds of forces.

* Relationships of matter to matter:
  - —Magnetism
  - —Conductors and non-conductors of electricity
* The primary source of the earth's energy is the sun.
  - —Energy transferral
  - —Energy transformation

    BOTH MAY OCCUR, BUT ALWAYS AT THE EXPENSE OF ENERGY LOSS OR ADDITIONAL WORK PERFORMED UPON THE SYSTEM.
* Energy is required to produce motion.
  - —Brief review of forces
  - —The nature of solids, liquids, and gases. Why a substance is in one form or another. The various forces which may cause change of state.
  - —Difference between 'temperature' and 'heat'
  - —Temperature as an indicator of quantity of heat energy
  - —In-depth study of pressure. Archimedes' principle-Factors which influence pressure. In-depth study of the nature of light

* The total energy received for a system cannot exceed the total amount of energy put into the system.
  - —Brief review of simple machines
  - —What simple machines do. (Increase speed, increase force or change the direction of force)
  - —What simple machines cannot do. (Produce energy)

CONCEPTUAL SCHEME: The Relationships of Organism and Environment

Sub-concepts:

* Organisms are interdependent upon and interact with their environment in carrying on the processes of life
  - — In-depth study of the various life forms of a small pond
* Organisms are interdependent with other organisms in carrying on the processes of life.
  - —Food chain in a well-stocked aquarium
  - —Development of a food chain up to man

* The primary function of living organisms is to produce the species.
  —The function of the various parts of the flower
* Living things come from preexisting life.
  —Life comes from life. Redi's experiments
* A living organism develops from a single cell.
  —The development of frog eggs — fertilization to tadpole and mature frog stages
* A living organism is a product of its heredity and environment.
* Living organisms react to various and environment stimuli.
  —Light-flower formation (length of day)
  —The effect of earth movements on living organisms
  —Change in living organisms with the progression of the seasons

BEHAVIORAL OUTCOMES

GRADE LEVEL FIVE

I. At the end of Conceptual Scheme Time and Space as Factors Affecting Both Living Organisms and Material Universe
The child should be able to:
. . . identify cycles of change: nitrogen, oxygen, carbon, and water.
. . . demonstrate the mechanisms of the water cycle.
. . . demonstrate, such as by using a light and two objects, lunar phases and eclipses.
. . .observe moon phases at night.
. . . demonstrate that the moon revolves around the earth with one side always showing.
. . . construct a diagram of the earth and sun to show the cause of day and night, such as by using arrows to show direction of the earth's rotation.
. . . make a list of evidence which indicates the earth is very old.
. . . to see the relationship of man's widespread habitation of the earth's surface as he considers his ability to adapt, to reason, and to venture into space and the depths of the ocean.

II. At the end of Conceptual Scheme The Relationship of Matter and Energy
The child should be able to:
. . . classify varieties of matter according to characteristics.
. . . see relationship of matter as found in the universe.
(stars, star systems, etc.)
. . . to use and-or make models of solar system.
. . . locate positions on the globe in terms of latitude and longitude.
. . . diagram the earth's magnetic field.
. . . perform experiments dealing with magnetism, conductors, and insulators.
. . . produce static electricity and describe its properties.
. . . demonstrate the relationship between strength of forces (magnetic, electric, and gravitational) and the distances separating them.
. . . perform experiments to illustrate various forces which cause changes in state of solids, liquids, and gases.
. . . demonstrate difference between temperature and heat.
. . . perform experiments to show factors which influence pressure.
. . . perform many experiments to show properties of light.
. . . demonstrate what simple machines can do and cannot do.
. . . measure expansion and contructions of materials on heating and cooling.
. . . demonstrate heat and heat transfer.

III. At the conclusion of Conceptual Scheme The Relationship of Organism and Environment
The child should be able to:

. . . maintain a balanced aquarium which demonstrates the food chain.

. . . show relationship of food chain from smallest organism up to man.

. . . identify flower parts and their function.

. . . measure and record camparative growth of plants growing under different conditions.

. . . maintain a terrarium.

. . . compare plant and animal populations in local environment.

. . . show how the life cycle of some local organisms adapts to its environment.

. . . observe and describe some seasonal adaptations of plants and animals in the local environment.

. . . observe development of frog eggs in local ponds.

. . . observe seasonal changes which bring about change in living organisms.

SUGGESTED ACTIVITIES

GRADE LEVEL FIVE

Conceptual Scheme: Time and Space as Factors Affecting Both Living Organisms and Material Universe

1. Divide class into four groups. Have each group to do research and to demonstrate, if possible, one of the following: nitrogen, oxygen, carbon or water cycles. (These cycles bring change.)

2. Condensation: Fill a gallon sized, glass jar slowly with hot water. Water from faucet will be hot enough. Leave it in jar for two minutes; then pour out all but one inch of it. Hold a piece of burning paper in the jar until it goes out, to create smoke. Chalk dust from an eraser may be used in place of the smoke but do not get an excessive amount of particles in the bottle. Fill a tin can which will fit over top of jar with crushed ice. Put can on top of gallon jar. Darken the room and direct a beam of light from the flashlight at the middle of the jar.

3. Show transparency on water cycle.

4. Using balls or balloons of different sizes construct a mobile of the solar system. Model planetarium and-or research will help to choose sizes.

5. Allow each child to become thoroughly familiar with the model planetarium. Note earth movements, earth movements in relation to the sun and moon movements in relation to the earth.

6. Follow accounts of any space flights that might occur.

7. Gravity: Prepare a place outside to discover if a cup filled with water and an empty cup will hit the ground at the same time if pushed at the same time.

8. Show any suitable filmstrips on the planets, night and day, seasons, the moon, space flights, gravity.

9. Show "Our Mr. Sun" (Bell Telephone free film) if students have not seen it previously. Also show "The Restless Sea" (Bell Telephone free film).

10. Observe fish or tadpoles swimming in water.

11. Visit a planetarium.

12. Use a telescope or binoculars to locate stars you cannot see with your unaided eye. Examine the moon and planets for features which are not visible without magnification.

1. If any fourth grade activities on this scheme have been skipped, choose suitable ones according to interest.

2. Some matter is heavier than other matter: Fill a tall, thin jar about half full of salad oil. Color some water with soluble ink and pour the colored water slowly into the tall jar until the jar is almost full. Observe carefully as you pour. Have the student to explain what happened and why.

3. All matter has a tendency to rest unless an outside force moves it. To discover this, have student to place a glass of water on one end of a sheet of paper. Grasp the other end of the paper and pull it quickly toward you. The paper is removed from under the glass of water but the glass does not move.

4. Matter exists in solid, liquid and gaseous forms: Put a pan containing ice cubes on a hot plate and heat. Observe carefully the change from a solid to a liquid and from a liquid to a gas.

5. Classification: Animals. How they move, how they behave, how they vary in size and color, how their homes are built in special ways, how they communicate with varying sounds and calls, how their species is propagated. (Some animals bear living young, some animals are produced from eggs laid by their mothers.)

6. Classification: Rocks. Scratch test for hardness. Use glass and penny. Make check list or use punch cards. Use commercially prepared rock collections. If children bring rocks to school, they should be unusual. Soil is often dislodged when rocks are removed.

7. Testing for limestone: Put a piece of limestone and three rocks which do not contain limestone on four separate dishes. Have student to pour vinegar on each rock. (The acid in the vinegar will react with the limestone causing bubbling which provides a convenient test for limestone.)

8. Illustrating sedimentary rocks: Mix cement, sand, gravel and water in a milk carton. When the mixture hardens, pool away the carton and examine carefully.

9. Examine the makeup of rocks by wrapping them in cloth and breaking them with a hammer. Use a magnifying glass to examine particles. Have student observe differences.

10. Inferring: Temperature changes can cause rocks to break down into soil. Heat a piece of sandstone over a hot flame for several minutes and drop into a bowl of cold water. (The sandstone will crack.)

11. Set up simple electromagnet using a knife switch and an electric bulb. Experiment with different materials which substitute for knife switch — such as, a piece of rubber or plastic. Classify as to conductors and non-conductors of electricity.

12. Work with bar magnets. Let students discover that various materials will or will not be affected by magnets.

13. Have children to do fourth grade activities on magnetism if they have not been done.

14. Air exerts pressure. Suspend yardstick horizontally from a table. Attach the end of two pieces of string 18 in. long to two ping pong balls. Attach the other end to the yardstick so that the balls hang about one inch apart. Blow hard into the space between the balls. (Balls will come together and bump. The force of blowing caused the pressure between the balls to lessen.)

