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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. This document consists of the inservice workshop kit manual that could be used by a teacher to provide an inservice program to a small group of other teachers. This manual explains how to give the inservice workshop and provides the trainer with background information about process skill teaching. Major sections address the skill areas of: (1) observation; (2) classification; (3) communication; (4) prediction; (5) inference; and (6) measurement. Appendices contain process skill activities, a listing of the basic science process skills and subskills performance objectives for science process skills, and an activity sheet form. (ML)

BASIC SCIENCE PROCESS SKILLS

AN INSERVICE WORKSHOP KIT

WORKSHOP MANUAL

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TABLE OF CONTENTS

INTRODUCTION

What is included in the BASIC SCIENCE PROCESS SKILL INSERVICE WORKSHOP KIT, and how is it used?

The kit includes the following components:

(1) This manual, which explains how to give the inservice workshop and provides the trainer (the term we use to refer to the person giving the workshop) with background information about process skill teaching.

(2) The videotape: BASIC SCIENCE PROCESS SKILLS (1/2" VHS format), which provides information about each skill, its subskills, and the evaluation of the skill.

(3) An Activities Kit, which provides materials for two sets of activities. These are typical science activities that might be used in teaching units about electricity and the human body, but they have been modified to make them process skill activities. These activities not only serve as models for teachers who are developing activities but they also are intended to help the trainees develop their own process skills.

(4) Learning Science Process Skills, a process skill workbook, which provides numerous examples of process skill activities.

The workshop, which lasts 5-6 hours, will include viewing the videotape, discussing the information from the tape, doing activities that develop each process skill, and developing and evaluating activities. The kit is designed to be used by the trainer and 8-12 trainee teachers.

A sequence for the workshop is given below:

Process Skills: Explain the purpose of the workshop
Show first segment of videotape
Review the overview of process skills

Observation: Show observation segment of videotape
Discuss skill, subskills [illegible]luation
Do observation activities
Discuss observation activity design
Design an observation activity

Classification: Show classification segment of videotape
Discuss skill, subskills, evaluation
Do classification activities
Discuss classification activity design
Design a classification activity

Communication: Show communication segment of videotape
Discuss skill, subskills, evaluation
Do communication activities
Discuss communication activity design
Design a communication activity

Prediction: Show prediction segment of videotape
Discuss skill, subskills, evaluation
Do prediction activities
Discuss prediction activity design
Design a prediction activity

Inference:	Show inference segment of videotape
	Discuss skill, subskills, evaluation
	Discuss inference activity design
	Do inference activities
	Design an inference activity
Measurement:	Show measurement segment of the tape
	Discuss how measurement is used
Summary:	Show final segment of tape

In order to conduct the workshop you will need the following: a videotape player and television set
a flat table or desk to work on
access to warm water (about a cupful)
a place to wash your hands.

<u>What is science process skill teaching?</u>

Teaching science through process skills is a method of teaching that allows the child to discover science knowledge the same way that scientists discover knowledge. The process skill approach allows the learner to experience the scientific enterprise.

Science is a special way of knowing about the world. Science provides us with a way of looking at the natural world which helps us understand our experiences. This scientific way of knowing relies on the use of observation, experimentation, logic and verification. This approach to the discovery of knowledge is based on the use of the basic science process skills. When we teach using a discovery approach, we stress the process of science, the use of these basic tools of scientific inquiry and discovery. We therefore teach our students to learn science the same way that scientists learn about the universe.

A process skill approach is a hands-on, discovery, inquiry-based approach to teaching science that ensures that students have the necessary skills to be sucessful do-ers of science.

Why teach science through a process approach?

First, a process approach emphasizes that science is a way of understanding our natural world.

Secondly, a process approach allows students to come to an understanding of science content in the same way that scientists discover the facts, principles, and relationships of the natural world. By discovering a science based in concrete reality, through the use of process based activities, students develop a clearer conceptual understanding of science.

Thirdly, a process approach to science will have children involved in activities that promote the development of scientific attitudes. A key to good science teaching is the development of attitudes such as: desire for experimental verification, scepticism, precision, a liking for new things, an objective attitude, and a respect for quantification. In addition, the experiences in a process skill science class will help students develop internal reward systems and reasonable explanations for things which happen to them.

What are the basic process skills?

The basic process skills are the fundamental activites that scientists do. Most basic of these skills is **observing** - the processing of information about our surroundings. **Classifying** skills allow us to organize our observations. **Communicating** skills are used to convey observations and instructions to others so they can replicate our findings. Observations that are organized in patterns permit us to use **predicting** skills so that we can better respond to our environment. When we propose causes for what we observe, we use **inferring** skills. **Measurement** skills are used in conjunction with all of the process skills.

How does one teach a science process skill?

The teaching of science process skills can be likened to the teaching of a variety of other skills. Sawing a board, sewing a seam, or kicking a soccer ball are skills that are frequently taught in our society. These skills differ from each other in the product of their execution, but they all can be learned in similar ways. Science process skills are similar. Although the product of science process skills is knowledge, the teaching of the skills is similar.

First, establish the need for the skill and the usefulness of using the skill. Just as a pro-golfer is unlikely to spend time learning how to kick a soccer ball, students who are only expected to memorize science facts are unlikely to spend time developing their inferring skills.

Second, determine the level of the skill that exists. Some children are good observers, while others may only use one sense, make rushed observations, or forget to record what they observe. You need to know at what level the children are for a particular skill so you can plan appropriate activities.

Third, break the skill down into subskills for yourself and your students. The subskills provide you with guideposts that help you identify specific weaknesses. For example, we might find that a poor classifier is good at several subskills but creates poor classification schemes because he/she uses poorly stated rules. Knowing this, we could help the student in the development of better rules for classifying.

