

CHAPTER 7

Web-Based Science Inquiry Projects

Alec M. Bodzin

Student groups in Juanita Jones' science classroom are investigating marine mammal migration patterns. Each group examines web-based archived migration data sets of different species that have had satellite tags placed on them. The elephant seal group notes that their seals travel 3,000 miles and arrive on a California shore at two different times during the year. In addition, they observe that both males and females arrive at the same location in the winter, but return to the same place at different times during the year. Students make inferences about the purposes of their visits to shore and raise new questions. They then consider scientists' research concerning the seals' migration. Finally, they communicate their findings to their classmates with a PowerPoint presentation that highlights the different migration patterns of male and female elephant seals.

This vignette illustrates a web-based inquiry (WBI) learning activity. Such activities support students as active learners. In these activities, students do not wait for a teacher or someone else to provide an answer. They conduct investigations with meaningful questions about everyday experiences, evaluate evidence critically to seek solutions, and ask new questions. Such inquiry-based approaches allow students to learn scientific practices by using those practices realistically. Learners who experience inquiry-based activities and instructional methods develop a broad understanding of science, along with the critical reasoning and problem-solving skills involved in scientific reasoning.

The web can be used to support inquiry learning in many classroom science investigations; however, not all web-based science activities are inquiry-learning activities. In fact, the majority of science activities on the web are designed to provide learners with scientific facts and concepts and do not engage learners with using scientific processes.

Web-based inquiry (WBI) projects are based on *Inquiry and the National Science Education Standards'* (NRC 2000) five "essential features" of scientific inquiry:

- ▶ Pursuing a scientifically oriented question.
- ▶ Collecting evidence related to that question.
- ▶ Drawing conclusions based on that evidence.
- ▶ Considering alternative conclusions.
- ▶ Communicating and justifying conclusions.

WBI projects require learners to use evidence and practices of the same type actual scientists use. Further, their activities emphasize reasoning and critical discussions of conclusions. Such inquiries may be *standalone* or *teacher facilitated* and may call for a combination of online and in-class activities. These projects combine group and individual work as appropriate. The extent to which the teacher directs or facilitates varies according to the nature of the inquiry. You can use the criteria listed in Table 1 to help you evaluate the characteristics of WBI activities.

Table 1.

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Criteria for Evaluating a Web-Based Inquiry (WBI) Activity.

Characteristics	Criteria
Three Inquiry Essentials	Does the WBI contain at least the first three essential features of classroom inquiry described in <i>Inquiry and the National Science Education Standards</i> (NRC 2000)?
	Learners are engaged by scientifically oriented questions that are stated explicitly or implied as a task.
	Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.
	Learners draw conclusions and/or formulate explanations from evidence to address scientifically oriented questions.
Learner Centered	Is the WBI phrased in such a way that learners would perceive it as directed at them? In a learner center project, the majority of the wording used in the WBI is directed at the learner (“you”), not at the teacher (“your students”).
Student Learning Science Concept or Content	Does the project support student learning of a science concept or science content? Science WBIs should fall into a recognized science discipline (biology, chemistry, physics, environmental sciences, astronomy, oceanography, and the like).
Web-Based	Is the WBI web-based? A WBI should be more than reformatted text from printed sheets placed on the web, describing how an inquiry activity may be completed. Instead, it should be enhanced or customized to take advantage of the features of the web to deliver instruction.

Scientific Evidence	Is the evidence used in the WBI of the same type an actual scientist would use?
Conclusions or Explanations Involve Reasoning	Are the conclusions and explanations in the WBI more than simple data analysis and reporting? They should involve reasoning.

Most WBIs are developed by science educators at universities, government agencies, and informal science education organizations and often take advantage of a variety of technology-based instructional resources that textbooks and other print materials are unable to offer (Bodzin and Cates 2002). Only a desktop computer containing a web browser (such as Internet Explorer, Safari, or Netscape) and an internet connection is needed.

Communication

Communication is an important feature of web-based inquiry projects. In an inquiry, the intent of communication is to share explanations and conclusions in order to permit one's fellow scientists to "ask questions, examine evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations" (NRC 2000, p. 27). Communication involves sharing with an audience other than the teacher. In a WBI activity, an audience might consist of fellow students, other users of the website, the website's developer(s), or a scientist.

