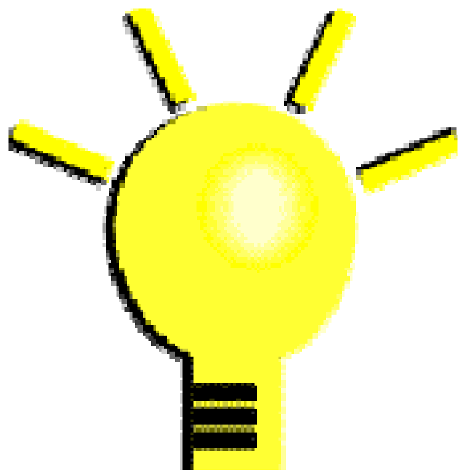
Bridgeport Public Schools
Science Department

Embedded Performance Task



Go With The Flow

Teacher Manual

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OVERVIEW OF THE ELEMENTARY AND MIDDLE SCHOOL CURRICULUM-EMBEDDED PERFORMANCE TASK MODEL

The Connecticut State Board of Education approved the Core Science Curriculum Framework in October of 2004. The framework promotes a balanced approach to PK-12 science education that develops student understanding of science content and investigative processes.

WHAT IS A CURRICULUM-EMBEDDED PERFORMANCE TASK?

Curriculum-embedded performance tasks are examples of teaching and learning activities that engage students in using inquiry process skills to deepen their understanding of concepts described in the science framework. Developed by teachers working with the Connecticut State Department of Education, the performance tasks are intended to influence a constructivist approach to teaching and learning science throughout the school year. They will also provide a context for CMT questions assessing students' ability to do scientific inquiry.

The three elementary performance tasks are conceptually related to Content Standards in Grades 3 to 5 and the three middle school performance tasks are related to Content Standards in Grades 6 to 8. The elementary performance tasks provide opportunities for students to use the Inquiry Expected Performances for Grades 3 to 5 (see Science Framework B.INQ 1-10 skills) to understand science concepts. The middle school performance tasks provide opportunities for students to use the Inquiry Expected Performances for Grades 6 to 8 (see Science Framework C.INQ 1-10 skills) to understand science concepts.

Teachers are encouraged to use the state-developed curriculum-embedded performance tasks in conjunction with numerous other learning activities that incorporate similar inquiry process skills to deepen understanding of science concepts. Students who regularly practice and receive feedback on problem-solving and critical thinking skills will steadily gain proficiency.

HOW ARE THE PERFORMANCE TASKS STRUCTURED?

Each performance task includes two investigations; one that provides some structure and direction for students, and a second that allows students more opportunity to operate independently. The goal is to gradually increase students' independent questioning, planning and data analysis skills. The elementary performance tasks introduce students to understanding and conducting "fair tests". The middle school performance tasks focus on designing investigations that test cause/effect relationships by manipulating variables.

Mathematics provides a useful "language" for quantifying scientific observations, displaying data and analyzing findings. Each curriculum-embedded performance task offers opportunities for students to apply mathematics processes such as measuring, weighing, averaging or graphing, to answer scientific questions.

Not all science knowledge can be derived from the performance of a hands-on task. Therefore, each curriculum-embedded task gives students opportunities to expand their understanding of concepts through reading, writing, speaking and listening components. These elements foster student collaboration, classroom discourse, and the establishment of a science learning community.

A useful structure for inquiry-based learning units follows a **LEARNING CYCLE** model. One such model, the “5-E Model”, engages students in experiences that allow them to observe, question and make tentative explanations before formal instruction and terminology is introduced. Generally, there are five stages in an inquiry learning unit:

- **Engagement:** stimulate students’ interest, curiosity and preconceptions;
- **Exploration**: first-hand experiences with concepts without direct instruction;
- **Explanation:** students’ explanations followed by introduction of formal terms and clarifications;
- **Elaboration:** applying knowledge to solve a problem. Students frequently develop and complete their own well-designed investigations;
- **Evaluation:** students and teachers reflect on change in conceptual understanding and identify ideas still “under development”.