Fourth, provide the students with a skill development activity that stresses the use of the subskills. Many activities are available that force the child to <u>use</u> a process skill; however, the process skill teacher needs to construct activities that emphasize the use of the subskills. Specific instructions need to be provided to ensure that the students will use the subskills.

Fifth, evaluate the level of the skill. Determine whether or not the subskills are used successfully.

Determine which students need additional assistance in developing the skill.

Finally, provide activities that use the skill. The refinement of the skill will come from extensive practice.

AN INTRODUCTION TO THE BASIC SCIENCE PROCESS SKILLS

A. Describe the purpose of the workshop and its format.

(The purpose of this workshop is to help teachers develop their own basic science process skills as well to assist them in developing science process skill activities.)

B. Show the first segment of the videotape. The objective of this segment is to introduce the trainees to the basic science process skill and to provide a rationale for a process skill approach to science teaching. When the orange screen with PLEASE STOP THE TAPE appears, press the stop button on your VCR.

C. Review the content of the videotape.

1. List the six basic process skills
   (observation, classification, communication, prrediction, inference, measurement)
2. List three outcomes of teaching science process skills.
   (discovery of content, development of scientific attitudes, experience in working like a scientist)
3. Answer any questions that the trainees might have at this point.

OBSERVATION

A. Background information for the trainer.

Observation is the most basic activity conducted by a scientist. For our students, observation provides the basis for understanding encounters with the natural world. The experiences that we ask our students to recall when we are teaching new concepts, that we expect students to use as a framework in which they embed new information, are established through the use of the observation skill.

More than simply looking at something, observation requires the processing of information. As teachers, we can improve the processing of information by providing our students with a clear focus for their observations and requiring them to record what they observe.

Qualitative observation, requiring the use of the five senses, is a common form of observation in all areas of science. It is used in the initial investigation phase in all kinds of scientific work. Some areas in science rely more on qualitative observations than others.

Quantitative observation, the use of measurements, is also common in most areas of scientific investigation. The use of measurements allows us to make our qualitative observations more precise. In doing so, we are better able to replicate our findings and have them confirmed by others.

Probably the most important thing we can do to help children become good observers is to provide them with interesting things and phenomena to observe. The use of tools like magnifying glasses to enhance our observation abilities can also make the common object more interesting. Observation of commonplace objects can be made more interesting by using appropriate measurement tools.

Observations made over a period of time can develop an understanding of the universal concepts of change and time. The time period may be seconds, as in the observation of a chemical reaction; weeks, as in observing the growth of a plant; or a year, as in observing the change in the length and position of shadows through the seasons.

After providing interesting objects and events for observation, students need to be directed to use the appropiate senses and measurement tools to make observations. If students are observing plants, they should be instructed to use senses of touch and smell, and if appropriate, taste. (WARNING - MANY COMMON HOUSE PLANTS ARE POISONOUS. USE TASTE ONLY IF YOU KNOW THAT THE PLANT IS SAFE TO EAT.) Try to get your students making observations with all of the senses, not just sight. Also, provide your students with measuring tools so that they can make quantitative observations.

Finally, the key to good observation is good record keeping. We need to stress the importance of listing our observations. A record of observations provides the teacher with evidence that observing has occurred. Without the list, we cannot evaluate the level of observing skills.

With younger children the list may be produced orally for recording on tape or by the teacher, or the record might be in the form of a sketch or series of sketches by the child.

In addition to providing teachers with a way of evaluating observation skills, a list of observations also provides the student with a record that can be used for reference and comparison to future observations. The record may reveal to the child the patterns in nature.

B. Show the next segment of the videotape.

The objective of this segment is to provide you with a description of the skill, its subskills, how to evaluate the skill, and some examples of students making observations. When the orange PLEASE STOP THE TAPE frame appears press stop on your VCR.

C. Discuss the videotape

1. Review the types of observations
    a. Qualitative - based on the five senses
    b. Quantitative - based on measurements
2. Subskills of observation
    a. Determine most appropriate senses
    b. Observe qualities of object/event
    c. Record qualitative observations
    d. Determine what to quantify
    e. Make appropriate measurements
    f. Record measurements

g. If change is involved record when observations were made.

3. Evaluation of observations

   a. The learner will record qualitative and quantitative observations about an object or event.

   b. If change is involved, the learner will record when specific observations were made.

4. Discuss any other questions the trainees may have at this time.

D. Observation activities

In this section, the trainees will work in groups of three or four doing an observation activity.

The first activity, Electroplating, shows how the energy of electricity can be used to move copper ions that are in a solution. This activity illustrates the concept of change by having the learner compare observations of the nail and the solution before the electric current is applied and after the current is applied.

The second activity is adapted from Learning Science Process Skills. In this activity, we are interested in what happens to gum when we chew it. (Actually, from a "human body" viewpoint, we are interested in what happens to us when we chew gum but it is easier to observe the gum than it is to observe the inside of the human body.) This activity points out that sometimes we have to make observations of objects other than the ones of direct interest. Indirect observations are common in science.

E. Discuss how to design observation activities

An ideal observation activity:

1. Requires students to list their observations.
2. Utilizes more than one sense.
3. Includes both quantitative and qualitative modes.
4. Incorporates the concept of change over time.
5. Is interesting.

Discuss the observation activities in the Learning Science Process Skills book (pp. 3-10) and evaluate them according to the above criteria. Evaluate the activities you did in section D according to these criteria.

F. Design an activity

Working in small groups (perhaps K-3, and 4-6) develop an observation activity that could be used in a science unit that is taught in your school. An activities sheet is provided for you but you may use any format.

As a group, evaluate the activity according to the criteria listed in E.

TAKE A TEN MINUTE BREAK.