15. Air can be compressed slightly in a closed container. Hold balloon over open end of an empty soda bottle. With pencil push it into neck. (Be careful not to drop balloon into bottle.) Stretch open end of balloon over mouth of bottle. Blow into balloon. Observe and explain results. (As the balloon inflated, it compressed the air in the bottle. When the air could not be compressed any more, the balloon stopped enlarging.)

16. When a material burns, the air pressure around it lessens. Outside pressure pushes toward the area of less pressure. Make a circular collar of blotting paper about ¼" wide to fit two water glasses of same size. Moisten the collar and set it on rim of one glass. Light with a match a small piece of paper and toss it into glass. Immediately place the other glass over the first so that the collar is between the glasses. Predict results. Observe what happens. (The bottom glass appears to be glued to the top glass and lifts it up.)

17. Simple machines: Review activities found in fourth grade section. Do them if they have not been done.

Conceptual Scheme: The Relationship of Organism and Environment

1. In the spring visit a small pond to observe and to study life forms.

2. Have students to help maintain a well-stocked aquarium.

3. Do research on food chains. Devise a food scheme up to man.

4. In the spring, carefully take apart the various parts of a flower. Mount on paper and label parts. Show transparency on flower parts after they have worked with actual plants.

5. Living organisms develop from a single cell. Bring frog eggs into class in the spring and raise tadpoles through maturity.

6. Living organisms react to various and environmental stimuli. Grow some plants with chlorophyll. Place in various amounts of light. Compare growth and record the effects of light on green plants.

7. Collect algae from streams and ponds. Bring samples to school. Examine specimens under microscopes. Sketch and color drawings to be displayed on bulletin board.

8. Fungi are plants without roots, stems, leaves, flowers, and chlorophyll. To see growth and effects of bacteria, put some milk in a jar, seal it, and place it in a warm place. Predict results. After several days, examine and record results.

9. Grow mold on bread.

10. As a review, show suitable filmstrips.

CONCEPTUAL SCHEMES

GRADE LEVEL SIX

EXPERIMENTAL SCIENCE PROGRAM

GRADE LEVEL: 6

CONCEPTUAL SCHEME: The Relationships of Organism and Environment

Sub-concepts:

* The structure and function of living organisms is influenced by their environment.
  - —Adaptations of a bird's body for flight
  - —Some organisms are able to change their coloration as the seasons progress — spring to winter.

* Non-Living matter may become an essential part of living matter.
  - —The production of food by green plants
  - —The purpose of iron in red blood cells of man

* Behavior involves both learned and unlearned responses to change.
* Balance of life is constantly maintained although living organisms undergo change.
  - —Drastic changes in an organisms way of life would probably result in the organisms not being able to reproduce the species. Therefore, change comes about over large periods of time.

CONCEPTUAL SCHEME: Time and Space as Factors Affecting Both Living Organisms and Material Universe

Sub-concepts:

* Large changes are the result of the sum of many smaller changes.
  - —The features of the earth's surface:
    1) have resulted over a large period of time.
    2) have come about as a result of:
       wind action.
       water action.
       glaciation.
       processes of plant and animal life.
       volcanism.
       etc.

  - —Consider the differences in man's living habits and his environment since colonial times.

NOTE: The concept to be developed here is that man is a social animal with complex behavioral patterns which hinge upon environmental relationships over a period of time.

(Correlate with Social Studies)

* In time, all non-living matter which has become connected with living matter is returned to the non-living state.
  - —The types and purposes of decay organism:
    1) bacteria
    2) fungi

* Change of perception of object with variation of distance.

CONCEPTUAL SCHEME: The Relationships of Matter and Energy

Sub-concepts: * All matter in the universe is organized into units which vary in size and complexity.

—Characteristics of the variety of matter

Sixth grade students should be adept at deriving and using classification systems. Here, we are making the assumption that they understand why classification systems exist.

—The unit nature of matter found in the universe:

Within living things
- Organs
- Tissues
- Cells
- Etc.

Atomic theory of matter
- Compounds
- Molecules
- Atoms
- Protons, electrons, neutrons

* The properties of matter are determined by the manner in which the units of matter are joined together.
  - —Properties of chemical compounds and elements
  - —Understanding of the periodic table of the elements
* Units of matter interact under the influence of a few kinds of forces.
  - —The nature of a chemical reaction (mechanism)
  - —In a chemical reaction, energy in the form of heat or light, or both, is involved.

* Relationships of matter to matter:
    - —Gravitational attraction of bodies to each other
    - —Atomic structure of matter. Historical background of the atomic theory
    - —Movement of sub-atomic particles (electron)
    - —The electrical nature of matter
    - —Relationships of electrical force to magnetic force and vice versa
* The kinds of changes which occur in matter and energy relationships are predictable, within limits.
    - —Predictions are based upon data collection and evaluation.
    - —Predictions usually involve mathematical evidence for support.
* Energy is required to produce motion.
    - —Study of Newton's laws of motion
      As they apply to the solar system
      As they apply to sub-atomic particles
    - —In-depth study of electricity
      Static electricity
      Electric current
    - —The use of light for food production in green plants
    - —Weather. The energy required for air movement
* The total energy received from a system cannot exceed the total amount of energy put into the system.
    - —Complex machines are made up of combinations of simple machines.
    - —Harnessing of energy for the operation of machines
    - —Friction — help or hindrance?

BEHAVIORAL OUTCOMES
GRADE LEVEL SIX

I. At the conclusion of Conceptual Scheme The Relationship of Organism and Environment

The child should be able to:

...give many examples of plants and animals that have structures which enable them to survive in their particular environment.

...describe and make models of bird structures which adapt its body for flight.

...give examples of protective coloration as seasonal changes take place.

...describe the role of decaying plant and mineral matter in supporting growth of plant life.

...distinguish between green and non-green plants.

...relate various plant structures to life processes.

...observe bacteria and fungi and note their functions.

...realize that non-living matter may become an essential part of living matter, iron in red blood cells, for instance.

...name the non-living materials from which a plant manufactures its food.

...observe behavior of various organisms which involves both learned and unlearned responses to change.

...study ones own behavior and predict outcomes under various conditions.

II. At the conclusion of Conceptual Scheme Time and Space as Factors Affecting Both Living Organisms and Material Universe

The student should be able to:

...describe disorganization of matter such as wind and water action, glaciation, erosion, weather, volcanism.

...observe any changes that are brought about by any of these factors in local environment.

...realize that man is a social being with complex behavioral patterns which are influenced by environmental relationships over a period of time.

...make models of volcanoes.

III. At the end of Conceptual Scheme The Relationship of Matter and Energy.

The child should be able to:

...become more adept at deriving and using classification systems.

...should be able to group many organisms according to characteristics, usefulness, structure, etc.

...identify organs, tissues, cells.

...use a microscope with success.

...be familiar with many compounds and elements.

...make tests to show presence of certain elements.

...identify chemical change.

...demonstrate several different forms of energy.

...perform experiments which demonstrate relationship of electrical force to magnetic force.

. . . devise his own electrical apparatus using simple equipment and materials.

. . . be more adept at predicting changes which occur in matter and energy.

. . . perform experiments involving motion, static electricity, electric current, and the effect of light on green plants.

. . . correlate temperature and cloud cover.

. . . use weather instruments to record data.

. . . demonstrate friction as a help or as a hindrance.

. . . perform simple chemical experiments.

. . . make simple machines and combine them to produce more complex machines.

. . . perform energy transfer by use of machines.

. . . note that levers, like other simple machines, trade distance for force.

SUGGESTED ACTIVITIES

GRADE LEVEL SIX

Conceptual Scheme: The Relationship of Organism and Environment

The structure and function of living organisms is influenced by their environment.

1. Adaptation of bird's body for flight: If possible, bring to class a bird. Examine carefully the contour of its wings. If a bird carcass can be found, examine bone structure. (This is an excellent time for students to become more conscious of conservation of wildlife.)

2. Visit nature museum. Observe the many schemes of protective coloration in animals. Relate to seasonal changes.

3. Green plants: Review photosynthesis. Remove chlorophyll from green plants by heating a leaf which has been submerged in alcohol.

4. Red blood cells: Examine a drop of blood under microscope. Prepare the slide or use commercially prepared slide.

5. Show "Hemo, the Magnificent" (Bell Telephone film).

6. Change requires long periods of time. Use a filmstrip or film which traces horses (or any other animal in which children are especially interested) from its earliest ancestors to the modern horse.

