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ABSTRACT

This handbook, and the VITAL Science Series videotapes, contain 12 lessons that are examples of some of the many ways of organizing elementary school classrooms for science instruction. The videotapes that are available separately demonstrate full class and small group activities, the use of learning centers, cooperative learning, and outdoor activities. Each lesson has the following organization: (1) introduction to the video tape; (2) questions for consideration; and (3) teaching this lesson (including focus, background to the lesson, challenge, materials and equipment, how-to-do-it, and further challenges). Lessons stress science process skills, thinking about science, scientific attitudes, scientific concepts, and doing hands-on science with a textbook. These materials are designed to be used in preservice or inservice teacher development programs through courses or individual study. (RH)

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VIDEO TAPES FOR INSERVICE TRAINING FOR ACTIVE LEARNING SCIENCE

CONTENTS

VITAL: SCIENCE SERIES

Introduction

Scientists, science educators, and elementary teachers who teach science have been in basic agreement for at least 20 years on how science should be taught to children. Concrete activities help students understand scientific concepts, become skilled in using the processes of science, and develop scientific attitudes. An impressive body of research supports this approach. (An excellent short summary of this research is provided in The National Science Teachers Association publication, <u>What Research Says about Elementary School Science</u>.)

Unfortunately, science is too often not taught at all or is taught solely as a reading lesson. Teachers who do make the effort to teach hands-on science in their classroom are rewarded by positive responses from their students. Indeed, students who <u>DO</u> science as opposed to merely reading about it, not only learn more science content and processes, but their attitudes toward both science and school improve.

This handbook, and the VITAL Science Series videotapes, contain lessons developed by teachers aware of problems which face many elementary teachers including limited scientific knowledge, limited access to materials and activities, and limited time for creation and presentation of hands-on activities in a lesson. We feel that children's responses and increased learning are worth the effort expended to solve these problems.

Teachers cannot learn to teach science solely by reading this book and watching the videotapes. To become confident and competent in science, teachers, like their students, should <u>DO</u> science. Therefore, we recommend that teachers do hands-on activities and discuss them with a teacher who is knowledgeable and experienced in elementary science methods as the videotapes are used. Research on how children learn, enumeration of the essential scientific attitudes and process skills, methods of combining hands-on science with a textbook program, and sources for non-text based lessons should be integrated into this study.

<u>How Children Learn</u>. In the early years of elementary school, children are usually in the pre-operation stage of development. During these years their study of science should emphasize making accurate observations using all appropriate senses. As children mature they are better able to think about their observations, and by the upper elementary level many are able to think abstractly. Often, children have difficulty using abstract thinking because they lack concrete, preferably hands-on, experiences to use as a framework for their ideas

Children do not learn just by doing, they learn by <u>THINKING</u> about what they are doing. Thinking is encouraged when children organize their observations, make purposeful changes in their materials through response to teacher questions, and most effectively, talk with other children about their activities.

Scientific Attitudes. Curiosity comes naturally to children. The successful science teacher helps children add persistence, objectivity, and cooperation to their natural curiosity. When a science demonstration does not turn out as expected, teachers should avoid saying, "What is supposed to happen is . . ." In science WHAT ACTUALLY HAPPENS IS WHAT IS SUPPOSED TO HAPPEN. If trying the activity again does not produce the anticipated result, and this result is essential to development of the concept, a teacher might tell what happens "under certain conditions" and explain that apparently other variables are affecting the outcome at the moment. If time permits, the search for the other variables often turns out to be a greater learning experience than the planned lesson.

Science Process Skills. Observation is the skill on which all other science processes depend. Other essential skills include classification, measuring and using numbers, inferring and predicting, and communicating. The process of experimenting requires all of these skills as well as formulating hypotheses, making operational definitions, and controlling variables. In the brief lessons of this project, time does not permit modeling the complete process of experimenting.

Doing Hands-On Science with a Textbook Program. Piaget said if you teach a child in one hour what the child could have discovered in two hours, you have wasted an hour of that child's time. Whenever possible, children should discover the concept of the lesson for themselves by participating in thinking about and discussing concrete activities that demonstrate the concept. Textbooks, films, and other sources of information are then used to reinforce and extend the concept. This is followed by presentation of technological and/or everyday applications of the concept. This teaching sequence is summarized as ACT -- Activity; Concept development; and Text.

Using the VITAL Project Materials

The lessons in this book are examples of some of the many ways of organizing classrooms for science lessons. Student or teacher demonstrations may be used in the activity phase if materials are limited or if the activity would be dangerous for children to do independently. However, whenever possible the lessons should allow students to participate in hands-on activities. The videotapes accompanying this guide demonstrate full class and small group activities, the use of learning centers, cooperative learning, and outdoor activities.

The lessons were developed by the teachers who taught them, using a variety of texts and activity books. Some lessons are based on commercial and non-profit programs such as TOPS, S-APA, ESS, and OBIS. References are indicated in the bibliography at the end of the handbook. We hope teachers who watch these tapes will find many ways in which these, and their own lessons, can be improved.

The following format has been used in this guide to present each lesson:

- Title
- Introduction to the Video Tape
  - Questions for Consideration
- Teaching this Lesson
  - Focus
  - Background to the Lesson
  - Challenge
  - Materials and Equipment
  - How-To-Do-It
  - Further Challenges

This format was adapted with permission, from Understanding the Healthy Body, CESI Sourcebook III, David R. Stronck, Editor.

Notes to the workshop leader on use of the tapes:

The video tapes and this instructional guide may be used in a variety of ways. Teachers, like students, should be actively involved in the learning process. Hands-on instruction helps adults as well as young people learn new concepts, skills, and to develop attitudes. The tapes are designed to be used as a part of a workshop in which participants have directed hands-on experience with the science concepts or materials presented in the videotaped lessons before viewing the tape.

Ways these materials have been used include:

1. SELF INSTRUCTION. An individual may select one or more lessons, read the guide materials in this booklet, and watch the video lesson(s). This approach works well if the teacher understands and is familiar with using manipulatives in instruction; wishes to see how another teacher approaches teaching a concept he/she has already taught; or wants to understand student responses to using manipulatives and the effect of manipulatives on student learning. Before using these materials and strategies with students it is strongly recommended that teacher's try using the materials themselves to better understand where children may have difficulty with the activity or the instructions.

2. GROUP SELF INSTRUCTION. In this approach these materials are used to stimulate discussion about instruction among a group of pre or inservice teachers. As with SELF INSTRUCTION, teachers select appropriate lessons, read guide materials, do the activities, and watch the video lessons. In this case a group of teachers, working together, take time to share their opinions on the demonstration lesson and share their experiences and feelings about using these materials and strategies in their own instruction. This can be a very powerful and effective learning process. Teachers have much to share and these materials may stimulate sharing in which all participants learn from each other and improve instruction for their students.

3. PRE or INSERVICE TRAINING. In this approach, a teacher leader teaches the science lesson to the participating pre and/or inservice teachers much as if they were elementary school children participating in the lesson. (This is an effective strategy for developing an understanding of the effect on learners of discovering science concepts for themselves.) The participants discuss reactions to the lesson and offer suggestions as to how they will/could use the demonstrated strategy with their students. Brainstorming other ways to use manipulatives to teach or reinforce concept learning is effective for stimulating further creative approaches to instruction.

   The relevant video lesson is then introduced using the discussion questions suggested in the introductions to each lesson in this guide, or questions developed by the workshop leader. The tapes may also be effectively introduced by simply saying "Here is a ____ grade class learning about ____________. What good teaching practices do you notice? What suggestions would you make to this teacher for improving the lesson?" Conclude by summarizing key points about teaching the lesson and preparing participants to teach similar lessons with their own classes.

   Alternatively, begin the lesson by first showing the video tape. Either show the whole lesson (10-15 minutes) followed by discussion using the guide questions or stop the lesson at predetermined places to do the activities, point out relevant actions, focus attention, or raise further questions for consideration. Then teach this or a related lesson to the group. This is followed by a summary discussion.

In all cases, it is important that teachers actively participate in these - or similar - activities in order to develop thorough understanding and facility with the goals and procedures presented in these demonstrations. We hope you find these materials of value and would be pleased if you would take the time to share your experiences with us in order that we can increase our ability to encourage improved mathematics and science instruction for young people.

LESSON 1
Sound: Teaching Observation Skills to Young Children for Grades: K-2

Teacher: Grace Fridgen **Demonstrated with 6-year olds**

Introduction to the Video Tape

Activities in this introductory lesson on sound are used to teach the science that explains everyday experiences. The activities also provide avenues for teaching appropriate social behaviors, such as sharing and listening.

Accurate observation is basic to all science. In these activities, young children are sharpening their auditory skills by listening for the direction from which sounds come and for environmental sounds that usually go unnoticed. They also match sounds by identifying the two containers in a group of containers that make the same sound when shaken. Informal inferences are made as they guess the substance which caused the sound in each pair of containers.

The teacher must plan for orderly movement between activities as well as for the activities themselves. Praise, in the form of specific positive comments by the teacher is effective for encouraging desired behavior.

Questions for Consideration:

1. The first grade teacher, even more than teachers at other levels, must vary the pace and intensity of instruction and provide frequent opportunities for students to move. What examples of this do you notice in these lessons?

2. How does this teacher insure orderly group movement?

3. Blindfolds are useful in many observation lessons to encourage children to use senses other than sight. What concerns might the use of one blindfold for the whole group cause? What would you suggest to resolve these concerns while keeping the advantages of using blindfolds?

Teaching this Lesson

Activity 1: Sounds Travel

Focus: Sound causes vibration and is transmitted in many different ways. Mechanics of the ear transfer the energy of the vibrations to the brain where it is translated into recognizable sound. One way sound travels is through air such as when a bell rings. A group of children show how sound travels using musical instruments.

Challenge: Can a blindfolded student point toward the person making a musical sound?

Materials and Equipment:

- Blindfolds
- Rhythm band set

How-To-Do-It: A student is blindfolded and placed in the center of a circle of children. Each student in the circle is given a rhythm instrument. Let them each practice making a sound with the instrument they have. Have all students hold instruments quietly. Point to one child to make a sound with his/her instrument. The blindfolded student points to the one who made the sound. If he/she points to the correct child, the blindfolded student exchanges places with the child playing the instrument.

Further Challenges: Have the blindfolded student cover one ear with the palm of his/her hand. Discuss if it is easier, or more difficult, to determine where the sound comes from.

Activity 2: The Shaking Game

Focus: Various objects make distinctive sounds. Students match sounds made by objects in small containers.

Challenge: Can you match the pair of containers that hold the same object?

Materials and Equipment:

- 4 to 6 Pairs of containers for each group
- Marbles
- Beans
- Cotton balls
- Pennies
- Rice
- Oatmeal
- Or any variety of small objects
- Trays (Plastic plates work well)

How-To-Do-It: Before class, prepare pairs of containers with the same objects. When you have them paired write numbers at random on the tops of containers, record which numbers are pairs, and place a set on a tray for each group of students. Each set must be the same.