CLASSIFICATION

A. Background information for the trainer.

The process of observation provides us with a wealth of information, but that information takes on meaning only when it is organized. Classification is the process skill we use when we organize information. This skill helps us make sense out of what we observe by separating and grouping information. Different classification systems have been developed to help us organize information for different purposes.

Binary classification is the most basic type of classification. We use this skill when we group objects as to whether they posess or do not posess a particular characteristic or property. As such, binary classification is used in defining concepts. For example, we use binary classification to identify objects as being magnetic or not magnetic. In doing so, we develop a working definition of the concept "magnetic." Our conceptual understanding of "magnetic" becomes based on our experiences with examples and non-examples of magnetic objects. Other examples include grouping objects into living or non-living, metal or not metal, aquatic or not aquatic. In our examples, you might note that we used a concept and its opposite ("not the concept"). In doing our binary classifications this way we include all possibilities. An object fits into either one category or the other category. Classifications like "plant" or "animal" (rather than "animal" or "not animal") get us into trouble when we deal with bacteria or viruses, organisms that do not fit into either category. The product of a binary classification is two groups.

Multistage classifications are used to identify objects within a particular set. You begin by using one characteristic of the set of objects to divide the set into two groups. In effect, you begin with a binary classification. However, each of the groups is subsequently divided into two smaller groups using other characteristics. The process is continued until each type of object is in its own category. The result of this process is a classification scheme known as a dichotomous key. A dichotomous key provides a series of two-way decision branches. These branches allow you to identify an object based on its unique characteristics.

Serial classification is commonly used when we want to later access information or objects. Serial classifications arrange data in some order or provide a ranking of data. We frequently arrange numeric information from smallest to largest. We might organize our observations in time from earliest to latest. Another way we might organize information is alphabetically. The product of a serial classification is list of objects in a particular order.

In teaching the classification process skill, the teacher usually selects the type of classification system to be created by the student. This selection should be based on the purpose of the system: a binary system for concept definition, a multistage sytem for identification, or a serial system for later access.

In a multistage classification the student will make and list observations of properties of the objects and will select the properties that will be used to generate the rules for the classification system. In binary and serial classifications, the teacher usually selects the relevant property on which the classification scheme is to be based.

In all types of classifications, it is important that the students be placing objects in the appropriate categories.

The evaluation of the success of classification activities is based on how well the students did in creating classification schemes. If they placed objects into a binary scheme, the objects should appear in the correct list. If they used a serial scheme, they should have objects in the correct order. If a multistage classification system was used, they should have a list of relevant properties, a set of workable rules, and a dichotomous key that works without ambiguities. (Ambiguities creep into schemes when non-exclusive categories are used or when unclear terms like "small" are used without quantification.)

B. Show the classification segment of the videotape.

The objective of this segment is to provide you with a description of each of the kinds of classification and examples of their use. In addition, this segment describes the subskills and information about the evaluation of the the skill. When the orange PLEASE STOP THE TAPE frame appears, press the stop on your VCR.

C. Discuss the videotape

1. Review the types of classification and purposes
   a. Binary - concepts definition - two groups
   b. Multistage - identification - dichotomous key
   c. Serial - later access - ordered list
2. Subskills of classification
   a. Determine the use of the scheme (see purposes)
   b. Determine type based on purpose
   c. Observe properties of objects (make list)
   d. Select qualities for classification
   e. Determine the rules
   f. Place objects in groups/order
3. Evaluation of classification
   a. If learners are given a set of objects for binary classification, they should create two lists indicating which objects belong to which group.

b. If learners are asked to serially classify a set of objects, they should create a list of the objects in correct order.

c. If learners are asked to classify objects in a multistage classification, they should create a dichotomous key that shows the rules used to identify each object.

D. Classification activities

In this section, the trainees will work in groups of three or four doing classification activities.

The first activity with electricity creates a binary classification of conductors. A list of conductors and a list of non-conductors should be created as a result of this activity.

The second activity begins as a series of binary classifications based on inherited characteristics. This activity is best done with a larger group of eight to ten people. After developing a variety of binary classifications, the trainees should attempt to construct a multistage classification scheme of all the trainees in the group.

E. Discuss how to design classification studies.

An ideal classification activity:

1. Provides a wide variety of objects
2. Specifies the appropriate type of classification

3. Results in the use of observations to create a classification scheme.

Discuss the classification activities in the lab book nd evaluate them according to the above criteria. Evaluate the activities you saw in the videotape according to these criteria.

F. Design an activity

Working in small groups, develop a classification activity that could be used in teaching a unit in your school.

As a group, evaluate the activity according to the criteria listed in E.

TAKE A TEN MINUTE BREAK

COMMUNICATION

A. Background information for the trainer

We usually think of communication as a language arts skill, but good communication skills are also essential in science. Scientists rely on communication during the process of verification. Scientific observations must be verifiable; that is, another person making the same observation should observe the same things which were observed by the original observer.

Scientific communications are of two types: descriptions and instructions. Descriptions are used to convey observations. For instance, a scientist discovers a new organism and then provides the scientific community with a description of the organism. Other scientists look for the organism and verify its existence when they find the discovered organism as described. Scientists also describe the behavior of what they observe, from viruses to galaxies. Instructions are directions about how to do something. Common instructions are those used by scientists when they convey the procedures they use in conducting experiments. These instructions allow other scientists to replicate the experiments and to verify the results.

Modes of scientific communications include verbal and written words, which most people use for communication on a daily basis. Scientists also use a number of special forms of communication. Maps are used to describe the location and distribution of landform features, mineral deposits, stars, or organisms. Diagrams and schematics are another mode of communication commonly used in science. Graphs and charts frequently are used to convey quantitative observations to clarify and emphasize patterns in the data. Models that are created by scientists are usually communicated as mathematical equations and formulas.

