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ABSTRACT

A science process skill project was developed to help elementary teachers meet competency standards in New Mexico for teaching the process approach in their science classes. An outline of the process skills along with recommended activities are presented in this document. Performance objectives are identified and a sample activity form is included. Two activities are provided for the skill areas of: (1) observation; (2) classification; (3) communication; (4) prediction; and (5) inference. Activities focus on topic areas such as electroplating, human genetic traits, circuit diagrams, circuit patterns and boards, fingerprints, and chemical reactions. (ML)

BASIC SCIENCE PROCESS SKILLS

AN INSERVICE WORKSHOP KIT

ROWLAND · STUESSY · VICK

BASIC SCIENCE PROCESS SKILLS

AN INSERVICE WORKSHOP KIT

OUTLINES AND ACTIVITIES

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3. Propose a relationship (infer)
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A. Inference Defined

Inferences are explanations or interpretations of observations that are supported by observations. Inferences begin with the observation of an effect and express a believed cause for that effect.

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2. Select appropriate measuring tool
3. Conduct measurement
4. Record results in appropriate units

PERFORMANCE OBJECTIVES FOR BASIC SCIENCE PROCESS SKILLS

Adapted from: Funk, J.H., et al. 1985. Learning Science Process Skills. Dubuque, Iowa: Kendall Hunt Publishing Company.

OBSERVATION

1. The learner will, given an object, substance, or event, be able to **construct a list** of qualitative and quantitative observations about that object, substance or event.
2. The learner will, given an event in which change is involved, be able to **construct a list** of qualitative and quantitative observations about the change before, during, and after it occurs.

CLASSIFICATION

1. The learner will, given a set of objects, **list observable properties** which could be used to classify the objects and **construct a binary classification system** for each property.
2. The learner will, given a set of objects, **construct a multistage classification system** and **identify the properties** on which the classification is based.
3. The learner will, given a set of objects, **identify properties** by which the set of objects could be serially ordered and **construct a serial order** for each property.

COMMUNICATION

1. The learner will, describe an object or event in sufficient detail **so that another person can identify it.**
2. The learner will, construct a map showing relative distances, positions, and sizes of objects with sufficient accuracy **so that another person can locate a particular place or object using the map.**

PREDICTION

1. The learner will **construct predictions** based on **observed patterns** of evidence.
2. The learner will **construct tests for predictions.**

INFERENCE

1. The learner will, given an object or event, **construct inferences from observations** about that object or event.
2. The learner will, given additional observations about the object or event, **identify the inferences that should be accepted, modified, or rejected.**

MEASUREMENT

1. The learner will **select the appropriate metric unit** for measuring any property of an object.
2. The learner will **select the appropriate instrument** for measuring a property of a given object.
3. The learner will, **measure** the temperature, length, volume, mass, or force of any object to an accuracy compatible with the equipment used.

Process Skill Activity Sheet Name_____

Process Skill:

Concept:

Objectives:

Procedures:

What the teacher does

What the student does

Materials:

Time required:

Evaluation: I will know that the student has mastered the process skill by the student doing the following things:

PART II - PROCESS SKILL ACTIVITIES

PHYSICAL SCIENCE ACTIVITY -- ELECTRICITY

OBSERVATION ACTIVITY 1: ELECTROPLATING

Observations are our perceptions of the world around us. We observe objects and natural phenomena through our five senses: sight, smell, touch, taste, and hearing. We can reference our observations to some standard unit of measurement (centimeters, milliliters, grams). Observation therefore divides into two general categories: qualitative observations and quantitative observations. Qualitative observations are those in which we use only our senses to gain information about an object or event. Quantitative observations are those in which we make our observations more precise by taking measurements.

In this activity you will make both qualitative and quantitative observations during the process of electroplating iron nails with copper.