Conceptual Scheme: Time and Space as Factors Affecting Both Living Organisms and Material Universe

1. Have students to look for examples of wind and water action at home and on school grounds.

2. Have students to learn what is being done to conserve soil in the local area.

3. Use filmstrip and-or transparencies on volcanism and glaciation.

4. Students who choose to do so might make a volcano. Soda and vinegar are perhaps the sofest "eruptions" to use.

5. Fungi: Bring mushrooms to class and examine. Be sure to warn children of the danger. Mushrooms which are to be eaten should come from the grocery store. Wash hands after handling specimens. Show filmstrip on fungi.

6. Bacteria: Examine with microscope prepared slides of bacteria. Classify these one-celled plants as being helpful or harmful. Be sure to include decay and nitrogen-fixing organisms.

7. This is an excellent opportunity to discuss skin care. Pimples (bacteria-caused) are often a very personal and real problem of sixth graders.

Conceptual Scheme: The Relationship of Matter and Energy

1. Classification skills should be more refined. For instance, group geometric shapes according to curved or non-curved edges or surfaces; two dimensional or not two-dimensional; every part of object is or is not a circle.

   Classify six, white, harmless powders (chalk, baking soda, sugar, talcum, cornstarch, etc.) according to solubility and foaming characteristics.

   Classify animals and/or plants and carry through three states.

2. Units of matter within living things:

   Organs: Examine actual specimens of organs from chickens, pigs, turkeys. Show transparencies of human organs.

   Tissue and cells: Scrape with rounded end of toothpick a small amount of tissue from inside of mouth. Place on clean slide and examine with microscope.

   Examine with microscope the cells of onion skin or an amoeba. (The nucleus will be the rather dark or dense formation near center of the cell. The substance around it is the cell body (cytoplasm). Protoplasm is the term used to refer to cytoplasm plus nucleus. The thin cell membrane holds it together.)

   Examine a living plant cell such as water weed (Elodea).

3. Atomic theory of matter: Discuss familiar compounds with which students worked in classifying unknown white powders.

Concept: Chemical compounds are made up of two or more elements.

Materials: Iron filings, sulfur, test tube, magnet, alcohol burner.

Procedure: Examine some powdered sulfur and iron filings carefully. Notice the color of each and the fact that the iron filings can be attracted to a magnet. Mix about two teaspoonfuls of sulfur with about one teaspoonful of iron. Put the mixture in a test tube and heat until it glows. Remove the contents of the test tube by pouring cold water over the hot test tube. This will shatter the glass. It can then be easily broken and the contents examined.

CAUTION: (Extreme care should be exercised in protecting the eyes from flying glass.)

Notice that the iron and sulfur are no longer distinguishable and that the substance formed is not attracted to a magnet. A compound of iron and sulfur has been formed by a chemical reaction.

Atoms, protons, electrons and neutrons have little meaning to sixth graders. Delete from study unless there are those who want to do research.

4. Periodic table of elements: Display chart. Gifted students (who are especially interested in chemistry or in experiencing something almost entirely new) might enjoy the chart. To the majority it will probably mean very little. Help those who are interested to find suitable library materials to answer their own questions.

5. Relationship of electrical force to magnetic force: Magnetic field produced by an electric current.

Concept: An electric current passing through a wire produces a magnetic field around the wire. The needle of a compass is a magnet and therefore is attracted by this magnetic field. When the current is turned off, the needle is no longer attracted.

Materials: One 1½-volt dry cell, knife switch, compass, two pieces of # 18 or # 22 covered copper wire.

Procedure: Attach one wire to the negative pole of dry cell, the other wire to the positive pole. Attach loose ends of the wires to the knife switch. Place compass directly under one wire. Close knife switch. Open switch and close again. Record results. (The needle of the compass lines up directly with wire when switch is closed.)

ELECTRICITY

Electricity may be classed as either static or current. Both are really the same, but in static electricity, the negative charges are still, or static. In current electricity these negative charges move.

Static electricity can be generated by rubbing certain materials such as amber or glass with silk or woolen cloth. Many times we produce static electricity when we walk across a new, fluffy rug or slide into a car on a brisk, dry day.

There are two types of current electricity — direct and alternating. Direct current is commonly known as DC. This particular type of electricity comes from the storage batteries used in cars, flashlights, toys, and so on. The second type is called alternating current or AC which is supplied by generators. These generators may be operated by water power, steam power, or atomic energy.

A few of the electrical concepts to be developed include:

1. Static electricity can be generated quite easily.
2. Static electrical charges can be positive or negative.
3. There are two types of electrical circuits, series and parallel.
4. In a series circuit all the current flows through each part of the circuit.
5. In a parallel circuit part of the current goes through one appliance and then back to the source.
6. An electric appliance is anything which uses electricity.

An Electric Light Bulb

Concept: An electric current passing through a wire of high resistance will cause the wire to become hot and sometimes glow.

Materials: Three 1½-volt dry cells, five pieces of 18 or 22 insulated copper wire, one switch, one 2-holed rubber stopper, a small glass jar, two steel nails, one short piece of very fine steel wire.

Procedure: Arrange the dry cells in series. Run one wire from cells to the switch and one from switch to one nail. Attach another wire from cells to other nail. Put both nails into stopper holes. Connect pointed ends of nails with the fine steel wire. Insert stopper firmly into jar. Close switch. Record results. (The piece of fine steel wire gets red hot.)

Application: An incandescent bulb is constructed in this manner. In a bag break a bulb. Examine parts.

Dry Cells in Series

Concept: The voltage of dry cells in series is equal to the sum of all the voltages of the dry cells.

Materials: Three 1½-volt dry cells, three short pieces of #18 or #22 insulated copper wire, three one-quart milk cartons, three paper straws (or use rubber or plastic tubing), water, sealing wax.

Procedure: Arrange cells in a row with negative terminals on the right-hand side. Connect one end of a wire to the positive terminal of the left cell. Connect a second wire to the negative terminal of left cell and positive terminal of middle cell. Connect the third wire to negative terminal of middle cell and positive terminal of right cell. Cells are now arranged in series.

A water experiment will explain the force of a series. Elevate a milk carton about 24 inches. Punch hole in side near bottom and insert straw about one inch. Seal with wax. Elevate second carton about 12 inches and insert straw; seal. Place third carton on table. Punch hole in side near bottom. Put small holes in tops of second and third cartons. Hold finger on bottom hole and fill all cartons with water. Release finger. Record results. (The water gushes out with great force.)

Static Electricity

Concept: As in magnetism, like electrical charges repel each other.

Materials: For every two pupils have: Two toy balloons, two pieces of string, a stand of some sort, a piece of wool cloth.

DRY CELLS IN PARALLEL

Concept: The voltage of cells wired in parallel is the same as that of one cell. Only a fraction of the total strength of the dry cell is used at one time.

Materials: Three 1½-volt dry cells, six short pieces of #18 or #22 insulated copper wire, three one-quart milk cartons, three paper straws (or rubber or plastic tubing), water, scaling wax.

Procedure: Arrange cells in a row with negative terminals facing away from you. Connect positive terminals (first to second, second to third) and negative terminals with short wires. These cells are now arranged in parallel.

Show their force with this experiment. Arrange milk cartons much as in Dry Cells in Series experiment; only keep them on the same level. Do not elevate. Fill all cartons with water. Release finger. Record results. (The water comes out with very little force.)

Questions and Answers: Would the voltage decrease or increase if one cell were removed: (Stav the same.)

Would the voltage decrease or increase if one cell were added? (Stay the same.)

What would be the voltage of fifty 1 ½-volt cells arranged in parallel? (1 ½ volts.)

Concept: Simple machines may be combined into a complex machine.

Materials: Toy block wagon, toy blocks, string, rubber band, books, two-feet board ruler.

Procedure: Fill a block wagon with blocks. Attach a rubber band to the wagon. Grasping the rubber band, lift the wagon to the top of a stack of three books. Measure the length of the rubber band as you lift. Place one end of a board on the stack of books and remove the wheels from the wagon or turn the wagon over and stack the blocks on the bottom. Grasping the rubber band, slide the wagon up the board. Measure the length of the rubber band as it moves. Put the wheels back on the wagon. Grasping the rubber band, pull the wagon up the inclined board. Measure the length of the rubber band as it moves. Compare the three measurements. Do the wheels and inclined plane assist in lifting a heavy load?

Examine the parts of an old clock to see that a variety of simple machines are present.

Energy is required to produce motion: Weather. The sun is a source of heat. Using a magnifying glass, focus the rays of the sun on a piece of paper. The paper will be charred by the heat provided by the sun. Occasionally a curved fish bowl causes a fire by acting as a lens and focusing the rays of the sun.

Use thermometers to measure the temperature of a variety of things and a variety of places. Record.