The performance tasks follow the “5-E” learning cycle described above. However, the teacher can decide the role the performance task will play within the larger context of the entire learning unit. Early in a learning unit, the performance task can be used for engagement and exploration; later in a learning unit, the performance task might be used as a formative assessment of specific skills.

HOW ARE PERFORMANCE TASKS USED WITH YOUR CLASS?

Curriculum-embedded performance tasks are designed to be used as part of a learning unit related to a Framework Content Standard. For example, while teaching a unit about human body systems (Content Standard 7.2,) the teacher decides the appropriate time to incorporate the “Feel The Beat” performance task to investigate factors affecting pulse rate. In this way, the natural flow of the planned curriculum is not disrupted by the sudden introduction of an activity sequence unrelated to what students are studying.

The performance tasks are NOT intended to be administered as summative tests. Students are not expected to be able to complete all components of the tasks independently. Teachers play an important role in providing guidance and feedback as students work toward a greater level of independence. Performance tasks provide many opportunities for “teachable moments” during which teachers can provide lessons on the skills necessary for students to proceed independently.

There is no single “correct” answer for any of the performance tasks. Students’ conclusions, however, should be logical, or “valid” interpretations of data collected in a systematic, or “reliable” way. Variations in students’ procedures, data and conclusions provide opportunities for fruitful class discussions about designing “fair tests” and controlling variables. In the scientific community, scientists present their methods, findings and conclusions to their peers for critical review. Similarly, in the science classroom, students’ critical thinking skills are developed when they participate in a learning community in which students critique their own work and the work of their peers.

Performance tasks should be *differentiated* to accommodate students’ learning needs and prior experiences. The main goal is to give all students opportunities to become curious, pose questions, collect and analyze data, and communicate conclusions. For different learners, these same actions will require different levels of “scaffolding” as they move toward greater levels of independence.

For example, if students have had experiences creating their own data tables, the teacher may decide to delete part or all of the data table included in the performance task. Other possible adjustments include (but are not limited to):

- Text readability;
- Allowing students to control all or some of the variables;
- Whether the experimental procedure is provided or student-created;
- Graph labels and scales provided or student-created;
- Expectations for communication of results; or
- Opportunities for student-initiated follow-up investigations.

There are many science investigations that are currently used in schools that provide inquiry learning opportunities similar to those illustrated in the performance tasks. Students need a variety of classroom experiences to deepen their understanding of a science concept and to become proficient in using scientific processes, analysis and communication. **Teachers are encouraged to use the state-developed curriculum-embedded performance tasks in conjunction with numerous other learning activities that incorporate similar inquiry processes and critical thinking skills.**

HOW ARE THE PERFORMANCE TASKS RELATED TO THE CMT?

The new Science CMT for Grades 5 and 8 will assess students' understanding of inquiry and the nature of science through questions framed within the CONTEXT of the curriculum-embedded performance tasks. Students are not expected to recall the SPECIFIC DETAILS OR THE "RIGHT" ANSWER to any performance task. The questions, similar to the examples shown below, will assess students' general understandings of scientific observations, investigable questions, designing "fair tests", making evidence-based conclusions and judging experimental quality.

Here is an example of the type of multiple-choice question that might appear on the Grade 5 Science CMT. The question is related to the "Soggy Paper" performance task:

Some students did an experiment to find out which type of paper holds the most water. They followed these steps:

1. Fill a container with 25 milliliters of water.
2. Dip pieces of paper towel into the water until all the water is absorbed.
3. Count how many pieces of paper towel were used to absorb all the water.
4. Repeat with tissues and napkins.

If another group of students wanted to repeat this experiment, which information would be most important for them to know?

a. The size of the water container
b. The size of the paper pieces *
c. When the experiment was done
d. How many students were in the group

Here is an example of the type of constructed-response question that might appear on the Grade 8 Science CMT. The question is related to the "Feel The Beat" performance task:

Imagine that you want to do a pulse rate experiment to enter in the school science fair. You've decided to investigate whether listening to different kinds of music affects people's pulse rate.