Materials:

equal arm balance with mass cubes
cupric sulfate (1 level teaspoon)
teaspoon
lamp with holder
100-ml. plastic beaker
D-cell battery with holder
two wires with clips
two nails
60 ml. water (hot if possible)

Procedures:

1. Make a data sheet which provides spaces for recording qualitative and quantitative observations before, during, and after the electroplating of the nails. Follow the format for the data sheet as diagrammed below:

Qualitative Observations	Quantitative Observations
Before Electroplating:	
During Electroplating:	
After Electroplating:	

1. Assemble the D-cell battery and holder, attach the two wires to the positive (+) and negative (-) ends. The clip ends should remain free.
2. Test the battery and wire connection by attaching the clips to the miniature lamp receptacle springs. The light should come on; if not, check all connections. When you are satisfied that the electrical connections are working, replace the miniature lamp and receptacle. It will not be used further in this activity.
3. Assemble the equal arm balance. Balance the empty trays by moving the red slides on the scale at the top of the equal arm balance.

Before Electroplating:

4. Examine the nails using the senses of sight and touch. Record qualitative observations of the nails as you begin the activity.
5. Place a nail on one of the trays of the balance. Add weights to the other tray until they balance. Be precise. Record the weight of the nail on the data sheet in the column marked "Quantitative Observations." Use "mass cube" as the unit of measurement.
6. Remove the nail which you measured and attach it to the clip extending from the negative battery terminal (the bottom of the battery). Attach the other nail to the remaining clip extending from the positive battery terminal.

7. Place one (1) level teaspoon of cupric sulfate in the 100 ml. plastic beaker. Pour approximately 60 ml. hot water into the plastic beaker. Use the teaspoon to stir the water and cupric sulfate until all crystals have dissolved. Record your observations of what happened when the crystals were dissolved in the water.
8. Place both nails, attached to the clips, into the beaker containing the blue cupric sulfate solution. Make certain the wires and nails do not touch each other in any way.

During Electroplating:

9. Observe the nails and solution carefully for five minutes. Make notes of your observations every 30 seconds. You may want to raise each nail slightly out of the solution for your observations. Raise the nails slowly and carefully, and try not to touch the nails to anything.

After Electroplating:

10. After 5 minutes, carefully remove the nails from the solution. Very carefully, place the nail from the negative lead back into the tray of the equal arm balance and record its weight. Make qualitative observations of the nails and record them.

LIFE SCIENCE ACTIVITY -- THE HUMAN BODY

OBSERVATION ACTIVITY 2: CHEWING GUM

Observations are our perceptions of the world around us. When making observations, we say an object is sticky, tastes salty, makes a rattling sound, or smells like rotten eggs. This type of observations is **qualitative**, that is, we qualify our observations by using our five senses. The second type of observation we can make about an object or event is to relate it to some standard unit of measure. This type of observation is **quantitative**. We quantify our observation of the object by saying how much is weighs, or how long it is, or what volume it occupies.

In this activity, you will make both qualitative and quantitative observations and record your observations before, during, and after the chewing of a stick of gum. We are asking the question, what happens to gum when we chew it.

Materials:

equal arm balance with mass cubes
metric ruler
chewing gum, 1 stick
piece of paper

Procedures:

1. On a separate piece of paper make two columns for recording your observations. Head one column as "Qualitative Observations" and the other as "Quantitative Observations." You may wish to record your observations in three categories as indicated below:

Qualitative Observations	Quantitative Observations
Before Chewing:	
During Chewing:	
After Chewing:	

Before Chewing:

2. Remove a stick of gum from its wrapper and begin recording your observations. Make qualitative observations using the appropriate senses of sight, smell, and touch. Record these observations in the column marked "Qualitative Observations."
3. Using the metric ruler, measure the linear dimensions of the chewing gum: length, width, thickness. Use millimeters as your unit of measurement. Record those measurements under the column marked "Quantitative Observations."
4. Assemble the equal arm balance and adjust the red buttons on the top of the balance until the indicator is centered. Place the stick of chewing gum on one pan of the balance. Measure the weight of the stick of chewing gum by adding mass cubes to the other pan of the balance. Record the weight in mass cubes as your unit of measurement.
5. Remove the stick of gum from the tray.

During Chewing:

6. Chew the gum for several minutes. Make additional qualitative observations as you chew the gum. Record these observations in the appropriate column.