Use anomometer and wind vane outside on windy days. (A reminder: Air movement is a result of energy.)

Friction: Visit a nearby garage to learn how friction is used in the brake mechanism for stopping a car. Examine the working of a door knob. Notice a bicycle in motion and what is required to stop it.

Oil the internal combustion engine model to observe results of reduction of friction.

MAGNETISM

Problem: Will magnets affect iron objects through water?

Procedure: Into a beaker pour 175 ml. of water. Into the water drop several paper clips. Move disc magnets in all directions around and under the beaker. Observe results.

Predict what will happen if magnets are moved at greater distances from the beaker. Establish field of magnetism through testing of various distances away from beaker.

Problem: How can a compass be made?

Procedure: Stroke one end of a needle at least twenty times (always moving in the same direction) against the N pole of a bar magnet. Stroke the other end of the needle at least twenty times (always moving in the same direction) against the S pole of a bar magnet.

Into a beaker pour 150 ml. of water. Lay the magnetized needle gently on top of the water. Needle may be floated by inserting it into a small cork. (The needle will act as a compass and demonstrate that unlike poles attract and like poles repel.)

ROLLING MAGNETS DERBY RACE

Using metric measure, determine the start and finish lines of race on a level surface. With a stopwatch, measure the time required to "push" one cylinder-shaped magnet with a second cylinder-shaped magnet to the finish line. (Textile plants sometimes discard these larger magnets. These magnets were supplied by a student.)

The formula $R = D \div T$ can be used as a follow-up. Time can be determined by finding the average time for a series of races.

LIGHT AND COLOR

Problem: How can an unbroken pencil appear to be broken?

Materials: 250 ml. beaker, pencil, water.

Procedure: Pour water into beaker until it is i-3 full. Place pencil into water and allow upper part to rest against edge of beaker. Observe pencil from various angles.

Note: The law of refraction states that when light passes through materials of different densities, the speed of light is changed. As a result the light rays are changed. Refraction is the bending of light, a form of energy.

Problem: Is white light really white?

Procedure: Allow each student to go to a sunlit window and to experiment with prisms. (While part of the students are doing this, another activity should be planned for the other students.)

Red, orange, yellow, green, blue, indigo and violet construction paper or crayons may be used to illustrate what was observed when sunlight passed through prism.

CONCEPTUAL SCHEMES

GRADE LEVEL SEVEN

LABORATORY SCIENCE PROGRAM

EMPHASIS: LIFE SCIENCE

GRADE LEVEL: 7

CONCEPTUAL SCHEME: THE RELATIONSHIP OF ORGANISM AND ENVIRONMENT

Sub-concepts: Animal behavior responds to special elements of the environment.
- —Behavior is predictable.
- —Animals exhibit a variety of behaviors.
- —Plants exhibit a variety of behaviors.
- —Animal behavior can be modified.
- —Gerbils, mealworms and earthworms
- —Water organisms

Plants and animals engage in similar life processes.
- —Many behaviors are common to many different kinds of animals.
- —Many behaviors are common to both plants and animals.

Parts of living organisms are related to environment by structure and function.
- —Comparative anatomy
- —Relationship of life styles to body structure
- —Complete and incomplete metamorphosis of insects
- —Special structure of plants and animals which are affected by light, gases, water, soil, minerals and temperature.
- —New plants and new animals originate in several different ways.
- —Life seems to come from pre-existing life.
- —Living things can be thought of as made up of smaller units.
- —Many living things are invisible to the naked eye.
- —Living things usually produce other living things like themselves.
- —Speecial traits as well as structures are inherited.
- —Predicting

SCHEME: Time and Space As Factors Affecting Both Living Organisms and Material Universe

Sub-concepts: Processes of living organisms change

—Life processes involve many exchanges with the atmosphere.

—Life processes involve exchange with soil and with water.

—Processes of non-living matter bring about changes.

Seasons are characterized by observable features.

—A plant or an animal changes in many ways from one season to another.

—Plants and animals have characteristics which change in periodic fashion.

—Seasonal characteristics are local.

CONCEPTUAL SCHEME: Scientific Evidence Which Will Help People To Make Decisions Regarding Ways of Keeping The Body Healthy Has Been Formulated.

Sub-concepts:

—One's feelings affect the operation of the body and body changes affect the feelings.

—Evidence shows that health can be endangered by using tobacco, alcohol or narcotics.

—Narcotics may lead to addiction.

—Human growth and development

—Predicting, measuring, inferring

CONCEPTUAL SCHEME: The Relationship of Matter and Motion

Sub-concepts: A change in motion is a result of unbalanced force.

—Pressure within a closed system is responsive to external environment.

Depth

Temperature

Physical force

—Objects at rest tend to remain at rest unless acted on by an outside force.

—Friction and gravity act as forces affecting the motion of objects.

—The momentum of a moving object is determined by its mass and its velocity.

—Predicting, measuring

LIFE SCIENCE PROGRAM FOR SEVENTH GRADE

by

Dr. Charles C. Matthews

Rationale.

In designing a science program for 7th grade students, it is important to recognize the implications of the cognitive level of the learners. It is assumed that any science program should be designed for "learning by thinking" as opposed to "learning by imitation." Learning by thinking requires that the learning environment and the educational activities be compatible with the thinking (or cognitive level) of the learner.

Children who are in the 7th grade will represent a wide range of cognitive abilities, emotional needs, and educational values. The emotional needs and educational values can best be determined on a day-to-day basis as the teacher uses a "responding mode" of instruction. Research during the last 50 years has suggested that children at this grade level will be a critical stage in terms of cognitive development. Many children in the 7th grade will have available concrete operational thought; other children will be entering the formal operational stage of thinking and will have available the cognitive skills associated with this cognitive level.

The concrete operational stage of thought (which begins around 7 or 8 years of age and continues until 11 or 12 years of age) represents the beginning of logical thought. The child is able to structure basic ideas of conservation in the sense that certain properties of objects remain invariant. Perhaps the most important characteristic of concrete operational thought is the limited but growing tendency to deal logically with the environment. The child who has access to concrete operational thought is tied to "concrete" reality — he must have real objects upon which to operate. Mental operations must be associated with physical operations. The child who has access to concrete operational thought can organize data from objects which are present to his immediate environment but he cannot formulate generalizing hypotheses or mentally abstract to all possible combinations of a given problem. When a child is around 11, 12, or 13 years of age, he characteristically begins to enter the stage of formal operational thought. He begins to develop a new set of operations: conjunction, disjunction, negation, and implication. He can think in terms of all possible combinations for a given problem and he can function at an abstract level without the necessity of perceiving the objects.

It is important to recognize in dealing with groups children who represent both concrete operational and formal operational thought that it is impossible for the teacher or the program developer to know in advance which children will utilize concrete operational thought or which children will utilize ıal operational thought.

The child with formal operational thought can often combine various mental operations to proceed from what is possible to what is emperically real. As verbal statements are substituted for objects, a new type of thinking, propositional logic, becomes available to the child. For the first time he might be able to construct general hypotheses about various phenomena in his environment.

It is necessary, then, that a science program which is designed to function with children who are in the 7th grade should have the following characteristics:

1. Any effort to teach a concept, a process, or a set of information should be associated with direct experience with concrete objects which the child manipulates in acquiring the concept, process, or set of information.

2. The child decides the extent to which he will use the concrete objects. The child with access to concrete operational thought will utilize concrete manipulations of objects and as he gradually progresses into formal operational thought he will begin to substitute verbal statements and abstract thinking for direct manipulations of objects.

3. Evaluation (or grading) must be informal and extremely flexible in order to allow for the success of the concrete operational child as well as the formal operational child. This is extremely critical at this grade level!

Structure

In order to permit children to choose activities in which they will engage, the program should be planned on a modular basis. This will also economize in terms of equipment and materials since it will allow different children to engage in different activities at the same time. Each set of materials could be used during the entire year as children "take turns" with it.

Objectives.

The fundamental assumption underlying a modern science curriculum should be: Learning how to learn is of major importance to the child. Self actualized learning is a major goal of education. The science program for the 7th grade student should have the following general goals:

1. The science program should enhance the thinking ability of the child. It should provide opportunities for the concrete operational child to engage in concrete operational thought in the pursuit of investigations or the solution of problems. It should provide opportunities for the formal operational child to engage in formal operational thought.

2. The science program should facilitate for each child the continued development of a positive self concept with regard to independent learning.

3. The science program should facilitate individual development of interests, attitudes, personality and creativity which enhance the continued development of individuality in the learner.