Students shake containers and listen to the sounds the objects make. They exchange containers within the group until the matching pairs of sounds are found. Group members help each other determine if their pairs are the same. Instruct students to place their paired containers on the table and put their hands in their lap when they are ready. The teacher identifies the numbers of matched pairs so that students may check their answers.

If a group has not correctly matched containers with the same object, have them shake their containers individually. The children may have had a difficult time matching the sounds because of the noise of everyone shaking containers at the same time.

After all pairs of containers have been identified, allow the children to look into the containers to see if they have the same objects in each pair.

Further Challenges: To compare the transmission of sound through air and solids, first have one student tap a penny on the table while the other children in the group listen. Then have the group lay their heads down on the table with one ear to the table and have the student tap the penny again. "Which sound is easier to hear?"

Tie a spoon in the center of a one-meter long string. While holding the ends of the string in each hand gently tap the desk or table top with the spoon. Next, have the children cover their ears with their hands while still holding the ends of the strings. Again, gently tap the desk or table with the spoon. "Is there a difference in the sounds? What causes the difference?"

Hold a ruler on the edge of a table. Pull down on the end of the ruler and let it go. "What happens?" Vary the length of the ruler extending over the edge of the table. "What difference does this make in the sound?" The children will discover the relationship of length of a vibrating object to pitch.

Notes:

LESSON 2
Caterpillars: Insect Development
for Grades: 1-6

Teacher: Grace D. Fridgen Demonstrated with 6-year olds

Introduction to the Video Tape

Children of all ages find live creatures exciting. Easy to care for insects give children a chance to watch the dramatic changes from egg to larva to pupa to adult. While children observe each stage of an insect, they learn how insects develop and grow. Measuring and recording skills are also increased.

The video tape shows children examining the tobacco hornworm in various life stages. Ordinarily these changes would be observed over a period of six to eight weeks as each child follows the growth cycle of a particular hornworm.

Questions for Consideration:

1. In these lessons children are not asked to measure their caterpillars in inches or centimeters but only to draw a line the same length as the caterpillar on their sheets. Why are standard units (centimeters, inches) not used with young children? What other ways of measuring without using standard units can you suggest?

2. Compare the reactions of your students to live organisms in the classroom with those of pupils in the film.

Teaching this Lesson

Focus: Children observe each stage of an insect as they learn how insects develop and grow.

Background to the Lesson: Magnifying glasses should be introduced to the students about three weeks before this lesson.

Challenge: Can you identify the little objects you have before you?

Materials and Equipment:

For each group:
- Small bag of salt
- Small bag of small stones
- Small bag of eggs**
- Tray (Family-sized meat trays from the grocery store work well)

For each individual:
- A magnifying glass and tweezers

How-To-Do-It: Have children empty each bag into separate piles on their trays. Then have students examine the contents of the piles with their magnifying glasses and tweezers. Encourage children to talk about what they think is in each pile. More than likely, they will be able to identify the salt and sand.

If students do not figure out what the eggs are, tell them that they will find out later. (Eggs of tobacco horn worms bounce like little balls.)

Further Challenges: This is the introductory lesson to a unit for the full development of moths or butterflies. On-going observations are recorded on work sheets (Examples 1 and 2).

**Butterfly or moth eggs may be obtained from local United States Department of Agriculture stations or biological supply houses. Often eggs ordered from a supplier are already hatched when you receive them. If this happens, have students measure and record caterpillar growth beginning with this stage.

Notes:

name

Caterpillars

Date arrived or hatched measurement what is it doing?	Date measurement what is it doing?
Date measurement what is it doing?	Date measurement what is it doing?
Date measurement what is it doing?	Date measurement what is it doing?
Date measurement what is it doing?	Date measurement what is it doing?

feeding

resting

molting

wandering

hanging

LESSON 3
Magnets: Use of Everyday Objects for Grades 2-3

Teacher: Sally Olson   Demonstrated with 7-year olds

Introduction to the Video Tape

Magnets are always a favorite with children. In this non-text lesson, children learn through observation that, although a magnet will attract most metal objects, it will not attract all metals.

Questions for Consideration:

1. What techniques does this teacher use to distribute materials? How does she keep children from playing with the materials when she wants their attention focused on the discussion?

2. In a classroom discussion, it is best if the teacher does NOT repeat student comments. Why is this?

3. How does this teacher encourage students to make predictions before testing with magnets? How does she help students feel comfortable about their predictions when testing demonstrates them to be inaccurate?

4. Why might it be better not to teach the concepts, "magnets attract" and "magnets repel" on the same day?

Teaching this Lesson

Activity 1:

Focus: Magnets come in many shapes and sizes. Children will experiment with a magnet on several kinds of objects and discover that certain things are "pulled" to the magnet. They will discover further that not all metal objects are "pulled," and that only metals with iron or steel in them will be pulled. (**Note:** Cobalt and nickel are also pulled but at this point only examples of steel are used.)

Challenge: Can you tell what kind of objects will be pulled by a magnet?

Materials and Equipment:

- Magnets (several kinds)
- Paper clips
- Scissors
- Foil
- Paper
- Crayons
- Pennies
- Staples
- Hangers
- Yarn
- Erasers

How-To-Do-It: Children are fascinated by magnets. Before beginning the formal lesson, let the children freely experiment with the magnets and objects around the room for 5-10 minutes. Show children the different kinds of magnets, and go over the care of magnets: do not hit or drop a magnet since the jolt will make it lose its strength; heating a magnet will also cause it to lose its strength; store magnets correctly. (**Note:** horseshoe magnets must be stored with a "keeper", which is a piece of iron placed across its poles. Bar magnets and cylindrical magnets should be stored in pairs, with opposite poles touching.) **Keep magnets away from computers and diskettes.**

Have a variety of objects on the tables. "Each of you will get a magnet. Look at the objects on the table in front of you. Put your magnet next to each object and see what happens." Let children have a few minutes to try each object out with their magnet. "What happened? Were all the objects pulled? What kind of objects were pulled? Do you think the ones that were pulled have something in them that the others do not have?" Explain to the children that objects that have steel in them are pulled.

Hand out aluminum and steel pop cans. Have children test their magnets on each can. "Which cans have steel? Which ones do not? The cans that do not pull are made of aluminum." When a magnet pulls an object or a can, we say it ATTRACTS that object or can. Which cans did the magnet ATTRACT? (The steel cans.) Which cans were not ATTRACTED to the magnet? (The aluminum cans.) How many of you save cans for recycling? How do you think steel and aluminum cans can be separated at a recycling plant?

Activity 2:

Focus: Magnets attract only certain objects.

Challenge: What items do magnets attract?

Materials and Equipment:

- Zip-lock bag for each child with a variety of materials (about 9 or 10) in each bag.
- 2 small pieces of paper with the words 'yes' and 'no' printed on them

How-To-Do-It: "Now from what you have learned about magnets we are going to try to play a guessing game. What will be attracted to a magnet and what will not? First, take out the words 'yes' and 'no' and put them on the table in front of you, a little way apart from each other. Now take the objects out of the bag and put them by 'yes' if you think the magnet will attract it and by the 'no' if you do not think the magnet will attract it (Example 3). "(DO NOT USE THE MAGNET.)

Give children a few minutes to make their choices. "Do you have them where you think they belong?" (Hand out magnets.) "Now take your magnet and test your answers. Put the objects in the right place if your guess was incorrect. If you made a mistake what was it? Did you think all metals are attracted?"

Hint for Success: Clear away materials from one activity before going on to the next activity to eliminate the possibility of children experimenting with objects not in that lesson.

Activity 3:

Focus: Magnets can pull (attract) or push (repel) each other. A lesson for second grade and up that avoids confusion between attract and repel.

Challenge: What will happen if you take a bar magnet and try to put it together with another bar magnet in different ways? Try as many ways as you can think of (Example 4).

Materials:

- One bar magnet for each pair of children.

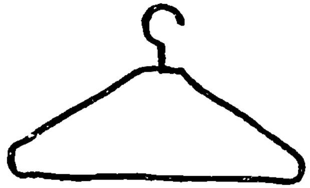
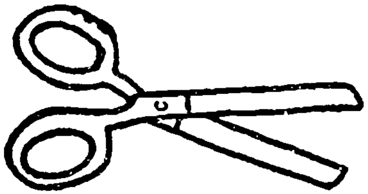
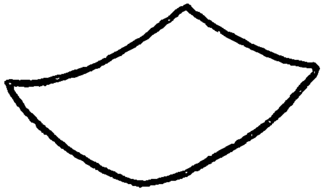
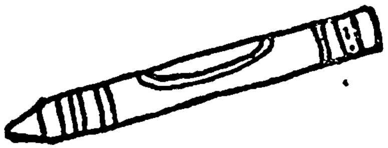
How-To-Do-It: Allow children time to experiment with the interaction of bar magnets. "When do the magnets pull each other? When do they push each other?" Demonstrate placing a North pole to a South pole. "What do we call this?" (ATTRACT) Demonstrate placing an North pole to a North pole and an South pole to a South pole. "What happens now?" Tell the children this "push" is called REPEL and write the word on the board.

Further Challenges: Hand out circle and horseshoe magnets and let children experiment with the push and pull of these magnets. Ask more capable students if they can tell which is the North Pole and which is the South Pole of the circle and horeshoe magnet by using the labeled bar magnet.

Notes:

Example 3

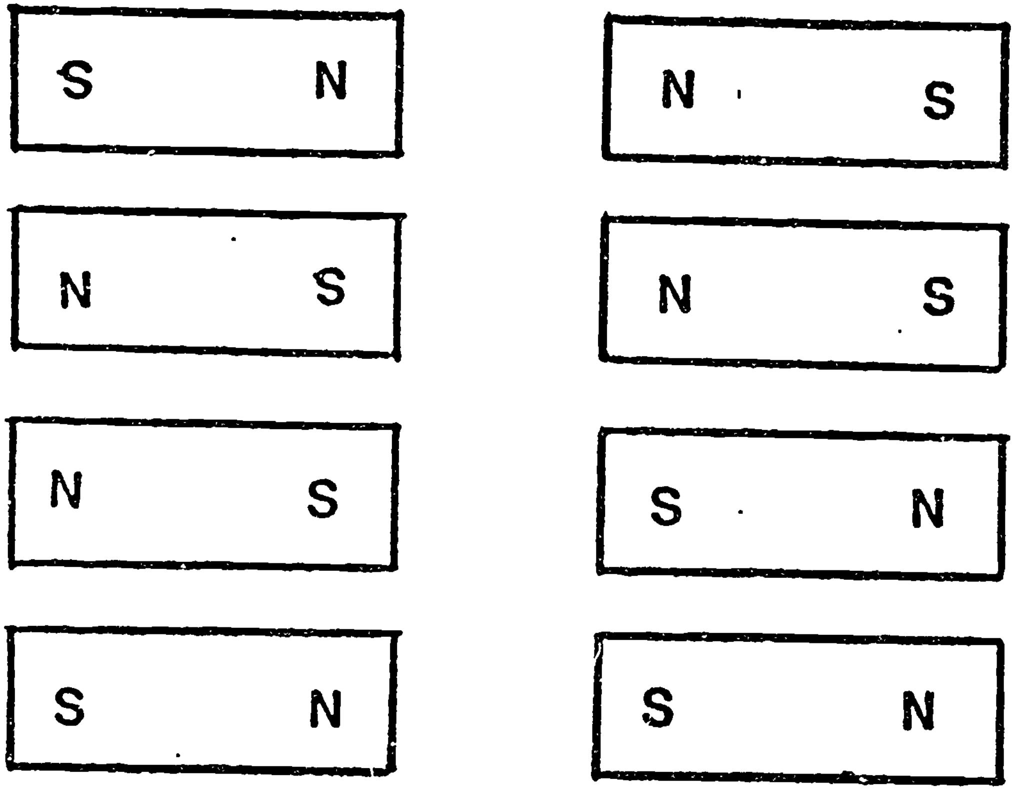
Magnets

ATTRACT	YES	NO	ATTRACT	YES	NO
					
					
					
					
					
					

Name

Example 4

Write Attract or Repel next to each pair.



