WHAT DOES EVIDENCE LOOK LIFE IN A WEB-BASED INQUIRY?

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Abstract

This article discusses how different forms of evidence in Web-based inquiry activities (WBIs) for learning science may be used to promote inquiry learning with classroom students. Such evidence includes real-time information, archived data, collaborative experiments, and primary sources. Specific WBI activities are described.

The World Wide Web offers activities that provide opportunities to learn science through inquiry-based activities. These Web-based inquiry (WBI) activities can encourage students to learn autonomously. WBIs can provide prompts for students to examine evidence (data), compare and synthesize resources, analyze and synthesize existing data sets to formulate conclusions, identify alternative explanations, and communicate findings to others in geographically diverse locations. These activities promote the active learning of science currently advocated by the *National Science Education Standards* (National Research Council, 1996) and often take advantage of a variety of technology-based instructional resources textbooks and other print materials are unable to offer. These include rich scientific visualizations, real-time data, archived data, distributed information sources, animations, and video. Such resources can assist learners in understanding scientific concepts and processes.

A science WBI meets the six criteria listed in Figure 1. In a WBI, evidence can be used in a variety of ways to promote inquiry. Just like classroom-based science inquiry activities, the use of evidence in science WBIs falls along a continuum from learner-directed to materials-directed. This continuum is displayed in Figure 2. Learner-directed uses of evidence involve students collecting data in a hands-on manner. In contrast, a materials-directed WBI provides learners with data to be analyzed. This article describes how different forms of evidence in WBIs may be used to promote inquiry.

Collaborative Experiments

Collaborative experiments 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, the learner is provided with a protocol to collect certain data. Once collected, these data are submitted to a collective database. Next, the WBI provides learners with cumulative data from diverse geographical placements and may instruct the learner on how to analyze the cumulative data. In collaborative experiments, a learner-directed component is followed by a materials-directed component. In many collaborative experiments, the host Website also provides a discussion area for students to share thoughts and report conclusions.

The use of discussion areas emphasizes the role of collaboration to enhance the knowledge of all participants.

An example of a collaborative experiment is *Boil, Boil, Toil and Trouble: The International Boiling Point Project* (http://www.k12science.org/curriculum/boilproj/). In this WBI, students collect and share data from multiple geographical locations to investigate which factor in an experiment (room temperature, elevation, volume of water, or heating device) has the greatest influence on boiling point. Students formulate a hypothesis and then complete an experimental protocol to determine the boiling point of distilled water. The protocol calls for learners to submit a variety of data to a Web database. These data include the class average boiling point, the class average room temperature, the elevation of the classroom, the volume of water used, and the heating device used by the class. Students are next instructed to analyze the cumulative data submitted by participating classrooms. The cumulative data may be viewed directly on the Website or may be downloaded as a spreadsheet file for analysis. The Website provides a discussion area where learners can communicate their results and conclusions to other project participants. This WBI takes advantage of using many classrooms as a distributed information source to complete an investigation.

Real-Time Information

The Web contains a variety of real-time information that can be used as evidence in inquiry activities. Learners can access current data from scientific tools in the field, such as drifter buoys in the ocean or seismic sensors in the earth. WBIs that incorporate real-time information often use the very same current scientific data used by actual scientists. This makes learning science an authentic activity that provides a motivating context for learning.

An example of a WBI that uses real-time information is *Project: Weather Charting* (http://inspire.ospi.wednet.edu:8001/curric/weather/graphing/). In this activity, learners use real-time weather sites to compare the weather in their city with three other cities from different areas of the United States and links to Websites containing current weather data and maps are provided. Learners are instructed to create a data chart and record information on a variety of weather parameters that including cloud cover, temperature, humidity, wind direction and speed, air pressure, and humidity. Questions are provided to assist learners in analyzing evidence and formulating conclusions and additional weather content resource Websites are provided to learners via hypertext links to assist with their consideration of alternative explanations.

Data Archives

Data archives are collections of scientific data that have been accumulated over long periods of time. They can be used as evidence to investigate questions that involve analyzing

data for temporal patterns. Data archives may be used to identify factors that influence changes in water quality or determine habitat preference for a species. In many WBIs, the vast collections of data that scientists use for their own investigations are converted to a more easily grasped form for classroom students, such as data visualizations or reduced data sets.

The *WhaleNet* Website (http://whale.wheelock.edu/) provides WBIs that use authentic marine mammal data sets to study migration patterns. In this case, satellite tags placed on marine mammals transmit data to scientists. These data include the time, date, latitude, longitude, dive depths, dive durations, and amount of time each marine mammal is at the surface. An archive of the data is placed on the Website and is incorporated into WBIs to allow students to investigate questions related to migration patterns. To help learners analyze the migration data sets, they may access a variety of Web-based devices, including such things as map generators, real-time drifter buoys, and visualizations of maps containing sea surface temperatures. These tools provide data representations of large amounts of data that can assist learners in formulating their conclusions.

Dissolved Oxygen (http://www.leo.lehigh.edu/envirosci/watershed/curricular/dom2/) is a WBI that uses a reduced data archive that allows investigation of the relationship between dissolved oxygen and temperature from data recorded from four different areas of a river. The data archive in this activity has been reduced markedly to make analysis more manageable for classroom learners. Only one day for each month over a two-year period is provided (Figure 3). Learners are instructed to graph the data and analyze existing patterns to determine the relationship between the two water quality parameters. This WBI provides links to explanations provided by water quality experts that permit learners to evaluate their explanations in light of alternative explanations. Learners are then instructed to create a poster presentation to communicate their findings.