Write a step-by-step procedure you could use to collect reliable data related to your question. Include enough detail so that someone else could conduct the same experiment and get similar results.

NOTE THAT THE CMT QUESTIONS DO NOT ASSESS A CORRECT "OUTCOME" OF A PERFORMANCE TASK OR STUDENTS' RECOLLECTION OF THE DETAILS OF THE PERFORMANCE TASK. Students who have had numerous opportunities to make observations, design experiments, collect data and form evidence-based conclusions are likely to be able to answer the task-related CMT questions correctly, even if they have not done the state-developed performance tasks. However, familiarity with the context referred to in the test question may make it easier for students to answer the question correctly.

INTRODUCTION TO "GO WITH THE FLOW"

In this performance task, students will explore ways that wires, batteries and a bulb can be arranged so that electricity will flow and light the bulb. Once they have discovered the concept of a circuit, they design and build a test circuit that can be used to find out which materials conduct electricity and which do not.

SAFETY NOTES:

- Use 1.5v batteries only; batteries with higher voltage cause wires to get too hot.
- DO NOT use rechargeable batteries (there have been reports of very hot wires when these batteries are short-circuited).
- Monitor students to be sure that wires are not inserted into wall outlets.
- Review expectations for appropriate behavior, handling of materials and cooperative group procedures prior to beginning this investigation.
- For more comprehensive information on science safety, consult the following guidelines from the American Chemical Society - http://membership.acs.org/c/ccs/pubs/K-6_art_2.pdf and the Council of State Science Supervisors - http://www.csss-science.org/downloads/scisaf_cal.pdf

FRAMEWORK CONTENT STANDARD(S): Go With The Flow relates conceptually to the following learning unit:

4.4 - Electrical and magnetic energy can be transferred and transformed.

- ♦ **Electricity in circuits can be transformed into light, heat, sound and magnetic effects.**

This learning unit is an informal introduction to ideas related to energy. As described in Project 2061 Benchmarks for Science Literacy, "At the simplest level, children can think of energy as something needed to make things go, run, or happen." During learning unit 4.4, students can see, feel and hear the results of static electricity, current electricity and magnetism.

UNDERLYING SCIENCE CONCEPTS (KEY IDEAS):

- An electric charge can be made to move in a current.
- An electric circuit allows the flow of electricity from an energy source through a closed loop back to the energy source. The closed loop is called a "complete circuit" or a "closed circuit".
- In a series electric circuit, only one path is available for the electrons to flow through.
- When any part of a series circuit is disconnected, no current can flow through the circuit. This is called an "incomplete circuit" or an "open circuit."

- Materials that allow electricity to move through them easily are called “conductors”.
- Metals are generally good electrical conductors; some metals are better conductors than others.
- Materials that do not allow electricity to move through them easily are called “insulators”.
- Insulators are used to prevent electricity from flowing where it is not wanted.

KEY INQUIRY SKILLS:

- Make scientific observations and recognize the difference between an observation and an opinion, a belief, a fact or a name.
- Make predictions based on preliminary observations and exploration.
- Make inferences based on evidence.
- Record data in an organized way.
- Use oral and written language to describe observations, ideas, procedures and conclusions.

MATERIALS NEEDED: Listed below are all the materials needed to complete the two experiments in Go With The Flow. Some materials are supplied in starter kits provided by the Connecticut State Department of Education. These materials are marked with an asterisk (*). The remaining materials are supplied by the school district:

For each group:

- AA, AAA, C or D-cells. At least 2 cells per group. (You may want to have different groups experiment with different size cells to discover any differences among them. Have additional batteries available to allow some groups to investigate the effects of adding more batteries to the circuit.)
- Battery holder *
- 1 bulb socket *
- 1 bulb *
- Plastic-coated bell wire (about 30 cm) *
- Assorted classroom objects (paper clips, rulers, erasers, paper, plastic, etc.).
- Chart paper, markers and scissors.