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LESSON 4
LIGHT AND SHADOWS
for Grades: 2-3

Teacher: Sally Olson   Demonstrated with 7-year olds

Introduction to the Video Tape

Many topics in the elementary science curriculum are introduced in the lower grades and developed more completely at a higher grade. This second grade lesson on light, is used in a spiral curriculum.

Questions for Consideration:

1. The best evaluation questions in a science lesson ask children to explain, predict, or control an event. In this video tape, children explain that objects that do not allow light to pass through cause shadows. What questions or activities can you formulate that require children to use information to predict or to control an event?

2. Have you ever realized that a student gave a correct answer that you did not recognize as correct because it was not the answer you were looking for? What did/should you do? If a teacher waits at least one second before responding to students they are more likely to recognize correct responses, students will give longer, more complete answers, more students will respond, they will ask more questions, and they answer each others' questions more often.

   The teacher in this video tape failed to recognize a correct response. Would waiting longer have helped?

Teaching this Lesson

Lesson I

Focus: We need light to see. Light travels in a straight line, but it can be reflected by certain objects.

Challenge: Can you see an object in a shoe box with the lid on it?

Activity 1:

Materials:

A shoe box with a paper towel tube pushed part way in one end, and an object taped inside at the other end. One for every 4 to 5 students.

How-To-Do-It: "Today we are going to talk about light. Who can tell me a little about light?" "On your table is a shoe box with a tube in it. Take turns looking through the tube. What do you see?" "Now lift the lid just a little and look again. Did you see anything this time?" "What did you need to see?" (Light)

Activity 2:

Materials and Equipment:

- Flashlight (focusing type is best)
- Hand mirror

Challenge: "Let's look at this flashlight. What is it used for? When I turn it on where does the light go?" (In a straight line.) "Can you make the reflection from the flashlight move to other places in the room by using the mirror?"

How-To-Do-It: Let children experiment witn the mirrors and flashlights for several minutes. Have them work in groups of three or four with one mirror and one flashlight per group. Be sure they take turns. "Look in the mirror. What do you see?" (Your reflection.) "What happens when you shine the flashlight into the mirror? (It is reflected.)

Have two children come up. Have one shine the light at the other's chest. Now have the one child keep shining the light where the other child stood. Have the second child move to another spot. "Can you make the light shine on the second child without moving the flashlight? (No.) Let's see if there is a way we can do it." Have a third child come up and give him/her a mirror. "Let's see how we can reflect the light from the flashlight to the second child by using the mirror".

Lesson II:

Focus: Light can be seen through some things, but not others. Things that block out light make shadows.

Challenge: How can we make shadows and how can we make them move?

Activity 1:

Materials and Equipment:

- Saran wrap
- Aluminum foil
- Tupperware lids
- Tissue
- Paper
- Overhead projector or film strip projector (light source)

How-To-Do-It: "There are several objects on your table. Hold one of them up and see if light from the window shines through. Now let's hold each of the other objects up, one at a time. Which things could you see a little light shine through? Which things did not let light through?"

"Let's see what happens to some of these things against a screen. What happens? Do they all make shadows? What causes a shadow?" (Some things block light. Some things let light pass through.) "Let's try one with you. Do you think you will let light through or will you block it out?"

Activity 2:

How-To-Do-It: Have a child come up and hold his hand up in fronc of a light. "What happens if you move your hand?" (Your shadow moves.) "Can you make it darker? Can you make it bigger? Is it still as dark? (No.)

"Now hold your hand still while I move the light. What happened?" (The shadow moved.) "Where does it go when I put the light down? Up? To the side? What makes a shadow move?" (The object moves or the light source moves.)

"Now two of you come up and let's see if you can make your shadows shake hands without actually touching your own hands together."

Notes:

LESSON 5
Bouncing ..lls: Predicting, Recording, and Interpreting Data for Grades: 2-4

Teacher: Elaine Moerke   Demonstrated with 8-year olds

Introduction to the Video Tape

Many scientific concepts and skills can be taught using materials familiar to children. In this lesson, students will have the opportunity to develop skills of predicting, recording, and interpreting data using different types of balls. The lesson is based on a level 3 activity from Science-A Process Approach (S-APA).

The developers of the new science education programs of the sixties and seventies all strongly advocated providing extensive concrete experiences for children before developing abstract concepts. In S-APA, the scientific concepts are developed incidentally as the processes of science are systematically taught.

This exercise gives children experience in using charts and graphs to record and communicate experimental data. They use their information for predicting values between observed data by interpolation. Most children have not yet used ratios, and it will be enough to show the pictorial relationship of dro· eight to bounce height on the bar graphs. Ratios can be intr· ed to children who are ready.

Questions for Consideration:

1. How does the care in giving directions contribute to the success of this lesson?

2. Why are the children not told how to graph their results at the beginning of the lesson when other directions are being given?

3. What reasons can you give to support emphasizing systematic development of science process skills?

4. Robert Gagne, a psychologist who helped plan S-APA, believed that if a child did not master science process skills in the elementary years, that child would never become a scientist. Why might he make t'is conclusion?

Teaching this Lesson

Focus: The height a ball bounces is directly related to its drop height. Students predict the bounce height by interpreting data they gather themselves. They then construct a bar graph showing the relationship between the height from which a ball is dropped and the height to which it bounces.

Background to the Lesson: In earlier exercises, children observed and described stationary or slowly moving objects. This exercise provides an introductory experience in observing and describing objects that are moving more rapidly. The children begin to realize that it is more difficult to make observations of rapid motions with the unaided eye.

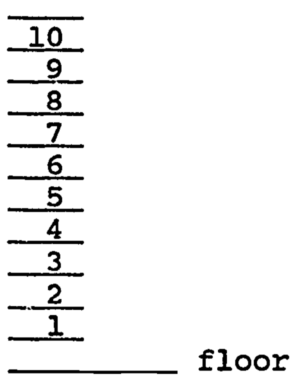
The observations on the bounce heights of different types of balls may lead children to ask: What causes the differences? The explanations are complex and involve the elasticity of the balls and of the surfaces on which they are bounced. You can mention these factors, but at this level you need not introduce technical considerations.

Challenge: Can you predict how high a ball will bounce when dropped from a certain height?

Materials and Equipment:

- Sponge rubber balls
- Golf balls
- Tennis balls
- Demonstration ball of a different type (for example a racquetball)
- Recording charts - a different color for each type of ball is recommended to avoid confusion
- Graphs - use the same color coding as above
- Adding machine tape to construct wall measuring strips
- Tape to attach measuring strips to wall

How-To-Do-It: Draw a series of horizontal lines one decimeter apart on adding machine tape. Label the lines from 1 to 10, with the zero line of the scale on the bottom edge. Attach the paper to the wall with the bottom edge of the paper at floor level. Make enough tapes so that each group of three children has their own measuring strip.



Stations for each group can be set up in the classroom, hall, or gymnasium where measuring strips can be mounted. These stations should have hard, level floors.

Show the children what they will later be doing in small groups. Hold a demonstration ball at the height of the tenth line and drop it without any pushing or throwing motion. Show children how to just release it from between thumb and forefinger so it always drops without being thrown. Have children predict how high they think it will bounce, record the prediction, and then have them see how high it actually bounces and record the results.

Repeat this procedure from several heights, always recording the prediction first, then dropping the ball and recording the actual height of the bounce. Help them realize that their eyes should be at the level of the return height and that they can read the height on the measuring tape more easily if the ball is held close to the wall. They should notice that the bounce heights become progressively shorter.

Divide the class into groups of three children. Each group should be equipped with a rubber ball, a golf ball, a tennis ball, recording charts and graphs for each ball and markers for recording purposes. Have children rotate duties with each ball they use. In a group of three, one child can drop the ball from each height, another can observe at eye level with the measuring strip, and the third child can record. The three children are to predict how high the ball will bounce from a certain height, and then bounce it and record the actual height of the bounce on the chart. When they are all finished, help children transfer the data from the chart onto the graph sheet (Examples 5 and 6).

Discuss results with the children. Suggest that they bring other balls from home to make their predictions and test them. "Super" balls, mothballs, and baseballs are interesting to test.

Further Challenges: Set up stations in the room where you can put two inclined planes end to end so that a marble released on one plane will roll up the other. The inclined planes should be pushed carefully together so that there will not be a bump at the junction of the planes. Use strips of paper to cover the planes, taping the paper at two or three places along the edge to keep it smooth during the test. With a light pencil line, mark the low point where the planes come together. Have a meter stick marked in centimeters available at each station. Books or boxes of various sizes can be used to elevate the ends. Vary the elevations at random to get a variety of data.

Give each group a marble, a strip of paper to cover the planes and to mark release points and roll points. Have the children measure and mark points on the plane at 1, 2, 3, 4 and 5 decimeters from the low point. (Alternatively, you might have this done for them.) The children take turns releasing the marble from the designated positions and marking the high point the marble reaches on the other plane. After each roll, measure to the nearest centimeter how far the marble rolled up from the low point and record this measurement with the corresponding release distance. Then have each group construct a bar graph to describe these data, predict roll distances from the intermediate release point and have them test their predictions.

Tell students to change the elevation of either or both planes in any way and to make new observations on another sheet of paper. Have them graph their new results, make predictions, and test them. (Since the inclines are at various angles, the data for the children will vary. Some children may want to examine several graphs to see if there is a general relationship between the release height and the corresponding upward roll height.)

