Connecting Oceans Academy

New Bedford ECHO Project

Using Tools of Scientific Inquiry to Explore and Understand Environmental Problems

Grades 6-8

Companion Module to: *Using Tools of Inquiry to Explore Student-Selected Research Issues*

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http://newbedfordecho.org/newbedford-echo-project-curricula.htm

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Using Tools of Scientific Inquiry to Explore and Understand Environmental Problems

Overview

This unit of study serves as a companion to the ECHO curriculum module entitled, *Using Tools of Inquiry to Explore Student-Selected Research Issues*, in which students learn a process for posing, refining, and answering researchable questions within any discipline of study—e.g., culture, science, math, language arts, history, or art. This unit of study provides an example of the inquiry process as it may be applied within a middle grades curriculum using an environmental problem selected by the student that stems from a topic of study in a science classroom. Throughout the module, a specific example is provided as an illustration. It assumes that a class has just completed a study of 'the transfer of energy' that addresses the National Science Content Standard B, Physical Science* for grades 5-8 (National Science Standards, National Academy of Sciences, 1996). Students apply what they have learned about energy while improving their inquiry skills through the study of a self-selected environmental issue that pertains to human uses of energy. However, the curriculum is presented in a way that enables the teacher to apply this curriculum to any scientific topic.

From Content Standard A, Students will:

- Acquire abilities necessary to do scientific inquiry.
- Demonstrate knowledge of the characteristics of scientific inquiry.

From Content Standard F, Students will know that:

- Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water and air.
- Human activities can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal; and such activities can accelerate many natural changes.
- There are risks associated with chemical hazards (pollutants in air, water, soil, and food).
- Individuals can use a systematic approach to thinking critically about risks and benefits, both to themselves, to their local community, and globally.
- Important personal and social decisions are made based on perceptions of benefits and risks.

Content Standard B: TRANSFER OF ENERGY

- *Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.*
- *Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.*
- *Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object--emitted by or scattered from it--must enter the eye.*

- *Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.*
- *In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.*
- *The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.*

Because there is a natural integration of science and social studies concepts as students explore the topic of energy use in the twenty-first century, students' learning would also include social studies concepts.

How to Use This Module

There are three ways in which teachers may use this module:

1. A teacher who is following the Learning Experiences presented in, *Using Tools of Inquiry to Explore Student-Selected Research Issues,* will find that the parallel Learning Experiences in this module provide examples of how a teacher may guide the learning experience using a specific topic within which students independently select and pursue their own research questions. Possible student responses are provided during each activity. As such, this module serves as a concrete example at each step in the process of inquiry.
2. A teacher may want to implement this module using the concept of energy, the same concept used in the module. In so doing, the teacher will find the examples of student responses and the specific classroom management strategies helpful. However, one must remember that the students' responses are provided solely as examples, rather than as expectations.
3. A teacher may want to confine students to conducting research on questions that fall within a specific topic of study, but not energy. This module then becomes a guide, in which the teacher can follow the Learning Experiences and the Activities within each learning Experience, substituting a different topic of study. The examples provided in the module will help to clarify the process. If using the jigsaw activity in Learning Experience One, the teacher will need to find a replacement for the article used, since the article used was chosen because it addressed a controversial issue specifically on the use of energy. In 'Notes to Teachers' at the end of the first Learning Experience, is a more generic substitute for Activity One that may be applied to any topic of study.

Teachers who choose options #2 or #3 will find the companion module, *Using Tools of Inquiry to Explore Student-Selected Research Issues,* a rich resource for helping students who need additional guidance during particular parts of the process of inquiry.

To keep the teacher instructions simple, the module is presented as though it were taught by a science teacher; however a unit such as this would be ideal for a cross-disciplinary team of teachers, including English/language arts, social studies and science.

An Introduction to Scientific Inquiry

In this unit, we explore the research processes and methods of scientific inquiry that will enable students to:

- Generate research questions and issues about which they care deeply
- Evaluate and refine the research questions
- Identify and gather sources of information
- Assess the reliability and efficacy (breadth and depth) of the information and gather additional information if necessary
- Extract relevant information from the various sources
- Identify information gaps and/or inconsistencies in the data and conduct additional research
- Synthesize data and identify findings consistent with the data
- Plan and share findings and conclusions for the target audience

Human beings are inherently curious. They want to understand why and how things are as they are. Over time and across civilizations, humans have sought to make sense of their social and physical environments. Their meaning-making has been immersed in and shaped by the cultures in which they live. Each group has constructed its own reality, truth, right, and wrong. Some have used narrative to understand. Others have turned to research and scientific inquiry to make sense of complex phenomena. This curriculum focuses on the latter. At the same time, it encourages teachers and students to discover the connections between the natural environment and social systems, and understand their potential roles as stewards of the environment and agents of social change.

Desired Results

This curriculum is intended for use in middle school content area classrooms. It aims to provide knowledge, skills, and strategies that students can use throughout their lives to explore and answers questions that are personally meaningful and can inspire social action. Specifically, students learn a process for posing, refining, and answering questions they may have about environmental issues that pertain to human applications in the area of science. Students acquire critical thinking skills, such as analyzing, drawing inferences, and synthesizing. Finally, they apply their learning and create and share a presentation that captures their learning.

The development of the unit and learning experiences in this curriculum unit was guided by the following *Understanding by Design* (UbD) principles:

- **W** The students know **where** they are going and **why**. They also know **what** is expected and required and how they will be evaluated.
- **H** Students are **hooked** or engaged in working with the enduring understandings and essential questions.

- **E** Students have opportunities to **explore** enduring understandings and essential questions and receive instruction they need for the required assessments.
- **R** Students have opportunities to **rethink**, **revise**, and **refine** their work based on feedback.
- **E** Students have opportunities to **evaluate** their own work and set learning goals.
- **T** Instruction is **tailored** to the needs of individual students using**:**
  - Differentiated instruction
  - Content area literacy strategies
  - Cooperative learning
  - Opportunities for oral language
- **O** **Organized** and sequenced

Enduring Understanding for Research (Inquiry)

Students will understand that acquiring knowledge on issues and interests involves:

- generating ideas and questions, and posing problems;
- gathering, evaluating, analyzing and synthesizing data from a variety of sources (e.g., print and non-print texts, artifacts, people, conducting experiments using scientific processes);
- using scientific inquiry as a means to reach a new understanding through questioning, hands-on investigation, rethinking data, and asking more questions; and
- communicating their discoveries in ways that suit their purpose and audience.

Essential Questions for Research

- What are reliable sources of information that are available for exploring and making sense of complex issues and problems?
- How does the use of multiple and varied sources help us understand the complex issues and problems we investigate?
- What are the limitations of relying upon a limited number and range of sources of information?
- How and when can I use strategies to comprehend, interpret, evaluate, and appreciate various sources of information?
- How is my research shaped by my cultural beliefs, assumptions, prior knowledge, experiences?
- What is the evidence for the findings of research? Is the evidence reliable and sufficient?
- How can I best communicate the outcome of my research to my particular audience and for a particular purpose?

Content-Related Enduring Understandings

- Students understand that the decisions of one generation create opportunities and impose restrictions for future generations
- Students will understand the importance of being personally responsible for themselves, society, and the environment.
- Understanding the past and present in all content areas leads to a sense of stewardship and personal responsibility for the future.

Content-Related Essential Questions

- How does decision-making at the individual, local, national, or international levels impact the natural environment and social systems?
- How can individuals prepare to be stewards of the local and global community?
- Why should humans care how their actions affect the natural environment and social systems?
- How do personal actions impact the natural environment and social systems and how can I behave in ways that protect the well-being of both?
- How do personal actions impact the natural environment and social systems and how can I behave in ways that protect the well-being of both?

Assessment and Evaluation

Each learning experience has been planned to give students the knowledge and skills necessary to meet the final assessment requirements. The teacher should allow time throughout the unit for students to form groups, plan, and research information for the final performances. A final evaluation rubric is provided for the teacher and students. However, the teacher may choose to work with students throughout the unit, to develop criteria and rubrics for successful completion of the final performances, and benchmarks along the way. Models and directions for creating rubrics can be found at:

http://school.discovery.com/schrockguide/assess.html#rubrics

Learning Experience One

Setting the Stage

Overview

Issues related to energy use offer a diverse array of compelling topics for inquiry and action. However, prior to asking students to brainstorm topics, this lesson is designed to 1) spark motivation and interest by engaging students in conversation about a recent issue related to human uses of energy, and 2) provide students with information for use in Learning Experience Two.

In *Notes to Teachers* at the end of this Learning Experience is an alternative to the jigsaw activity used in Activity One, that does not rely upon a specific article and can thus be used for any topic of study.

Evaluation

Students write a reflection paper on the environmental issue discussed in this Learning Experience.

Materials

- "Fall of the Wild." *National Geographic.* May 2006: pp. 42-77. Available online at http//:ngm.com/0605, under 'Features,' "Alaska's North Slope." For multimedia show: select 'Multimedia' and click on, 'Begin Your Journey.'
- Optional: Digital projector and computer with Internet access
- National Geographic *a*rticle divided into 4 sections, sections numbered consecutively from #1 - #4; sufficient copies of each section according to number of students in class (1/4 of students in class/section: (1) text from pp 42-51 (end before last paragraph), (2) text from pp 51, last paragraph-71, column 1 (end before last paragraph), (3) text from pp 51, column 1, last paragraph-72, column 2 (end before first paragraph), (4) text from pp 72, column 2, paragraph 1-77. A set of all pictures for each student.

Activity One: Learning about the Issue

- Tell students that their goal will be to work in groups to identify the main ideas in a controversial article on drilling for oil on Alaska's North Slope
- Use a jigsaw:
    - If necessary, arrange seating for group work.
    - Divide class into heterogeneous groups of at least 4 students each. Groups may have more than 4 students, but not less.

- Ask students in each group to assign a number to group members from #1 - #4, counting over if there are more than 4 students in the group. Students make note of their assigned number.
- Distribute the numbered segments of the article, along with the set of photographs from the article. Students receive the section number that matches their assigned number. Be certain before proceeding that each group has at least one person assigned to each segment.
- Explain the activity and then guide students through each step, moving among the groups to mediate.
    1. The groups that students are seated in are called the 'home team,' so students should make note of their team members and where they are sitting.
    2. The home teams break up and students sit with those who have the same numbered assignment. This new team is called the 'expert team.'
    3. Students in the expert team first read the information silently (Alternatively, one person can be assigned as the reader for the group.), then discuss it within their team so that everyone is prepared to explain the information to members of their home team. Remind students that they are reading for main ideas. This is such an important role, that expert teams should be instructed to create notes for each team member to take back to the home team. The teacher should check in with the teams periodically to be sure they move from individual reading to team discussion, and then to organizing the notes they will use for their explanations. Each group selects photographs that illustrate information from their section of the article.
    4. When the work is completed, students leave their expert teams and return to home teams.
    5. Following the segments in ordered sequence, beginning with segment #1, the experts explain the information they have learned to the other members of the home team, using the notes they have prepared and showing selected photographs. Home team members ask questions of the experts to be sure everyone understands all the information. Students are instructed to listen for the main ideas.
    6. Each home team prepares a list of what the members agree are the 3-5 most important or main ideas.
    7. A member of each team reads this list to the class, while the teacher charts the ideas, using a check mark to indicate when an idea is repeated.

Activity Two: Taking a Stand on this Issue

- Ask students to stand when they agree with a statement that you make.
- Statements:
    - *I am very concerned about (repeat this phrase for each of the following):*

1. *The noise pollution from oil drilling that is driving the whales farther from shore where the hunters cannot reach them.*
2. *The oil drilling because it drives away the caribou herd, eliminating an important food source for the Inupiat.*
3. *The oil drilling because it results in the loss of habitat for wildlife, such as falcons and hawks.*
4. *The fact that drilling mars the land that has sustained an ancestral way of life for the Inupiat.*

- *Since oil has become such an important part of the Inupiat economy, the oil industry must be supported despite the environmental impacts.*
- *Preservation of the natural beauty, the native plants and animals, and the Inupiat ancestral way of life are more important than the money the Inupiat earn from the oil industry.*
- *I would be willing to (or already do) make personal sacrifices in order to reduce the need for oil. [Ask for examples from those who stand: e.g., I ride my bike or walk whenever possible, even if it's inconvenient, to avoid using gas. I insist that my family be very conservative of our use of electricity—not leaving the TV or computer on when no one is using it, keeping the thermostat turned down in cold weather, keeping lights off in rooms not in use, doing things manually whenever possible (e.g., opening cans)].*
- *I am actively involved in solving an environmental problem. (Ask those who stand to state what they are doing.)*
- *I want to become involved in solving an environmental problem.*

- Discuss how individual students felt, either when they chose to stand or chose to remain seated for any of the statements. If not mentioned, explore the conflict in the article between preserving the traditional Inupiat way of life which was in harmony with the natural environment, and promoting the new economy, which brings modern conveniences to the Inupiat but also threatens the very environment on which the Inupiat depend for survival. Students should realize that there is no easy answer, and it's OK if they find they can't take a firm stand one way or the other.