After Chewing:

8. Place the chewing gum in the empty tray on the equal arm balance. Record your quantitative observations.
9. Observe the gum after it has been chewed. Make qualitative observations and record them.

PHYSICAL SCIENCE ACTIVITY -- ELECTRICITY

CLASSIFICATION ACTIVITY 1: CONDUCTORS AND NONCONDUCTORS

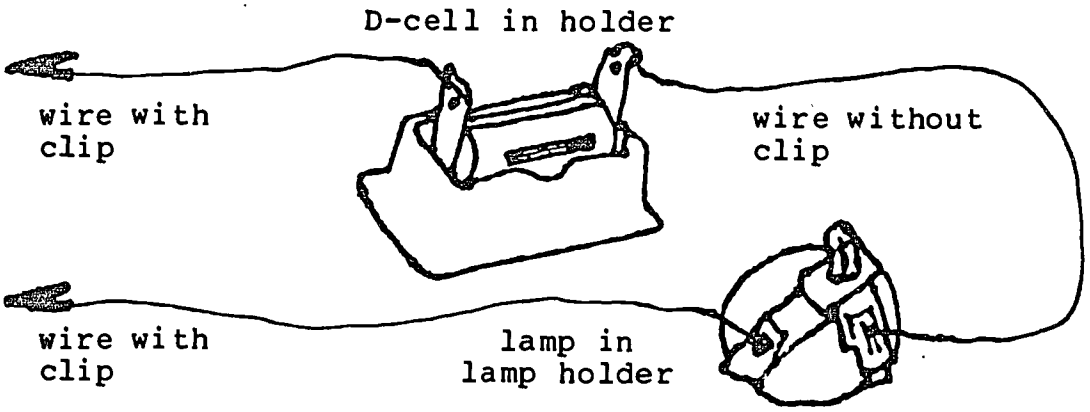
In this activity you will construct a **binary classification system.** To construct a binary classification system you must first identify a property possessed by some but not all of the objects within a particular set. The property for binary classification we will use in this activity is **electrical conductivity:** Does the object conduct electricity or not? As you do this activity, consider how you are developing a working definition of the concept, conductivity.

Materials:

D-cell battery with holder
miniature lamp with holder
3 wires, 2 with clips
assortment of objects for classification

Procedure:

1. Construct the test circuit as diagrammed below.



2. Test the circuit to make sure that the miniature lamp will light when the wires with the clips are touched together.
3. Begin testing the assorted objects on the basis of their electrical conductivity by clipping them between the two wires. If the bulb lights, classify the material as a conductor.
4. Record the results of testing the objects on a data sheet which classifies the objects as:

Conductors	Nonconductors

LIFE SCIENCE ACTIVITY -- HUMAN BODY

CLASSIFICATION ACTIVITY 2: HUMAN GENETIC TRAITS

Classification is the process of grouping objects for a specific purpose. We use many different classification systems daily, each designed for information retrieval in some predictable way. Our gradebooks are arranged in a way to facilitate access to student information, a grocery store uses a specific classification system to order the items within the store, and the library uses a different classification system to arrange its books for user access.

Classification systems can themselves be classified into three general types, depending on their purposes or use. A **serial classification** system provides information access and ranks objects. A **binary classification** produces two groups and is the basis for concept definition. A **multistage classification**, which is an extended binary system, is used for identification.

In this activity you will construct several binary classification schemes based on observable genetic characteristics, which when combined will result in a multistage classification scheme for the people participating in this workshop.

Materials:

blackboard or other large surface for diagrams
pieces of notebook paper for writing multistage classification schemes

Procedures:

This activity is divided into two parts: Part I is the construction of several binary classifications, and Part II is the construction of a multistage classification scheme.

Part I. Binary Classification

Working as a class, construct a binary classification scheme based upon the following genetic characteristics:

1. Eye Color. Brown or Not Brown. Draw on the blackboard a binary classification scheme using eye color (i.e., brown or not brown) as the classification criterion. Under the appropriate heading record the number of people exhibiting each characteristic. Save this list for Part II.