Notes:

29

______ Ball
(type of)

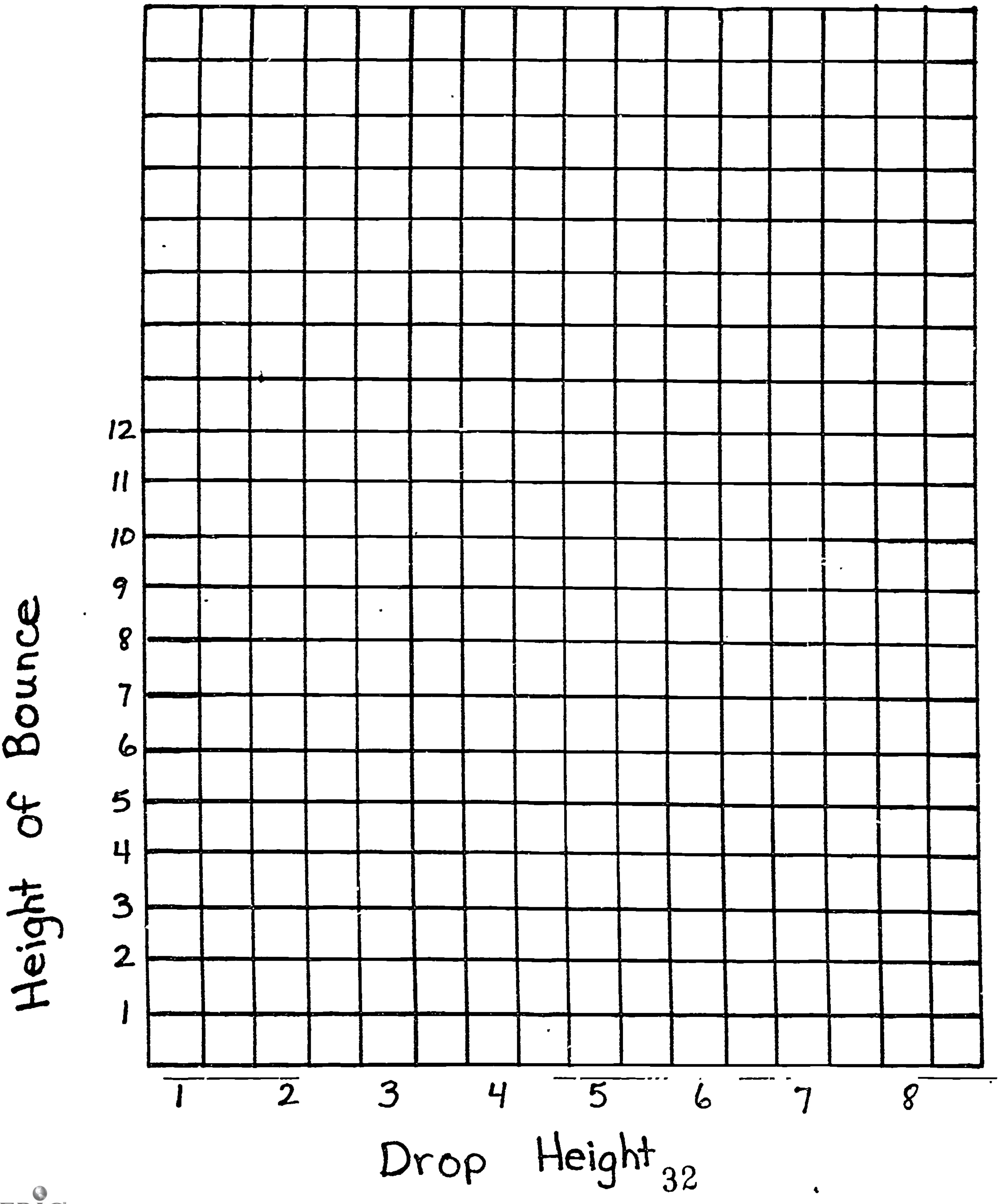
Drop Height	Bounce Height – My Guess	Actual Bounce Height
8		
7		
6		
5		
4		
3		
2		

Page 24

Example 6

Ball

(type of)



LESSON 6
Light: Learning Centers
for Grades: 4-6

Teacher: C. Beth Rengstorf   Demonstrated with 9 and 10-year olds

Introduction to the Video Tape

Learning centers are used in this lesson to introduce a fourth grade unit on light. Children do activities which demonstrate the concepts to be learned and present necessary scientific terms.

Questions for Consideration:

1. Why would these learning centers be used at the beginning of the light unit instead of after the concepts have been explained in the textbook?

2. A fourth grade text teaches that there are six colors in the rainbow -- red, orange, yellow, green, blue, violet. Yet, teachers have often taught the colors of the spectrum using the acronym, ROY G BIV--red, orange, yellow, green, blue, indigo, and violet. Have rainbows changed? Is the text wrong? If you are using a text that lists six colors and a student says: "My mother told me there are seven colors. . .", what will you reply?

3. What advantages and disadvantages do you see for having children work in small groups rather than individually?

4. What advantages and disadvantages are there for working in small groups rather than in a full class setting?

Teaching this Lesson

Focus: Learning Centers provide a chance for children to experiment with different behaviors of light. The observations students make in these activities provide the concrete experience which enable them to understand ideas presented in textbooks. The activities are designed to be done by the students individually or in small groups. The following concepts are covered:

Colors in Light I & II. Two activities demonstrate the dispersion of light. As light passes through a medium, a prism or bubble, each color is separated.

Refracted Light I & II. Two activities demonstrate that light bends when it passes through different kinds of matter. For example, light bends because it slows down when it passes through water or a hand lens.

Reflected and Absorbed Light I & II. Two activities demonstrate that light striking an object may be absorbed or reflected. Light-colored objects reflect most of the light that strikes them, whereas dark-colored objects absorb more light. Light reflected from a smooth surface like a mirror stays together in a regular pattern. Rough surfaces scatter light in different directions.

Materials and Equipment:

Colors in Light I:

- Dish of bubble soap
- Wire circle wand or bubble wand

Colors in Light II:

- Prism
- A light source: Sunlight, slide projectors, or overhead projector

Refracted Light I:

- A glass of water
- A pencil or straw

Refracted Light II:

- A glass of water
- A hand lens

Reflected and Absorbed Light I:

- Large box painted black inside
- Flashlight
- Different objects to demonstrate light reflection or absorption:

Black felt	Mirror
White felt	Blue paper
Aluminum foil	Plastic object
Crumpled aluminum foil	Wash cloth

Reflected and Absorbed Light II:

- 2 Drinking glasses
- 1 Piece of black construction paper
- 1 Piece of white construction paper
- 2 Thermometers
- A light source - sunlight, slide projector, or overhead lamp
- Red, blue and green cellophane

How-To-Do-It: Learning center task cards are designed that give directions to the children and ask questions about their observations. Possible answers and brief scientific explanations are located on the back of each task card (Examples 7 through 12). At the end of the lesson, discuss activities and summarize:

1. White light is really a mixture of the seven colored lights in a rainbow.

2. Light can be bent or refracted.

3. Light can be reflected or absorbed.

Further Challenges:

Colors in Light: Have students look at different colored construction paper through red, blue and green cellophane.

Make your own rainbow. Turn on a lawn sprinkler that breaks the water into a fine mist. Do this early in the morning or late in the afternoon so that the sun's rays are more horizontal. Stand between the sprinkler and the sun. You should be able to see a rainbow in the spray.

Refracted Light: Place a coin in the bottom of a shallow dish or bowl. Have a student back away from the bowl until the coin is just visible over the edge. While the student remains in position, fill the bowl with water. The coin will no longer be visible since the light reflected from the coin will be refracted as it passes from the water to the air.

Reflected and Absorbed Light: Go to a window where there is direct sunlight. Hold a hand mirror in a horizontal position face up. Where is the light beam? The light has traveled in a straight line from the sun to the mirror where it has "bounced off" or reflected in another straight line to the ceiling. Lay a piece of white paper over the mirror. What happened to the light beam? Why? The paper having an irregular surface reflected the light in all directions.

Notes:

Example 7

Front of Task Card A

COLORS IN LIGHT
Learning Center I

1. Dip the circle wand into the dish of soap.
2. Blow gently on the film of soap. Look for colors as a bubble forms.
3. What colors did you see in <u>light</u> that traveled through the soap bubble?
4. What was the color of the light that passed into the soap bubble?

Back A

COLORS

The colors you see are:

red
orange
yellow
green
blue
violet

<u>White</u> is the color of light that passed into the soap bubble.

The above colors are contained in the sunlight. These colors appear when rays of white light which pass through a soap bubble are bent at different angles and separated.

Example 8

Front of Task Card B

COLORS IN LIGHT
Learning Center II

1. Look at the light from the projector or direct sunlight through a prism.
2. What colors did you see around the objects you saw through the prism?
3. What was the color of light that passed into the prism?
4. How are a prism and rainbow alike?

Back B

The colors you see are red, orange, yellow, green, blue, and violet.

White is the color of light that passed into the prism.

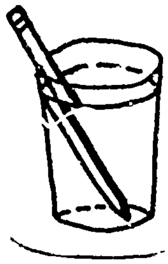
The prism is doing what each drop of water does in a natural rainbow - separating the light waves by differential refraction.

Example 9

Front of Task Card C

HOW LIGHT BENDS - REFRACTION
Learning Center I

1. Hold a pencil partly under water.
2. Look at it from above and from several places at the side.
3. When viewed from the side, what seemed to happen to the size of the pencil?
4. When viewed from above, what seemed to happen to the shape of the pencil?
5. What is the bending of light rays called?
6. Is the pencil in this glass really bent?

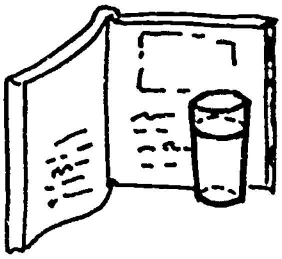


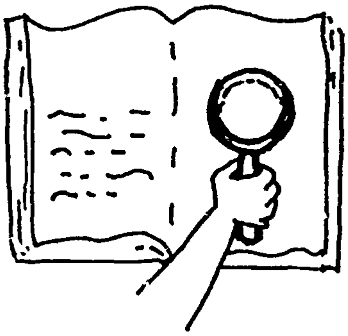
Back C

- From the side view your pencil looked larger or magnified.
- From the top view your pencil appeared to be bent.
- Because light is shining on it, and because waves of light are reflected to your eyes, you see the pencil.
- Air transmits light faster than water does. In water the light travels from the pencil in straight lines.
- When the light reaches the air it changes direction and gains speed, causing the pencil to seem bent!
- Bending light rays is called <u>refraction</u>.

Front of Task Card D

HOW LIGHT BENDS - REFRACTION
Learning Center II





1. Hold the numerals on this page behind the glass of water.

2. Look at the numerals when it is close to the glass. Hold the book back on the table and look again through the glass.

3. What seemed to happen to the numerals when it was held back from the glass?

4. Look at the numerals through a hand lens. Hold the hand lens close to the numerals and then farther from the numerals.