Teacher Notes

**Encourage students to search their own beliefs and not be concerned about what stand their friends or fellow classmates take on a statement.*

**Invite students to create their own 'belief statements' for the class.*

Activity Three: Reflecting on the Learning Experience

- Close with students writing a reflection. Offer a prompt such as one or more of the following:

- With regard to the natural environment, it is my responsibility to . . .
- I believe that drilling for oil in the North Slope of Alaska (should/should not) be continued because . . .
- I am torn between drilling for oil in the North Slope and preserving the Inupiat ancestral way of life because . . .

Notes to Teachers

1. Resources

- Useful resources that are available both online and hard copy are publications from organizations that educate the public about environmental issues, such as *National Geographic, The Nature Conservancy, The Audubon Society, The Sierra Club, Earth Justice, National Wildlife.*
- Newsmagazines, such as *Time* (e.g., March 27, 2006 on an oil spill in Alaska's North Slope) and *Newsweek*, often present environmental issues.

2. Alternative Learning Experience to Activity One

Prior to Lesson:

- Students select their own energy-related concern, either bringing in a representative article or briefly describing the issue and telling why the student is concerned about it. Articles or personally written environmental concerns should be submitted at least the day before Activity One so that the teacher can review them and plan Activity One accordingly.

Activity One: Discussing Environmental Issues

- Set up seating in front of the room for a panel of 4-5 volunteers—or students selected because of specific articles submitted—to face the class.
- Acting as moderator, ask first panelist to describe her issue. Then ask why the student has selected this issue, i.e., why it is important or of personal concern. Invite other panelists to offer comments. Then open for questions and comments from the class. Proceed to next panelist.
- If time, create a second panel or call on students to describe the issue they have brought to class, allowing 15 minutes before close of class to complete the activities that follow.

Teacher Notes

**While students are presenting their issues, jot down 'belief statements' to use in the following activity.*

Activity Two: Taking a Personal Stand on the Issues

- Ask students to stand when they agree with a statement that you make.
- Statements:
  - I am very concerned about [insert one of the issues presented]. *Example: global warming*
  - It's important to preserve our natural environment and keep our air, water and land unpolluted, even if it requires a heavy economic cost to humans.
  - I am willing to (or already do) make personal sacrifices in order to remedy or reduce this problem. [offer one or more appropriate examples] *Examples: ride my bike or walk whenever possible, even if it's inconvenient, to avoid riding in a car and therefore using fuel and adding carbon dioxide to the atmosphere; use less energy for heating (or cooling) the place I live in even if it means being uncomfortable.*

    Repeat above bullets for additional issues
  - I am actively involved in solving an environmental problem.
  - I want to become involved in solving an environmental problem.
- Briefly discuss how individual students felt, either when they chose to stand or chose to remain seated for any of the statements.

Teacher Notes

**Encourage students to search their own beliefs and not be concerned about what stand their friends or fellow classmates take on a statement.*

**Invite students to create 'belief statements' for the class.*

Activity Three

- Close the lesson with students writing a reflection. Offer a prompt such as the following: Because human uses of energy impact the natural environment, it is my responsibility to . . . or, An environmental issue of great concern to me is _____, because . . .

Learning Experience Two

Choosing a Topic

Overview

As a first step in selecting a question for scientific research, the teacher leads students in a brainstorming activity to generate problems related to human uses of energy. These problems are then evaluated according to criteria developed by the students to select potential research topics.

Evaluation

Each student selects a preliminary topic or issue for study that meets the criteria established by the class.

Materials

- Poster or handout of Enduring Understandings and Essential Questions (located in Notes to Teachers)
- Handout: Final Evaluation Rubric (pp78-79) for each student
- Chart paper and markers, tape for posting
- Optional for Activity Two: computer and projection equipment and a program such as Inspiration for creating a web
- Computers with Internet access for individuals or pairs of students
- Access to the Media Center

Activity One: Introducing the Unit of Study

- Invite students to read one of their reflections from the prior lesson.
- Connect these reflections to the purpose of this unit of study: Students will apply what they have learned about energy to investigating a self-selected environmental issue that pertains to human uses of energy, to communicate what they have learned to an appropriate audience, and possibly to take action on this issue.
- Tell students that they will be involved in scientific research—or, scientific inquiry. Elicit descriptions from students about what they expect they will be doing when they are conducting research. Post ideas. Ask students to defend their ideas—i.e., why each idea is important in a research study. Enhance the list, if necessary. Refer to Notes to Teachers, #2, for the National Science Standards on Inquiry. Ask students to give examples of when they use, or should use these research strategies in their everyday lives.
- Introduce the Enduring Understandings (#1 in Notes to Teachers) for the unit of study, indicating that this list will remain posted in the classroom and referenced

throughout the unit. Explain that the students will be evaluated, and will evaluate themselves, based on their efforts to approach these understandings.

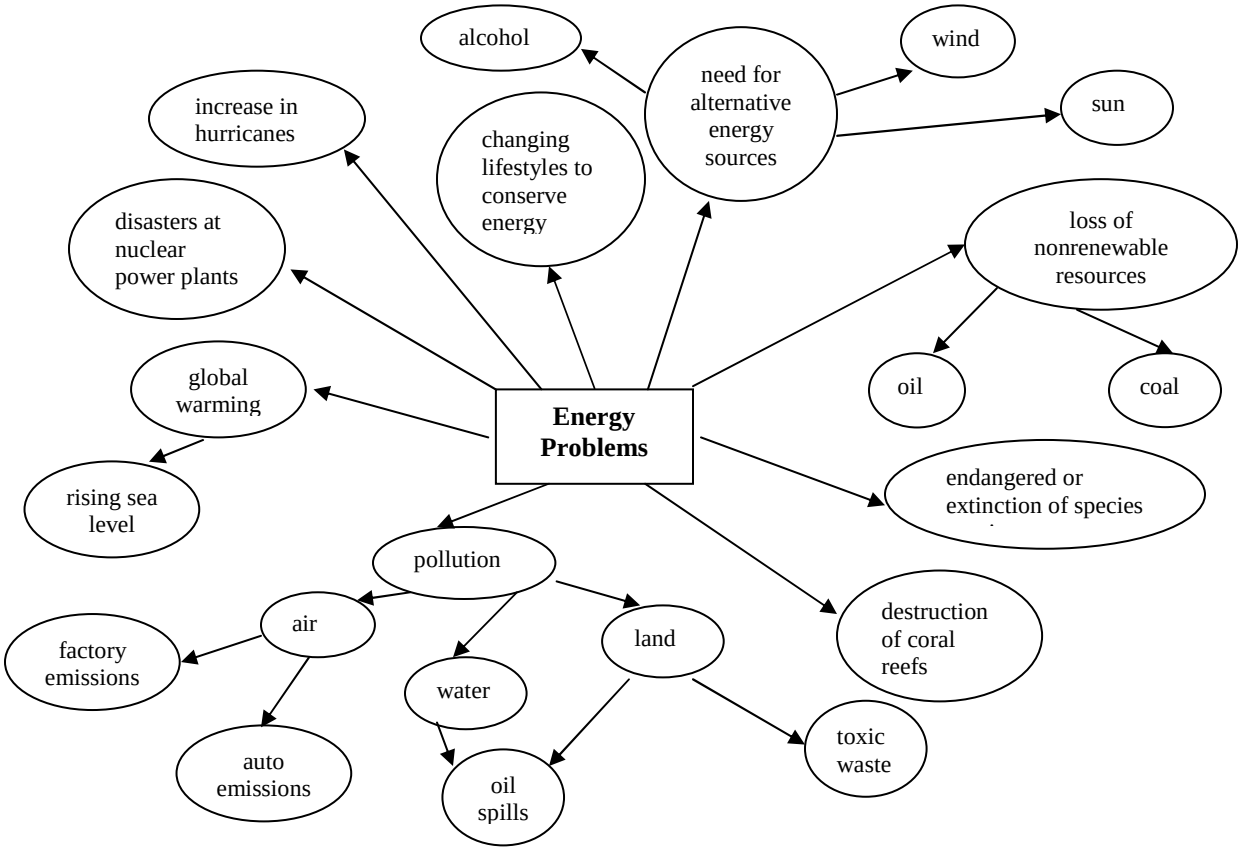
- Review the Final Evaluation Rubric with students, showing how it is aligned with the Enduring Understandings. Compare the rubric to the list of research skills that were generated. Invite and respond to questions and concerns.

Teacher Notes

**The amount of time devoted to introducing the concept of research will depend on the students' level of understanding and their research skills.*

Activity Two: Brainstorming Issues and Topics

- Explain that students will engage in a brainstorming activity as a whole class as a first step in helping each student made a well considered selection of a problem to research.
- If necessary, review the rules for brainstorming: generate as many ideas as you can, accept all ideas that come into your head without evaluating or judging, avoid talking about each idea.
- The topic for brainstorming is: What problems have arisen throughout the world because of people's ever increasing need for, and use of energy?
- A web is illustrated below.



Teacher Notes

** Be attentive to the rules for brainstorming. In particular, students should not make judgmental comments about their own or other's ideas or derail the process by discussing or explaining a contribution.*

**A computer graphics program such as Inspiration may be used to display students' responses.*

**If not using a computer program, teacher records students' responses on chart paper, rather than a black or white board, so the results of the brainstorm can be preserved for future reference.*

Activity Three: Creating Criteria for Topic Selection

- Remind students that the purpose of brainstorming is to generate as many ideas as possible. The result of a brainstorm doesn't necessarily mean that all the ideas will be good for research.
- Explain that the goal of this exercise is to develop a tool to help them select a research problem. Ask students what they think would make a problem good for research. Phrase the suggestions in the first person. Scribe onto chart paper, questioning and eliminating suggestions that won't be helpful to students. Add ideas if necessary. Examples:

  - *I have a strong interest in the problem.*
  - *I anticipate that information about the problem is readily available.*
  - *I think scientific studies have been conducted.*
  - *I think the information is likely to be understandable to me (not too technical).*
  - *I can see a strong connection between the topic and our study of energy.*

- Introduce the term criteria, and refer to the refined list as, *Criteria for Selecting a Researchable Problem*. Number the criteria for easy reference in Activity Four.

  Criteria for Selecting a Researchable Topic

  1. *I have a strong interest in the problem.*
  2. *I anticipate that information about the problem is readily available.*
  3. *I think scientific studies have been conducted.*
  4. *I think the information is likely to be understandable to me (not too technical).*
  5. *I can see a strong connection between the problem and our study of energy.*

Activity Four: Applying the Criteria to Select a Topic

Preparation: Arrange for use of a computer with Internet access for individuals and/or pairs of students and for access to the Media Center; advise Media Specialist(s) of topics beforehand.

- Ask each student to write a problem from the brainstorming that is of personal interest for research. The students have now met Criterion #1 from prior activity.
- Group students by their selected problem. Keep groups to no more than 5 students by subdividing larger groups. Suggested process for grouping: Ask students to: 1) write the name of their problem in bold letters on an index card; 2) stand with a pencil/pen, some paper, and their index card; 3) walk about the room displaying their chosen problem on the index card and 4) join with other students who have the same (or a related) problem.

- Each group selects a recorder and facilitator.
- Recorder for each group writes the numbers of the Criteria (in this example, from #2 - #5). Beside each number, the group decides whether the recorder is to write a yes, no, or don't know. Demonstrate with an example from a student, coaching the student to respond to the criteria.
- Facilitator helps the group assign tasks to members to verify the group's responses to Criteria 2-5.
  2. *I anticipate that information about the problem is readily available.*
     Task: One or more students assigned to use a computer search engine, such as 'Google' to find out how many 'hits' the problem nets.
  3. *I think scientific studies have been conducted.*
     Task: Student(s) assigned to use a computer search engine to search for scientific studies on the topic.
  2. *I think the information is likely to be understandable to me (not too technical).*
     Task: Student(s) use a computer search engine, select some of the web addresses and scan the information for readability.
  3. *I can see a strong connection between the problem and our study of energy.*
     Task: Student(s) write a statement explaining the connection. This may require some research.
- Allocate a class period (and assign as homework) for students to verify that their problem will be appropriate for research. Provide guidance. Media specialist(s) can also support student searches.
- Groups convene to review the results of individual members' searches and prepare a chart of results for a report to the class.
- Groups report results to class. Encourage other students to ask questions and offer suggestions. If a problem is found unsuitable because it doesn't meet all the criteria, the students in that group can be invited to join a group that has selected a different, successful topic that is of personal interest.