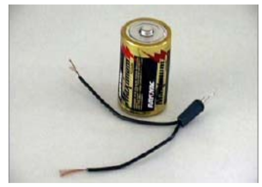
For each student:

- Magnifier, science notebook

ADVANCE PREPARATION FOR THE TEACHER:

1. Carefully read through all teacher and student materials. Modify the Student Materials based on the needs of your students. Then print and photocopy Student Materials.

2. Cut a piece of wire about 30 cm in length for each lab group. Strip away 2 cm of the plastic coating from both ends of the wire. Students or parent volunteers can be helpful in doing the advance cutting. An inexpensive wire stripper, purchased from a local hardware store, can be useful for this task.
3. Additional lab groups or science classrooms can conduct circuit experiments by cutting up strings of miniature holiday lights. This eliminates the need for additional bulbs, bulb holders and battery holders. Wrap a thick rubber band around the ends of the battery to hold the wires in contact with the terminals.



MATERIALS DISTRIBUTION:

Get students involved in distributing and returning materials. This saves time for the teacher and also teaches students collaborative skills and self-reliance. One way to distribute materials is through a "cafeteria style" distribution center. All materials are laid out on a table or counter, and each group sends a representative to pick up the required materials. Trays or plastic shoeboxes work well for transporting materials from the center to the lab groups.

ESTIMATED COMPLETION TIME AND PACING SUGGESTIONS: (45-60 minute blocks)

Day 1: Experiment #1 – Steps 1 and 2: Observation and circuit exploration

Day 2: Experiment #1 – Step 3: Group analysis and diagram preparation

Day 3: Experiment #1 – Steps 4 and 5: whole class debriefing; Step 6: expository journal writing during Language Arts block (or on Day 4)

Day 4: Experiment #2 – Steps 1-4: Observation, prediction, planning

Day 5: Experiment #2 – Steps 5 and 6: Data collection

Day 6: Experiment #2 – Data analysis and discussion

Day 7/8: Communicate Your Learning – letter writing

PEDAGOGY: Consult the teacher notes accompanying each step of the performance task for suggestions related to classroom implementation, differentiation, assessment and extension strategies. The ▲ symbol is used to indicate a differentiation opportunity. Each Teacher Note is followed by a reference to the Framework inquiry skill featured in that task component. For example, the notation "**B INQ.3"** indicates an inquiry skill related to designing or conducting a simple investigation.

Go With The Flow

A Guided Exploration of the Properties of Electric Circuits

ENGAGE

During a thunderstorm you may have seen a bright flash of lightening streak across the sky. Lightening is electricity that is easy to see. Right now there is electricity around you that can't be seen. Even though you can't see it, you know it is there because it's making things work. How many things can you find?

Teacher notes: Lead a class discussion to identify different uses of electricity. Students may note things such as the room lights, the clock, the computers, the calculators (batteries provide electricity), etc.

EXPLORE

In this activity, you and your partners will explore how electricity works to light a bulb.

To Get Ready:

Gather the following materials:

Batteries	Bulb holders
Wires	Assorted classroom objects (paper clips, erasers, rulers, etc.)
Battery holders	Magnifier
Flashlight bulbs	Scissors

Experiment #1: Different Ways To Light A Bulb

1. OBSERVE the wire, the battery and the bulb. Use the magnifier to get a closer look at the inside of the bulb. In your science notebook, DRAW a detailed diagram of the wire, the battery and the bulb, and label the parts you have observed.

Teacher notes: Have students set up an observation table in their science notebook, with 2 columns labeled "I Notice" and "I Wonder". Students should observe properties of the battery, such as the different appearance of the terminal ends and the different materials used in the wires, the bulb and the battery. **B INQ.1**

2. Work with your partners to make the bulb light. See how many ways you can arrange the wire, battery and bulb to make the bulb light. In your science notebook, DRAW a diagram of <u>each</u> arrangement of battery, wire and bulb you try. Record next to each diagram whether or not the bulb lit.