4. The science program should facilitate the child's tendency to accept the existence of individuals who have ideas and values which are different from his own.

The science program for 7th graders should have specific objectives associated with both affective and cognitive learning. The cognitive objectives should be associated with the goal of communicating to children what science is and how creative and systematic thinking relates to solving self perceived problems. The child who completes the science program should be able to design activities (without suggestions) and do activities (without instructions) in which he: (1) manipulates objects in a way which is dependent upon the properties of the objects, (2) identifies relationships among the properties of static objects or among the factors which affect the behaviors of dynamic systems, and (3) manipulates objects to test the usefulness of the relationships which he has identified.

The affective objectives should be associated with the development of a positive self concept with regard to independent learning in science. The child who completes the science program should identify himself as a person who can be successful in science and who voluntarily chooses to use his competencies in science. He should describe science in terms of activities which make sense to him. He should state his own explanations for natural phenomena and should modify these only when they cease to be compatible with his own interpretations of his environment. He will frequently state alternative explanations for an observed phenomenon and will identify tentativeness as an important characteristic of scientific knowledge.

More specific and precisely-identifiable objectives may be stated for each of the activity modules in the following section. Flexibility is important in the statement of these objectives. It should be kept in mind that a given activity module should result in different outcomes for children who have different emotional and cognitive characteristics and who possess different educational values. A rigid adherence to a predetermined set of objectives will result in learning by imitation (as a result of prescription) rather than learning by the employment of one's own thinking.

Activities.

Module 1: Behavior of Mealworms

For beginning studies of animal behavior, a relatively simple organism is essential. Mealworms are almost entirely unaffected by the artificial conditions of the classroom, and they exhibit reasonably consistent and definite behavior. Since little information about these creatures is available in non-specialized literature, pupils must rely on their own evidence. Mealworms are convenient subjects for experimentation, both in school and at home, since they are clean and odorless, require practically no care, and can be purchased inexpensively from a number of sources (for example, a local pet shop).

Studying the behavior of mealworms stimulates children to ask questions about the observable behavior of an unfamiliar animal and then directs them to ways of finding answers for themselves. As children observe and experiment, they learn some things about the process of scientific inquiry and about the sensory perception of the mealworm. How to carry on an investigation is the most important thing that children learn from the unit; the factual knowledge about mealworms is comparatively incidental. In the course of their investigations children will be able to answer by direct experimentation questions such as these: Can a mealworm see? How do mealworms follow walls? How do they find a pile of bran? How can a mealworm be made to back up? In their attempts to solve these problems, the pupils devise experiments, observe, measure, keep records, design and build equipment, and draw conclusions.

Reference source for the teacher: A booklet, Teachers Guide for the Behavior of Mealworms, has been written by "Elementary Science Study." This booklet is published by the Webster Division of McGraw Hill Book Co. (New York City). The booklet is written for teachers and describes the necessary materials and gives likely activities and outcomes associated with the use of the activity module in classrooms.

Module II: The Common Housefly

The common housefly is an excellent organism for use in the classroom. It is easy to culture and carries on all the life processes of birth, feeding, excreting, mating, reproducing, and death. These processes are carried on in the open for any interested observer to see. The housefly is large enough for easy manipulation and observation and yet it is small enough to be cultured in large colonies. The housefly is an ideal organism for studying life cycles in the classroom.

Reference course for the teacher: A booklet, The Housefly as a Classroom Animal, is available from Educational Science Consultants (P.O. Box 1674, San Leandro, California, 94577). This booklet describes basic husbandry techniques and apparatus for culturing the fly. Suggestions for behavioral experiments with larvae, nutrition studies, and reproduction are also discussed. The housefly is also discussed as an organism for elementary genetic studies.

Module III: Investigating the Inhabitants of Pond Water

This activity requires only simple equipment. With the exception of microscopes and slides, most of the materials can be found in homes and hardware or variety stores. After a trip to a local pond each child can study his own collections of water. mud, sticks, frogs, plants, and water insects. Children can devise simple experiments to learn more about the organisms themselves and about the complicated interactions of life in the local pond.

Reference source for the teacher and the child: A booklet, Pond Water, has been written in the Elementary Science Study project and is published by the Webster Division of McGraw Hill. This booklet describes necessary materials and suggests approaches fo. the teacher. Seventeen student cards are also available to give children information on keeping pond water animals alive, making good microscope slides, maintaining aquariums, collecting and making nets, and identifying specimens.

An additional source is the article, "The Wonders of Ponds and Streams," by Lela N. Goodwin, 6th grade teacher at the Garrison Elementary School in Washington, D.C. This article was published in the September, 1967 issue of Science and Children.

Module IV: Putting Bones Together

This activity takes advantage of the child's natural interest in collecting bones and his interest in finding out what they are. Children learn much about the skeletal system and become familiar with the many kinds of bones, noticing the similiarities and differences among them. Sorting and classifying the bones of a disarticulated skeleton, children assemble them into skeletons. X-ray motion pictures of human hands, feet, shoulders, elbows, jaws, and necks in motion are available to acquaint students with the human skeletal structure as well.

Reference source for the teacher: A booklet, Bones, has been developed by Elementary Science Study and is published by the Webster Division of McGraw Hill. This booklet describes materials available and suggests teaching strategies.

Module V: Studying Molds

In this activity students become familiar with the remarkable growth and diversity of molds. Children can develop pure culture procedures and carry out historical experiments which demonstrate the importance of molds and other micro-organisms in the cycles of growth and decay, as well as the evolution of microbiological techniques from Pasteur to the present.

Reference source for the teacher: A Booklet, Microgardening, has been written by the Elementary Science Study project and is published by the Webster Division of McGraw Hill.

Module VI: Studying the Gerbil

The gerbil is a small, odorless and easy-to-care for animal for behavioral studies in the classroom.

Reference source for teachers and children: The booklet, The Curious Gerbils, was prepared at the ESS and is published by the Webster Division of McGraw Hill. This is a handbook for children and teachers on the care and observation of the gerbil.

Module VII: Reading about an Insect

There are very few science books which are written for children. How a Moth Escapes It's Cocoon is an account written by a scientist and intended to expose students to the intricate processes of scientific research. It is an outstanding example of an appropriate science book for children. The children follow the author's observations of a moth's struggle to leave the cocoon and have the experience of reading an actual scientific report written in language they can understand. After children have read this account they may be encouraged to study behaviors of similar animals and to seek out written accounts of observation of other animals.

Children can also write up their own observations, bind their reports, and share their written accounts of scientific observations with other children. This book is available from the Webster Division of McGraw Hill.

Module VIII: Reading about Scientific Studies of Animal Behavior

The book, How Barn Owls Hunt, is a first person account of a biologists's attempt to study the hunting behavior of barn owls. The methods of observation described in the author's interpretations give the students insight into the processes of scientific investigation. This book can be correlated with the children's study of the behaviors of animals which are available in their local environment. Their own written accounts of the studies of animal behaviors can be added to the classroom collection of scientific accounts of animal behavior studies. This booklet is also available from the Webster Division of McGraw Hill.

Module IX: Growing Seeds

The general activity of planting and observing the sprouting and growth of seeds into plants is a worthwhile activity for all children. It is particularly appropriate for children who have not developed the ability to design and implement "sophisticated" investigations. It is also ideal for children who do not have verbal skills which would be necessary for modules VII and VIII.

Reference source for the teacher: Teachers Guide for Growing Seeds has been written by Elementary Science Study and is published by the Webster Division of McGraw Hill. It provides suggestions of teaching strategies and also gives some indications of what children might do with germinating seeds and growing plants.

Module X: The Microscopic World

In this set of activities the student becomes acquainted with his own microscope, compares the size of an onion cell with the width of a hair, discovers how stain affects cells and then launches into investigations of other living and nonliving things to determine whether they too are made of cells. Experiments designed to distinguish cells from crystals help them make such decisions. A microscope which was specially designed to accomplish this unit is sturdy and simple to use. (It is available from Elementary Science Study).

Reference sources and materials for the teacher and the child: A teacher's guide, a student booklet, a film loop, and sets of materials for use by students are available from the Webster Division of McGraw Hill, and also from Selective Education Equipment, Inc. of 3 Bridge Street, Newton, Massachusetts 02195. (Contact also the Oregon Museum of Science and Industry for materials needed in this and other modules.)

DESIRABLE OUTCOMES OF SCIENCE PROGRAM

I. Teacher

1. Teacher has materials available so that each child can manipulate concrete objects.

2. Teacher moves around the room to observe each child.

3. Teacher talks to students to ascertain what the students may be thinking.

4. Teacher encourages students to manipulate materials in many various ways.

5. Teacher suggests activities to students only when they seem disinterested and need direction.

6. Teacher seldom talks to class as a whole but rather interacts with individuals or small groups of students.

7. Teacher does not direct the students' thinking by cuing responses, leading the student, or telling the student he is right or wrong.