5. How did the numerals look through the water and through the hand lens?

Back D

- The numerals appear to be larger or magnified when you looked at a book through a glass of water and a hand lens.

- When you move the book back, the numerals appear to be smaller and will be reversed or upside down.

- Refraction is the bending of light rays.

Front of Task Card E

REFLECTED AND ABSORBED LIGHT
Learning Center I

1. There are several objects in the boxes below. Shine the flashlight on each object.

2. Which objects absorb the light? (look dull) Which objects reflect light?

3. Does the color make a difference in the amount of light reflected?

4. Does the texture (smooth or rough) of the object make a difference?

5. When can lake water reflect like a mirror?

(One inch squares of each sample are placed inside each box.)

Back E

- Absorb light: black felt, blue plastic, wash cloth.

- Reflect light: Mirror, glass, tin foil.

- The lighter the color of the object is the brighter it is - reflects.

- The darker the color of the object is the duller it is - absorbs.

- Yes the texture makes a difference. Smooth surfaces reflect and rough surfaces do not reflect.

  Because the mirror has a smooth surface the light which strikes it is reflected in lines. Light rays striking a rough surface bounce off in all directions.

- Lake water reflects like a mirror when it is very still and smooth.

Example 12

Front of Task Card F

REFLECTED AND ABSORBED LIGHT
Learning Center II

1. Two drinking glasses are wrapped in paper. One is in white paper and another is in black paper.
2. The thermometers were put in the glasses filled with water at room temperature.
   The glasses have been sitting under the lamp for 15 minutes or longer.
3. Check the two thermometers. What is the temperature of the white glass? the black glass?
4. In which glass did the water heat up the most?
5. Where did the energy that heated the water come from?
6. Why is there a difference between the water temperatures in the glasses?

Back F

- The black paper will absorb more light than the white paper. The absorbed light energy is changed to heat energy. Some of the heat travels to the water in the glasses.
- The black paper transfers more heat energy to the water than the white paper does.
- The energy used to heat up the water came from the light.
- Black - absorbs - <u>winter clothes</u> are often dark in color because they absorb light and heat and are warmer.
- White - reflects - <u>summer clothes</u> are often light in color because they reflect the light and heat and are cooler.

LESSON 7

Mystery Powders: Observation, Recording, and Inferring
for Grades: 4-5

Teacher: C. Beth Rengstorf Demonstrated with 9 and 10-year olds

Introduction to the Video Tape

The fifty-six units of the Elementary Science Study (ESS) Program may be used in any ord r and at various grade levels. Teacher guides for the progra: give detailed information about materials and help the classroom teacher direct activities by suggesting questions and describing how other children have reacted to the questions and materials. There are no pupil textbooks, but students are encouraged to record their experiences in note books, as well as using graphs and pictures to communicate their discoveries. Most evaluation is informal and occurs as the teacher notices the process skills students are using, the attitudes they display, and as students talk with teachers about what they are doing. The teacher is not required to have extensive training in science, but becomes a learner along with the students.

Questions for Consideration:

1. Why might Mystery Powders be a particularly good unit to use at the beginning of the school year?

2. What would be the advantage of substituting an ESS unit for a textbook unit rather than adding it onto the textbook program?

3. A guide for using ESS with handicapped students is available. Why might this program be a particularly good one to use with special students?

4. What helps keep the cost of this program minimal?

Teaching this Lesson

Focus: Mystery Powders is one of fifty-six self-contained units of the Elementary Science study (ESS) program. The scientists, psychologists, and educators who developed the program believe that the way to <u>LEARN</u> science is to <u>DO</u> science. Like other ESS units, Mystery Powders uses the natural curiosity of children to teach science concepts or processes. Careful observation and record keeping are stressed in this lesson.

Background to the Lesson: In earlier lessons in this unit, children have observed the five mystery powders using the senses of touch, smell, and sight, including examination of the powders under a microscope. They have compared the powders to known substances and have identified them as corn starch, baking soda, sugar, salt, and detergent. They have also observed how each interacts with water.

Challenge: How does each powder react to iodine? Can iodine be used to distinguish one powder from another?

Materials and Equipment:

For each group of three to four students:
- Small plastic cup of each powder -- cornstarch, baking soda, sugar, salt, and detergent. If cups are not easily available these may be placed, well separated, on plastic wrap or waxed paper.
- Flat toothpicks for stirring
- Small cup or bottle of iodine and dropper (dilute one ounce of tincture of iodine with two quarts of water). **Reminder: Iodine is poisonous.**

How-To-Do-It: Students place three drops of iodine on each substance and observe and record the results. In discussing their observations they may need to be reminded that the iodine is mixed with water. Help students recall the results of their earlier test in which they added water to each substance. If paper cups are used, students may observe that the paper also reacts to the iodine.

Further Challenges: What other substances will react to iodine? (Students may bring a variety of substances from home to test.)

In later tests, students discover how each of the mystery powders reacts to vinegar and to heat. As a conclusion, and for evaluation, children are given a mixture of two or three powders. Using their records, they test their mystery powder to see which of the known powders it contains. Children may also be challenged to identify three liquids (water, iodine, and vinegar), without smelling them, which have been disguised by red food coloring.

Notes:

LESSON 8
Heat: Textbook Based Lesson
for Grade: 5

Teacher: Angela Brodigan Demonstrated with 10 and 11-year olds

Note: This lesson is designed to supplement pp. 79-81 of Barufaldi, et.al., Heath Science, D. C. Heath and Co., 1985. It may be adapted for use with other texts.

Introduction to the Video Tape

The format for this textbook lesson relies on Jean Piaget's theories of learning. Piaget found that children need to think about concrete experiences in order to develop new concepts. Therefore, children begin this lesson by experimenting with and manipulating materials. Sometimes, due to safety, time limitations, or lack of materials, it is necessary to subsititute a demonstration for the actual hands-on experience, but the hands-on activity is preferred. After this experience, the activities are discussed in order to develop concepts and learn the proper scientific terminology. Finally, the text is read to reinforce and extend concepts that children have learned from experience.

Questions for Consideration:

1. What are the advantages and disadvantages of using this format?

2. The Council for Basic Education reports that pupil texts are not necessary for teaching elementary science and suggests that if texts are used, they be given to children after they have directly experienced the concepts being taught. How could you justify the time spent on activities to a person who believes schools should get back to the basics?

3. Do you think textbooks are important in elementary science? Why?

4. When an activity does not turn out as expected, why is it important that the teacher NOT say: "What is supposed to happen is. . . ?"

5. To begin discussion after each activity, the teacher asks "What happened?" or "What did you see?" Why might this be a better question than to ask, "What do you think causes. .?".

Teaching this Lesson

Focus: Molecules move at different speeds in different states of matter. When molecules are heated, they move faster and farther apart which causes expansion. As the molecules are cooled, they slow down and move closer together which results in contraction. Children will observe and participate in activities which demonstrate these concepts.

Challenge: How can you push an egg into a bottle without touching it?

Activity 1:

Materials and Equipment:

- 3 Milk bottles or glass baby bottles
- 3 hard boiled eggs (peeled). They should be slightly larger than the bottle opening, so that the egg rests on top of the bottle opening.
- Matches
- Small piece of paper

How-To-Do-It: Use one milk bottle. Place an egg on the opening of the bottle. It should sit on top of it. It may be helpful to show children up close that the egg fits part way into the opening but is too large to slip into the bottle. Then, remove the egg and place a small piece of burning paper into the bottle. Quickly place the egg on top of the bottle again. The egg will jiggle and then PLOP into the bottle.

Ask children for ideas to explain what happened. Repeat the activity to test their ideas. It is unlikely that students will be able to explain the event at this point but accept their ideas and tell them they will be able to explain this "trick" after the lesson.

Hint: Practice may be needed to light the paper and get it into the bottle so it stays lit (fire burns in an upward direction). If your first attempt is unsuccessful, cool the bottle before attempting it again, or use a fresh bottle.

Activity 2:

Materials and Equipment:

- Three small, clear, plastic cups - (one with hot water, one with cold water, one with ice) and one color of food coloring for each group

How-To-Do-It: Readiness behavior - students know that all matter is made up of molecules and that molecules move faster in gases than in liquids and faster in liquids than in solids.

To help students review and extend the readiness concepts, split them into groups of not more than three individuals. Each group has three containers - one each of hot water, cold water, and ice. Ask children to observe carefully what happens as you put a drop of food coloring into each container.

"What do you see happening? Using what you know about molecules and how they move, can you explain what is happening?" You should expect to hear: "Since the food coloring is mixing faster in the hot water than the cold water or the ice, then the molecules must be moving faster in the hot water. The molecules in the ice move so slowly that the food coloring does not mix."

As a further review of the concepts, light a match and remind children that the smoke is an example of a gas. Ask children to compare the speed of the molecules in the gas (smoke) to that of the liquid and solid molecules.

Hints: First, keep the ice cups frozen solid with no liquid on the tops or sides, (2) make sure the cold water is very cold and the hot water is very hot, and (3) use only one color of food coloring in order to control variables.

Activity 3:

Materials and Equipment:

- Plastic, 1-quart freezer boxes (2 for each group)
- Small round balloons (1 per group)
- 8 oz. glass drink bottle
- Boiling water
- Ice water

How-To-Do-It: Each group should fasten a balloon to a bottle top, and put the bottle into a plastic freezer box filled two-thirds full with ice water.

Ask children to observe what happens. (There should be little or no change.) Then have the children put the bottle into the other plastic container. Fill this container two-thirds full with hot water. Ask: "what will happen to the air inside the bottle as I pour hot water into the container? What might cause this to happen?" You should expect to hear: "the hot water causes the molecules inside the bottle to heat and move more quickly. They move farther apart and take up more room. This causes the air to push up into the balloon making it get larger."

Introduce the term, EXPAND: "When the balloon gets larger, we say it expands." Ask: "how can you make the balloon get smaller?" Children will suggest putting the bottle in cold water. As this is done, introduce the term CONTRACT. "As the balloon gets smaller, we say it contracts."

Hint: Use small balloons for greatest effect and use containers deep enough for the water to cover at least one-half the bottle in order to heat the air inside the bottle. This will also give some protection in the unlikely event that a bottle cracks from the temperature change.

These activities give children a concrete understanding of the concepts. The textbook can now be used to show technological applications that cannot be demonstrated in the classroom and to relate the textbook concepts to the activities done in the lesson. Doing and discussing activities BEFORE reading the text provides the concrete experience that develops understanding that cannot be achieved through words and pictures alone.