2. Tongue Rolling. Roller or Non-Roller. Some people have the ability to roll their tongues into a U-shape when the tongue is extended from the mouth. This ability is caused by a dominant gene. Construct a binary classification scheme based on the ability to roll or not roll your tongue. Draw the scheme on the blackboard, record the number of individuals with each characteristic and save this information for Part II.

3. Ear Lobes. Attached or Not Attached. A dominant gene determines whether ear lobes hang free and are therefore not attached directly to the head. In some people, the ear lobe is attached directly to the head. Construct a binary classification scheme based on the observable genetic characteristic of having attached ear lobes or not having attached ear lobes. Record the individuals in groups as before and save for Part II.

4. Ring Finger Length. Longer than the Index Finger or Not Longer than the Index Finger. Extend your hand outward, holding your fingers together. Is the ring finger longer or shorter than the index finger? This is also a genetically-controlled characteristic. Using this characteristic, record the individuals who do exhibit a ring finger longer than the index finger and those who do not. Save this information for Part II.

5. Handedness. Dominant Right Hand or Not Dominant Right Hand. Which hand do you usually use for writing? Construct a binary scheme based on handedness. Save this information for Part II.

6. Widow's Peak. Widow's Peak Present or Not Present. Some people exhibit the characteristic of a hairline that comes to a distinct point in the middle of the forehead. This is known as a widow's peak. Create a binary classification scheme of the group based on this characteristic.

7. Hitchhiker's Thumb. Hitchhiker's Thumb Present or Not Present. Hold you hand flat and with the fingers together, bend the thumb back away from the fingers as far as possible. If it bends back more than 45 degrees then you have a "hitchhiker"s thumb." Classify your group using this characteristic and save your results.

Part II. MultiStage Classification.

In this part of the activity, you will construct a multistage classification system. The class will be the population to be classified. Construct a multistage system using the observable genetic traits classified in Part I. You may have to add other classification criteria such as sex, hair color, height, eyesight, etc., to complete the classification. The multistage classification scheme is complete when each person in the class has been identified as a unique individual.

PHYSICAL SCIENCE ACTIVITY -- ELECTRICITY

COMMUNICATION ACTIVITY 1: CIRCUIT DIAGRAMS

Our ability to communicate with others is basic to everything we do. Effective communication is clear, precise, and unambiguous and uses skills which need to be developed and practiced. This activity will help you analyze effective communication skills and emphasize the importance of feedback when giving directions. How effectively you communicate will be measured by the closeness of similarity between the designs you describe and those constructed by your partner.

Materials:

circuit diagrams
batteries and holders (2 each)
miniature lamps with holders (2 each)
wire, 10 sections

Procedures:

1. Erect a barrier between you and your partner so that each cannot see the table or space in front of the other.
2. One person, the "sender," will verbally describe a circuit diagram to his/her partner, the "receiver." The receiver will construct the circuit according to the instructions given.

Trial One: Without Feedback

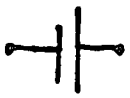
3. The sender describes the circuit for the receiver to construct. The receiver **cannot** ask for any clarification or additional information.

Trial Two: With Feedback

4. Reverse roles; sender becomes receiver and receiver becomes sender. Select another ciruit diagram and proceed as before, except the receiver can now ask questions that would help in constructing the circuit.
5. Repeat step 4 until several circuits have been constructed.