There are three main types of science inquiry projects on the web:

- ▶ Comprehensive websites
- ▶ Collaborative projects
- ▶ Curricular enhancement activities

Types of WBI

Comprehensive Websites: Comprehensive websites are usually large websites that include both curricular activities and web-based resources to support an in-depth study of a particular science topic or geographical area. These sites contain instructional materials that meet all WBI criteria and often include scientific data or other materials that constitute "evidence" for an investigation. In addition, comprehensive websites contain important background knowledge that learners may need to understand to complete an inquiry. The WhaleNet website (<http://whale.wheelock.edu>) at Wheelock College is an example of a comprehensive site that provides extensive marine mammal background information and WBI activities that use authentic data sets to study marine mammal migration patterns.

Collaborative Projects: Collaborative projects involve learners from diverse geographical locations using a shared database to complete an investigation. In these investigations, evidence is used in two distinct ways. First, learners are provided with a protocol to collect certain data. Once collected, these data are submitted to a collective database. Next, the website provides learners with cumulative data from diverse geographical locations and prompts learners to analyze the cumulative data. In many collaborative projects, the host website also provides a discussion area for students to share thoughts and report conclusions. The Annenberg Media’s Journey North Monarch Butterfly website (www.learner.org/jnorth/monarch) is an example of a collaborative project that permits learners to investigate the monarch butterfly annual migration through North America.

Curricular Enhancement Activities: Curricular enhancement activities are topic-oriented investigations designed to augment one’s science curriculum. These activities are designed to be applicable to a wide range of audiences. Typically, the length of these activities may vary from one day to two weeks. Projects may take a variety of forms. For example, students may develop solutions to problems such as designing a bridge that can endure an earthquake, or they might investigate a critical habitat in a wetland and prepare a report to persuade others of the value of protecting that site. The *Earth Exploration Toolbook* (EET) chapter, “When is Dinner Served? Predicting the Spring Phytoplankton Bloom in the Gulf of Maine” (<http://serc.carleton.edu/eet/phytoplankton>) is an example of a curricular enhancement activity, in which learners investigate the timing of the spring phytoplankton bloom in the Gulf of Maine and predict where the bloom should occur.

What the Research Says

Online inquiry projects began with the idea of creating communication links among classrooms to share e-mail and data. In 1986, a series of projects was created to link classrooms through telecommunications to become a global school community. These projects, such as the National Geographic Society Kids Network (TERC 1986), were designed for students to investigate authentic problems that were not yet solved by scientists. They would collect and submit data to a centralized community database, make interpretations of the data, share thoughts and ideas across the network, and elaborate on the ideas put forth by others.

In the early 1990s, TERC and other science education groups created a group of subsequent “network science” projects. These included Global Lab (TERC), Kids as Global Scientists (University of Michigan), Classroom BirdWatch (Cornell Lab of Ornithology), and EstuaryNet (Wells Estuarine Reserve, Maine). These pioneering projects promoted important features of inquiry-based instruction and took advantage of computers with Internet connections for use in schools. Successful

teacher participation in these complex and demanding curricular projects required a great deal of expertise in a diverse set of areas, including time management and inquiry-based teaching approaches (Songer 1998).

Research findings from these “network science” projects have noted that the design of the curricular activities and the nature of support provided for these projects plays an important role in promoting student understandings (Feldman et al. 2000; Songer 1998). In these projects, the use of real-time internet resources and using collaborating students as information resources for data reporting has the potential to enhance student understandings of scientific phenomena. For example, the peer-to-peer dialogue of students in the Kids as Global Scientists project included explanations and information about scientific information (Songer 1996). However, researchers also contended that, when collaborative projects do not design materials to promote reflective discourse that engages students in critical discussions about their data, the student dialogue may tend to be more social in nature and not related to the scientific investigation being studied (Feldman et al. 2000).

Web-based science curricular enhancement activities were being developed in the mid-1990s by university, informal science educators, and corporate partnerships with schools. By the late 1990s, science education website developers began establishing large comprehensive websites that included both web-based resources and curricular activities. Information about select science inquiry projects on the web is provided in the box on the following page.