Further Challenges:

Activity 1: Ask: "can you use what you have learned about expansion and contraction to explain why the egg fell into the bottle?" (Repeat the activity.) The children should conclude that when the air inside the bottle is heated the molecules move farther apart. The air expands. As the air expands it pushes out of the bottle causing the egg to jiggle. (The egg acts as a one way valve. Air can go out of the bottle but cannot get in.) When the oxygen inside the bottle is used up, the flame will go out. With the heat source removed, the air inside the bottle cools and contracts. Because there is now less air pressure inside the bottle, the higher outside air pressure pushes the egg into the bottle. (PLOP!)

"How can you remove the egg from the bottle without a spoon or other implement? (Hint - think "heat".) (The egg may be removed by holding the bottle upside down under a stream of hot water. Will other ways work, such as: dropping burning paper in again; or first, blowing into the bottle and then sucking the egg out?)

Activities 2 and 3: With children working with partners, ask them to use food coloring to arrange containers with different temperatures of water from hottest to coldest.

Notes:

LESSON 9
Legos Machines: Cooperative Learning

Teacher: James E. Ellingson   Demonstrated with 10 and 11-year olds

Introduction to the Video Tape

Teaching students about simple and complex machines using Lego brand materials has many advantages. The materials are highly motivational for students and teachers (in large part due to the enthusiastic responses of the students). An organizational management system is built into the kit, and teachers quickly feel comfortable with the concepts and processes. As in any scien activity, it is advisable for teachers to build and test the project before using it in class.

This lesson uses a cooperative group approach to learning. The social skill emphasized is encouragement. Students are asked to support each other with helpful comments.

Questions for Consideration:

1. What does the teacher do when some students are unsuccessful?

2. What does the teacher do when students are successful?

3. Advocates of cooperative learning suggest that cooperation may be more important for success in the workplace than specific skills. What is your opinion about this?

4. In some cooperative learning systems all members of a group receive the same grade on a project. How do you feel about this?

Teaching this Lesson

Focus: In this hands-on science lesson, students progress from exploration to concept naming and application of knowledge about simple machines. The entire progression would normally take two or three class periods.

Another facet of the lesson deals with the way this teacher chooses to structure learning. Lessons can be individualistic, competitive, or cooperative. A significant amount of research indicates that the appropriate choice among the three teaching methods is critically important in terms of learner outcomes. Each of the three methods is appropriate depending on the lesson and needs of the learner.

Activity I:

Focus: Using Lego Technic 1032 to Construct Simple Machines - Exploration One. This exploration is not part of the video lesson though it is an important part of the sequence.

Background to the Lesson: The lesson assumes students have been introduced to the proper care and use of the Lego kit.

Materials:

- Lego Technic 1032 set
- Lego Technic Construction Guide 1033 #5

How-To-Do-It: Use your red Lego rods to construct long and short levers. Which lever works best? Discuss the variables of the model--length of Lego, weight lifted, fulcrum point, etc. As students work in groups of three or four, encourage them by asking: Does the weight lift easier when the pivot rod (fulcrum) is closer to the weight: How much weight could be lifted with the longest red Lego rod?

Activity 2:

Focus: Constructing Models - Concept Naming 1.

Materials:

- Pictures of machines from Technic 1033 set of picture card model plans.

How-To-Do-It: Suggested Activities include: (1) Review the simple machines from Exploration one and Exploration two. (2) Study the gears in a ten-speed bicycle. Determine when it is easier to propel the bike, the best gear for starting, and the best gear for high speed. (3) Study the gears on an egg beater. Why does the wheel you turn go slow compared to the beater blades? (4) Lift your teacher using a plank and fulcrum. The same could be done on a playground see-saw. (5) Emphasize the uses of the simple machines in the Technic 1033 picture card model plans.

Activity 3:

Focus: Constructing Models (a table saw) - Application One.

Materials:

- Lego Technic 1032 Kits - one kit for every three students
- Lego Technic 1033 Picture Card Guides

How-To-Do-It: Can your group construct a Lego model of a table saw? Group members number off 1-3. Their construction responsibility in the group relates to these numbers. The person with number one will "do" step one of the construction. Continue this plan until the sixth and final step is completed.

Does it matter whether one or two sets of pulleys and belts are used? What is making that rubbing sound? Would it be easier to construct this saw (with step-by-step directions) or the band saw which has only a single picture for directions? Where is the wheel and axle in the table saw you are building? Is the saw blade moving faster, the same speed, or slower than the set of pulleys?

Further Challenges:

There are many more lessons that can be designed from the Lego Technic 1032 - 1033 materials. A teacher may want to include the wheel and axle in the next Exploration. This could incorporate such processes as designing an experiment, predicting, and classifying. Construction of other models in the 1033 guides are good for application lessons.

For more information about LEGO Technic sets, write: Lego Systems Inc., Educational Department, 555 Taylor Road, Enfield, Connecticut 06082.

For more information about cooperative learning see Johnson, Learning Together and Alone.

Notes:

LESSON 10
The Big Bang: Electrical Circuits and Fuses
for Grades: 5-6

Teacher: James E. Ellingson Demonstrated with 10 and 11-year olds

Introduction to the Video Tape

The Big Bang is a lesson taken from TOPS Learning Systems #32, Electricity. Students respond enthusiastically to the study of simple circuits and later to fuses constructed on blown up balloons.

TOPS has two lessons that deal with fuses. They show how fuses work to protect circuits from shorts and overloads. In the Big Bang lesson, students are asked to make predictions, i.e., which kind of steel wool is more likely to pop the balloon, a thick strand or a thin strand? In the process, electrical resistance is studied.

Questions for Consideration:

1. How does this teacher depart from the ACT (Activity, Concept development, and Text) format? What might be the reason that the teacher has not followed this format? What advantages do you see for using the ACT method? (See Introduction to the Series, pg. 2.)

2. When might a teacher be justified in skipping lessons that are designed to be presented in sequence?

3. What do you notice about this teacher's interaction with students that contributes to the success of the lesson?

Teaching this Lesson

Focus: For electricity to flow, a path or circuit must be created. Students begin their study of electricity by attempting to light a bulb using one wire, one D size battery and one bulb. Predicting whether the circuit is complete is the next concept studied. The next part of the sequence is the exploration of series and parallel circuits and resistance among wires. With a background in circuits and resistance, students are ready to explore fuses.

Materials and Equipment:

- one wire per student
- one bulb per student
- one D-size battery per student
- prediction sheets #2 and #3
- resistance sheet #14
- fuse sheets #17 and #18
- aluminum foil
- balloons - two or more per student
- pennies
- two or three sizes of steel wool
- scotch or masking tape
- 3 x 5 index cards
- clothespins
- trays - one per three students

If enough materials for three to four students are stored on cardboard trays for this and other TOPS electricity lessons, the time spent with material distribution is minimal.

Activity 1:

Challenge: Can you light a bulb using one wire, one bulb, and one battery? Which path is a complete circuit?

How-To-Do-It: Students may work independently or with partners on this activity. They should be instructed to make their own discoveries. If a student is successful at lighting the bulb, he/she should be encouraged to find a second, third, and fourth way to light it. Students who need encouragement or who cannot light the bulb after many tries are best given assistance through questions by the teacher. Ask questions such as these to stimulate thinking: do two parts of the bulb need to be touched to let electricity flow? A battery has two parts that must be touched also. Can you find them?

After all students have been successful in lighting the bulb in at least one way, they examine their bulbs with a magnifier. Through observation and discussion, students review or develop a large outline of a bulb on the chalkboard and help students find and name the parts (Example 13). By discussing the glass insulator, flow of electrons along a path, and the thickness of the wires in a bulb compared to the filament, a beginning understanding of circuits and resistance is developed.

Without using the b[illegible]eries and bulbs, students use TOPS electricity sheet[illegible] make predictions (Example 14, copied with permission). [illegible]y to do this section of the lesson is to have two or three [illegible] working on one sheet. Instruct students to sign their initials at the bottom of the sheet when everyone agrees to the predictions made by the group. Students should continue to discuss the predictions until everyone is in agreement.

When all groups have agreed, students should try the six ways (A-F) to light a bulb checking their own predictions. Following this activity, a class discussion is useful. Past experience has shown that students who had made incorrect predictions were able to understand the error and describe the reason for the corrected prediction through this discussion.

Activity 2:

Challenge: Which kind of steel wool fiber is more likely to get hot and pop the balloon?

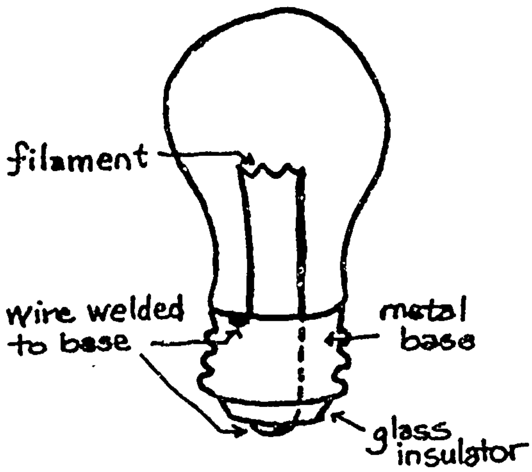
How-To-Do-It: In the TOPS electricity unit the big bang is used as a lead-in activity to the study of fuses and a way of demonstrating how hot a wire can become. It can also be used to introduce resistance and serves as an ideal inquiry lesson. In the fourth step of the activity (TOPS Elctricity #18), students place the events leading to the popping of the balloon in order (Example 15, copied with permission). Inquiry questions such as: Why did the balloon pop? Would it pop using thicker steel wool? Why didn't your balloon pop? are used.

Some students connect their two batteries incorrectly. The electrical current will not flow in this case. Trouble shooting then becomes an important part of the inquiry. For students who get the balloon to pop quickly, a challenge using wire or different size steel wool could be given.

Further Challenges: TOPS electricity activity #17 is a good follow-up to the big bang activity (Example 16, copied with permission). Students are ready to add switches and different thicknesses of wire and/or steel wool. It is also a good time to observe the design of house or car fuses. This section on fuses and resistance is given meaning for most students when it is preceded by the big bang activity and lessons on simple circuits, and series and parallel circuits.