Teacher notes: ▲ Encourage students to try several different arrangements to get the bulb to light. If students need prompting, suggest that they try touching different parts of the wire to different parts of the battery and the bulb. Groups that are "stuck" should be encouraged to visit other groups to get ideas. Groups that light the bulb quickly should be challenged to find a variety of other arrangements that also work. **B INQ.4**

3. Make a break in your circuit so you can easily "switch" the light on and off.

Teacher notes: A simple switch can be made by cutting the wire and twisting the bare wire ends together. Students can use their scissors to cut and strip wire. Ask the children, "How were you able to make the light turn on and off?" and "What happened to the electricity coming from the battery when you disconnected the wires?" **B INQ.4**

4. TALK with your partners about what you have discovered about how to light a bulb. Look at all your "bulb lit" diagrams. In what ways were they similar? Look at all your "bulb not lit" diagrams. In what ways were they similar?

Teacher notes: **B INQ.5**

EXPLAIN

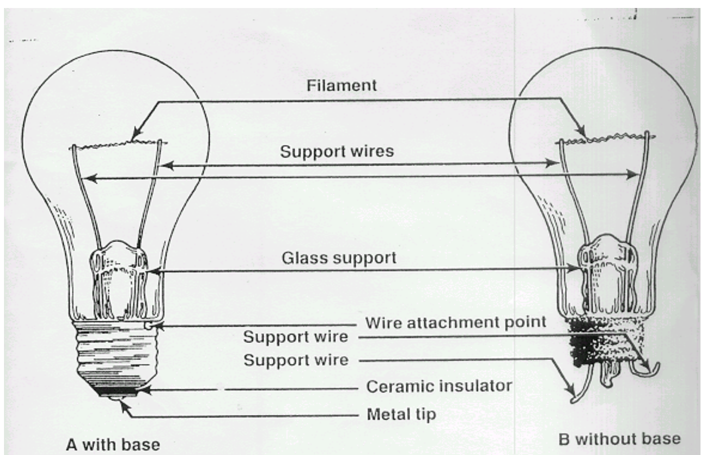
5. SHARE your ideas with the class. Using 2 pieces of chart paper, draw 1 diagram that shows a way you got the bulb to light, and another diagram that shows a way the bulb did NOT light. Show the exact position of the battery, the wire, and the bulb. Then use arrows to label the path you think the electricity is moving.

Teacher notes: Once all groups have completed their "lit" and "not lit" diagrams, collect all the "bulb lit" charts and hang them together in the front of the room. Ask each group to describe their "complete circuit". Casually begin to use the terms "complete circuit" (or "closed circuit") and "incomplete circuit" (or "open circuit") as you ask the students to talk about their diagrams. The terms can be used interchangeably. As students describe their diagrams, they will find the terminology useful and will begin to use the science words quite naturally. **B INQ.6**

The teacher lists on the board all the "things that were the same." Some examples that children may come up with are: "You always had to touch one wire to the bottom of the battery." Or "You always had to touch one wire to the top of the battery." or "You always had to touch both ends of the battery with the wires." or "You couldn't get it to light *by touching the bulb to the curvy part of the battery." etc. As a result of sharing diagrams, students should recognize that there are several ways to construct a complete circuit; in all of them, the electricity leaves the battery at the "positive" terminal, travels through the wire inside the bulb, and returns to the battery at the "negative" terminal.*

Once all groups have described their circuit diagrams, ask the class to identify "what was always the same" when the light bulbs lit. Then ask each group to describe their "not lit" diagram, and lead a class discussion about what was always the same when the bulbs did not light. Note students' ideas about the direction of the electricity's flow. You may want to have students come to the front of the room and support their ideas with evidence using a light bulb and battery.

Students will be able to observe the complete circuit path if they can see where the electricity goes when it is inside the bulb. If you prefer not to remove the base of the bulb, you can use a diagram similar to the one below:



6. What have you discovered about electric circuits? Write your conclusions in your science notebook.

Teacher notes: A language arts connection would be completing a comparison organizer (matrix, venn diagram, T-Chart, etc.) to show the similarities and differences between the two types of circuits. Some possible writing prompts are as follows:

- *Explain how the two types of circuits are similar and/or different*
- *Write the procedure explaining how to build each type of circuit*
- *Explain how electricity flows through a circuit*

Students should use the appropriate scientific vocabulary in their written responses. **B INQ.7**

INVESTIGATING FURTHER

In Experiment #1, you made electricity pass through wires. In this experiment, you will test different materials to find out which ones let electricity pass through them.