Guidelines for Best Practice

Like most curricular activities, WBIs do not accommodate every learner, classroom teacher’s pedagogical style, or classroom-learning environment. The following design guidelines modified from the Synergy Communities Aggregating Learning About Education (SCALE; <http://scale.soe.berkeley.edu>) curricular framework describe a helpful way for using a web-based science inquiry project (Bodzian and Shive 2004):

(1) Provide a motivating entry point.

Provide an activity or story to introduce the project and motivate student interest (e.g., an introduction to a locally relevant problem or a fictional story). The project should begin with phenomena that students find interesting. The focus of the investigation should be local. For example, if conducting an investigation to compare ponds in the United States, show digital photos of a nearby pond that has been used as a trash disposal area to illustrate a local environmental problem. Provide students with opportunities through class discussion to demonstrate that they understand the issue and what they might need to do to address it. Include background information about the problem or about the physical setting if needed.

SELECT SCIENCE INQUIRY PROJECTS ON THE WEB**Comprehensive sites**

GLOBE (Global Learning and Observations to Benefit the Environment): The GLOBE program is implemented through a cooperative agreement between NASA, the University Corporation for Atmospheric Research (UCAR) in Boulder, Colorado, and Colorado State University in Fort Collins, Colorado. The GLOBE program supports a worldwide network of students who make environmental observations. Data is submitted and used for the developing scientific data visualizations. The site includes many inquiry-based learning activities.

(www.globe.gov)

Water on the Web: This extensive website for lake and stream water quality investigations resides at the University of Minnesota. Data is provided in real-time and archived formats from Remote Underwater Sampling Stations and stream monitoring stations located in Minnesota, as well as from cooperating projects nationwide. Data visualization tools enable students to watch data change through time, and view several parameters simultaneously.

(<http://waterontheweb.org>)

Collaborative Projects

Pathfinder Science: This project was established in 1997 with support from a U.S. Department of Education Technology Innovation Challenge grant as the Kansas Collaborative Research Network. Activities use a guided research inquiry framework for environmental and biological science investigations. The website includes protocols, data submission, retrieval from interactive databases, background information for research areas, and a publication area for students to submit and display their research work.

(<http://pathfinderscience.net>)

Classroom FeederWatch: Developed and located at the Cornell Lab of Ornithology, this project was once known as Classroom BirdWatch. Students construct bird feeders and conduct a winter survey of the birds that visit feeders in North America. The collected data is used each year by ornithologists to track changes in the abundance and distribution of bird species that use feeders in winter.

(www.birds.cornell.edu/cfw)

CEISE Collaborative Projects: This website is developed by the Stevens Institute of Technology's Center for Innovation in Engineering and Science Education. The site houses a series of collaborative projects in a variety of science topics. Student-collected data is contributed to a shared, web database. Activities involve student publishing on the web.

(www.k12science.org/collabprojs.html)

Curricular Enhancement Activities

Project Athena, Earth and Space Science for K-12: This site was developed in partnership by Science Applications International Corporation and the Office of Superintendent of Public Instruction in the state of Washington. This site includes curricular activities for the study of oceans, Earth resources, weather, space, and astronomy. (<http://vathena.arc.nasa.gov>).



WISE—Web-based Inquiry Science Environment: This website from the University of California, Berkeley contains a variety of secondary science projects in life, Earth, and physical science topic areas. Projects are interdisciplinary and primarily focus on real-world application of science-process skills. (<http://wise.berkeley.edu>).

(2) Provide access to authentic data.

Provide students with opportunities to explore authentic data. Data may originate from students' own data collection, historical data, a simplified data set, or elsewhere. The data should be authentic, come from a reputable source and relate directly to the problem at hand.

(3) Provide students with the means to make sense of the data.

Provide students with access to materials and activities that help them to understand and interpret the data. This includes making sure important background information is included and tools are provided that help students organize data and identify patterns. Data sets need to be simple in design. Real data tends to be messy, and large data sets are often cumbersome to work with. Ensure that students have

a goal of developing a scientific explanation, grounded in the data, for addressing the investigative question. For example, in a pond study this explanation could address whether or not the water is safe to use in different ways (swimming, fishing, for livestock, etc.) or could explain historical trends in the data (evidence that pollution is getting better or worse). This explanation would likely provide details of mechanisms that drive water quality (e.g., eutrophication), and use data to support its claims.