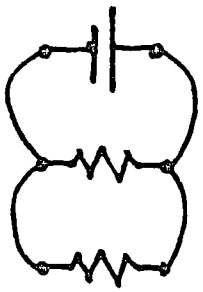
COMMUNICATION CIRCUITS

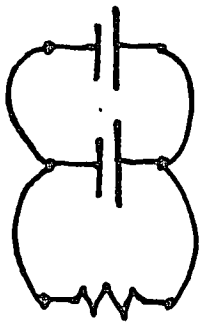
KEY

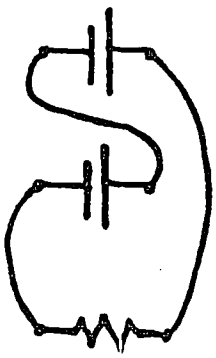
Battery in holder 

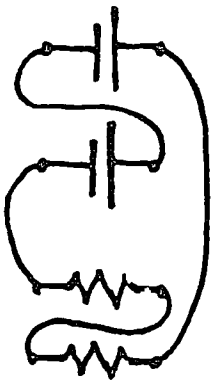
Bulb in holder 

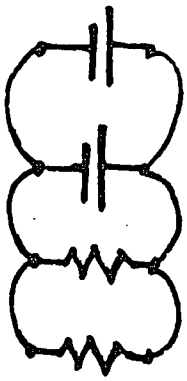
Wire

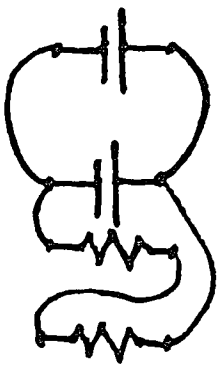
A. 

B. 

C. 

D. 

E. 

F. 

LIFE SCIENCE ACTIVITY -- HUMAN BODY

COMMUNICATION ACTIVITY 2: FINGERPRINTS

Our ability to communicate with others is basic to everything we do. We express our ideas, feelings and needs to others using pictures, displays, graphs, written descriptions, and verbal explanations. The method (mode) of communication we choose to employ depends on the nature of the information we need to convey. Regardless of how we relay information, our communications must be effective. Effective communication is clear, precise, unambiguous and uses skills which need to be developed and practiced.

In this activity you will practice effective communication skills by describing fingerprints to your partner. How effectively you communicate to your partner will be measured by the degree to which your partner is able to identify the specific fingerprint you describe.

Materials:

ink pad
3 x 5 inch index cards (5 or 6 each)

Procedures:

A. Preparing the fingerprint cards:

1. Choose partners to work in pairs for this activity.
2. Using the ink pad, each person should ink his/her thumb and index finger by rolling them across the ink pad.
3. Transfer your fingerprints to the index cards. Make a set of prints (thumb and index finger) on enough cards so that each pair of two people will have a set of your prints.

   Note: It is suggested that when transferring your thumb print to the index card, you roll your thumb toward your body, press firmly on the index card but not so hard as to "stretch" your print. Be careful not to let your thumb slip across the card. When transferring your index-finger print to the card, roll your finger across the card in a direction away from your body.

4. Allow the ink prints to dry, then give each of the other groups one of your print cards.
5. Each pair should now have a print card from each person in the session. Arrange all the cards on the table so that you and your partner can easily see them.

B. Communication Without Feedback

6. One person selects a specific print to describe without telling his/her partner which print has been selected. This person begins to describe the print to the partner and continues adding to the description until the partner (receiver) can identify the specific print. The person receiving the description cannot ask any questions or ask for clarification in any way, i.e., without feedback.

C. Communication With Feedback

7. Reverse roles. Use the same procedures as before. This time you and your partner may engage in any verbal exchanges necessary to help identify which specific print is being described.
8. Repeat step 7.

PHYSICAL SCIENCE ACTIVITY -- ELECTRICITY

PREDICTION ACTIVITY 1: CIRCUIT PATTERNS

A prediction is a forecast of what a future observation might be. Prediction is based on careful observation and the inferences made about relationships between observed events. As we develop an understanding about relationships between observed events we begin to recognize patterns and develop the ability to predict from the patterns what future observations might be. Children need to learn to ask such questions as "If this happens, what will happen next?" "What will happen if I do this?" Prediction is the basic process skill that helps students develop scientific inquiry and problem solving skills.

In this activity you will make predictions based on observed patterns and construct tests for your predictions.

Materials:

2 D-cell batteries in holders
2 miniature lamps in holders
6 wires
schematic circuit diagrams

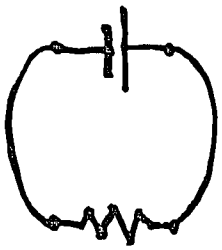
Procedures:

1. Construct the circuits labeled open, closed, and short. Observe the bulb and record your observations.
2. Select a circuit diagram. Carefully observe the circuit, and then make a prediction about which lamps will light.
3. Test your prediction by constructing the circuit you selected.
4. Repeat steps 2 and 3 with different circuit diagrams until you have predicted and tested all circuits given..