Good communication depends on the producer of the communication doing several subskills. The communicator, or "sender," should describe the observed properties of the objects; he/she should not describe objects using inferences. Because inferences cannot be directly observed, not all people will agree on the inferences about an object. For example, good communication about a rock would not include that you think it came from a volcano. Another person might look at the same rock and infer that it came from a lakebed. Communication of direct observations avoids the problems of differences in interpretation of those observations.

Good communicators also exclude extraneous information. If you were giving instructions for conducting an experiment, you would not include anecdotes about the people you worked with during the last time you did the experiment. Such irrelevant information overloads the communication process.

Although some information should be excluded, it is important that communications be complete and accurate. If incomplete or inaccurate instructions are given to someone who is trying to replicate an experiment, the results are likely to be different and may fail to verify the original findings.

Communication skills also require that precise language is used. Instead of describing a bird as "big" you would be clearer in your description by saying it was "about 50 centimeters long from the tip of the beak to the end of the tail." This example shows how quantification of observations helps make descriptions more precise.

The viewpoint of the receiver of the communication must be considered by the sender of the communicaton. The sender must use vocabulary that is familiar to the receiver. Any new terms must be defined so that the receiver will understand the message. Although technical names of objects improve the accuracy of descriptions and instructions, these terms must be understood to have the same meaning by both the sender and the receiver of the communication.

Feedback is the key to good communication. It is essential that the receiver of the communication provide the sender some means of feedback to ensure that the communication was effective. When the communication is descriptive, the feedback may take the form of the receiver identifying the described object or sketching the object observed. For example, if a sender describes a bird, the receiver might give feedback by finding a picture of the bird in a bird book. The feedback would be the pointing out of the bird in the book. If the sender was a successful communicator, then the bird would look like the one observed. For communication of instructions, the best feedback is frequently the "doing" of the activity instructed. If the instructions are good, the receiver will do what was expected. The sender will be able to judge how good the instructions were by how well the reciever performs.

Whenever possible, alternative forms of communication should be us The use of verbal and written instructions may be useful ar appropriate. Many times schematics or diagrams that accompany written words make the communication better.

B. Show the communications segment of the videotape

The objective of this segment is to provide the viewer with examples of the purposes and types of communication, the subskills, and the evaluation of the skill. When the PLEASE STOP THE TAPE frame appears press the stop button on the VCR.

C. Discuss the videotape

1. Purposes and types

    a. Purposes

        (1). Convey observations - descriptions

        (2). Provide directions - instructions

b. Types

(1). verbal

(2). written words

(3). maps or schematics

2. Subskills

a. Describe what is observed (not inferred)

b. Exclude extraneous information

c. Use precise language

d. Consider other person's viewpoint

e. Be accurate and complete

f. Provide a means for feedback

g. Provide an alternative description

3. Evaluation

a. Feedback for descriptions in form of identification. (picking out a card)

b. Feedback for instructions in form of doing the activity of the instructions.

D. Communication activities

The electricity activity involves some trainees as senders who read schematic diagrams and translate them into instructions; other trainees as receivers provide feedback by constructing electrical circuits. Clear communication will be required to establish the correct circuits.

For the fingerprint activity, the trainees will work in pairs with sets of fingerprint cards. Each set of cards will contain prints from every trainee. Time is allowed for each trainee to make enough cards so that each pair will have a coomplete set. (It may take some practice to make a good set of prints.) This activity should help develop an appreciation for the detail of the human body as well as the uniqueness of each person. Communication skills will be developed as the trainees search for descriptive terms to identify this uniqueness.

E. Discuss how to design communication activities

1. Good communication activities should provide a clear opportunity for feedback. The feedback is necessary for evaluation purposes. It is important to remember that the evaluation is of the sender and not the receiver even though both are involved in the success of the communication.
2. Descriptive activities should provide a wide variety of objects to be described. These objects should include features that overlap as well as unique features that distinquish one object from all others. The objects should require the students to develop precise, accurate, and complete objective descriptions.
3. Instructional activities should provide an appropriate level of complexity as well as clear results that show the difference between good instructions and poor instructions.

4. Ideally, a communications activity will provide the learners with an opportunity to diagnose what errors are caused by poor communication and how that communication can be improved.

Discuss communication activity 2 on page 28 of the workbook. Evaluate this activity and the ones you have been doing using the above criteria.

F. Design an activity

In small groups, develop a science communication activity that can be used in a science unit taught in your school. As a large group, evaluate the activity using the above criteria.

TAKE A BREAK.

PREDICTION

A. Background information for the trainer.

For many people, the most important role of science in their lives is to provide them with a basis for predicting what will happen to them and around them. Much of the predictability of nature is taken for granted. As we are driving a car, we predict that depressing the brake pedal will slow the car. We probably don't think about the concept of friction as we stop for a red light, but the predictable nature of friction is a prerequisite for us to put our bodies in machines that move at speeds of 25 meters per second.

Scientists use predictions to verify their understanding of regularities in nature. Predicting is the forecasting of future observations. It is done by scientists to see if their ideas on how the natural world behaves are correct. Scientists develop ideas about how the natural world works by making observations and looking for patterns in what they observe. The patterns are used to develop explanations (inferences) of why something happened. The explanations are supported by the making and testing of predictions which are based on the patterns in the observations. If predictions are tested and found to be accurate, then the scientists have evidence which supports their explanations. The development of scienctific explanations about occurances in the natural world are thus confirmed and refined by using the skill of prediction.