Notes:

Example 13

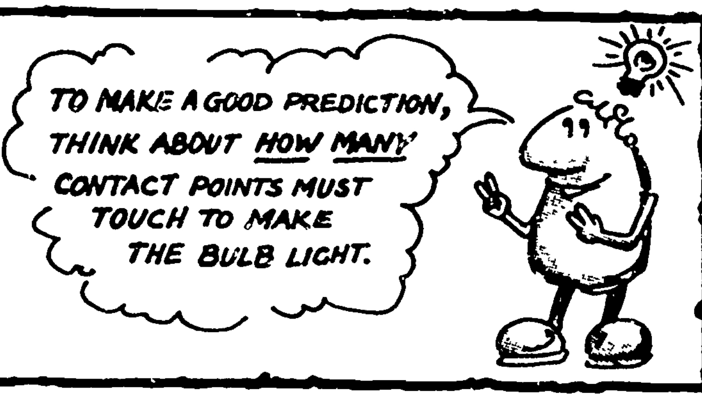


NAME: CLASS: Example 14

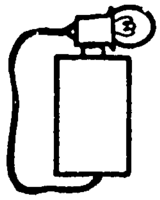
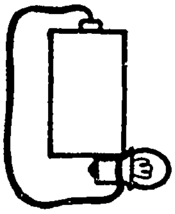
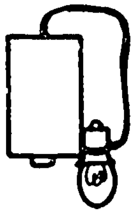
LIGHT BULB PREDICTIONS

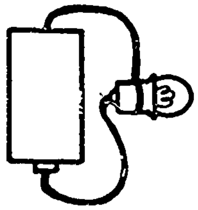
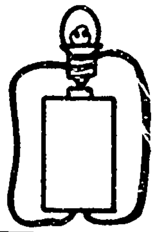
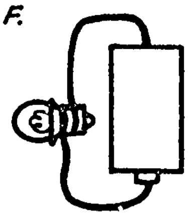
1 In the table below, guess if the dry cell lights the bulb. Write your *prediction* next to each hook-up.

After you predict, experiment to see if you are right. Write each result in the table.



2

HOOK-UP	PREDICTION Will it light?	RESULT Did it light?
A. 		
B. 		
C. 		

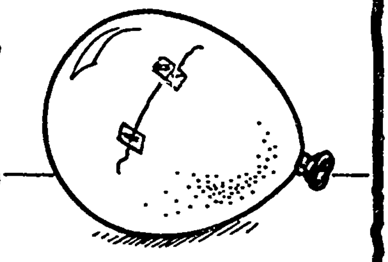
HOOK-UP	PREDICTION Will it light?	RESULT Did it light?
D. 		
E. 		
F. 		

3 You are now an expert on how to light a bulb. Write directions for someone who doesn't know how:

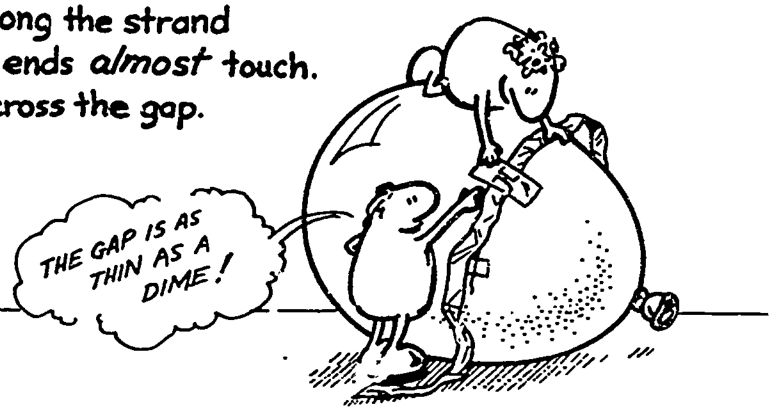
TOPS LEARNING SYSTEMS

BIG BANG

1 Tape a strand of steel wool to a balloon.

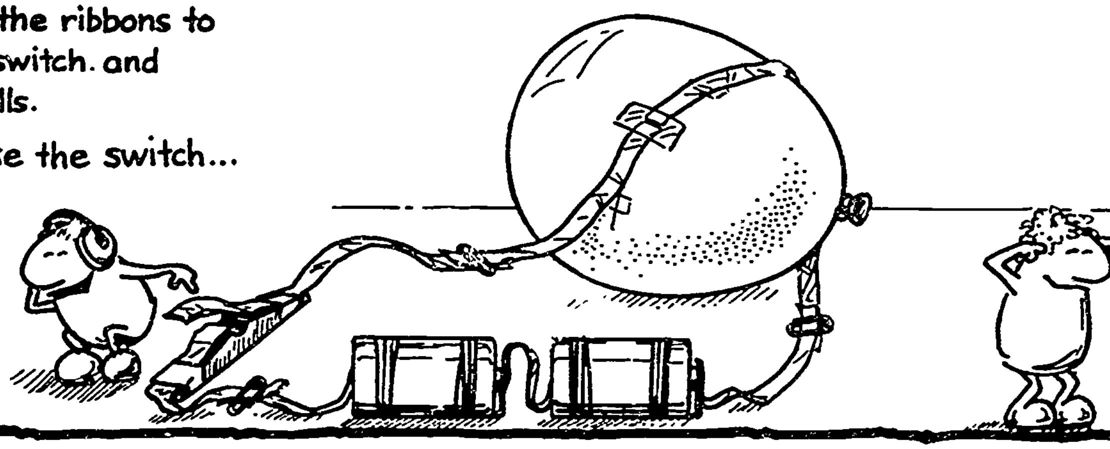


2 Lay 2 foil ribbons, end to end, along the strand so the ends *almost* touch. Tape across the gap.



3 Connect the ribbons to an open switch. and 2 dry cells.

Now close the switch...



4 Number these boxes in the proper order to explain why the balloon pops.

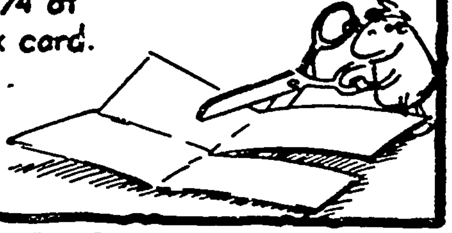
- [ ] THE HOT WIRE MELTS THE SKIN OF THE BALLOON.
- [ ] ELECRICITY PASSES THROUGH THE STEEL WOOL STRAND, WHICH IS VERY THIN.
- [ ] ELECTRICITY FLOWS FROM THE DRY CELL.
- [ ] THE BALLOON POPS!
- [ ] THE THIN WIRE HAS HIGH RESISTANCE, SO IT GETS HOT.

5 Use your own words to explain why the balloon pops. Write a paragraph.

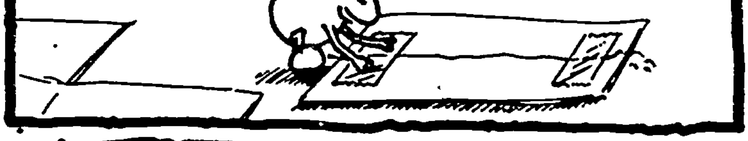
TOPS LEARNING SYSTEMS

BUILD A FUSE

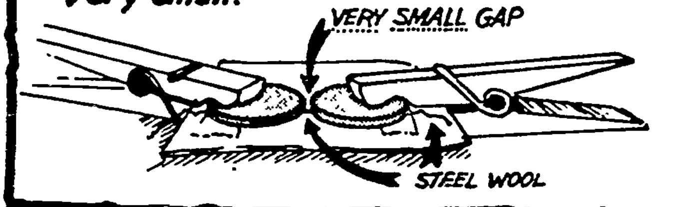
1 Cut out 1/4 of an index card.



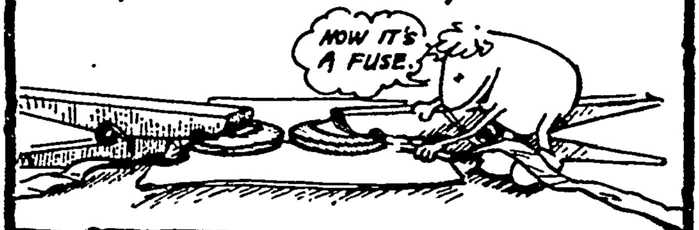
2 Pull off a single strand of steel wool as thick as a hair, and tape each end to the piece of card.



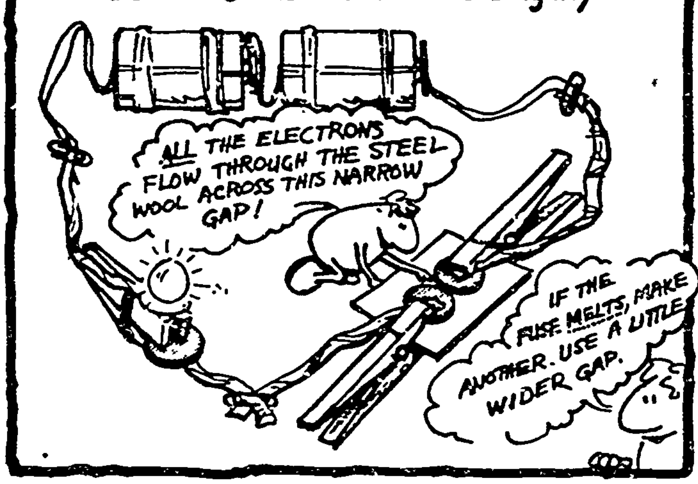
3 Clamp 2 pennies on the steel wool with clothespins. Keep the space between them *very small.*



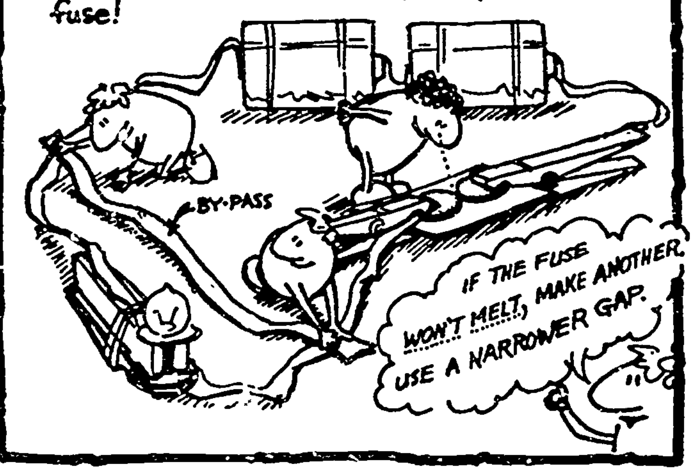
4 Clamp a foil ribbon over each penny. Keep the pennies so close that they *almost* touch.



5 Put this fuse in series with 2 dry cells and a bulb: The bulb should shine brightly.



6 While the bulb is shining brightly, by-pass it with another ribbon. Keep your eye on the fuse!



7 Electric wires in a house can get too HOT if...

A. the appliances are by-passed (SHORT CIRCUIT)...

B. too many appliances draw electricity off the same line (OVERLOAD).

How does a fuse protect a house from fire?

A fuse should be neither too weak nor too strong. Explain.

TOPS LEARNING SYSTEMS

LESSON 11
Classification: Creating a Biological Key
for Grades: 4-6

Teacher: Nancy Harger **Demonstrated with** 12-year olds
At the Regional Science Center, Moorhead State University

Introduction to the Video Tape

Children at different developmental stages handle the classification of objects differently and with varying degrees of skill. This process skill is one of the essential tools that help us interpret information about our world.

Scientists have classified plants and animals based on their distinguishing characteristics. Biological dichotomous keys, developed using the classifying characteristics, serve as guideposts to help identify unknown plants or animals. In these lessons, students use their observation and classification skills to develop their own dichotomous keys. Students share their keys and compare how they may have chosen different distinguishing characteristics.