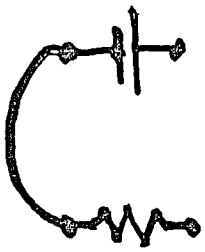
PREDICTION CIRCUITS

Construct the following circuits and note which bulbs light.

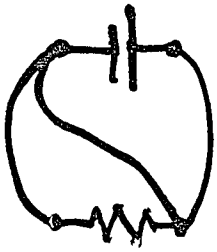
CLOSED

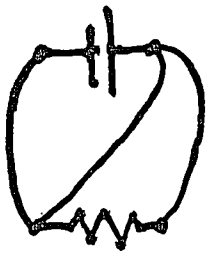


OPEN



SHORT

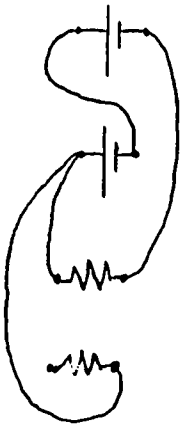




PREDICTION CIRCUITS

Examine the following circuit schematics and predict which bulbs will light. After you have recorded your predictions, construct each circuit and record which bulbs actually lit.

A.



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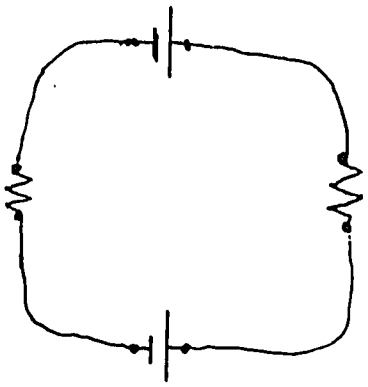

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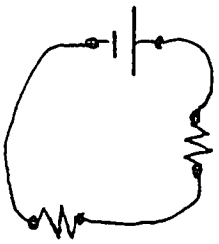
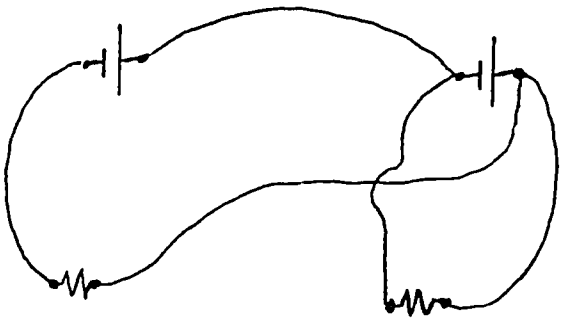


D.

E.

F.



LIFE SCIENCE ACTIVITY -- HUMAN BODY

PREDICTION ACTIVITY 2: PULSE RATE AND EXERCISE

A prediction is a forecast of what a future observation might be. In order to make a rational prediction we must have some information upon which to base our prediction. Therefore, in order to make a prediction we must first collect data through careful observation. During the data collection process we search for patterns between variables and infer cause-and-effect relationships. Next we construct a statement about what the future observation might be, based on the information we now have. The final phase of making a prediction is to construct an investigation to test the prediction.

In this activity you will predict your pulse rate after a specific exercise.