Prediction is important for children. Children must learn that there are predictable results when a set of actions is executed. Otherwise, they develop a sense of ineffectiveness in controlling their destiny. Coming to an understanding that actions have consequences is essential in the development of the responsible individual. Such an understanding must be based on a conceptual framework of cause-and-effect relationships. Prediction activites in science can foster the development of that conceptual framework. By observing and successfully predicting the regularity of the natural world, children learn that they indeed influence outcomes. By changing the length of string on a swinging washer, children realize that their actions influence the behavior of the swing. Further guidance in the activity allows the child to become a successful predictor of the outcome of other changes.

The process followed in prediction activities is a mirror of that followed by scientists. First, data is collected by making observations. Frequently, these observations are quantitative but that is not always true. The data is then organized to see if there are any patterns. Usually the data is organized by using a serial classification by time, location, or magnitude. Graphs are often used to expose patterns in the data. If patterns are found in the data, then inferences are made to suggest what relationships might exist. These relationships may be expressed in words and then converted to a mathematical form, equations that express the relationships. The expressed relationship is then used to make a prediction of a future event that has not been observed. The prediction is tested when that event is eventually observed. The success of the prediction is measured by whether or not the prediction matches the observation that is eventually made.

B. **Show the prediction segment of the videotape.**

The objective of this segment of the tape is to provide examples of prediction activities and to define the skill, demonstrate the subskills, and provide a way to evaluate the skill. When the orange PLEASE STOP THE TAPE frame appears, press stop on the VCR.

C. **Discuss the videotape.**

1. Prediction defined
    a. A forecast of a future observation
    b. Based on patterns in observed data
2. Subskills
    a. Make observations to collect data
    b. Classify the data and search for patterns in it
    c. Infer a relationship to explain the pattern
    d. Make a **testable** prediction
    e. Test the prediction (make the future observation)

3. Evaluation

   a. Examine the list of observations made (data)

   b. Examine the alleged pattern for its existence in the data

   c. Evaluate the prediction by examining its basis in the alleged pattern

   d. Compare the prediction to the results of testing it

D. Prediction activities

The first activity is to be done in small groups and begins with the building of open, closed, and short circuits. The purpose of this part of the activity is to establish the pattern of how electrical circuits work. The trainees then make predictions about what lights will light in other circuits for which they have been provided the schematics. They then test the predictions by building the circuits.

The second activity should be done with a group of 8-12 people. The trainees are testing the inference that there is a relationship between the resting pulse and the pulse after moderate exercise. After the predictions have been tested, the trainees might try to see if other factors (like age) serve as predictors of the after-exercise pulse rate.

E. Discuss how to design prediction activities.

1. Just as observation activities always include lists and communication activities always include

feedback, prediction activities must include a way to establish a pattern. Instructions should lead students to collect data that shows a pattern.

2. The activity should help the student organize the observations so that patterns are revealed. Data sheets in the form of charts and graphs help the student realize the value of organizing the information to find the pattern.
3. A good activity leads the student to make a testable observation.
4. The prediction should be tested and an oportunity should be provided to compare the test results to the prediction.

Discuss prediction activity 4 on pages 62-64 in the workbook and evaluate it using the criteria given above. Evaluate the activities you did in section D according to these criteria.

F. Design an activity

Working in small groups, develop a prediction activity that could be used in teaching a unit in your school.

As a group, evaluate the activity according to the criteria listed in E.

TAKE A TEN MINUTE BREAK

INFERENCE

A. Background information for the trainer.

Scientific curiosity leads us to ask questions about objects and events. The answers to many of these questions cannot be observed, directly. We might observe something and ask, Why did it behave that way? What caused it to look like that? What happened in the past to make it come out this way? The answers to "why" questions and questions of "what happened in the past" cannot be directly observed. To answer these questions, we rely on the inference process skill.

Inferences are explanations or interpretations of observations that are supported by evidence. Inferences begin with the observation of an effect and express a believed cause for that effect. The believed cause comes from the inferrer's knowledge base acquired from prior experiences and observations. As such, inferences work in the opposite direction as predictions. When we predict, we rely on an assumed cause and state an effect of that cause. When we make an inference, we examine an effect and try to state the causal agent of that effect.

The process of inferring begins with the accumulation of observations which form a knowledge base upon which to express believed causes for observed effects. One of the reasons that very young children are poor inferrers is that they have not had enough experience to have accumulated the observation knowledge base for making good inferences. Children who are developing their inference skills, must have had the prerequisite experience upon which to base their inferences. It would be more appropriate to have young children make inferences about wind on the playground, for instance, than about mountain building.

After making observations, the observer asks a "why" or "what causes" question about something observed. Perhaps a certain part of the playground is observed to be very windy. The appropriate question might be, Why is this part of the playground windier than other parts?

Next, the observer searches his/her experiences for previous encounters with similar encounters. Our windy playground observer may remember that it always seem windier in alleyways between buildings.

Using information from previous encounters, the observer proposes an answer to the question regarding the causal agent. The wind observer proposes that the wind is faster on that part of the playground because the wind is being channeled to that part of the playground by the school building and other buildings.

The proposal is tested for logical consistency. The observer looks around to see if the buildings would channel the wind to where it is windiest. Realizing that the wind is blowing from the wrong direction for this to be true leads the observer to reject this inference.

More observations are made. The speed of the wind is measured at other places in the school yard and a map is made showing wind speed at selected locations. By looking at the map, it appears that the windiest place on the playground is the highest place on the playground.

The proposed cause for windiness is revised: wind speed is greater at higher altitudes so the windiest place is the highest place. This revised cause is logically tested. Support for this cause may be accumulated by making measurements of wind at a variety of altitudes. The measured increase of wind speed with altitude helps support the idea that the windiest place is windy because it is the highest place.