It is important to note that there are no wrong ways to separate or classify the different objects. However, to make their keys "universal," student scientists would have to agree on their distinguishing characteristics, as scientists have. The students then take their keys and use them on "live" subjects in the out-of-doors.

Questions for Consideration:

1. When dealing with difficult topics such as plant or animal classification, it is beneficial to use familiar objects or situations to develop these skills. What examples of this did you notice in this tape?

2. This lesson is a mixture of indoor and outdoor activities, what benefits do you see in organizing the lesson in this manner?

3. How does the instructor encourage concern for the impact the class may have on the environment?

Teaching the Lesson

Focus: Students develop their skills in classifying objects and apply them to create a key of familiar objects and then one of natural objects found in the outdoors.

Background: As children, students begin early classifying familiar objects according to shape, size, and color. Often, however, when they grow older and are confronted with a biological dichotomous key, they have trouble following its development. These activities allow students to develop their own keys of

familiar objects and thereby acquire a direct, concrete understanding of how keys function. There is no right or wrong way of classifying and students may choose different methods or reasons for separating their objects. An additional benefit to these activities is the development of clear and concise written descriptions of the classification level options.

Challenge: Can students separate the objects into one-object piles based on their differing characteristics?

Materials and Equipment:

- nails -- 10 different kinds for each group of students
- large sheets of white/manilla paper
- pencils or markers
- leaves from 5-10 different trees, these leaves may be collected beforehand or by the students on a walk -- be sure to check if plant collecting is allowed where you are hiking.
- large sheets of paper
- pencils or markers

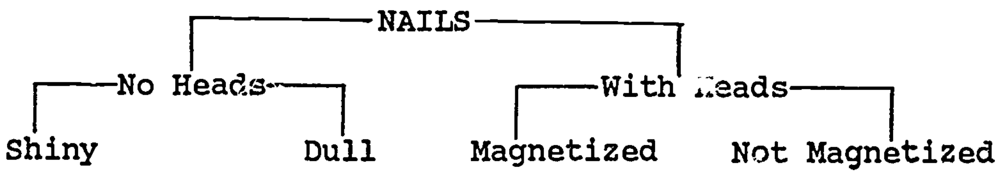
Activity I:

How-To-Do-It: Students separate into 2-3 person groups to encourage discussion. Each group is given paper, pencil and a sack containing the different nails. Each group is told that their job is to separate the nails into single-nail piles BUT to reach those piles they must go through a "yes-no" process with each nail.

The "yes-no" questions will be developed by the students as a result of their observations. This process is done one level at a time, in a descending hierarchical fashion. Each group discusses among themselves the different characteristics of their objects. They must separate their objects into piles, decide on concise statements describing their pile separations, and write them down on their sheets.

For example, in closely examining the nails the students noticed a structural difference -- that 6 of the nails have "heads" and 4 do not. So their initial level would separate the nails into TWO piles -- "yes" the nail has no "head."

Example:



Once the initial separation is made, the piles must again be divided into sub-groups and both physically and descriptively written on their sheets. Students continue this process until they have each object in its own pile. Then students share their different methods of dividing and describing. No method is incorrect so long as they have been adequately described and separated.

Activity 2:

Challenge: Can students separate different leaves into single-leaf piles based on their different characteristics and then use their keys to identify trees?

How-To-Do-It: Give each group a bag containing 5 to 10 different tree leaves OR have all of these leaves in a pile in the middle of the table and have each group select 5 to 10 different tree leaves from the pile. Students examine their leaves -- noting similarities and differences. (What clues indicate that the leaves come from different trees?) and separate their leaves into single-leaf piles -- describing their level by level path.

*** Remind them of how they handled the nail "key" and that the clarity of their descriptions will help them when they use their "keys" outside.

Once all leaves have been separated into single-leaf piles, identify their leaves for them. It is not necessary to identify them before this time, but students will be interested, once they are outside, in knowing what tree they are examining.

Have students take their "keys" outside. By examining trees and following through their keys with the "new" tree leaves, students should be able to identify the trees.

Further Challenges: If you are in an area where you can collect natural objects have students select representative leaves (or other objects) of your keyed trees. Press these leaves between wax paper and create a mobile which follows the separation levels of the key they created.

Have students look at how scientists have classified plant and animal kingdoms -- have them pick out some of the major differences at each branching. Work towards understanding the logic of the "overall picture." For example:

LIFE

Plants — Animals

Animals: Vertebrates — Invertebrates

Notes:

LESSON 12

Bean Bugs: Science - Mathematics Connection
for Grades: 5-7

Teacher: Nancy Harger   Demonstrated with 12 year olds
At the Regional Science Center, Moorhead State University

Introduction to the Video Tape

Biologists are concerned with the number or population size of different organisms. This task is relatively easy when the populations are small and/or compact. However, estimating techniques are often needed when they are large or spread out.

In these lessons, students are asked how many organisms live in an experimental population. They solve this problem by estimating--basing their estimates on observations, data gathered, and relationships noted between their quadrat counts and the total population.

They utilize and/or develop many of their mathematical skills in the estimating process. Formulas and algorithms are understood better if they are arrived at intuititively by students attempting to solve real problems. Students who have struggled to determine the number of square decimeters in 10 x 4 meter plot, as in this activity, are less likely to make decimal errors than students who have been taught to do calculations by rote without concrete experiences.

The use of "homemade" equipment makes these activities inexpensive and once the material is collected, these activities are easy to repeat with other classes and/or different populations.

Questions for Consideration:

1. In science, even the most carefully planned activity can go awry. What variables did you notice in the activities which might lead the students to arrive at estimates considerably different than the true population?

2. In the video tape, students use a number of math skills to solve their tasks. What examples did you notice? Could you use a science activity such as this to test your students' math skills?

3. How does the instructor help create a responsible awareness of the natural area being used by the students before and during their activities?

Teaching this Lesson

Focus: Through concrete learning activities, students gain an understanding of how to estimate the number of organisms in a large population. This is then correlated with biological field study methods.

Background: Field biologists, in studying a plant or animal community need to know the number of organisms in their study population. For small populations, the biologist could count all of the organisms. However, in large populations or large areas biologists must count the organisms within smaller random samples of the total area. Averaging the samples gives a good indication of a representative sample, this is then multiplied by the number of small areas/samples possible in the whole site. This small area is called a quadrat.

Mathematical skills including averaging, and finding the area of a rectangle, are used in this lesson. If students have had formal work in calculating area, the activity provides meaningful practice. For students who have not yet learned to calculate area the activity is especially valuable as an intuitive and concrete introduction to the technique.

Challenge: To estimate the number of organisms in a large population.

Materials:

Activity 1:

- Large quantity of marbles, jelly beans or sunflower seeds -- count them. If too many to count, measure or weigh a small sample and estimate the total number
- Large container
- Small baby food jars
- Water
- Notepad and pencil

Activity 2:

- Clip boards/pencils (for inexpensive clipboards - cut up corregated cardboard to size and place rubberband around board to serve as the "clip")
- Four stakes
- ball of string or two lengths of string cut to 10m each and two lengths of string cut to 4m each (this will be your total population area)
- One pound of bean "bugs" (e.g. beans, split peas, or lentils)
- At least two meter sticks
- Sampling square: coat hangers (one for every 4 students-- untwist hanger, bend into 10cm by 10cm square, and tape ends together).

How-To-Do-It:

Activity 1:

Show students the large container filled with objects (e.g. jelly beans) ask them how many jelly beans they think are in the jar. How did they arrive at their guesses? How would they make a more accurate guess without counting them all? Lead to the idea of taking samples and estimating the total numbers from those samples.

Have five different students take a baby food jar sample of the beans and count them. Have one student be the recorder and keep track of the numbers for each sample. When all the samples are counted, the recorder should average them.

- What would happen if the samplers all used different sized jars -- would the samples be "fair"?
- Would it be "fair" just to take one sample of the total?
- Is it necessary for all samplers to be filling their jar to the same level?
- Is knowing how many beans are in your <u>sample</u> jar enough to tell you how many beans are in the large jar?

Next, the students need to know how many of their sample jars will fill the large jar. Have one of the students fill baby food jars with water and count how many jars it takes to fill the large jar. Lead a discussion to the idea that an average of the samples taken, times the number of jars it would take to fill the large container, equals a fair estimate of the total number of beans.

Through this process students will have taken a number of random, standard SAMPLES, AVERAGED, and ESTIMATED the total POPULATION of beans!

Activity 2: "BEAN BUGS", an OBIS activity copied with permission.

Mark off a study area 10m x 4m using the string and stakes. Tell students that you will introduce a population of bean bugs into the study area and show the youngsters the bag of beans you are using to represent the bean-bug population. Walk around inside the marked-off area, and distribute the bean bugs evenly throughout the area. Ask if anyone has an idea of how to find out how many bean bugs are in the population. Acknowledge all suggestions, but focus attention on ideas that relate to counting bean bugs in a small area and multiplying by the number of small areas in the site. Explain that such a method of counting organisms is called a **quadrat census technique.**

Explain that for this activity, the quadrat size is 100 square centimeters or 1 square decimeter. Show the youngsters a wire square and say that its area is 1 square decimeter. Explain that an accurate quadrat census involves counting the organisms in as many randomly selected quadrats as possible, and then finding the average number of organisms per quadrat.

The youngsters will toss their wire squares into the site, count the bean bugs within, and then toss the square again for another count. Using a data chart, go over the calculations involved to determine the population size.

Demonstrate the sampling procedure by tossing a wire square into the study area, and having a couple of youngsters count and record the number of bean bugs inside the quadrat. (Give them a clipboard with index card and pencil.) Divide the group into teams of two. Tell them that each team should toss their wire square ten times, and record the number of bean bugs in each quadrat sample. Give each team a wire square, an index card, and a pencil, and let them start taking their quadrat counts.

As the teams finish taking their quadrat counts, ask them to average their results. Some of the teams may need help with this. Delegate one team to measure the dimensions of the study site so that its area can be calculated or see if the group can figure out, either explain that because there are 100 square decimeters in a square meter, they must multiply the area of their study site (in square meters) by 100 to get the total number of quadrats in the study site. Tell the teams that all they have to do is multiply their quadrat averages by the number of quadrats in the whole study site to arrive at a population estimate for the entire area.

Record each team's estimate and explain that you estimated the number of bean bugs in the population before the activity. Reveal your "accurate" estimate at this point. Discuss the range of estimates and ask the teams what might be responsible for the variation. Some possibilities are: arithmetic errors, incomplete counts of bean bugs in the quadrats (they can be hard to see), too few quadrat samples, the bean bugs were not uniformly distributed throughout the study area.

Average the teams' quadrat averages on the data board to get a group quadrat average. Multiply the group average by the number of quadrats in the study area. Compare this estimate with the estimate you determined in advance. Is it close? Closer than most of the individual team estimates? Why?

Notes:

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