Experiment #2: Which Materials Conduct Electricity?

1. OBSERVE the wires. In your science notebook, LIST some properties of the wire materials.

Teacher notes: Ask students to theorize about which part of the wire the electricity moves through and which part it does not move through. **B INQ.1**

2. COLLECT objects from home, the classroom or your backpack that are made of different materials. You will test these objects to see if they allow electricity to flow through your circuit.

Teacher notes: Encourage students to gather objects that they think will and will not complete the circuit. The classroom usually provides many materials that students can test: chalk, paper clips, wooden rulers, plastic rulers, coins, pens, pencils, etc. Pencils can be especially interesting if students test the different components (e.g., eraser, metal band, lead). **B INQ.1**

3. Place the objects you will test on your work table. THINK about the materials from which they are made. PREDICT which ones you think will let electricity pass through them and which ones will not. SORT them into separate piles.

Teacher notes: ▲ Depending on the materials your students choose to test, some of them may be better conductors than others. This may mean that some will light the bulb brightly, while others will light the bulb dimly or not at all. Students may want to sort their materials into 3 piles to reflect these options. **B INQ.1**

4. THINK of an organized way to keep track of your test objects, your predictions and your findings in your science notebook. This is called a "**data table**". You will "**record**" the results of your experiment in your data table.

Teacher notes: ▲ *Have students record their observations in an organized table, similar to the one shown here. If your students are experienced at using observation tables, they may want to design their own table. If so, delete the table shown here and encourage students to design their own data table.* **B INQ.4**

MATERIAL	**PREDICTION**	**ACTUAL** **(bright, dim, no light)**

5. DESIGN and build an electric circuit that you can use to TEST your predictions. DRAW a diagram of your tester circuit in your science notebook. WRITE a description of how you will use it to find out which materials let electricity pass through them and which do not.

Teacher notes: Review the closed circuit diagrams from Experiment #1. Remind students how they made a break in their circuits to switch the light on and off. Encourage students to figure out how to insert test materials within the circuit so their conductivity can be tested. If some students are having difficult building their tester circuit, the teacher may have other groups share their designs or model how to build the tester circuit. **B INQ.3**

6. TEST the objects you've collected and record your findings in the data table in your science notebook.

Teacher notes: Students will probably become interested in testing additional objects. The more objects they test, the better the opportunity for them to see a pattern in their evidence. **B INQ.3**

7. ANALYZE YOUR RESULTS. Look for a **pattern** in the data. Is there anything similar about all the materials that lit the bulb? Is there anything similar about all the materials that did not light the bulb? WRITE your conclusion in your science notebook

Teacher notes: Encourage students to look at the <u>*properties*</u> *of the materials that lit the bulb. They may note that these materials were all shiny, solids, or opaque. They may also say that these materials are "made of metal".* **B INQ.5**

8. SHARE and compare your findings with the rest of your class.

Teacher notes: Call on several groups to describe the results of their conductivity tests. First, ask students to note how others' experiments were similar to or different from their own. Then ask students to compare their predictions to their findings. Were they surprised by any results? Introduce the term "conductor" as you ask them to tell about materials that lit the bulb. As students describe their observations, they will also begin to use the term "conductor". Ask questions such as: "Were all the conductors similar in any ways?" "Were the insulators similar in any ways?" After students share, teacher should synthesize the class' discoveries by recording and displaying them along with any further questions the students may have. **B INQ.6**

9. WRITE in your science notebook what you have discovered about materials in electric circuits.

Teacher notes: Students may describe their findings using the science terminology (e.g., conductors, insulators, complete circuits, incomplete circuits), but it is more important that they be able to describe what they understand about these materials and their arrangement to light a bulb. **B INQ.7**

ELABORATE

Experiment #3: Investigating Your Own Questions (optional)

You have worked with batteries, wires and bulbs to learn some things about the movement of electricity in circuits. What were you curious about as you worked with your circuits?