The best explanation is selected. We tentatively accept the idea that the windiest place on the playground is windy because it is the highest place on the playground. We accept this tentatively because we may find evidence that argues against this explanation. For example, if we found a very high wind speed in a low place we would have to make further observations and perhaps revise our explanation.

It is important to keep in mind that inferences are tentative. They are a "best guess" of what is happening or has happened, but they are limited by the known information on which they are based. The discovery of new information (sometimes as the result of new technologies) can force us to change our explanations of why things do what they do. Medicine is one area where inference is used widely. The patient describes a symptom to the doctor and the doctor, using memory of past experience (direct and indirect), infers what is causing the symptom. The results of further lab tests may cause the doctor to revise her/his understanding of the cause. It is essential that the tentativeness of the inference be kept in mind.

B. Show the inference segment of the videotape.

The objective of this segment is to define inference, examine the inference subskills, and introduce how to design and evaluate inference activities. When the PLEASE STOP THE TAPE frame appears, press the stop button on the VCR.

C. Discuss the videotape

1. Characteristics of inferences
   a. Inferences provide a way to propose and examine causes of what we observe.
   b. Inferences explain or interpret observations.
   c. Inferences are supported by observations.
   d. We observe effects and infer their cause.
2. Subskills
   a. Make observation and ask "why" question
   b. Search memory for previous encounters with similar experiences
   c. Propose causal agent
   d. Test for logical consistency with other known information
   e. Make further observations

f. Propose and test alternative causes

g. Select best explanation

3. Evaluation

a. Students should list observations

b. Students should list inferences

c. Students should identify which observations support their inferences

D. Inference activities

The electricity activity is the one described in the videotape using the sealed circuit boards. Trainees should work in small groups to answer the question, How are these circuits constructed? The results of all of the small groups should be compared on the blackboard to see what circuit boards do or do not produce consensus on how they are "wired."

The second activity begins with an observation concerning the air you exhale and asks, Why does it behave this way? You may want to devise and make other observations to support your answer to the question. The observation should be made in small groups and the discussion carried out within the larger group.

E. Discussion of how to design inference activites.

A good inference activity should:

1. Require a list of observations

2. Ask a clear question ("Why" or "what causes" questions would be most appropriate. If you are

asking "what will happen" questions, you are designing a prediction activity.)

3. Allow for several possible inferences to show that inferences are not the same as observations.
4. Reveal additional information to allow revision of the inference. This would help point out the tentative nature of the inference.
5. Require that inferences be supported by observations.

Discuss inference activity 2 on page 74 and evaluate it using the above criteria. Also evaluate the unknown gasses activity on page 81.

F. Designing inference activities.

In small groups, develop a science inference activity that could be used in your school. As a large group, evaluate that activity using the above criteria.

TAKE A BREAK

MEASUREMENT

A. Background information for the trainer

Measurement should be taught as a part of doing science, not as a separate skill. Measurement is a skill that we do to improve the precision of our observations. Measurement skills are used in all of the other process skills when we quantify our observations.

This is not to say that measurement is unimportant. On the contrary, measurement is essential to making the kinds of observations that allow scientists to find patterns in our natural world. Without measurements, science would make little progress. However, the teaching of measurement skills should be done within the context of making observations. The proper use of a measurement tool should be taught when purposeful use of the tool is needed. For example, the proper way to use a balance should be taught when there is a need for measuring weight. Measurement activities that are done within the context of doing science reinforce that measurement is an integral skill of science, not an end unto itself.

Becoming a good measurer is based on several subskills. First, the appropriate type of measurement must be selected. If you wanted to show how a grape changes as it dries out you should measure its mass and volume; you might measure its length; but you would not measure its temperature.

Secondly, the appropriate tool for making the measurement should be selected. Do not use a meterstick to measure the weight of a piece of gum or the length of a fly's leg.

Thirdly, the measurement must be conducted using the procedure appropriate for the tool. Since there are many measuring tools we will not explain how to use each type. There are several sources, including other videotapes, that show how to use specific types of measuring tools.

Finally, like any observation activity, the observation must be recorded. The record should be made in the most appropriate units.

B. Show the measurement segment of the videotape

The objective of this segment of the tape is to show that measuring is an integral part of all of the process skills and that it is a special type of observation.

C. Discuss the videotape

1. Measurement
    a. Purpose is to precisely quantify observations
    b. Types
        (1) Linear
        (2) Mass (weight)
        (3) Volume
        (4) Temperature

2. Subskills

    a. Determine type of measurement

    b. Select appropriate measuring tools

    c. Conduct measurement

    d. Record results in appropriate units

3. Evaluation

    a. Evaluate the selection of the type of measurement and tool used

    b. Evaluate the record made

THERE ARE NO ACTIVITES WITH THIS SECTION . AFTER YOUR DISCUSSION, VIEW THE REMAINDER OF THE VIDEOTAPE.

APPENDIX A - 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.

<u>Before Electroplating</u>:

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.

<u>During Electroplating</u>:

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.