Notes to Teachers

1. Enduring Understandings and Essential Questions

Enduring Understanding for Research (Inquiry)

Students will understand that acquiring knowledge on issues and interests involves:

- generating ideas and questions, and posing problems;
- gathering, evaluating, analyzing and synthesizing data from a variety of sources (e.g., print and non-print texts, artifacts, people, conducting experiments using scientific processes); and
- communicating their discoveries in ways that suit their purpose and audience.

Essential Questions for Research

- What are reliable sources of information that are available for exploring and making sense of complex issues and problems?
- How does the use of multiple and varied sources help us understand the complex issues and problems we investigate?
- What are the limitations of relying upon a limited number and range of sources of information?
- How and when can I use strategies to comprehend, interpret, evaluate, and appreciate various sources of information?
- How is my research shaped by my cultural beliefs, assumptions, prior knowledge, experiences?
- What is the evidence for the findings of research? Is the evidence reliable and sufficient?
- How can I best communicate the outcome of my research to my particular audience and for a particular purpose?

Content-Related Enduring Understandings

- Students understand that the decisions of one generation create opportunities and impose restrictions for future generations
- Students will understand the importance of being personally responsible for themselves, society, and the environment.
- Understanding the past and present in all content areas leads to a sense of stewardship and personal responsibility for the future.

Content-Related Essential Questions

- How does decision-making at the individual, local, national, or international levels impact the natural environment and social systems?
- How can individuals prepare to be stewards of the local and global community?

- Why should humans care how their actions affect the natural environment and social systems?
- How do personal actions impact the natural environment and social systems and how can I behave in ways that protect the well-being of both?
- How do personal actions impact the natural environment and social systems and how can I behave in ways that protect the well-being of both?

2. **Research Skills and Understandings** (*National Science Standards*, National Research Council, 1996; http://www.nsta.org/standards)

Understandings about Scientific Inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.
- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

Abilities Necessary to Do Scientific Inquiry

Identify Questions That Can Be Answered Through Scientific Investigations. Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should

develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.

Design and Conduct a Scientific Investigation. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

Use Appropriate Tools and Techniques to Gather, Analyze, and Interpret Data. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.

Develop Descriptions, Explanations, Predictions, and Models Using Evidence. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description--providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.

Think Critically and Logically to Make the Relationships Between Evidence and Explanations. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.

Recognize and Analyze Alternative Explanations and Predictions. Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.

Communicate Scientific Procedures and Explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations

Use Mathematics in All Aspects of Scientific Inquiry. Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.

Learning Experience Three

Assessing Prior Knowledge, Refining the Topic

Overview

Now that students have identified a general problem area, they engage in a series of activities that leads to the selection of a specific research question. This learning experience assumes that students have no prior experience in, or knowledge about conducting scientific research.

Evaluation

Students write a research question and a brief paragraph that describes or explains the origin of the question.

Materials

- Computers with Internet access for individuals or pairs of students
- Access to the Media Center
- Handout: KWLH Chart

Activity One: Investigating for Availability of Information about the Topic

Preparation: Arrange for use of a computer with Internet access for individuals and/or pairs of students and for access to the Media Center; advise Media Specialist(s) of topics beforehand.

- Explain that this next step will give students direction in narrowing their general problem to a specific question that will be the focus of their research. Demonstrate the KWLH process (described in Notes to Teachers), using one group's problem and engaging the whole class in responding to Columns 1 and 2. Use the KWLH Handout as a model for creating a large chart to post students' responses. Suggestion: If there is a solo student, use that student's problem as the example.
- Allow approximately 10 minutes for each group to complete the first 2 columns of KWLH for its topic, using the KWLH Handout. Example follows.

Research Topic: Oil Spills

1. What do we know?	2. What do we want to learn?	3. What have we learned?	4. How can we learn more?
*There have been many serious oil spills. *The U.S. imports large amounts of oil from the Middle East. *Oil goes through a process before it can be used as a fuel. *Oil comes from under the ground. *Some oil is drilled in this country. *There is a pipeline that brings oil over land from the North Slope of Alaska so it can be transported.	*How much of the oil that is used in the U.S. must be imported from other countries? *What are all the ways that oil moves from where it is drilled to refineries, and then to customers? *How many major oil spills have occurred? *Where were the major oil spills? *What effects did the spills have on the environment? On the consumers? *How are oil spills cleaned up? *What is the best method for cleaning oil spills? *What research is being done to reduce or eliminate the chances for oil spills? *What research is being done to find the best method for cleaning up oil spills?		

- Allocate one class session for students to explore their topics, working either individually or in pairs. Explain that their research shouldn't be exhaustive. There are two purposes for this inquiry: 1) to ensure that there is ample and technically understandable information about the topic and 2) to help students begin to focus on a specific question to research. Students enter their findings in the 3rd and 4th columns of the KWLH Handout. Example provided below.

    - *In Column 3: Note briefly the kind of information found on the topic, including the web address or other resource in which the information is located.*
    - *In Column 4: Record other sources of information that students do not investigate, but know are available.*

1. What do we know?	2. What do we want to learn?	3. What have we learned?	4. How can we learn more?
*There have been many serious oil spills *The U.S. receives oil from the Middle East *Oil goes through a process before it can be used as a fuel *Oil comes from under the ground *Some oil is drilled in this country	*Where do oil spills occur? *What are all the ways that oil moves from where it is drilled to refineries, and then to customers? *What is our community willing to do to help reduce the chance of oil spills? *How much of the oil that is used in the U.S. must be transported from other countries? *How many major oil spills have occurred? *Where were the major oil spills? *What effects did the spills have on the environment? On the consumers? *How are oil spills cleaned up? *What is the best method for cleaning oil spills? *What research is being done to reduce or eliminate the chances for oil spills?	From: NOAA website (url is below the table) *Oil spills into rivers, bays, and the ocean and onto land *"Oil is transported in tankers, barges, and pipelines refineries, and storage facilities, usually while the oil is being transported to us, its users." *"We can find ways to avoid using oil in the first place: for example, we can bicycle, walk, or take the bus rather than taking a car to some places we need to go. When we use less oil, less needs to be transported, and there's a lower risk of future oil spills. We should understand that it is because we rely on oil that we run the risk of oil spills. That means that all of us share both the responsibility for creating the problem of oil spills and the	*Obtain information from a variety of websites, such as: www.epa.gov/**oil**spill/ www.BugsThatEat**Oil**.com www.itopf.com/effects.html (for effects of oil spills) www.epa.gov/oilspill/response.htm (for government responses to oil spills) www.fws.gov/contaminants/Issues/OilSpill.cfm www.wikipedia.org *Do an experiment to determine the best method for cleaning oil spills. *Survey our local community to find out what people are willing to do. *Look at an Encyclopedia entry on oil spills

	*What research is being done to find the best method for cleaning up oil spills?	responsibility for finding ways to solve the problem."	

NOAA website:
http://response.restoration.noaa.gov/audience_catalog.php?RECORD_KEY%28audience_chosen%29=audience_id&audience_id(audience_chosen)=2

Activity Two: Selecting a Question to Research

- Explain that students will need to narrow their problem area to a specific question they want to answer. Demonstrate the difference between a broad research problem and a researchable question (see example below; more examples are provided in Notes to Teachers). Good questions are not easily answered. Explain to students that they can expect to discover differing opinions in their research, and may have to generate their own data (such as through questionnaires or experiments)—these are the very things that make research so exciting! Emphasize that good questions require the researcher to arrive at his own answer after extensive and thoughtful examination of information collected from a variety of reliable resources. Explain that even if the research question is focused on creating one's own information, such as by surveying people or conducting experiments, it's still necessary to do the background research. Ask students why it's important to do background research before developing a survey, or creating an experiment. Students must find out what is already known, and will want to avoid duplicating information that already exists, before designing a questionnaire or an experiment. Also, doing the background research may raise another, more intriguing question to research.

  Example of a broad problem: Oil spills

  Examples of researchable questions on oil spills:
  - *What should be done internationally to eliminate the chances of an oil spill occurring?*
  - *What can be done to minimize the impact of an oil spill on the environment?*
  - *What are the members of our local community willing to do to reduce oil consumption?*
  - *What have been the long-term effects of the major oil spills?*

- Ask students to use their KWLH chart as a reference as they generate one or more questions, and to describe in a brief paragraph the reason the student is interested in finding an answer to the question, or to provide background information that led the student to ask the question.

- Group students again by topic to share their questions and help each other examine the questions to be sure they are specific and clearly stated. Groups can also help students who are having trouble developing a good question.

Teacher Notes:

** Creating a focused research question usually requires coaching either by the teacher or appropriate resource person, such as a scientist, journalist or political activist. It's important to keep within the student's area of interest, while assuring that the research is narrow and technically appropriate so that the student can be successful.*

** Consider inviting resource persons to the classroom to serve as advisors.*

** Some students may use the group time to find a partner with whom to share a research question.*

Reference

Ogle, D. S. (1986). K-W-L group instructional strategy. In A. S. Palincsar, D. S. Ogle, B. F. Jones, & E. G. Carr (Eds.), *Teaching reading as thinking* (Teleconference Resource Guide, pp. 11-17). Alexandria, VA: Association for Supervision and Curriculum Development

Handout: KWLH Chart

Research Topic: _____

1. What do we know?	2. What do we want to learn?	3. What have we learned?	4. How can we learn more?

Notes to Teachers

1. KWLH Process

The following explanation is adapted from a web page created by the North Central Regional Education Lab at:
http://www.ncrel.org/sdrs/areas/issues/students/learning/lr1kwlh.htm .

The K-W-L-H teaching technique is a strategy that helps students activate prior knowledge. The process was originally developed by Donna Ogle (1986) as a strategy for reading comprehension, but is also a good organizer for engaging in any inquiry.

K - Students recall what they **KNOW** about the subject.

W - Students determine what they **WANT** to learn.

L - Students identify what they **LEARN** as they conduct their research.

H - Stands for **HOW** we can learn more (other sources where additional information on the topic can be found).

2. Examples of Researchable Questions

Topic: Alternative Sources of Energy
Questions:

- What are the most environmentally friendly methods for producing electricity?
- Is there an alternative to vehicles powered by gasoline that is environmentally friendly, uses an energy source that is renewable, and is affordable?

Topic: Conservation of Nonrenewable Natural Resources Used for Energy
Questions:

- What are the ways in which our community, and the individuals within our community can be responsible consumers of fossil fuels (i.e., oil, gas, coal) which are nonrenewable energy sources?
- Is nuclear power a good alternative to power produced by fossil fuels in terms of being environmentally friendly (including humans) and economically affordable?

Learning Experience Four

Determining Appropriate and Reliable Sources of Information

Overview

In the first two activities, students are guided by the teacher and classmates to generate and categorize a comprehensive list of information resources, and to select from this list those sources most appropriate to solve their research problems. In so doing, students learn that the sources they will require depend on the nature of the problem they have selected. For example, some problems require students to conduct questionnaires, while others necessitate conducting one or more experiments. In the third activity students learn that throughout their inquiry they will need to ensure that the information they include in their findings is reliable.

Evaluation

- Each student completes a list of information sources that is appropriate to the research question.
- Each student demonstrates an awareness of the importance of determining the reliability of information sources by writing a reflection paper.

Materials

- Access to the Internet for individuals or pairs of students
- Large post-its, 15 per research question
- Handout: duplicate each article (there are 5), making enough copies of each for each individual in a group (assumes there are 5 groups; one group per article)
- Index cards, e.g., 3x5; one per student
- Chart paper

Activity One: Identifying Sources of Information for Research Questions

- Ask for 2-3 volunteers to each name a general or specific source of information they plan to use to help answer their research question. Record examples on chart paper or white board.

Teacher Notes

** Invite students to refer to the preliminary research they have already conducted. Ask where in that research they could find some sources of information (the right-hand column of their KWLH charts).*

** Some examples: magazine article, encyclopedia, National Geographic, science book, website of an environmental group, expert, NOAA website, U.S. Department of Energy, a researcher, an engineer*

- Ask students to each make a list of up to 10 possible sources of information they think they will want to investigate to help them answer their research question.