Teacher notes: As a result of their circuit explorations, students probably have become curious about other questions. This is a good opportunity to encourage them to design an investigation to answer <u>their own</u> questions. Remind students about the "Noticings" and "Wonderings" they generated in the first observation activity. These, as well as other things they have noticed during Experiments #1 and #2, can stimulate questions to investigate further. **B INQ.1**

1. TALK with your partners about things you were curious about during your circuit experiences. Decide on an electric circuit question that you can investigate.

Teacher notes: You may ask students to share their questions with the class and have the group discuss which ones are investigable vs those that are better answered through print research. For example, "Does a larger battery make the bulb light brighter?" is an investigable question. However, "How do they get the plastic insulation around a copper wire" is a question that is better suited for research in books or the internet. **BINQ.1**

▲ *If some students need help with ideas, you might suggest the following:*

(a) how do circuits with one battery compare to circuits with two or more batteries;

(b) the effect of different battery sizes ("AA", "AAA", "C" and "D" size);

(c) how does changing the wire length affect the brightness of the bulb;

(d) how does adding more bulbs to the circuit affect the brightness of the bulbs?

As a classroom management suggestion, you may want students to individually choose a question they are interested in and find other students who are interested in the same question to form a group (groups of 2 or 3 are recommended).

2. THINK about how you can use your circuit experiences to test your idea. Then decide what results you will record.

Teacher notes: **B INQ.3**

3. PLAN the steps you will follow in your experiment, and use your science notebook to record the question you are investigating and the steps you will follow.

Teacher notes: **B INQ.3**

4. DO your experiment and record your findings in an organized way in your science notebook.

Teacher notes: **B INQ.4**

5. THINK about your results. What new ideas do you have as a result of your experiment? What are you still wondering about?

Teacher notes: **B INQ.5**

Communicate Your Learning

The school newspaper is doing an article about science projects going on around the school. Write an article for the newspaper describing your electric circuit investigations. In your article, tell about:

- The main ideas your class was studying;
- Why you think these ideas are important to know;
- What experiments you did and how you did them;
- What you learned from your experiments about electricity and about how scientists work; and
- What was difficult for you and what was fun for you.

Teacher notes: ▲ *Before asking students to write about their learning, you may want to give students an opportunity to deepen their understanding of electric circuits by conducting further research. A variety of nonfiction reading materials can be used (e.g., leveled readers, internet sites, biographies of Edison or Morse, or textbooks) to enhance literacy skills and deepen science understanding.* **B INQ.2 or B INQ.8**

TEACHING RESOURCES

Websites for Students:

http://www.miamisci.org/af/sln/ - Miami Museum of Science website with animated information and activities about electricity, batteries, electrical safety, atoms and more.

http://www.schoolscience.co.uk/content/3/physics/circuits/chal1.html - build circuits with or without switches, add up to four batteries…all with the click of the mouse!

http://fly.hiwaay.net/~palmer/motor.html - using ordinary materials, build a simple electric motor.

http://www.energyquest.ca.gov/index.html - information and activities all about energy: everything from electricity to fossil fuels to nuclear energy in a child-friendly format.

Websites for Teachers:

http://www.eskimo.com/%7Ebillb/ele-edu.html - Everything you ever wanted to know about electricity, plus common student misconceptions, textbook errors and suggested activities. Written in a user-friendly format by an electrical engineer at the University of Washington.

Electricity Unit Plan:

http://www.parks.ca.gov/pages/501/files/unit.pdf - a 14-lesson teaching unit developed around a field trip to a hydroelectric generating station. Includes explorations of series and parallel circuits, switches, electromagnets, and several open-ended student investigations. Includes a teacher's guide.

Nonfiction Trade Books:

Electricity: From Amps to Volts. Cooper, Christopher. Heinemann Library, Chicago, IL. 2004.

Circuits, Shocks, and Lightning. Peters, Celeste A. Raintree Steck-Vaughn, Austin, TX. 2000.

Thomas A. Edison. Mason, Paul. Raintree Steck-Vaughn, New York, NY. 2002