<u>After Electroplating</u>:

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

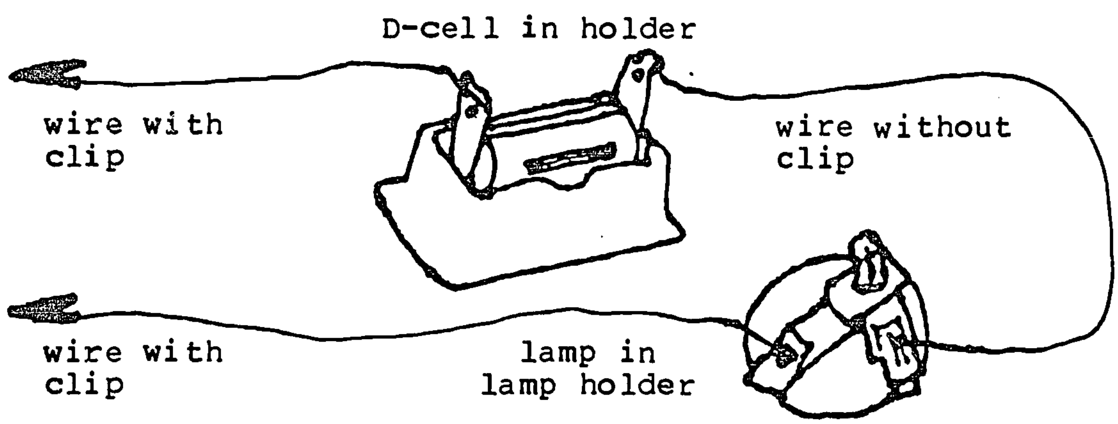
In this activity you will construct a **binary classification system.** To construct a binary classification system you must first identify a property possessed by some but not all of the objects within a particular set. The property for binary classification we will use in this activity is **electrical 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:

<u>Conductors</u> <u>Nonconductors</u>

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

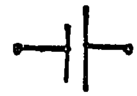
3. The sender describes the circuit for the receiver to construct. The receiver **cannot** ask for any clarification or additional information.

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

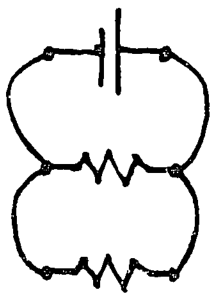
KEY

Battery in holder 

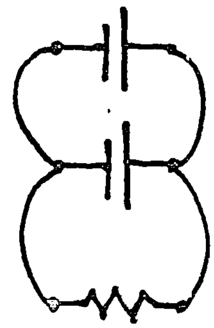
Bulb in holder 

Wire

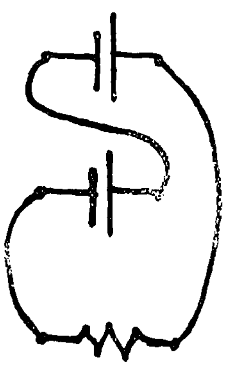
A.



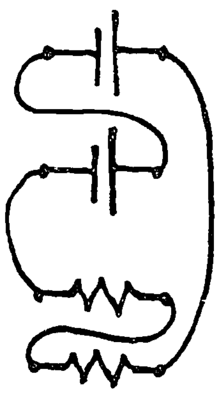
B.



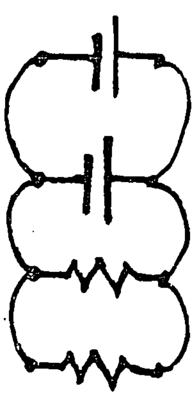
C.



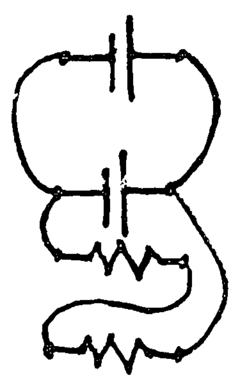
D.



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

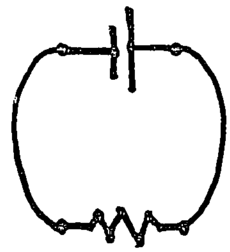
Procedures:

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..

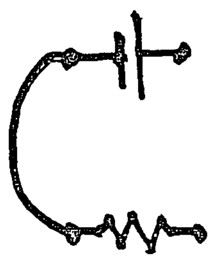
PREDICTION CIRCUITS

Construct the following circuits and note which bulbs light.

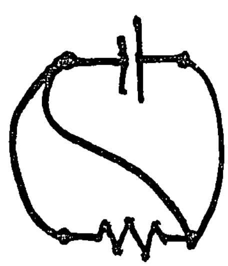
CLOSED

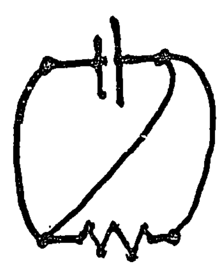


OPEN



SHORT

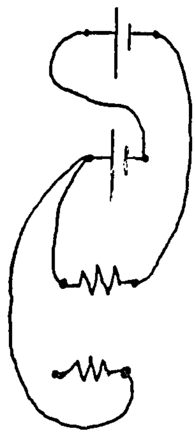




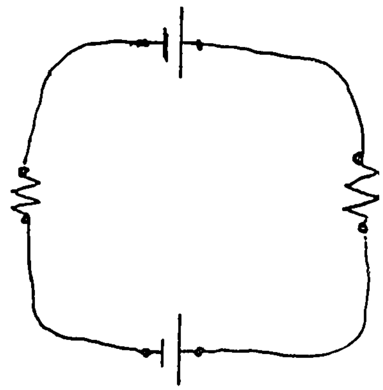
PREDICTION CIRCUITS

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.

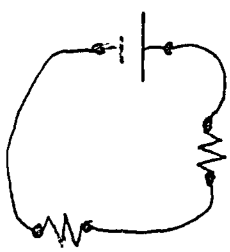
A.



B.

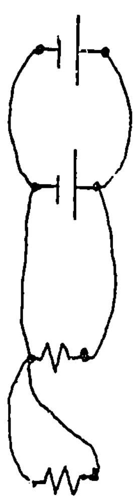


C.

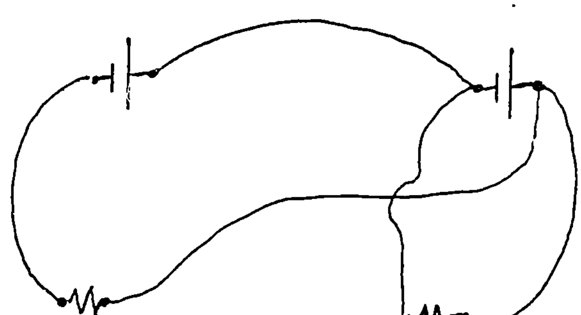


D.