II. Students

8. The students are actively engaged in manipulating materials related to the lesson.

9. The students seem to be engaged in an activity that is appropriate for the lesson and is within the abilities of the students.

10. Students extend interest which orignated in classroom to science activities at home.

11. Students have the opportunity to participate in experiments, demonstrations, field trips, construction projects, library research, group discussions, and discussions with informed members of the community.

III. Parents, Community and Other School Personnel

12. Citizens and parents are invited through the newspaper and personal contact to visit the science program. Program is explained and described through the same means.

13. Families of students have become involved, thus an on-going program.

14. Reporting to parents is done regularly.

15. Science room is open at least twice during the year at night — preferably P.T.A. night for convenience on the part of the parents.

16. Teachers and principals from other schools are invited to observe.

17. Pamphlets concerning science program are available for visitations.

REPORTING TO PARENTS

NAME.. TEACHER.....................................

YEAR.. SCHOOL.......................................

Children learn best when they have materials in their hands to manipulate. We are using an inquiry approach to learning thus providing motivation in all areas of learning. Some of the behaviors children develop are listed below. It is not a complete list. Few children exhibit all these behaviors all the time.

Kindergarten, first and second grade children will have experiences involving behaviors 1-7. Third through sixth grade children will have experiences involving the eleven listed behaviors and others.

Some of the behaviors your child has exhibited are checked. Other behaviors will develop as he has additional science experiences.

1. Observes differences and changes.
2. Does classification by size, color, texture, shape and other properties.
3. Communicates his ideas and understandings clearly.
4. Uses new materials and procedures.
5. Listens to and tries ideas of others.
6. Asks questions.
7. Tries to find answers by manipulating materials.
8. Makes inferences.
9. Predicts.
10. Forms hypotheses.
11. Performs original activities with materials.

Please sign in the space below at the completion of each grading period.

1. ______________________ 4. ______________________

2. ______________________ 5. ______________________

3. ______________________ 6. ______________________

Please sign and return with report card.

Experienced teachers realize that the student who has had science taught with the traditional approach — that is, book and often teacher-centered manner, cannot suddenly handle an extreme amount of freedom. Therefore, too much activity and too many materials at the very outset is often confusing for the teacher as well as the student. Controlled freedom must be developed gradually in most classrooms.

Our program in September, 1969, began with the "Adaptation to Environment of Reptiles" and proved to be a wise choice. One has the advantage of student interest which is an absolute necessity when any new program is undertaken. Using the actual specimens which will be brought in, the opaque projector, filmstrips, and transparencies the instructor is able to use a variety of equipment. This variety can hardly leave any place for boredom on the part of the instructor or student. Continue any such unit only as long as interest is keen. A class-prepared outline to organize their discoveries is preferable to long individual reports. Assembling library books and checking them out from science classroom will facilitate the locating of answers to their own questions.

From this type of unit, we moved to simple physical science experiments. An excellent booklet is prepared by Edward J. Stokes — Physical Science Experiments, F.A. Owen Publishing Company, Dansville, New York 14437. Plan in advance always. At times simple items can be brought from home. When families of a community become involved in the school program, the school-image thermometer rises quickly.

If there is a control group as well as the laboratory group, it should be clarified at the beginning that the special equipment and materials are not to serve as a central supply system for the school.

If the students must be graded and, at the same time, a positive attitude toward science is to be developed, the two top evaluations are advisable on two conditions:

(1) Do not interfere with the work or concentration of any classmate.

(2) Do not damage purposely any material or equipment. (Dr. Charles Matthews, Florida State University)

When using microscopes, it is quite easy to damage the slides. Instructors would do well to have small groups engaged at one time in this activity. If one is not alert, lenses can disappear. A chairman for perhaps each group of six students should see that all parts are intact. Student responsibility for equipment must be developed. This is not done in an attitude of teacher distrust but as a precaution. Children are often tempted to "borrow" science objects as they are fascinating.

It would be advisable, therefore, to have good storage space set up during the summer. Disorganized and careless handling of equipment and materials is perhaps a worse lesson in citizenship than having too little with which to work.

In case a telescope is provided, it would be wise to remove lenses except when in use for night sessions or instruction as to use during the daytime.

Some questions have been asked concerning recording and testing. Recording results is perhaps best accomplished with check-lists, graphs, short summaries by individual students, class-prepared outlines, graphs and charts and art work. To emphasize long, written observations would destroy the "spirit" of the course. When a child can do what he set out to do, teacher observation can usually provide the evaluation. Our students did keep a composition book so that their work would seem worthy enough to keep. It also served as a classification project and something tangible that parents could see.

As for testing, AAAS has an innovative procedure and is well worth consideration. Occasional reviews will strengthen the course more than frequent tests. Stanford Achievement Tests were used in the fall and spring to measure progress. Of course, the unskilled reader was penalized even though he had been an involved science student. However, for lack of a truly suitable test, it did indicate that progress had been made. One cannot measure innovative approach results with a traditional approach test.

In some science courses, study sheets are provided. This is an easy way out although it might serve a good purpose on high school level in a few areas. There could be little creativity and imagination involved when inflexible directions are given by the teacher to be followed unquestionably by the child. However, when chemicals and electrical equipment are to be used, the teacher must be nearby. Even if study sheets have been handed out, directions are not always understood and followed and could pose a serious safety problem.

SAFETY IN SCIENCE TEACHING

Quality science instruction involves the use of a wide variety of equipment and materials. Therefore, the risk of accidents and injury is always present. It is urged that all teachers be aware of precautions which can be taken to reduce this risk. Good safety procedures in science instruction cultivate attitudes that will persist beyond the formal schooling of the student.

The following guidelines for safety in science teaching is not comprehensive; it is expected that each teacher will develop supplementary methods to meet local conditions.

General Safety Practices

1. If there is a question about hazards in working with the materials and equipment of science, the watchword to use is "DON'T."

2. A teacher should work through the handling of equipment and materials, find out about all possible hazards, and be sure that the experience is a reasonably safe one before proceeding.

3. Teachers should practice general safety procedures in relation to the use of fire and instruct children in how to take appropriate precautions. Teachers should consult with the principal regarding fire regulations.

4. At the beginning of any experience, if there is any special hazard, children should be specifically instructed regarding the recognition of dangers and the precautions to be taken. This particularly includes experimentation and study trips.
5. If the children are working in groups with limited amounts of equipment, each group should be small enough to prevent confusion which might result in accidents.

6. When using equipment that might present special hazards, individual and group work should be arranged in the classroom so there can be constant teacher supervision.

7. All accidents resulting from the handling of equipment should be reported to the teacher.

8. Children should never carry equipment through the halls when classes are passing.

9. Children should be allowed sufficient time to perform experiments, because haste sometimes causes accidents.

10. A child should not perform any experiments, at school or at home, without thorough investigation by the teacher before a child proceeds.

11. Any piece of equipment that has been heated (microprojector, hot plates, A.V. devices) should not be moved until it has cooled. A sign showing "HOT" should be attached until the equipment has cooled.

12. Hazardous materials and equipment not in use should belabeled "KEEP HANDS OFF."

13. Before permitting children to work with sharp tools, the teacher must be assured that children are competent to use those tools.

14. It is to be remembered that there is always danger when heating a liquid which is confined in a container.

15. Glass wool and steel wool should be handled with gloves.

Safety in Relation to Animals and Plants

1. All mammals used in a classroom should be inoculated for rabies, unless purchased from a reliable scientific company.

2. The following animals should never be brought into the classroom: wild rabbits, snapping turtles, poisonous snakes, or insects that may be disease carriers. Children should not bring their pets to the classroom unless the activity is carefully planned by the teacher.

3. Before a small animal is brought into the classroom for observation, plans should be made for proper habitat and food. The living quarters of animals in the classroom must be kept clean, free from contamination, and secure enough to confine the animals. Plans should be made for care of the animals over the weekends and during vacation periods.

4. Animals should be handled only if it is necessary. This handling should be done properly according to the particular animal. Special handling is required if the animal is excited, is feeding, is pregnant, or is with its young.

5. Children should wash their hands after nandling turtles, snakes, fish, frogs, toads, etc Also, the water from the habitat should be disposed of carefully.

6. Children should be cautioned never to tease the animals or to insert their fingers or objects through wire mesh cages.