Teacher Notes

** Help students distinguish between a resource and a strategy. For example, a survey or questionnaire is a strategy, while the resource for the information is the individuals who are being surveyed. The individuals can be described by the group they represent, such as local citizens, people who say they are environmentalists. Similarly, a computer search is a strategy, while a website is a source of information.*

- Group students as in the prior lesson by research topic. Instruct each group to consolidate the members' individual sources, writing in large print on post-its up to 15 sources, each on a separate post-it. Invite groups to add more sources.
- Ask two persons from each group to stick their group's post-its to the white board or chalk board. They should look at what others have posted, checking to see if any are exactly the same as theirs (e.g., magazine). If so, they should stick their post-its on top of the existing ones that are the same.
- Allow time for all students to look at what has been posted, making a mental note of questions.
- Facilitate a class discussion to respond to students' questions.
- Create categories: If no one has observed that there are categories for grouping the sources, raise the question of how all the sources may be organized into groups or categories. Invite four volunteers to come to the board and move the post-its into categories. As the class observes the process, invite students to join the group if they want to offer input, and then return to their seats. Only one student at a time should join the group. Then ask the volunteers to explain the reasoning for their groupings. Allow time for discussion among the class. Then place names for the categories—some may already have been named as sources of information.

Teacher Notes

** Some examples of sources are: reference books, organization websites, government websites, experts, individuals in the community*

- If experiment isn't on the list, ask the students what a scientist would do if there were no already existing sources of information. If no one suggests that a scientist could conduct experiments to answer the question, provide this option to the class and ensure that students understand the role that experiments play in generating new knowledge to answer research questions.

- If the idea of interviewing or surveying individuals isn't on the list, ask students how they would answer a question about how the public feels about a problem, or to learn how much the public knows about a problem.
- An example of a completed categorization of sources is provided below, using the topic, human uses of energy. Most of the information in this example came from the students' KWLH charts completed in Learning Experience Three.

Teacher Notes

** The specific examples that are generated will depend on the research questions that have been selected. It's not important at this time to have identified an exhaustive list. The objective is for students to be aware of the range of sources, from information available in print (e.g., books, periodicals, websites) to information that is not available and must be generated by the students through surveys or experiments.*

Sources of Information on Human Uses of Energy

Written Material		Gov't Agency	Individuals in Commun.	Expert, e.g. at a Univ. or retired	Experi-ment	Organi-zation	Website
Book	**Periodical, Newspaper**						
Fuel and Energy – Seldenberg	*Time*	NOAA	voters	geologist	What materials absorb oil?	Alternative Energy Inst.	www.eere.energy.gov/states
Protecting Our Planet – Parker	*Newsweek*	U.S. Dept of Energy	adults	biologist		Am. Society for Renewa-ble Energy	OilSpill.cfm
Environmen-tal Experiments about Renewal Energy - Rybolt	*National Geographic*	EPA	youth	chemist		Center for Resource Solutions	www.epa.gov/
	EERE News	U.S. Dept of Agricult.	car drivers	environment-alist		Energy Star	www.energy.wsu.edu/library
	Solar Energy		owners of hybrid cars	ecologist		E&Co	Energy-quest.ca.gov
	Boston Globe			public works employee			www.Ecokidson-line.com
							www.wikipedia.com

- Transfer the headings to chart paper, making a list:

  List of General Resources
  Written material: books, magazines/journals, newsletters, newspapers
  Experiments
  Experts
  Government Agencies
  Individuals living in the community
  Organizations
  Documentaries available as Videos, DVDs, or Film
  Websites

- Discuss where overlaps occur (e.g., websites often contain periodicals, organizations and agencies also have websites; experts can be interviewed, but they can also write books and articles and appear in documentaries).
- Ask students to discuss the following questions:
  1. How will you decide whether to contact an expert directly or rely on written or visual materials? Students may recognize that after reading material written by an expert or watching an interview, there could be value in contacting that person to obtain more specific information, more ideas, or suggestions on where the student may find additional information.
  2. How will you decide whether to access written material on a website or in hard copy? If necessary, tell students that not all information on the Internet is free.
  3. When would you need to gather information from individuals who live in our community? Examples: Research questions that seek to determine the level of awareness of the community about a problem or collect data on where the community stands on an issue; questions that compare the opinions or extent of knowledge about a problem between different groups of individuals, such as different age groups or gender. Briefly talk about methods for collecting data from large numbers of people (paper surveys vs. interviews; going where large numbers of individuals gather, such as at school, churches, shopping malls).

Activity Two: Determining Which Sources are Appropriate

- Ask students to write their research question on an index card. Refer students to the List Of General Resources generated in Activity One, writing on the index card those resources they think they will be using during their research.
- Explain that students will use a consulting process to get assistance from each other on thinking through the resources they'll need. Place students in groups of three and have each group number its members from 1 to 3. Explain that student #1 will read her research question to the group. The other 2 members of the group will offer suggestions on the kinds of resources the student will need to use and possible methods for obtaining the information. The group should discuss why each resource is needed. The reader should add to her list any resources

that he didn't already include. Allow 5 minutes for each student, giving a one-minute warning and announcing when it's time to move to the next student.

- Ask students to move to different areas of the room based on the following:
    1. You plan to conduct surveys or interview large numbers of individuals.
    2. You think you will need to conduct one or more experiments.
    3. You can get all or nearly all you need through the Internet.
    4. You are still uncertain about whether you will need to conduct surveys or experiments.
    5. You don't think you fit into any of the first four categories.

Teacher Notes

** You may want to post a sign on the wall by each group: surveys, experiments, Internet, still uncertain, don't fit into any of the first 4 categories.*

** Allow students who think they fit in more than one group to make a choice.*

** If any groups are too large for discussion, ask students to subdivide into 2 or more groups as necessary.*

- Each group assigns a reporter. Allow 5-10 minutes for students to discuss within their group the reasons why they joined the group and to determine if any of them does not actually need to be in that group. (students can move to another group) Allow another 2 minutes for students to agree on what the reporter will say that describes what their research questions all have in common that puts them in that group.
- Before each group reports out, ask some students in the group to state their research question. After the report, ask if there are others who think they fit in that group. If so, they should read their question and explain why they think their question fits within that group; ask the members of the group whether or not they agree, and to justify their decision.
- Invite students to return to their seats to review their list of sources, modifying it if necessary. Collect the cards to review students' choices. Arrange to consult with individual students as necessary.
- Discuss, with examples from the class, the statement: Different kinds of research questions lend themselves to different kinds of research approaches.

Activity Three: Ensuring Information is Reliable

- Form 5 groups. Provide each student within a group with the same 'mystery article' from handout #2. Ask students to designate a group facilitator, reporter and recorder. Instruct students to read the article independently and to answer the question, "Is this article in favor of wind turbines as a source of alternative energy, is it opposed to the use of wind turbines, or is it neutral?"

- Assign each group the following tasks (Handout 1, Part 1):
    1. Discuss your individual answers and then agree on a group response: is the article favorable or opposed or neutral to wind turbines?
    2. Discuss whether the group thinks the information in the article is reliable. Consider these questions:
        - Does the group think that the article is based on facts? Why or why not?
        - Is the article free of bias? Why or why not?

    Recorders use Handout 1, Part 1 to make a list of the reasons discussed to support the group's answer to each question.

- Ask the students why they think you titled the articles, 'mystery articles.' It should be evident that it was because the students did not know the source. Provide each group with information about who wrote the article and who published it. The information is located in Notes to Teachers at the end of the Learning Experience. Ask groups to reconsider their answers now that they have more information (Handout 1, Part 2):
    1. Does this new information support your trust in the reliability of the article, or make you more uncertain about its reliability? List your reasons.
    2. What questions do you now have that you would need answered before you could say for certain whether your article is reliable.

  Recorders use Handout 1, Part 2 to list the group's answer and reasons under #1, and questions under #2.

- Ask each group to report to the class (post the following questions on chart paper or board):
    1. What was the article about, and did the group decide it was in favor of, opposed to, or neutral about wind turbines?
    2. What evidence did the group find that the article is either fact-based or unsupported by facts?
    3. What evidence, if any, did the group find that the article is biased?
    4. Did finding out the source (author or publisher) of the article make the group more, or less trusting of the article—and why?
    5. What additional questions does the group have that would help determine whether the article was reliable?

Teacher Notes

**Post groups' responses to Questions #4 and #5 on chart paper or the board. They will need this information to create a checklist.*

- Discuss what students have learned from this exercise that will help them in their research.
- Tell the class that it might be helpful for them to have a checklist they can refer to as they search for information, to be sure the information they are collecting is based on supportable facts and is unbiased—and is therefore reliable. Ask students to look at the questions they generated, and the issues raised by knowing the author and publisher (that you have posted). Begin by brainstorming. An example follows:

Brainstormed Checklist for Determining the Reliability of Information

  - Is the author or publisher affiliated with a specific cause that may make the information biased to support the cause?
  - Does the author cite references from sources you would consider expert?
  - Does the information contradict or support other sources?
  - Is the author writing about his or her own research?
  - Is the author a politician or the publisher affiliated with a political stand?
  - Is the information up-to-date?
  - Is the website owned by an industry or business that serves to profit from the information that is on the website?
  - Was the research cited the source conducted by an individual or group that would benefit from the published results?

- First synthesize the list by combining similar ideas.
- Discuss each item in the checklist to assess whether it is a useful question, and whether it still may involve some pitfalls. Ask questions that will help students realize that the best research never depends on a single source because even experts can be wrong, or have a bias. Have students justify their answers. Examples of questions:
  - Would information you find published by an environmental organization necessarily be biased?
  - Is an expert always right, always unbiased?
  - Can a politician be a reliable source?
  - Is federal or state government always a reliable source?
  - Is information from a business that seeks to profit necessarily incorrect?
  - How many sources should be consulted to ensure information is reliable?
  - For what kinds of research questions are opinions that are not even supported by facts acceptable sources? (e.g., When the purpose of the research is to survey a group's opinion)
  - Are you being objective when you do your research, or are you liable to be viewing information through your own biases, favoring some information you find simply because you personally agree with it, rejecting other information because it goes against your beliefs? How can you be sure you are being completely open-minded (i.e., unbiased) as you collect information?

- Discuss with the students whether a checklist such as the one they have been trying to design is useful. You may want to focus the concern about reliability on the students' research results, rather than focus on the sources they use. That is, work with the students to create a checklist for ensuring that their research contains information that is reliable. An example follows:

Checklist for Ensuring Our Research is Reliable

- I will always be aware that the information I collect may be unreliable, so I should check the facts I include in my research by using multiple sources of information.
- I will be particularly wary of sources that might seek to profit from publishing the information they provide. I will always know the source.
- I will know the date of the information Ifind. If the information was obtained from another source (there is a quote and/or a reference provided), I will check the date of that original source.
- I will keep an open mind until all the information has been collected and studied.

Teacher Notes

**Books may take 2-3 (or more) years to be published; professional articles are more current, but may also take a year or more to be published.*

**Even experts don't always agree. Knowledge derived from scientific studies may later be disproved or revised. Methodology and accuracy affect results.*

**If students are collecting information regarding the opinions or level of awareness of a group of individuals on a certain issue, reliability is determined by the way the questions are asked and the methods used to collect the information. Students conducting surveys should investigate resources on how to conduct a reliable survey.*

Handout #1

Group Tasks and Responses, Part 1

Group: _____ Mystery Article # _____

Is the article favorable of, opposed to, or neutral about wind turbines?

Reasons for your answer:

Is the information in the article is reliable?

1. Does the group think that the article is based on facts? Why or why not?

2. Is the article free of bias? Why or why not?

Handout #1

Group Tasks and Responses, Part 2

Group: _____ Mystery Article # _____

Now that you have information about who wrote or published the article . . .

Does this new information support your trust in the reliability of the article, or make you more uncertain about its reliability? List your reasons.

What questions do you now have that you would need answered before you could say for certain whether your article is reliable?

Handout #2

Mystery Article #1

1. Industrial wind developers are interested only in providing a public service.

Their primary purpose is to take advantage of extraordinary income sheltering opportunities.

2. Windplants [wind energy turbines, often called windmills] do not harm wildlife.

Despite industry insistence this won't happen, it already has.