(4) Provide an opportunity to develop a culminating experience or a final artifact.

Have students create a final artifact or participate in a culminating activity tied to the explanation. This could be participation in a debate or creation of a poster or PowerPoint presentation. The intent of the culminating experience is to provide learners with the opportunity to communicate their findings to an audience. In the pond study example, a presentation could be given to a local government policy-making group.

(5) Provide flexibility.

Web-based inquiry projects should be flexible to promote active participation of classrooms. Be aware of the time demands of the project. Some projects are more flexible with deadlines for data gathering and submitting data than others.

Examples of Best Practice

Three examples follow that illustrate how WBIs may be used effectively in science classrooms.

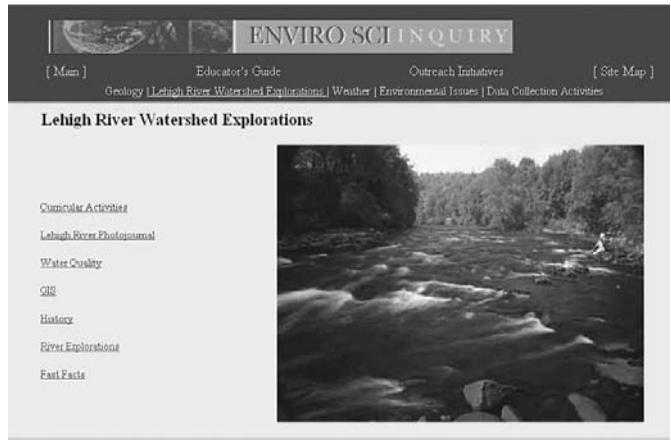
Lehigh Earth Observatory (LEO) EnviroSci Inquiry
(www.leo.lehigh.edu/envirosci)

The LEO EnviroSci Inquiry is a comprehensive website at Lehigh University containing a variety of instructional materials designed to support investigations in the Lehigh River watershed. To motivate learners to understand an important aspect of watershed studies, a teacher has students complete the Dissolved Oxygen activity. This WBI activity highlights chemistry understanding and assists learners in understanding how to analyze and interpret water quality data. The teacher introduces the Lehigh River watershed by presenting MPEG movie watershed flybys located in the Lehigh River Watershed Photojournal to provide students with a graphical overview of the topography of the watershed area. GIS maps from the website are then shown to highlight how streams, tributaries, and the river connect to each other. Cities are added to the GIS map to illustrate population centers along the river.

In class, students use the Photojournal to virtually explore the area. They also look at the History of the Lehigh Watershed section to learn how science and technology have impacted the watershed over time. Prior to a water quality sampling trip to a nearby stream, students use the Water Quality website section to become familiar with water quality background information and probeware sampling protocols for data collection. Data is collected during a field trip to a stream and is then submitted to the LEO Partner Schools water quality database. The students' data is compared to other water quality data located in the database, including data from the same sampling location taken by the teacher's classes from previous years. The teacher prompts students to compare relationships between water quality variables. The students construct a series of posters highlighting their investigative findings of water quality in the watershed, and they present their posters to the public during the school's community outreach night.

Figure 1.

Home page for Lehigh River Watershed Explorations.
(www.leo.lehigh.edu/envirosci/watershed)



Human Genetics: Is the dominant trait most prevalent?

CEISE Collaborative Project website at the Stevens Institute of Technology's Center for Innovation in Engineering and Science Education

(www.k12science.org/curriculum/genproj)

The CEISE Collaborative Project is designed for students to investigate the prevalence of dominant alleles of particular human traits in the general population. Students are intrinsically motivated to investigate why some of their physical characteristics may differ from others. A teacher presents the students with the activity's driving question for the investigation. A classroom survey of select trait differences are conducted that include free or attached earlobes, curved or straight thumb, straight or bent pinky, and the presence or absence of white forelock, dimples, mid-digit hair, and colorblindness. The teacher then asks the students if they think the class data is characteristic of the general population. After a discussion about sample sizes, the teacher presents the Human Genetics web-based project and informs the students that their class data will be contributed to a much larger database containing traits from students across the

world. After the class data has been submitted and verified by the website's project staff, the students download the cumulative database as an Excel spreadsheet file. Students analyze the large data set and note the phenotype percentage displayed for each trait. Possible genotypes for each trait are discussed in class, and then students construct a data-supported response to the question, "Is the dominant trait most prevalent in the sampled population?" The class discusses what might cause a recessive trait to be more common in a population and posts a report describing the investigation to the "Final Reports" area of the website.