7. Any child who is bitten or scratched by an animal should report immediately to the school nurse.

8. After a period animal observation is completed, animals should be returned to their natural environment.

9. Before taking study trips into wooded areas, identify and discuss plants which produce poisonous effects.

10. The use of flowers and mold which have excessive spores should be used with caution because of possible allergies of children.

11. There is a great danger of contamination from bacteria cultures unless sterile techniques are used.

Safety with Chemicals

1. Have a chemical first aid chart available at all times.

2. When heating test tubes, keep open end pointed away from oneself and from ones classmates.

3. Label all bottles so that their contents may be identified.

4. Pupils should never taste any chemical.

5. Chemicals should never be mixed just to see what will happen.

6. If volatile or flammable liquids are used in a demonstration, extreme care should be taken to insure that hot plates or open flames are at safe distances from the fumes.

7. Rosin, shellac, alcohols, charcoal, etc., should be stored in glass-stoppered bottles or in bottles with plastic tops.

8. Combustible materials should be kept in a metal cabinet equipped with a lock.

9. Chemicals should be stored in a cool place but should not be stored in a refrigerator.

10. Children should never experiment with rocket fuel propulsion devices.

11 Volative substances which are spilled should be disposed of in fireproof receptacles.

12. The use of such preservatives as formaldehyde and alcohol demands protection for the skin. Preserved specimens should be washed in clean water and kept in salt water for use during the day. To remove specimens from preservatives, use tongs and rubber gloves.

Safety with Electricity

1. At the beginning of the study of a unit on electricity, children should be told not to experiment with the electric current of home and school circuits.

2. Children need to be taught safety precautions regarding the use of electricity in everyday situations.

3. Children should never handle electric devices immediately after their use because these devices might retain a high temperature for a period of time.

4. To remove an electric plug from a socket, pull the plug and not the cord.

5. It is to be recognized that short-circuited dry cells can produce a high temperature which can cause a serious burn.

6. Storage batteries are dangerous because of the acids that they contain and the possibility of short circuits within them.

Safety with Glassware

1. Glassware which is to be heated should be only Pyrex or a similarly heat-treated glassware.

2. All glass tubing used with corks or stoppers should be polished or have the edges beveled with emery paper.

3. A soap solution or glycerine should be used on the top of glass rods or tubing for lubrication before inserting them into a cork or stopper. Tubing should be wrapped with several layers of cloth or in a rubber tubing holder. The tubing should be held as close to the cork as possible.

4. Corks should be removed from tubing to keep them from adhering and "freezing." "Frozen" stoppers can be removed by splitting them with a razor blade and then reclosing them with rubber glue.

5. Broken glassware should be disposed of in a special container marked "BROKEN GLASS."

6. The fingers should never be used to pick up broken glass. A whisk broom and dustpan can be used for large pieces, and large pieces of wet cotton can be used for very small pieces.
7. Glassware should be thoroughly cleaned after use.
8. Children should never drink from glassware that has been used for science experimentation.

9. Sharp edges on mirrors or glassware should be reported to the teacher.

10. Glass objects which might break should be wrapped with plastic wrap or wire screening.

EVALUATION SUMMARY

The evaluation results presented herein were derived from test scores indicating grade level achievement in the area of science. Valid test scores for each pupil at four test date intervals were obtained for 99 fifth and sixth grade pupils enrolled as an experimental group in classes utilizing laboratory instructional methods and 81 pupils enrolled as a control group in classes which did not use laboratory instructional methods.

In order to determine achievement in science for each of the groups, the Stanford Science Achievement Test was administered to pupils in the experimental and control groups as a pre-test at the beginning of the program in October, 1969. Subsequent tests were administered in May, 1970: March, 1971; and March, 1972. Mean scores of grade level achievement are presented in the accompanying table representing test scores upon entry into the laboratory science program and subsequent scores of pupils in the two classes which participated for the full three year project period.

Test Results
Grade Level Achievement in Science

Testing Date:	October, 1969	May, 1970	March, 1971	March, 1972	Net Gain – Three Year Project Period
Experimental: (99 pupils)					
* Class I	3.9	5.1	7.1	8.3	4.4
** Class II	4.6	6.8	9.1	9.9	5.3
Control: (81 pupils)					
* Class I	3.7	4.6	5.1	6.0	2.3
** Class II	4.6	5.5	6.0	6.8	2.2

* Class I entered the program as fourth graders in 1969.

** Class II entered the program as fifth graders in 1969.

The basic objective of the project was to demonstrate greater achievement among pupils participating in an elementary laboratory science program when compared to pupils participating in traditional testbook-oriented science instruction.

Summary conclusions:

1. Mean grade level achievement scores for both experimental and control group were approximately equal at beginning date (October, 1969) of project.

2. The experimental program appears to be successful in that the students enrolled in the experimental classes scored higher on achievement than the control students.

EXPORTABILITY REPORT

A. Introduction

The Laboratory Science Program in Clover could be replicated in most elementary schools with little difficulty and with reasonable expenditure of funds. The basic features necessary to implement such a program include:

a. A standard size classroom with tables (or other flat-topped surfaces), chairs, running water, adequate electrical outlets. (Although most high schools include gas outlets in their science laboratories, this is not recommended for use by children at the elementary level due to the hazards involved.)
b. A teacher capable of utilizing the laboratory science teaching methods.
c. Adequate equipment and science supplies.

The number of children that could be served by one laboratory would vary according to the size of the room, the number of minutes per day that a pupil would be scheduled for laboratory activities, and the number of days per week that the teaching method would be utilized in a particular class.

B. Context of Program

1. The school district has a pupil population of 2,700. It is served by three elementary schools, one middle school and one high school. The population of Clover is approximately 4,000. Sixty percent of the working population in Clover are employed in manufacturing of which the chief industry is textiles.
   Clover Middle School is located in the heart of the black community in the city of Clover. Current enrollment is approximately 750 in grades 5 - 8. The student body is 70% white and 30% black.
2. Special Factors for Consideration of Adoption. No special factors noted.

C. Program Description

1. Scope - Basic objective was to increase acheivement of 182 pupils in grades 5, 6, and 7 involved in the Laboratory Science Program.
2. Activities - Students sit at tables instead of desks. Laboratory equipment is available on a check-out basis. Instruction is individualized and features pupil selection of learning activities from a wide range of alternatives. Utilization of science textbooks is minimal with emphasis on learning through inquiry-discovery laboratory techniques. Informal day to day evaluation of pupil

progress is utilized in place of formal testing as a means of determining performance for grading purposes.

3. Pre-service and In-service Training - Involvement of the laboratory science teacher in pre-service and continuing inservice training is considered essential. Pre-service training should include visitation to a laboratory science program and a workshop or individual consultation with science consultants qualified to advise teachers in the utilization of the laboratory science methods.
4. Facilities - A regular classroom would be adequate. It would be necessary to have running water and adequate electrical outlets. Tables or other flat-topped surfaces would be required. Storage cabinets for materials and equipment would also be needed.
5. Materials and Equipment - See attachment.
6. Project Budget - See attachment.

D. Cost Effectiveness Analysis

1. Development Costs - Developmental and planning costs would be approximately $1,000.00.
2. Initiation Costs - The purchase of supplies and equipment, the renovation of classroom, the costs of staff development, and the cost of additional staff would be approximately $6,000.00. If a full time science coordinator is to be employed, the costs would be increased by $10,000 or $12,000.00

This figure is very misleading. $600 is allowed by our dis-
ict for total operational costs of the school per pupil; i.e.,
00 + 6 classes = $100. Last year I spent $14 for new science
terials. It costs no more than a regular science class after
plementation.

1. Strategy - Research type of design utilized control and experimental groups. Process Evaluation: Constant feedback provided by staff. Product Evaluation (Pre-test and post-test science achievement): six experimental groups and four control groups. A comparison of achievement progress of experimental and control group was made.
2. Findings
   a. The Stanford Science Achievement Test was used to measure achievement of the six experimental classrooms and the four control classrooms. Between the pre- and post-test administrations, the control groups made an average gain in grade placement scores of 0.8. The experimental groups made an average gain of 1.8 grade placement points. There is evidence that the objective of increased science achievement has been met by the experimental science program.

b. Pupils appeared to participate in the laboratory science learning activities with enthusiasm.

c. Many visitors to the program were sufficiently impressed as to recommend to their superintendents that consideration be given to implementing a similar project in the schools where they taught.

d. Audit reports indicate that expenditure funds conformed very closely to projected costs.