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.

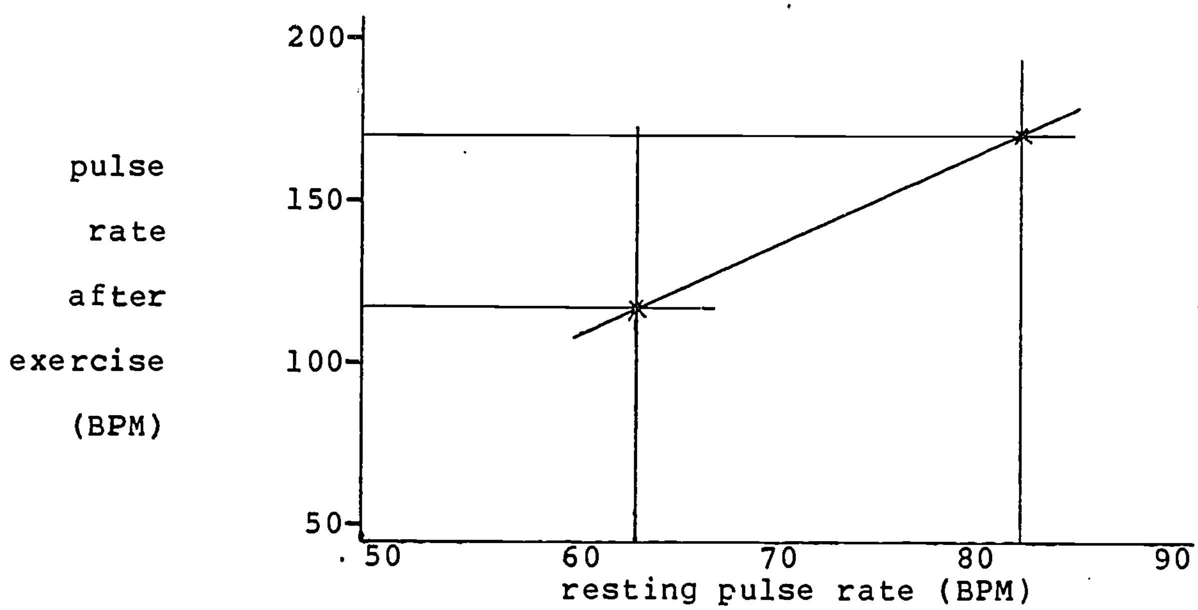
Materials:

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.

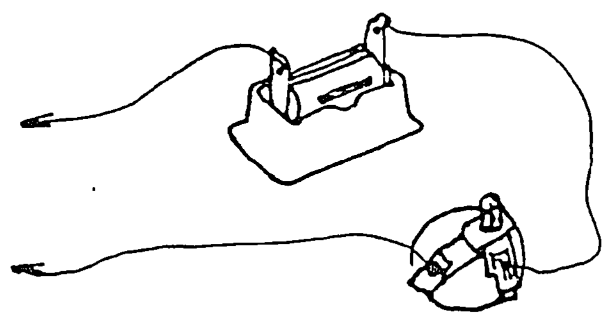
Objective: To discover that an inference may need revision and that several different inferences may be equally reasonable.

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.

APPENDIX B - HANDOUTS FOR TRAINEES

BASIC SCIENCE PROCESS SKILLS AND SUBSKILLS

I. OBSERVATION
   A. Types
      1. Qualitative - use the 5 senses
      2. Quantitative - requires measurement
   B. Subskills.
      1. Determine what senses will be most appropriate.
      2. Observe the qualities of the object/event.
      3. Record the observations.
      4. Determine what observations can be quantified.
      5. Make appropriate measurements.
      6. Record the measurements.
      7. Note whether or not change was occurring and what the observations were before and after the period of change.

II. CLASSIFICATION
   A. Types of classification are related to their use
      a. Binary classification - concept definition
         - produce two groups
      b. Multistage classification - identification
      c. Serial - access
         - ranking
   B. Subskills
      1. Determine use of classification system
      2. Determine type of classification system
      3. Observe properties for use in classification
      4. Select qualities for classifying objects
      5. Determine rules
      6. Place objects in groups/order

III. COMMUNICATION
   A. Purpose and type
      1. Purposes
         a. Convey observations (descriptions)
         b. Provide directions
      2. Types
         a. verbal
         b. written
         c. maps/schematics

   B. Subskills.
      1. Describe what is observed (not inferred)
      2. Exclude extraneous information
      3. Use precise language
      4. Consider other persons viewpoint
      5. Be accurate and complete
      6. Provide a means for feedback
      7. Provide an alternative description

IV. PREDICTION

A. Prediction defined

Prediction is a forecast of a future observation based on patterns of past observations. It requires skills of observation, classification, and inference.

B. Subskills

1. Collect data (observe)
2. Search for a pattern (classify)
3. Propose a relationship (infer)
4. Make testable prediction
5. Test prediciton

V. INFERENCE

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.

B. Subskills

1. Make observation
2. Search memory for previous encounters with similar experiences
3. Propose causal agent
4. Test for logical consistency
5. Make further observations
6. Propose and test alternative causes
7. Select best explanation.

VI. MEASUREMENT

A. Purpose and types

1. Purpose of measurement is to precisely quantify our quantitative observations.
2. Common types of measurement
   a. linear
   b. mass
   c. volume
   d. temperature

B. Subskills

1. Determine type of measurement
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:

<u>What the teacher does</u> <u>What the student does</u>

Materials:

Time required:

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