Primary Sources

Primary sources are collections of evidence that students examine and analyze while performing investigations. Such evidence may use multimedia representations of content, including video clips, animations, still images, 360-degree panoramas, or Web cameras that permit learners to explore a geographically distant area. Primary sources may also include scientific reports, newspaper articles, and policy documents. Not all scientific evidence on the Web is created equal, however. Information on the Web may come from practically anyone. Thus, when students use primary sources as data for their investigations, they should consider carefully where it originated.

An example of a WBI that uses primary sources is the *WISE How Far Does Light Go? Debate* (http://wise.berkeley.edu/). In this activity, students investigate two theoretical positions about how far light travels: "The Light Dies Out Theory" and "The Light Goes Forever Theory." Learners examine and critique evidence taken from both scientific and everyday primary sources that focus on the different features of the physics of light. The provided evidence includes an interactive movie that shows a light probe measuring the intensity of light coming from a light source, digital photographs and video clips of light use during dark evening hours, a chart of flashlight data with and without a mirror reflector, video and text information on night-vision goggles, photographs from the Hubble Space Telescope, and information on how telescopes work. Learners are also prompted to develop their own evidence based on a personal experience that describes a situation in which light appears to either go on forever or die out. Students use a Web tool called *SenseMaker* to assist in developing and refining an argument for one theory or the other. Final arguments are presented as part of a classroom debate.

Closing Remarks

Despite the prominence of "hands-on" laboratory activities in current science teaching, inquiry-based learning does not always need to be a "hands-on" experience. Analyzing primary sources and authentic data sets provided by the Web is one method for students to engage in scientific inquiry when scientific questions and evidenced-based arguments are used. Figure 4 lists Websites that contain multiple WBIs that take advantage of Web-based materials to promote inquiry learning with classroom students.

One of the advantages of the Web and of WBIs is that they permit learners to approach larger, more authentic scientific problems using real data-collection and data-representation tools scientists might use in their own investigations. This may help to free teachers and their students from working only with the limited data sets and tools available in most school settings.

As is the case in all scientific investigations, however, it is important to emphasize the key role of evidence in scientific analysis and thought. Learners in classrooms need opportunities to interact with diverse and realistic forms of evidence and Web-based scientific sites appear well suited to providing such opportunities.

References

National Research Council. (1996). National Science Education Standards. Washington, DC: National Academy Press.

National Research Council (2000). Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. Washington, DC: National Academy Press.

Figure 1. WBI Qualification Criteria

Criteria	Title	Descriptor
1	**Three Inquiry Essentials**	A WBI must contain at least the first three essential features of classroom inquiry described in *Inquiry and the National Science Education Standards* (National Research Council, 2000*)*: **1.** Learners are engaged by scientifically oriented questions that are stated explicitly or implied as a task. **2.** Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions. **3.** Learners draw conclusions and/or formulate explanations from evidence to address scientifically oriented questions.
2	**Learner Centered**	The WBI should be phrased in such a way that learners would perceive it as directed at them. The majority of the wording used in the WBI should be directed at the learner ("you"), not at the teacher ("your students").
3	**Student Learning Science Concept or Content**	The WBI must support student learning of a science concept or science content. Science WBIs must fall into a recognized science discipline (biology, chemistry, physics, environmental sciences, astronomy, oceanography, and the like).
4	**Web-Based**	The WBI must be Web-based. A WBI is 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.
5	**Scientific Evidence**	Evidence used in a WBI should be of the same type an actual scientist would use.
6	**Conclusions or Explanations Involve Reasoning**	Conclusions and/or explanations in WBIs should be more than simple data analysis and reporting. They must involve reasoning.

Figure 2. Continuum of evidence in WBIs.

	Learner Directed		**Materials Directed**	
	Learner-driven with much initiative and independence.	**Decisions to make, but support & scaffolding, particularly with process.**	**Much selecting from provided materials. Limited choices.**	**Materials-driven. Few choices and much direction given.**
Learners give priority to **EVIDENCE,** which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.	Learner determines what constitutes evidence and develops procedures and protocols for gathering and analyzing relevant data (as appropriate).	Directs learner to collect certain data, or only provides portion of needed data. Often provides protocols for data collection.	Provides data and asks learner to analyze.	Provides data and gives specific direction on how data to be analyzed.

Figure 3. Simplified archived data.

DO and Temperature Data for the Lehigh River Near Blakeslee, PA

Year 2	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temp (degrees C)	0.9	1.0	4.9	9.0	8.3	14.9	16.9	19.0	15.2	10.5	1.6	1.5
Dissolved oxygen (mg/L)	11.6	11.5	11.6	9.6	10.2	8.1	7.0	7.9	7.3	9.6	11.0	11.9
Year 2	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temp (degrees C)	0.9	1.0	4.9	9.0	8.3	14.9	16.9	19.0	15.2	10.5	1.6	1.5
Dissolved oxygen (mg/L)	11.6	11.5	11.6	9.6	10.2	8.1	7.0	7.9	7.3	9.6	11.0	11.9

To find the relationship between dissolved oxygen and temperature, you should graph month vs. temperature and month vs. DO. Label the horizontal axis from Jan of Year 1 to Dec of Year 2. Use the same graph for temperature and for DO. If you need some graphing tips, click the graph button. Graph

Figure 4. Websites that contain WBIs.

WISE – The Web-based Inquiry Science Environment	http://wise.berkeley.edu/
CIESE Online Classroom Projects	http://k12science.org/currichome.html
KanCRN Collaborative Research Network	http://kancrn.org/
CERES Project	http://btc.montana.edu/ceres/
Water on the Web	http://wow.nrri.umn.edu/wow/
The GLOBE Program	http://www.globe.gov/
Athena, Earth and Space Science for K-12	http://inspire.ospi.wednet.edu:8001/