3. Windplants will reduce the mining/burning of fossil fuels and lessen dependence on foreign oil.

The wind industry in the East will not put much of a dent in our reliance on fossil fuels.

4. Windplants are highly efficient and provide power for significant numbers of homes.

The press often prints this inflated fiction as truth. Wind technology is very problematic from an energy production standpoint.

5. Locals who oppose the wind industry are NIMBYS [Not in my backyard]**.**

One of the most persistent hypocrisies from corporate wind. … many politicians who vote to enable industrial wind do so fully aware that windplants will be built in someone else's back yard, realizing they would not survive the political backlash if one were constructed in their district.

6. Windplants will generate significant local revenue and increase property values.

...two recently constructed windplants... have contributed virtually nothing to the local tax base.

7. The wind industry will create many local jobs.

This is a cruel untruth, especially in economically depressed areas. Very few permanent jobs will likely be created—perhaps a couple of low wage maintenance employees.

8. Wind technology is noiseless and creates few disturbances.

Tall wind turbines in concert with each other, especially those sited on prominent ridgetops, create profound noise reverberations extending out for more than a mile, sounding like "a boot tumbling in a dryer" or the revving of jet engines on a runway.

9. Wind technology consists of "windmills" on "wind farms."

The reality is that they are mammoth industrial factories. The reality is that the technology consists of mammoth industrial factories often targeted for areas which pride themselves on their natural beauty.

10. Those who are concerned about windpower are not true environmentalists.

The facts demonstrate otherwise. Example: Notable environmentalists such as Robert Kennedy, Jr. and Chandler S. Robbins have studied the issue and urge that wind technology be carefully evaluated before implementation decisions are made.

Handout #2

Mystery Article #2

Windmills are sprouting on hillsides across the Midwest, but this city is encouraging the use of electricity-producing wind turbines everywhere — even in homeowners' backyards.

Mason City this week became the first Iowa town to set rules that allow windmills in commercial, industrial and residential zones. The City Council unanimously approved the ordinance Tuesday.

City planner Tricia Sandahl says the council initially considered permitting windmills only in industrial areas. "Then we decided, let's just take a bolder step," she says. "We wanted to encourage small wind systems in residential areas. With electric prices going up, it just makes sense."

A few generations ago, almost every farm around here had a windmill that generated enough energy to pump water or grind grain. Those old-fashioned windmills became extinct after rural electric cooperatives extended power in the 1940s. In the last decade, commercial wind farms sprouted as energy costs soared.

The increasing popularity of wind energy is part of a surge in the development of alternative energy sources that's apparent here. Mason City, population 28,000, also is home to a plant that produces ethanol, a fuel made from corn and grain. A plant that will process soybean oil into biodiesel fuel will be finished late this year.

"Iowa is doing an awful lot to capitalize on its natural resources," says Gary Swanson of Energy Management Solutions, a consulting company. He's working with several Mason City manufacturers who are considering building windmills.

'Stream of revenue'

The Midwest is leading a spike in wind projects:

• Minnesota passed a law last year that encourages new windmills by cutting red tape and offsetting some construction costs.

• Michigan's public service commission changed its policies last year to allow consumers to sell excess electricity from windmills back to utilities.

• North Dakota last year reduced application fees and made it easier to get permission to build windmills.

Lisa Daniels, executive director of Windustry, a Minneapolis-based non-profit group, says wind

energy is a natural fit in rural areas. Farmers lease their land to commercial wind farms and in many states can sell back excess electricity from their own windmills.

Wind power soars

Electricity generated nationally
by wind power: (in megawatts*):

1981: 10
1985: 1,039
1990: 1,525
1995: 1, 697
2000: 2,578
2005: 9,149

Top producers
States generating the most electricity from wind power, as of Dec. 31 (in megawatts*):

California: 2,150
Texas: 1,995
Iowa: 836
Minnesota: 744
Oklahoma: 475

* a megawatt equals 1 million watts
Source: American Wind Energy Association

"People are seeing that it's not only good for the environment, but it's also ... a new revenue stream that fits in well with the corn and the soybeans," Daniels says.

Tax credits and low-interest loans are making windmills more affordable. A small home-based system costs about $40,000.

Last year, a record 9,149 megawatts of electricity was produced by wind in the USA, says Christine Real de Azua of the American Wind Energy Association, a trade group.

That's just 0.5% of all electricity generated in the country, but production this year is expected to top 12,000 megawatts and keep climbing. One megawatt is enough to power 300 to 1,000 households at any one time, depending on climate and other factors.

"It's possible we could generate up to 20% of our electricity needs through wind and turbine," President Bush said Tuesday at the National Renewable Energy Lab in Colorado.

Marv Schlutz helped make Mason City a wind-energy pioneer. He asked the zoning board for a variance so he could put a 100-foot windmill at Mason City Warehouse, his storage business. He

figured he'd save enough on electric bills to pay for a $40,000 system in eight to 10 years.

"The neighbors raised heck with me," Schlutz says. They worried about whether birds could be killed by rotating blades, TV signal interruptions, interference with the local hospital's emergency helicopter and bad odors that could be sent their way.

Opposition faded as gas and electricity prices kept rising. School districts in Forest City and Spirit Lake, also in northern Iowa, were using windmills to cut utility bills. The Cerro Gordo wind farm in Ventura, a few miles west of here, has 55 large turbines on 2.4 acres.

Tom Hurd, a Mason City architect, installed two 35-foot-tall windmills outside his office. His windmills and solar-energy panels produce 90% of the electricity used by his company, Spatial Designs.

"If the wind is 15 mph or less, you don't even hear it," he says. "Once a year you have to check whether the blades are tight, and that's all you have to do."

Hindrances, ordinances

There can be drawbacks. The 300-foot-tall wind turbines that stretch for miles along Altamont Pass, Calif., have been blamed for the deaths of tens of thousands of birds. Residents of Cape Cod, Mass., who oppose a proposed offshore wind farm say it would create visual pollution. Nebraska is studying whether transmission lines have to be updated to handle electricity produced by windmills, diminishing their cost-effectiveness.

Mason City's ordinance requires permits for windmills and sets limits on where they can be built. Residential windmills can't exceed 100 feet tall and can be put only in backyards. The lot has to be big enough so that if the windmill topples it doesn't cross property lines.

Sandahl, the city planner, says several homeowners have called to get information about installing a windmill. Bill Hammond, who manages an alternate-energy loan program at the Iowa Energy Center, a research facility at Iowa State University, predicts that more people will want windmills as they recognize the potential.

"There's actually money in that wind," he says, "and people want a piece of it."

Handout #2

Mystery Article #3

The U.S. Environmental Protection Agency today announced that it will power three of its research facilities in Cincinnati, Ohio, with 100 percent renewable energy through an agreement with Community Energy, Inc., a renewable energy marketing company. By early 2002, EPA will be receiving nine percent of its electricity from green sources, at facilities located in Richmond, Calif., Golden, Colo., Chelmsford, Mass., Manchester, Wash., and Cincinnati, Ohio.

"The Bush Administration has asked the government to be the first to conserve energy," said Administrator Christie Whitman. "These purchases represent a creative and innovative approach to help solve our nation's energy crisis, while achieving tremendous environmental benefits and charting the way for the emerging green power market."

The EPA Cincinnati facilities have committed to purchasing a total of 15,560,000 kWh of premium renewable energy annually for three years, with a three-year option to renew. Community Energy, Inc. will supply 778,000 kWh of New Wind Energy TM each year from the Exelon Power Team at Mill Run, Pennsylvania, which will make up five percent of EPA Cincinnati's estimated usage. ComEd, a subsidiary of Exelon Corp. that serves customers in Northern Illinois, in partnership with Environmental Resources Trust (ERT), will supply the remainder of the renewable energy contract with landfill gas energy from ComEd's territory in Illinois.

By purchasing wind and biomass energy, EPA can claim large reductions in emissions associated with the purchase of conventional energy. The emission benefits associated with this purchase are approximately 16,000 tons carbon dioxide, 112,000 lbs. nitrous oxides and 246,000 lbs. sulfur dioxide each year.

Brent Alderfer, president of Community Energy, Inc., said, "With this purchase of New Wind Energy, the EPA is leading the way to a cleaner and more sustainable energy future. EPA's decision to buy locally generated wind energy shows others that there are sensible clean energy choices that can help to create a clear future. This is the kind of real environmental leadership that will make a difference."

Handout #2

Mystery Article #4

For more than two years, I have watched the raging debate over wind power projects in West Virginia, and I have concluded we need to expand wind capacity even as various opponents mistakenly challenge it.

Wind projects are technically and economically feasible, produce useful amounts of electricity at reasonable prices with minimal environmental impact, provide a significant boost to the local economy during construction and contribute significant amounts of tax revenue to the local government. During operation, wind projects create good jobs for West Virginians to support their operation and maintenance.

Wind projects are also good for the nation. They help reduce air pollution and global warming, help reduce our nation's dependence on imported fuels and protect electricity consumers from volatile fuel price increases.

Claims that utility-scale wind energy projects produce "very little" or "insignificant" amounts of energy are wrong. Wind projects currently proposed in West Virginia would generate as much electricity as 200,000 households use. As new households are being constructed, they must get their electricity from somewhere.

Opponents of these projects often give the impression that the choice is between a wind farm and nothing. In the real world, the choice is always between wind and something else, usually something that is more damaging to the environment.

Some opponents identify the concern about wind turbines harming bats. I know that scientists, wildlife experts and the wind industry have and continue to work together in a collaborative fashion to learn more about the interaction between bats and wind turbines as well as to develop possible solutions. I know of no reputable scientist who predicts that large scale use of wind turbines will significantly reduce the bat population to the point of endangerment.

Research carried out at wind farms regarding birds has found that the impact of wind energy projects is extremely low compared with other human-related activities. No matter how extensively wind is developed in the future, bird deaths from wind energy are unlikely to be never more than a small fraction of bird deaths caused by other human-related sources, such as cars, cats, buildings and pesticides.

Wind turbines are not noisy. I have visited the Mountaineer site just off Route 219 in Tucker County. If you hear beyond the noisy truck traffic, loud banging and jack hammering of the adjacent gravel pit, you may be able to faintly hear the closest wind turbine about 500 feet away.

Finally, as to the visual impacts of turbines, beauty is in the eye of the beholder.

Our children need this type of responsible economic development so there are good opportunities to find good jobs here in West Virginia. If we don't build wind farms, we will build something else.

Wind power is a reality today. In 2005 alone, enough wind generation to serve the equivalent of more than 650,000 average American homes was installed in the United States. President Bush stated that wind energy can provide as much as 20 percent of the nation's electricity. The national energy policy includes government encouragement to accelerate the development of this increasingly competitive source of energy to provide at least 6 percent of U.S. electricity by 2020.

West Virginians can contribute to the nation's energy needs. West Virginia has many energy resources, and we should encourage their development as part of encouraging responsible economic growth in the state. Developing the state's wind energy resources is one of the more environmentally friendly development actions we can take

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Handout #2

Mystery Article #5

In 1991, a national wind resource inventory taken by the U.S. Department of Energy startled the world when it reported that the three most wind-rich states—North Dakota, Kansas, and Texas—had enough harnessable wind energy to satisfy national electricity needs. Now a new study by a team of engineers at Stanford reports that the wind energy potential is actually substantially greater than that estimated in 1991.

Advances in wind turbine design since 1991 allow turbines to operate at lower wind speeds, to harness more of the wind's energy, and to harvest it at greater heights—dramatically expanding the harnessable wind resource. Add to this the recent bullish assessments of offshore wind potential, and the enormity of the wind resource becomes apparent. Wind power can meet not only all U.S. electricity needs, but all U.S. energy needs.

In a joint assessment of global wind resources called Wind Force 12, the European Wind Energy Association and Greenpeace concluded that the world's wind-generating potential—assuming that only 10 percent of the earth's land area would be available for development—is double the projected world electricity demand in 2020. A far larger share of the land area could be used for wind generation in sparsely populated, wind-rich regions, such as the Great Plains of North America, northwest China, eastern Siberia, and the Patagonian region of Argentina. If the huge offshore potential is added to this, it seems likely that wind power could satisfy not only world electricity needs but perhaps even total energy needs. (See data.)

Over the last decade wind has been the world's fastest-growing energy source. Rising from 4,800 megawatts of generating capacity in 1995 to 31,100 megawatts in 2002, it increased a staggering sixfold. Worldwide, wind turbines now supply enough electricity to satisfy the residential needs of 40 million Europeans.