What's in a House?

(<http://wise.berkeley.edu>)

What's in a House? is a WISE (Web-based Inquiry Science Environment) curricular enhancement activity at the University of California, Berkeley, in which students design an energy-efficient house for a desert environment. In class, students are learning about heat and energy. To set the stage for the activity, the teacher asks the students to think of ways they might make their home more energy efficient. Next, the teacher introduces the WISE activity by asking the question, "What is the best way to design a desert home?" Students must design an energy-efficient house for a desert climate that will keep cool in the daytime and warm during the night. In groups, students complete a sequence of web-based activities to learn about plant adaptations for reflective surfaces, heat retention, and large heat capacity. Next, they apply these strategies as groups of students are assigned to design a roof, walls, or windows for a desert home based on evidence from their research on building materials. Each group presents their design to the rest of the class.

Conclusion

Web-based science inquiry projects take a variety of forms that include collaborative projects, curriculum enhancement activities, and comprehensive websites designed to support an in-depth study of a particular science topic or geographical area. Successful uses of WBI activities are enhanced if investigations are meaningful and relevant to students and take advantage of local phenomena to gain student interest. As the examples in this chapter illustrate, you may need to enhance a project with a more relevant, motivating context to assist with capturing the interest of your own students.

The primary learning environment for web-based activities is the classroom. Even though the WBIs described in this chapter are designed to promote inquiry learning, you are the most important person for structuring the inquiry process in the classroom. The inquiry process is enhanced when you provide appropriate prompts and suggestions for analyzing data, and promoting critical thinking and reasoning skills.

WEB-BASED INQUIRY ACTIVITY

One high school science class wanted to investigate the following research question: *How healthy is the creek next to our school?*

The teacher, Kate Prince, located a website from the state's Department of Natural Resources (DNR) that is designed to assist student watershed studies of local streams. The site contains many resources, including protocols for water quality data collection, links to Geographic Information Systems (GIS) maps containing environmental data, a database of water quality data collected by students from across the state, and information about watershed studies conducted by state scientists. The website also contains a link to a simulated creek investigation activity developed by a local university.

Kate decided this activity would present her students with a motivating context to conduct a local stream study while at the same time helping them to understand important water quality concepts better than the activities provided in the school-adopted textbook.

The students, with guidance from Kate, visited the creek one time during the fall, winter, and spring to obtain a seasonal data set. The class followed the website's procedures for using probeware to gather water quality data. The collected data was submitted to the DNR site using a provided web-based form. Kate used the prompts provided on the website to assist students with their data analysis:

- ▶ *What patterns do you observe?*
- ▶ *Does one variable seem to be related to another?*
- ▶ *Is this what you would expect to see? Why or why not?*
- ▶ *What about the outliers? Where do they come from? Why?*
- ▶ *Can you see changes over time?*

One group noticed related data from a nearby school participating in the DNR watershed project. In class discussion, the students decided to use the GIS maps and collected stream and tributary data from other schools located in the river's watershed to look for additional data patterns. They discussed findings in class after the analysis was completed. Then, Kate prompted the students with questions to think about alternative explanations that may account for their findings. She reminded students that they can access relevant and reliable scientific knowledge from research scientists on the DNR website.

After additional research, students discovered information about two river tributaries contributing abandoned mine drainage. This information led to further class discussion about ways to remediate abandoned mine drainage to the river.

The student groups then submitted a written report of their investigation to the DNR website. The reports were displayed on the website along with other watershed study reports from schools across the state.

In many WBI activities, students investigate problems that are also studied by scientists. These activities require learners to use evidence and practices of the same type actual scientists use. These investigations are purposeful and a variety of scientific processes are emphasized. Science learning, therefore, becomes an active process that transforms the classroom into a place more closely resembling the working environment of scientists.