3. Unanticipated Outcomes - One of the most significant observations of the project director relates to the attitudinal change which occurred in students participating in the laboratory science program. Students in this age group are usually characterized by disciplinary problems, carelessness, lack of responsibility, and general disregard for the care of school facilities. The project director reports that pupils enrolled in laboratory science (a) seldom became disciplinary problems even though the same student might have been a problem in another class, (b) exercised responsibility in the selection of learning activities from a range of alternatives and in the check-out and use of equipment and materials, and (c) showed a better attitude toward the conservation and care of facilities.

The project director reported that the problem of having materials and equipment stolen from the classroom was practically unknown, table tops were not written on, and windows were not broken. The project director was not aware of there ever having been any attempt to break into the classroom or storage cabinets. While these factors may bear little relationship to the improved achievement of the participants, they are important indicators of changes in attitudes that occurred among pupils participating in the laboratory science program.

F. Conclusion

The start-up costs in setting up an elementary science laboratory can be highly variable. Many schools already have adequate audio-visual equipment to meet requirements of a laboratory science program. Many classrooms already have adequate electrical outlets, storage space and water supply. The larger problem is usually that of encouraging teachers to conduct activity-centered rather than textbook-centered science instruction.

In a laboratory science program at the elementary level, a large variety of inexpensive materials is usually more useful than a few expensive items. The amount to be spent on materials varies according to the supply of science materials already on hand. The need for science equipment varies greatly according to the science background of the students involved. Generally, there is little need for highly sophisticated science equipment. Basically, the success of the program is dependent upon the ability of the teacher to create a learning environment in which each child experiences success. Teachers, therefore, must plan activities that are meaningful, relevant and simple enough for the student to accomplish with a minimum of help. Parents and/or older students may be utilized to assist the teacher where it is impossible to provide a teacher aide.

IMPLEMENTATION COSTS

EQUIPMENT LIST

2	Listening Stations	$ 172.00	
1	Sony Tape Recorder	135.00	
1	Fire Extinguisher	20.00	
1	Aquarium and Furnishings	30.00	
5	Elementary Microscopes	100.00	
1	Small Animal Cage	8.90	
6	Alcohol Bruners	10.00	
10	Beakers, 1 liter, pyrex	18.40	
15	Beakers, 1–0 ml., plastic	3.00	
15	Meter Sticks	21.00	
5	Electric Bells	12.00	
5	Bulb Sockets	1.75	
6	Cylinder Sets	13.80	
6	Lever Apparatus	9.00	
8	Circuitboards	8.50	
1	Sexless Mini-Torso	82.00	(Optional)
6	Stethoscopes	18.00	
6	Globe Kits	41.10	
5	Spectroscope Kits	9.90	
1	Mineral Collection	10.35	
1	Electric Hotplate	15.00	
6	Reading Glasses	9.00	
1	Barometer	19.75	(Optional)
5	Carts, Ball Bearing Wh.	17.25	
16	Compasses, drawing	4.80	
15	Compasses, Magnetic	3.00	
1	Incline Plane	7.00	
2	Spring Scales	5.00	
1	Filmstrip Projector	130.00	
1	Projection Screen	51.00	
1	Overhead Projector	150.00	
	TOTAL COST FOR EQUIPMENT	$1,136.50	

SUPPLY LIST

1	pt.	Alcohol, Methyl	$ 1.90
1	pt.	Alcohol, Denatured	1.90
1	pt.	Alcohol, Isopropal	.60
400	gm.	Alum	2.00
8	oz.	Baking Powder	.40
1	bx.	Baking Soda	.35

1		Balloon Set	.90
1		Ball Set	4.80
1	pk.	Batteries, D Cell	3.40
½	lb.	Calcium Hydroxide	1.50
1	bx.	Candles	1.10
2	pk.	Cards (3 x 5)	1.00
5	lb.	Clay, Powder	7.50
20	gm.	Colbalt Chloride Crystals	.60
1	lb.	Copper Sulfate Crystals	5.00
30	bx.	Crayons	7.50
1	pk.	Eggs, Brine Shrimp	.95
100	gm.	Filings, Iron	.70
1	set	Food Coloring	.50
1	bottle	Glue	.40
15	ml.	Iodine	1.00
500	gm.	Iron Ore	5.00
2	vials	Litmus Paper, Blue	.50
2	vials	Litmus Paper, Red	.50
8		Magnet Bars	14.00
5		Magnet Sets, Horseshoe	20.50
1	pk.	Measuring Stick Sets, Unmarked	5.75
1		Measuring Tape, Metric and English	.50
15		Medicine Droppers	1.20
6	pk.	Microscopic Slides (Plain)	4.20
15		Mirrors, Plane and Front Surface	6.75
1	pk.	Mothballs	.50
1	pk.	Nails, Aluminum	.40
1	pk.	Nails, Copper	.50
1	pk.	Nails, Steel	.50
1	pk.	Paper Blotter	.60
1	pk.	Paper Clips	.25
1	pk.	Paper, Construction	.75
1	pk.	Paper Fasteners	.25
1	pk.	Paper, Graph 1 cm. grid	4.70
2	vials	Paper, PTC Taste Test	2.70
2		Pens, Marking Set	1.00
2	sets	Petri Dishes	3.60
1	set	Pipe Cleaners	2.55
6		Prisms, Glass	18.00
3	sets	Rods, Conductivity	8.50
4		Tuning Forks	8.50
1	pk.	Rubber Bands	.40
30		Rulers, 30 cm.	2.95
18	pks.	Seeds (grass, corn, mung bean)	8.35
[illegible]	pk.	Shapes, 1 cm. wooden cubes	.75

1	pk.	Steel Wool	.60
1	pk.	Straws, plastic	.50
1	box	Tacks, Thumb	.35
6	rolls	Tape, Masking	6.00
15		Tapes, Recording, Blank	25.00
6	pks.	Test Tubes	5.10
5		Tubes, Viewing	15.60
5	liters	Vermiculite	1.65
2	pks.	Wire, Bell	1.00
5	pks.	Filmstrips and Transparencies	23.05
		TOTAL COST FOR SUPPLIES	$ 247.50

OTHER COSTS

Furniture: 5 Tables and 36 Chairs	600.00
Classroom Renovation:	100.00
Staff Development: 3 Day Workshop	500.00

TOTAL COST FOR ADDITIONAL STAFF $3,700.00

Designate an existing science-oriented elementary teacher as the lead teacher. She would be employed for 10 months. This would enable the lead teacher to work one month during the summer to prepare for implementation of the science program.

additional month's salary = $1,000.00

A full-time aide should be provided for the lead teacher to assist in clerical work and to provide some released time for the lead teacher to assist other teachers.

1 full-time aide salary = 2,700.00

TOTAL IMPLEMENTATION COST

Equipment	$1,136.50
Materials	247.50
Staff Development	500.00
Cost of Additional Staff	3,700.00
Furniture	600.00
Renovations	100.00
	$6,284.00

The costs listed here are considered to be the minimum investment required of a district to implement a laboratory science program. Costs could range upward depending on the degree of sophistication that a district would choose for its program.

The following article appeared in the CLOVER HERALD on March 28, 1973:

CLOVER LABORATORY SCIENCE PROJECT VALIDATED

Word has been received by Martin Ramsey, Superintendent of Clover School District, and Mrs. Sara G. Dillard, Project Director, that the Clover Laboratory Science Project has been validated. A team of four out-of-state experts made an on-site, intensive study of all phases of the Title III project recently when they spent three days in Clover. The team was composed of John Powell, Dr. Al Eiss, Ken Watkins and Dr. Robert Nelson, Chairman.

The team studied the data and documentation concerning the progress of the program since it started as a Title III three year pilot program in 1969 and operated for three years before being taken over this year with local school funds.

Dr. Nelson pointed out that the committee was in Clover not to evaluate the project but to validate it as to requirements and documentation. The favorable report was unanimous.

Mr. Watkins spoke on the phase of innovativeness after the team visited the laboratory "in action". He stated that it is the only program of this type in South Carolina in which you get more than one year's achievement in one year.

In speaking on proof of effectiveness, Mr. Powell said, "Success was demonstrated through the results of measured learning. A testing program was carried on consistently. Achievement test results show that the fifth, sixth and seventh grade laboratory students averaged two grades higher than national average in science achievement. The data was termed accurate; the personnel administering the tests were found to be well-qualified.

Dr. Nelson spoke on the cost of the project saying, "It would be hard to find a better way to spend science dollars for education as the money was spent to achieve end results of teaching science to this age students."

As to the exportability of the project, Dr. Eiss stated that the cost made it possible for others to duplicate; that it is internally staffed with a fine supportive staff, and that it)uld be successful if tried in other schools.