Wind is popular because it is abundant, cheap, inexhaustible, widely distributed, climate-benign, and clean—attributes that no other energy source can match. The cost of wind-generated electricity has dropped from 38¢ a kilowatt-hour in the early 1980s to roughly 4¢ a kilowatt-hour today on prime wind sites. Some recently signed U.S. and U.K. long-term supply contracts are providing electricity at 3¢ a kilowatt-hour. Wind Force 12 projected that the average cost per kilowatt hour of wind-generated electricity will drop to 2.6¢ by 2010 and to 2.1¢ by 2020. U.S. energy consultant Harry Braun says that if wind turbines are mass-produced on assembly lines like automobiles, the cost of wind-generated electricity could drop to 1-2¢ per kilowatt hour.

Although wind-generated electricity is already cheap, its cost continues to fall. In contrast with oil, there is no OPEC to set prices for wind. And in contrast to natural gas prices, which are highly volatile and can double in a matter of months, wind prices are declining.

Another great appeal of wind is its wide distribution. In the United States, for example, some 28 states now have utility-scale wind farms feeding electricity into the local grid. While a small handful of countries controls the world's oil, nearly all countries can tap wind energy.

Denmark leads the world in the share of its electricity from wind—20 percent. In terms of sheer generating capacity, Germany leads with 12,000 megawatts. By the end of 2003, it will have already surpassed its 2010 goal of 12,500 megawatts of generating capacity. For Germany, this rapid growth in wind power is central to reaching its goal of reducing carbon emissions 40 percent by 2020.

Rapid worldwide growth is projected to continue as more countries turn to wind. In addition to the early leaders—Denmark, Germany, Spain, and the United States—many other countries have ambitious plans, including the United Kingdom, France, Brazil, and China.

In densely populated Europe, the off-shore potential for developing wind is also being exploited. Denmark is now building its second off-shore wind farm, this one with 160 megawatts of generating capacity. Germany has some 12,000 megawatts of off-shore generating capacity under consideration.

Wind power is now a viable, robust, fast-growing industry. Cheap electricity from wind makes it economical to electrolyze water and produce hydrogen. Hydrogen is the fuel of choice for the highly efficient fuel cells that will be used widely in the future to power motor vehicles and to supply electricity, heating, and cooling for buildings. Hydrogen also offers a way of storing wind energy and of transporting it efficiently by pipeline or in liquefied form by ship.

With the wind industry's engineering know-how and manufacturing experience, it would be relatively easy to scale up the size of the industry, even doubling it annually for several years, if the need arose. If, for example, crop-shrinking heat waves raise food prices and generate public pressure to quickly reduce carbon emissions by replacing coal and oil with wind and hydrogen, it will be possible to do so. If the need arises to shift quickly to hydrogen-fueled automobiles, this can be done by converting gasoline-burning internal combustion engines to hydrogen with inexpensive conversion kits.

For energy investors, growth in the future lies with wind and the hydrogen produced with cheap wind-generated electricity. Solar cell sales are growing at over 30 percent a year and are likely to supply much of the electricity for the 1.7 billion people who are still without electricity, most of them living in developing country villages. But solar cells are still too costly to supply the vast amounts of energy required to power a modern economy.

World coal burning peaked in 1996 and has fallen 2 percent since then. It is a fading industry, not an exciting investment prospect. Nor is oil particularly promising, since world production is not likely to expand far beyond current levels. Production of natural gas, the cleanest and least climate-disruptive of the fossil fuels, is likely to continue expanding for a few more decades, fortuitously developing an infrastructure that can be adapted for hydrogen. Nuclear power

generation is expected to peak soon, when the large number of aging plants that will be closing down will exceed the small number of plants that are under construction.

The energy future belongs to wind. The world energy economy became progressively more global during the twentieth century as the world turned to oil. It promises to reverse direction and become more local during the twenty-first century as the world turns to wind, wind-generated hydrogen, and solar cells. Wind and wind-generated hydrogen will shape not only the energy sector of the global economy but the global economy itself.

Notes to Teachers

- Information for Activity 3. The sources are numbered below to correspond to the Mystery Articles. Prepare a copy of each source for groups according to the article assigned to the group.

1. "The Top Ten False and Misleading Claims the Windpower Industry makes for Projects in the Eastern United States," by the organization, (no date provided) StopIllWind, http://www.stopillwind.org/lowerlevel.php?content=topten_intro

2. "Midwest's windmills generate buzz" by Judy Keen, February 24, 2006, Copyright 2006, originally published in *USA Today* http://www.climateark.org/shared/reader/welcome.aspx?linkid=53041

3. "EPA Announces Renewable Energy Purchase for Cincinnati Labs" by Chris Paulitz, 202-564-9556/paulitz.chris@epa.gov, a news release of the Environmental Protection Agency on August 17, 2001

4. "Wind power is good investment for W.Va." by Donald W. Lyons, professor of engineering at W. Virginia University, published in the *Herald*-Dispatch, October 1, 2006 http://www.heralddispatch.com/apps/pbcs.dll/article?AID=/20061001/OPINION/610010318/1034/ARCHIVE

5. "Wind Power Set to Become World's Leading Energy Source" by Lester R. Brown, June 25, 2003-4, Copyright © 2003 Earth Policy Institute, http://www.earth-policy.org/Updates/Update24.htm

- Resource for determining the reliability of sources: http://owl.english.purdue.edu/owl/resource/553/03/

  This is a useful checklist of questions a student may ask while reading.

Learning Experience Five

Developing an Action Plan

Overview

Students will develop a plan for conducting their research that falls within the time frame provided by the teacher. Each student will obtain constructive feedback from two other students and from the teacher before finalizing the plan.

Evaluation

Students complete a detailed, appropriate plan of action for their investigation, including a timeline.

Materials

- Handout 1: Template for Action Plan
- Transparency film of Handout 1 and overhead projector, or computer with Handout 1 saved and projection device

Activity One: Developing the Research Action Plan

- Introduce this activity by agreeing with students on the number of weeks they will have to complete their research and prepare a final product. Post the deadline for completion of the final product.
- Explain that in the world of work, individuals and teams often have large projects to complete, with deadlines that must be met. To ensure a timely completion, most professionals will prepare a plan of action or 'action plan,' sometimes called a strategic plan. Since the students' research projects are sufficiently large to need similar management, they will also be preparing a plan of action.
- Give students a copy of the Action Plan template (Handout 1) and instructions on how to complete it. As a class, work through an example, having a student volunteer, with your assistance. Use the overhead or computer to fill in the columns as the class observes. Both of you should talk about the decisions as she enters the information, so that students can follow the reasoning. Others in the class should be invited to ask questions and offer ideas. The volunteer will become the teacher's assistant to help others complete their plans.

SAMPLE Handout 1 **Student's Name:** *Miguel*

ACTION PLAN

Research Question: *What are the members of our local community willing to do to reduce oil consumption?*

Task	Resources	Deadline	Approved
Make a list of the kinds of information I need to find before I prepare my survey	*Reference librarian* *Teacher* *Environmental expert*	*10/6*	
Collect information: locate reliable sources, take notes, organize the information	*Library* *Internet* *Note taking materials*	*10/16*	
Learn about doing surveys—how to prepare a reliable survey, good methods for getting people to complete the survey, how many people I need to survey	*Find an expert to help me—maybe university person or someone who does surveys for marketing* *Or find a reference book or article*	*10/23*	
Write the survey, test it with some people, finalize	*A few people willing to try out the survey and give me feedback*	*10/30*	
Conduct the survey	*Copies of the survey* *People to take the survey*	*11/10*	
Tally the results, draw conclusions		*11/13*	
Decide on how to present my results and prepare my presentation	*Teacher, classmates*	*11/20*	

- Ask students to work within their topical groups to prepare their own plans. Those who are partnering on a research question should each have a copy of their plan. Members of the group can help each other. The volunteer and teacher spend time within groups to review the process and affirm or offer ideas.

Activity Two: Obtaining Feedback and Finalizing the Plan

- Explain that students will use the consulting process again, this time to get assistance from each other before submitting their Action Plans for final approval. Place students in groups of three. Ideally, group students who plan to conduct similar kinds of research, i.e., conducting surveys, performing experiments, or doing primarily library and Internet research. Ask each group to assign numbers to its members from 1 to 3. Explain that student #1 will show his Action Plan his partners. The other 2 members of the group will comment on the plan, supporting parts of the plan that are strong and offering suggestions that student #1 may or may not want to use. Allow 5 minutes for each student (unless students seem to need more time), giving a 1-minute warning and announcing when it's time to move to the next student. The student assistant and you circulate among the triads, contributing suggestions and affirming strengths in the plans.
- Review all plans and meet with students whose plans need any alterations, to discuss with them the necessary changes.
- Students submit their Action Plans for final approval.

Handout #1 **Student's Name** _____

ACTION PLAN

Research Question:

Task	Resources	Deadline	Approved

Notes to Teachers

- Review all Action Plans. The right-hand column is for the teacher to check each step when approved.
- Help students understand that the Action Plan is a guide to help keep them on track and on schedule. It's possible that a plan may need to be revised later. It's OK to make changes, but students should always have a plan that is approved by the teacher, including any changes in a plan.
- The teacher should find a way to schedule periodic conferences with each student, or research team to review progress and help students work in a way that ensures deadlines can be met.

Learning Experience Six

Gathering and Organizing Information

Overview

Students acquire systematic strategies for gathering information. They then work independently on their research. Students who are planning to ultimately generate their own data from surveys or experiments are researching the existing knowledge base until they are sufficiently informed to know what kind of information they wish to gather through surveys or experiments. Students conducting surveys also research the methodology of surveys. The teacher schedules regular consultations with students to verify they are using appropriate research strategies, ensuring reliability,

Evaluation

Students adequately document their fact finding, including paraphrased, appropriately quoted, and fully referenced information.

Materials

- Overhead slides of Handout 1 and projector, or Handout 1 loaded on computer with projection device
- Handout 1 for each student
- Handout 2, cut into separate kinds of sources, a copy of one source for each member of the group assigned to that source

Activity One: Learning a System for Taking and Referencing Notes

- Explain the process the class will use for the next step in their research: collecting and analyzing information. Students will first learn a note-taking and referencing system. Then, they will be working independently for 2-3 weeks. The students will schedule conferences with the teacher to be held twice a week. On occasion, the class will convene for peer consulting in groups of three, as they have done before. At this time, the class may also meet as a whole, or groups of students may meet with the teacher to learn particular skills needed in their research or to solve common problems.
- Explain the importance of having a system for taking notes. Students will be gathering a lot of information, and from a variety of sources. When it's time to organize all the information, it will be much easier and take much less time, if the information was originally documented in a systematic way. Point out the pitfalls of not having a system, such as losing track of where a particular piece of information came from and therefore not being able to use it; having to search

through pages and pages of unorganized notes to locate information that was on a specific topic.

- Teach students a system, such as use of large index cards for taking notes and smaller cards to write down the source. To keep the notes organized, students write only a single piece of information on a note card. Write a heading on the note card that describes what that information is about. For example:

Statistics **4.93**

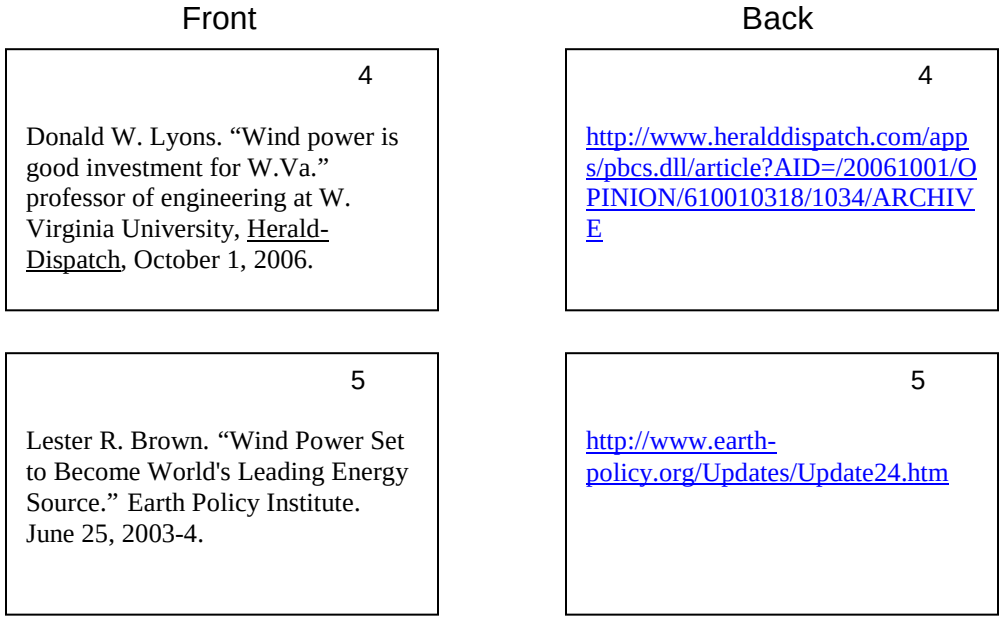
In 2005 alone, enough wind generation to serve the equivalent of more than 650,000 average American homes was installed in the United States.