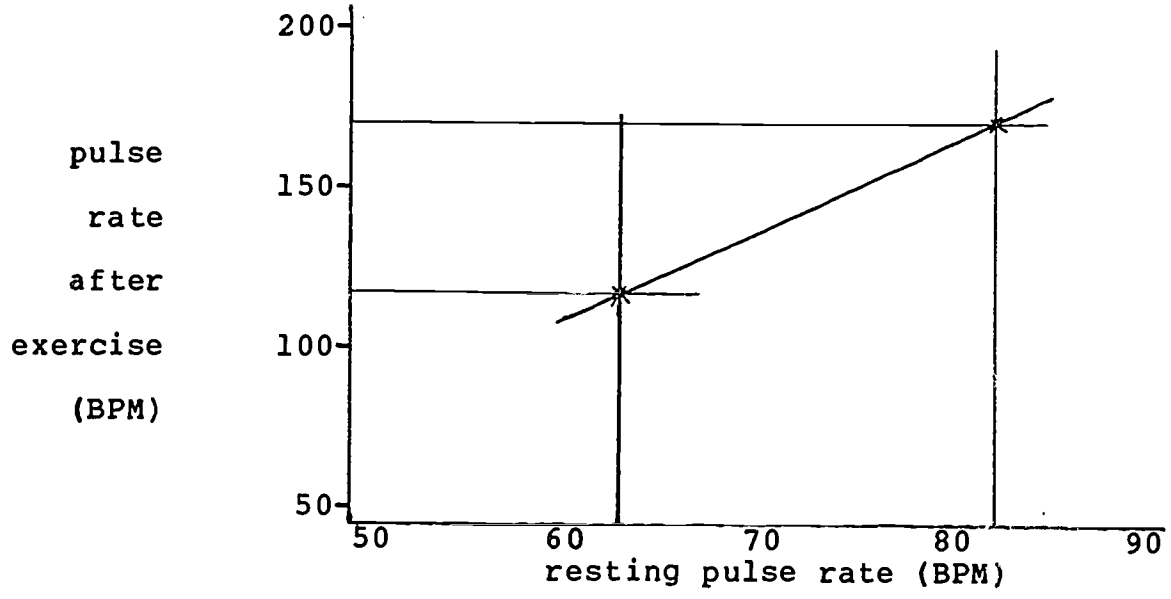
Materials:

watch with second hand
blackboard or large poster paper

Procedures:

1. Record your resting pulse rate. Comfortably seated with your arm resting on a table, count the number of pulses during a 15-second time interval. Multiply this number by 4 to get your average pulse rate per minute or beats per minute (BPM) at rest. Record this number for later use.
2. Designate one person from the class as the recorder.
3. The recorder draws a graph on the blackboard. Label the horizontal axis (x-axis), "resting pulse rate." Label the vertical axis (y-axis) "pulse rate after exercise." Mark each axis in equal increments. Begin the numerical scale for both axes at 50 BPM. Extend the increments on the x-axis to approximately 100 BPM; extend the y-axis to approximately 200 BPM.
4. Determine who in the class has the lowest resting pulse rate. Record that pulse rate on the graph by drawing a vertical line extending upward, originating on the x-axis at the numerical value for the resting pulse rate and parallel to the y-axis.
5. Determine who in the class has the highest resting pulse rate. Record this information on the graph in the same manner.

6. The two people whose pulse rates were graphed will now determine their pulse rates after exercise. To do so, they should each individually step up onto a chair then off the chair twenty (20) times as fast as they can. Immediately following this activity they should sit down and determine their pulse rates using the same procedure as before.
7. Their after-exercise pulse rates should be recorded on the graph. Draw a horizontal line extending outward parallel to the x-axis and intersecting the vertical lines just drawn. Begin with the person who had the lowest resting pulse rate. Where the lines intersect, mark an X. Repeat this procedure for the person who had the highest at-rest pulse rate, marking an X where the lines intersect.
8. Connect the two X's with a line. This line will serve as a reference for the rest of the class to predict their after-exercise pulse rate.
9. The entire class should now use their resting pulse rates and the graph on the board to predict their after-exercise pulse rate. Each individual should record his/her resting pulse rate on the graph and predict the after-exercise pulse rate using the line which connects the two X's.
10. Each individual should test his/her prediction by performing the exercise activity (i.e., stepping onto a chair 20 times). When finished, the individual should sit down and immediately determine his/her pulse rate after exercise.
11. For class discussion answer these questions: Do your predicted and actual after-exercise pulse rates differ? What other factors might help you predict the after-exercise pulse rate?
12. Challenge: Can you determine if **age** is a good predictor of the after-exercise pulse rate?



PHYSICAL SCIENCE ACTIVITY -- ELECTRICITY

INFERRING ACTIVITY 1: CIRCUIT BOARDS

In this exercise you will **infer** the connection patterns on each of four circuit boards. You will use the circuit tester to determine which pairs of contacts make a closed circuit (i.e., when the light comes on). On the data sheet you will write the number of the circuit board being tested and record your inferences about the circuit construction in the form of sketches.