(Donald W. Lyons is a professor of engineering at W. Virginia University)

Statistics **5.28**

Over the last decade wind has been the world's fastest-growing energy source. Rising from 4,800 megawatts of generating capacity in 1995 to 31,100 megawatts in 2002, it increased a staggering sixfold.

- Explain the importance of having a system for referencing all their sources. Students already know that there is always a question about the reliability of a source. What if someone wants to check any of your sources? That person will need to know exactly how to locate the source. Also, what if <u>you</u> want to return to a source you used? Perhaps you want to verify or clarify information on which you took notes. Maybe you decide that you want to collect additional information from that source. You want to be sure that you can locate it. If you forgot to write down the date, the author or person, or other essential data, you may never find that source again. Show the students how the notes they write and the sources of those notes are connected through a numbering system. Using the notes shown previously, here is what the reference cards would look like. The number in the upper right corner connects the notes that were taken to their source and page number. Also, the page is referenced on the note card. For example, on the first note card, the source was #5 and the page number was 93.



- Use the examples above to introduce the concept of using a formatting style for ensuring that the information about the reference is complete. Tell students there are many different styles. Many professional organizations have their own style. Likewise, publishers will require a certain style. In college, professors usually require students to use a particular style. There are guide books and online resources for each style. See Notes to Teachers for online access to MLA style.
- Distribute Handout 1, which is a guide to the use of the Modern Library Association (MLA) style for writing citations that provides examples of a citation for common types of references, such as, books, periodical articles, newspaper articles, Internet sources. Ask students what they observe as they compare the citations. Help students, if necessary, recognize that:
    1. The format of the documentation differs according to the type of source.
    2. There is logic to the MLA style; there is a consistency in the punctuation, regardless of the type of source.

  Assure students that they don’t need to memorize the protocol. The handout is their guide.
- Optional practice using a Jigsaw: Place students in 5 expert groups. Provide each group with a type of source: a book, a magazine article, an encyclopedia article, a newspaper article, a website (Handout 2). Be sure each source has all the information the students will need to write a citation using the MLA style. Each group prepares the citation using the MLA style depicted in Handout 1. Each student writes the citation on a small index card. Assign students in each expert group consecutive numbers. Each number corresponds to a new group. Regroup students into the new groups, #1, #2, #3, etc. In the new groups, each student presents to the group the citation that was created. Ask students to compare the citation to the example in the Handout. If there is a question about

whether a citation has been formatted correctly, students present the sample to the class for approval or correction.

Teacher's Notes

** For teachers not familiar with the structure of jigsaw grouping: When the students in the expert groups are assigned numbers for regrouping, the numbers should go no higher than the number in the smallest group. For the larger groups, once that number is reached, begin numbering again in the group beginning with #1 until all students have a number. To regroup students for the presentations, number the locations in the room so that students with the same number are sitting together.*

Activity Two: Gathering and Analyzing Information

- Make arrangements with the principal and media specialist(s) to ensure students can use the media center as necessary. Provide the school's media specialist(s) and local library's reference librarian(s) with the research timeframe and a list showing the research question for each student or team.
- Students conduct their research. Establish a schedule and process for student consultations. For example, post a calendar that includes the dates and times for each student's consultations. Instruct students to bring their completed note cards, their Action Plan, and any successes and problems they want to discuss. Listen for bias and help students be aware of their own preconceptions and biases that may be influencing their research and interfering with their maintaining a scientifically objective perspective.
- Provide additional guidance to students who will be developing surveys or experiments. (Refer to Notes to Teachers below) Be sure that these students begin their research by first gathering sufficient background information.

Teacher's Notes

** It's helpful to secure volunteer experts to serve as mentors. Often there is a local Retired Professionals Association for locating individuals. The PTA/PTO may also be a resource. Sometimes university professors will volunteer. For students conducting research or experiments, mentors are extremely valuable because these students will require more assistance than the teacher may be able to provide, both in terms of time and expertise.*

**Prepare mentors for working with the students. Give them the evaluation rubric.*

Handout #1

How to Use the Modern Library Association (MLA) System for Citing Sources

- ***Helps you document your search***
- ***Helps you create a Works Cited page at the end of your research***

MLA Sample Citations (from a variety of sources)

Confused about citations and source card "fields"? When it comes time to make the final page of your product, the "Works Cited" page, you must list all of the sources you used in your researching, with "fields" like copyright date, URL address, author, title and more. This handout will help you do the citations correctly the first time.

How to use this handout.

On the following page are samples of all the kinds of media you might use as sources.

For each citation card you prepare:

1. Copy the "fields" needed for the type of media you used (book, web site, magazine, interview, newspaper article) as shown below. *You will see that there are different "fields" for different media: books, web sites, magazines, interviews, etc. all have their own required fields.*

2. Write beside each field the information from your source.

3. Be sure you place a number on the top of the card to indicate which of your sources it is.

If you need more help, samples of citations and Works Cited pages can be viewed at: **http://mciu.org/~spjvweb/mla.html**

Using technology to make citations

To make citations fun and interactive try the interactive, free "Son of Citation Machine," which guides you and then prints out a Works Cited page. Go to: **http://citationmachine.net/**. Son of Citation Machine can be used for MLA (used in this unit), APA, Chicago and Turabian.

Handout #1 (continued)

Media Source	**Fields**
Book	Author's name (last name, first name) Year published Title of book Place published (New York, for example) Publisher (Scholastic, Inc. for example) Page(s)
Magazine article	Author's name (last name, first name) Date the magazine was published "Title of article used" Title of the magazine Page(s)
Web Site	Author's name (last name, first name) Date published on that site (or last updated) "Title of article" Name of the organization that made the site web address (URL or www electronic address) Date you visited and accessed this site
Newspaper article	Author's name (last name, first name) if given "Title of newspaper story" Date the story was in the newspaper Name of the Newspaper Place published Page(s)
Interview or email exchange	Writer's name (your last name, first name) Subject (interview with a scientist, for example) Document description (transcript of interview or email exchange) Date of document or interview

Handout #2

Information on Kinds of Sources

Newspaper article on the Internet

Author: Donald W. Lyons
Newpaper: Herald-Dispatch
Date: October 1, 2006.
Title: Wind power is good investment for W.Va.
Url:
http://www.heralddispatch.com/apps/pbcs.dll/article?AID=/20061001/OPINION/610010318/1034/ARCHIVE

Website

Author: Lester R. Brown
Website article
Date: June 25, 2003-4.
Title: "Wind Power Set to Become World's Leading Energy Source."
Organization: Earth Policy Institute
Website url:
http://www.earth-policy.org/Updates/Update24.htm

Encyclopedia

Encyclopedia Britannica
Author: Janet McCleary
Article: Windpower
Edition: 2003

Book

Author: Hanie Ito
Book: Alternative Energy for the Twenty-First Century
Pages cited: pp. 42-58
Date: 2004
Publisher: Manahan
City and State: Buffalo, NY

Magazine

Magazine: Wind Power Times
Author: Maurice Bernstein
Article: What Is the Downside of Wind Turbines?
Date: January, 2006
Journal Number: 10
Pages: 15-22

How to Create Your Bibliography or Works Cited Page

The **Works Cited** page is a separate page at the very end of your project. The Works Cited page is a list in alphabetical of the sources you used in your research project. The Works Cited page lists all the sources you used in your research. This includes

- books
- magazine articles
- interviews
- websites
- databases
- media sources
- primary sources

The page should be titled, “Works Cited.”

Entries should not be numbered.

Each entry must end with a period.

Entries should be double-spaced within a source and between sources.

Entries should be listed in alphabetical order by the author’s last name. If a source does not name an author, alphabetize by the first major word of the title (not “A,” “An,” or “The”)

The Works Cited page should be numbered in sequence. If your report is 8 pages long, then the Works Cited page is page number 9. In the upper right hand corner of the Works Cited page, type your last name and the page number.

What follows is a **sample** Works Cited page by a student whose last name is McDonagh

Works Cited

- Barry, L. Patrick. *Earth's Fidgeting Climate.* NASA.>http://science.nasa.gov/headlines/y2000/ast20oct%5F1.htm<. January 17th 2007.
- Feinstein, Dianne. "Transcript of speech as recorded in the Congressional Record. June 21, 2005."
- *Edmunds Automobile.* 1995-2007. >http://www.edmunds.com/hummer/index.html<. January 23, 24, and 29, 2007.
- EPA. Feb. 5th, 2007. >http://www.epa.gov/<. Jan.23rd, 30th, Feb. 5th.
- Gutsch, Jochen-Martin. Jan.18, 2007. *A Small Fish Becomes an Indicator of Global Warming.* Spiegal Online International. >http://www.spiegel.de/international/spiegel/0,1518,459995,00.html<. Jan.18, 2007.
- Johnson, L. Rebecca. 1990. *The Greenhouse Effect*. Minneapolis, MN. Lerner Publications Company. 43- 47, 16.
- Global Warming. >http://www.mililanins.K12.hi.us/depts/science/global_warming/politics.htm<. January 16, 2007.
- MSNBC. January 30, 2007. *Bush pressure seen on Climate Experts.* >http://www.msnbc.msn.com/id/16886008/<.
- Steitz, E. David. July 20, 2000. NASA. >http://ftp.hq.nasa.gov/pub/pao/pressrel/2000/00-112.txt<.
- *Sen. Inholf: Climate 'Hysteria' Targeting Kids.* January 30, 2007. >http://www.newsmax.com<.

Notes to Teachers

- Activity One may not be necessary if students already have note-taking skills for documenting research. Some students may have access at home to, or the school may provide, an electronic research notation tool, such as *EndNote*. An abbreviated version of Activity One may be used as a review.

- For online guidance that is comprehensive on formatting all kinds of sources using MLA style:
  http://www.liu.edu/cwis/CWP/library/workshop/citmla.htm

- Refer to the companion module for guidance on:
  - Use of primary sources, including interviewing and surveying
  - Locating information
  - Extracting relevant information from sources
  - Identifying information gaps or inconsistencies in the data

Learning Experience Seven

Analyzing, Evaluating, Synthesizing Information

Overview

After students have spent a few days conducting independent research and meeting with the teacher for individual consultations, it is important to take time to analyze and evaluate all the information collected and determine whether there are gaps, inconsistencies or biases. Cooperative learning groups provide a safe and supportive environment for students to engage in these critical activities. The group process also offers opportunities for students to learn research strategies from each other.

Evaluation

Students write a reflective paper, documenting what they have learned through the analysis and evaluation of their research findings and how they have adjusted their action plan in response to what they have learned.

Materials

- Each student's research notes and references, and action plan
- Handout 1: How to Write a Status Report
- Handout 2: How to Provide Feedback

Activity One: Preparing a Brief Status Report

Notes to Teachers

**Give students advance notice of this activity and ask them to bring their research notes and references, and their action plan.*

**Even if working with a partner, each student should prepare and give a report.*

- Instruct students on how to prepare a 5-minute status report with a visual, which they will present to 2 other students. Distribute and review Handout 1, How to Prepare a Status Report and Handout 3, Guide for Listeners. The latter, which is an excerpt from the final performance rubric, serves as a guide for students to assess the status of their research. It's not necessary at this time that the questions can all be answered affirmatively. Rather, a negative answer to any question is a signal for w still needs to be
- Allow a class period for students to prepare their report so that you can provide assistance, assigning as homework the completion of this report.

Activity Two: Evaluating the Status of Research using Cooperative Learning Groups

Notes to Teachers

**Give careful consideration to the composition of the groups. It isn't necessary for students to be grouped according to topic or methodologies (i.e., surveys or interviews vs experiments vs internet/library research). Groups should be diverse with regard to learning styles and talents so that there are rich opportunities for students to help and learn from each other.*

- Assign students to groups of 3. Provide instructions for the reports, distributing and reviewing the Handouts 2 and 3, How to Offer and Accept Feedback and Guide for Listeners.
    - Agree on ground rules for giving and receiving feedback, such as, offer ideas in a constructive manner, no put downs, accept feedback politely and without comment, always be respectful.
    - Listeners use the Handout, How to Offer and Accept Feedback, as a guide. For example, listeners look for evidence of bias and for inconsistencies in the data. They can consider questions the report raises for them that might mean there are gaps in information that was collected. Listeners take notes during the report.
    - Students who are reporting also use the Handout as a guide. They must limit their presentation to 5 minutes. Assure students that they do not need to accept feedback, but should consider it carefully before rejecting any of it. When listening to the feedback, the presenter takes notes.
- Act as timekeeper, allowing each student 5 minutes for the report. 2 minutes for clarifying questions, and 8 minutes for receiving feedback.
- Assign students the task of preparing a reflective paper, documenting what they have learned through the analysis and evaluation of their research findings and how they have adjusted their action plan in response to what they have learned.
- After reading the reflective papers, consult with students as necessary.

Handout #1

How to Prepare a Status Report

Why would you prepare a status report?

A status report tells what you have learned. It is understood that you are only part way through your research. The purpose is to organize what you now have collected so you can determine:

- ✓ Are you on track? That is, are you still working toward your answering your research question?
- ✓ Are you missing any important information? What else do you need to find out?
- ✓ Is your information unbiased, or at least fair in covering all the different opinions?
- ✓ Do you have any conflicting data? Information that is strictly factual should be the same regardless of the source, but sometimes it isn't. Has this happened to you?

Here are the steps you will take in preparing your report

1. Sort your research notes in the way you would like to share your information in your status report. Here are some examples:
    - The information can be organized historically, by date, so that you can tell a story about how the information you found grew and changed over time.
    - You may have different areas of information. You could then group your notes by subject. If you your question was, '*What can be done to minimize the impact of an oil spill on the environment?'* your subjects might include the reasons for oil spills, the largest oil spills, the environmental consequences, the economic consequences, laws created to help prevent oil spills, etc.

2. Write your report. Even though you will be giving it orally, you will need it written, so you can practice reading it to be sure you can tell it in 5 minutes. Include:
    - ✓ Your research question
    - ✓ The reason why you chose this question
    - ✓ What you have learned so far, organized according to the plan you selected in step #1 above. It's not necessary to read all your notes. Decide what you need to tell that gives the listener a complete picture of what you have learned. Tell about the sources you used.
    - ✓ As you prepare your report, take the opportunity to critically review your research. Here are some tips:
        1. Are there gaps in the information? You'll notice this if you find yourself asking more questions. Include these new questions in your report.
        2. Do you have data from different sources that contradict each other? If they are just different opinions, that's OK, but examine the facts that are used to support an opinion for accuracy and thoroughness. You may have to do more research later to verify the accuracy of the facts.

Handout #2

How to Offer and Accept Feedback

Whether you are the presenter or a listener:

Always be respectful.

When you are in the role of a listener:

1. **Wait until the presenter has stopped speaking before you talk.**
2. **First ask questions if you don't understand something that was said.**
3. **Then provide your feedback politely and as clearly as you can.**
4. **As much as possible, give specific examples in your feedback.**

When you are the presenter:

1. **First ask for questions about anything that was unclear to your listeners.**
2. **Answer any questions as briefly as possible to leave time for the feedback. The teacher will only allow 2 minutes.**
3. **Listen quietly to your classmates' feedback, unless you don't understand the feedback and need to ask for clarification.**
4. **Take notes on the feedback so you can review it later.**

Handout #3

Guide for Listeners

Instructions: Write down evidence or an explanation to support each answer that you give. You may not be able to answer every question.

1. Is the information collected focused on answering the research question?
Yes or No
Evidence:

2. Were many sources used to be sure facts were accurate?
Yes or No
Evidence:

3. Is the information well organized so it is understandable?
Yes or No
Evidence

4. Have different opinions been represented and explored?
Yes or No
Evidence:

Notes to Teachers

Refer to the *companion module* for guidance on evaluating the data for information gaps, biases and inconsistencies, and for synthesizing the data.

Learning Experience Eight

Finalizing the Research

Overview

Students continue to conduct research and engage in consultations with the teacher until the previously agreed-upon deadline. Students then follow a procedure similar to Activity One in the previous Learning Experience (LE) for organizing all the information, then analyzing and synthesizing their findings. At the end of this LE, students will have constructed an answer to their research question, and posed more questions.

Evaluation

Students prepare a one-page summary of their research according to given criteria.

Materials

- Students' research notes and references
- Handout: Guide to Preparing a One-Page Summary

Activity: Preparing a One-Page Summary of the Research

- Tell students that this is an opportunity for them to organize their research findings and draw conclusions. The end result of this activity will be a 1-page summary of their research results. This exercise will prepare them for the next and final activity: to plan and present their final product.
- Distribute the Handout: Guide to Preparing a One-Page Summary. Review the instructions to ensure students understand the process.
- Allow students who have partners to work together, but ask each student to write his or her own summary.
- As you circulate, ask provocative questions about the data and students' findings.
- When students have organized their findings and are in the process of working on their interpretations, provide a class period for students to discuss their data and preliminary conclusions with classmates, and obtain input. To ensure that every student has time to give and receive help, keep groups small and structure the group time. The process used in Activity Two of the previous LE (7) can be used as a model. In this case, students wouldn't be preparing a formal presentation, but would instead be speaking informally about their research, or a particularly troublesome or confusing piece of data for which they would appreciate input from others. Partnering researchers can be given the option of remaining together or being in different groups. Adjust group size accordingly so that there are no more than 3 studies being discussed in each group.

Teacher's Notes

* Expect that some of this activity will be conducted as homework. Review work that is completed outside the classroom and provide feedback.

Handout

Guide to Preparing a One-Page Summary

1. If you haven't already done so, organize your information. You may decide to use the same organization as for the Status Report, or select a different way of organizing.

2. Organize your references: Using the system agreed upon, prepare a bibliography. Your resource is the Handout, Examples of Source Citations Using MLA Style. Number your alphabetized list. You will use the numbers in your Summary.

3. Review, and then analyze all the information you have collected. The various research methodologies will require different strategies. You will all have conducted some internet and library research, but you may have also collected data by conducting surveys, interviews or experiments. Your goal is to find one or more answers to your research question.

4. Write your Summary:
   - ✓ Paragraph 1: Write your research question and state why you are interested in it.
   - ✓ Paragraph 2: Describe the evidence you have, and where you found the evidence. Remember to begin with a topic sentence. Do not include complete references. Instead, include in parentheses the *number* of the reference from your bibliography. For your own survey tallies and data from your own experiments, state that the data came from your own survey or experiment.

     Helpful Tip: To keep your summary brief, it may help to imagine you are an attorney delivering a final summation to the jury. What is the most convincing evidence you found? Or, what is the most convincing way to summarize what you want the jury to know?

   - ✓ Paragraph 3: What are new questions or interests that this research has raised for you? Don't forget to begin with a topic sentence.
   - ✓ Attach your Bibliography or Works Cited page(s).

Notes to Teachers

- The skills of analysis and synthesis that will be employed here are challenging even for adults. Discussion groups and your continuous mediation will promote higher level thinking. A simple technique is to think out loud as you're helping students. This models for them how one engages in the process of higher level thinking.
- It is more difficult to write a concise and clear 1-page summary than a longer report. Encourage students to write without too much attention to length. Then provide students with strategies for editing. English/language arts teachers are an excellent resource for editing strategies.

Learning Experience Nine

Planning the Final Product

Overview

Students are given choices on how they will present their research results. This LE provides a process for this decision making, and the ways the students and teachers can use the Final Evaluation Rubric to enhance the quality of the final product.

Evaluation

The students' final products are evaluated using the Final Evaluation Rubric.

Materials

- Handout: Final Evaluation Rubric
- Chart paper, overhead projector or white board and markers

Activity: Deciding How to Communicate the Research Findings

- Congratulate students on the completion of their research. Invite students to describe their greatest challenge and the part of the research that gave them the greatest sense of satisfaction. Encourage a freely flowing conversation among the students, so that they are sharing their experiences, rather than talking to the teacher. Seating students so that they are facing each other facilitates this.
- Explain that the final step for any researcher is to communicate her findings. Ask students to offer reasons why communication of research results is so important. It's important that students know that they can use their research results to positively impact society or the natural environment, locally, regionally, nationally or globally.
- Ask students to think about the audience with which they want to communicate their particular results. Record their ideas. Ask students to justify their choices. For example, if a research question asked what the community knew about a topic, a logical and appropriate audience would be that community. If the findings advanced the scientific knowledge, one likely audience would be the scientific community.
- Ask students to now suggest strategies (venues and means of communication) for reaching each of these audiences. Post their ideas. As examples, a local community can be reached through an article in the local newspaper, a radio interview, a report at a town council meeting or a called meeting, to name just a few of many other possibilities; the scientific community can be reached by creating a website and posting the results, creating a blog (this would be unusually informal, but would encourage feedback), or arranging with a local

university to offer a presentation at a scheduled departmental meeting, Point out, if necessary, that presenting an oral or written formal report are not the only means of communication. Students can convey their information through, for example a skit, song, poem (presented or published, or both), cartoon, mural, exhibit, or poster.

- Give students time to consider, for their own research results, which audience and what strategy they prefer, selecting something that is feasible and offers a good chance of having a positive impact (see Teacher's Notes). The strategy should include both the venue (e.g., a PTA/PTO meeting) and mode of communication (e.g., skit). If students can't decide on an audience and/or can't think of a feasible strategy, open the problem to the entire class for brainstorming. Students who are working with others should talk with their partners. Partners can either work together or separately.
- When all students have made their decisions, ask them to submit them in writing for approval. You, a mentor, or family member will likely need to help make arrangements for each of the different audiences and venues. Set a deadline for completion.
- Distribute the Handout: Final Evaluation Rubric. Discuss each criterion, being sure students understand. Provide, or have students provide examples of how the criteria would be demonstrated, based on their own particular choices for communicating their results. Continue to help students meet all the criteria as they prepare their final products.

Teacher's Notes

**Encourage students to consider a means of communication that stands a good chance of having a positive impact. Therefore, if the choice of audience is between the class and the entire student body, the latter may be a better choice, if feasible. The choice of strategy should be held to the same scrutiny. Products may even include service to the local community. For example, if the research results pertain to conserving fossil fuels, a product could include creating a tips sheet on how to conserve (which is economically advantageous for the individual while reducing greenhouse emissions and saving resources). The student can then arrange with local government on an effective way to broadly distribute the information. Going further, the local government or utility company may be encouraged to piggyback existing or new incentives along with the student's product.*

Depending on your particular content learning goals, you may choose to revise the rubric. Be sure that any criteria you add are measurable or observable.

Handout

Final Evaluation Rubric Page One

Criteria	Descriptors
Data Collection	
There is strong factual evidence to answer the research question.	There are many different, reliable sources of information focused on the research question.
The research methods match the question.	Surveys or experiments are conducted when necessary, Sources used are appropriate.
Many sources were used to be sure the facts are accurate.	Information is documented with citations from at least 2 sources.
The sources appear to be reliable.	Scientific data comes from scientific sources (researchers), original sources are used when available.
Bias is revealed (if appropriate) and addressed.	Claims that aren't supported by facts from 2 or more other sources are identified as likely biased or incorrect.
The information is adequately referenced.	Citation style is used consistently, every source has a citation.
Analysis and Synthesis	
The information/data presented addresses the research question.	The information has an obvious connection to the question.
Different opinions are represented and explored.	At least 2 different opinions are presented and either supported or refuted by data from other sources.
The researcher's own opinions and beliefs are acknowledged.	The author identifies his or her own point of view or belief on the subject, giving facts to support or refute.
The results or answer(s) reported are supported by reliable facts.	There is a logical and obvious connection between the researched information and the stated result.
New questions or areas for research are given.	The author suggests at least one new research question or area of interest linked.

Final Evaluation Rubric Page Two

Criteria	Descriptors
Communication of Results	
The choice of audience is appropriate.	The audience matches the topic and research question, are people who are interested and can use in the results.
The choice of venue for communicating is effective.	The place is one that the specific audience would likely visit (either physical location or on the internet, radio station, etc.).
The information is presented in a way that is clear and understandable.	A reader or listener can tell back accurately the message(s) the author is presenting.
The choice of product and presentation is strategic, demonstrating social responsibility.	Given the options, the choices were made intentionally to have the greatest impact possible.