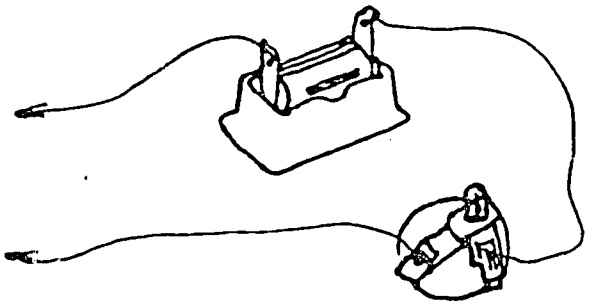
Objective: To discover that an inference may need revision and that several different inferences may be equally reasonable.

Materials:

D-cell battery and holder
miniature lamp and holder
3 sections of wire, 2 with clips
circuit boards

Procedures:

1. Construct the basic test circuit as illustrated below:



2. Test the basic circuit by touching the two wires with clips together. The miniature lamp should light.
3. Using the sample circuit board, place one wire clip in the opening under the letter "A"; place the other wire with clip in the opening under the letter "B." Does the light come on? What can be inferred about the A-B connection?
4. Continue testing the circuit by keeping the same clip in position "A" and moving the other clip to "C","D","E","F." Sketch your inferences of the connections on the data sheet. (Since you cannot see these connections you will be making inferences based on the lighting of the bulb.)

5. Next, test all the connections from "B." Keeping one clip in "B," test the B-A, B-C, B-D, B-E, and B-F connections. On the data sheet, sketch your revised inferences of the connections. Show all connections that you believe to exist.
6. Repeat this procedures for positions "C," "D," and "E." Sketch each inferred connection on the data sheet.
7. Repeat steps 3-6 for the remaining circuit boards. Draw your final inference of each circuit board on the blackboard. We will compare results as a group.

Note: As you progress from A-F on each of the circuit boards your inferences about the connections will change as you gather more information.

INFERENCES: CIRCUIT BOARD DATA SHEET

	CIRCUIT BOARD ___	CIRCUIT BOARD ___	CIRCUIT BOARD ___
Inferences after testing contact A	A B C D E F	A B C D E F	A B C D E F
Inferences after testing contact B	A B C D E F	A B C D E F	A B C D E F
Inferences after testing contact C	A B C D E F	A B C D E F	A B C D E F
Inferences after testing contact D	A B C D E F	A B C D E F	A B C D E F
Inferences after testing contact E	A B C D E F	A B C D E F	A B C D E F

LIFE SCIENCE ACTIVITY -- HUMAN BODY

INFERENCE ACTIVITY 2: CHEMICAL REACTIONS WITH BTB

An inference is an explanation or interpretation of an observation. When making an inference we make a statement about our observations that goes beyond the directly observed evidence and attempts to explain the evidence. Inference statements are made when attempting to explain why an event occurred or how an object was formed, without having directly observed the formative process involved. In this activity you will make inferences based on your observation of a chemical reaction.

Materials:

100-ml. plastic beaker
bromthymol blue in a plastic bottle
vinegar
water
straw
wood splint

Procedures:

Part I

1. Pour approximately 50 ml of water into the 100-ml plastic beaker.
2. Add 4 drops of bromthymol blue to the water and stir with the wood splint.
3. Add 1 drop of vinegar (acetic acid) to the bromthymol blue/water mixture. Stir and record your observations.
4. Continue adding vinegar 1 drop at a time, stirring after each additional drop is added until the mixture has changed colors. Record your observations after each drop of vinegar has been added.
5. Discuss your observations as a class.
6. Discard the mixture, rinse the plastic beaker, and proceed to Part II.

Part II

1. Pour approximately 50 ml of water into the 100-ml plastic beaker.
2. Add 4 drops of bromthymol blue to the water and stir with the wood splint.
3. Using the straw, slowly exhale into the bromthymol blue/water mixture. Exhale 4 times into the beaker with long deep breaths. Record your observations after each breath.
4. What caused the water to change color? Explain your observations. Support your inferences with observations you have made.