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Table of Contents

If you're viewing this document online, you can click any of the topics below to link directly to that section.

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Teaching Science through Inquiry with Archived Data. ERIC Digest.

Teaching science through inquiry has long been promoted by science educators (See

Haury, 1993) and is strongly endorsed by the "National Science Education Standards" (NSES; National Research Council, 1996). According to the "Standards," "Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments" (Chapter 6). For most teachers, however, the shift in emphasis from traditional instructional approaches to inquiry is a difficult transition. "The focus is shifted away from merely 'learning about' science to 'doing it'.--with time set aside for the collection, discussion and analysis of data" (Falk & Drayton, 2000).

Teaching through inquiry can take many forms, with most descriptions of inquiry emphasizing investigations. According to the NSES, however, the essential features of teaching through inquiry (National Research Council, 1996; Olson & Loucks-Horsely, 2000) are:

1. Learners are engaged by scientifically oriented questions.

2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.

3. Learners formulate explanations from evidence to address scientifically oriented questions.

4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.

5. Learners communicate and justify their proposed explanations.

Though inquiry-based teaching strategies typically engage students in investigations, it is not the physical activity that defines inquiry. Teaching through inquiry is distinguished by its emphasis on a questioning attitude, gathering data, reasoning from evidence, and

communicating explanations that can be justified by available data.

EXTENDING INQUIRY BEYOND SCHOOLROOMS

Defining student inquiry in terms of questioning, analysis of data, gathering evidence, and formulating explanations rather than particular classroom activities greatly broadens the potential range of inquiry-oriented lessons. What if students could pursue answers to questions about phenomena that cannot be studied within the classroom? What if science students could have access to results, equipment, or procedures not typically available in schools? What if students in one school could collaborate with other students or research groups at distant locations in the world? All of these options are possible through the World Wide Web; the Web can be used to connect science classrooms with data sets, facilities, and other students or researchers around the world. This is a relatively new approach to inquiry-based teaching, but some early experiences have been described (Walters, 1997; Wallace; Kupperman, Krajcik, & Soloway, 2000). It has been noted that the Web provides access to specialized information and data on diverse topics that may match student interests or spark questions (Windschitl, 1998).

Though there is no substitute for direct experiences and active investigation, extending the realm of inquiry through electronic communications can greatly enrich and extend inquiry approach to science teaching. Presented below are two strategies for engaging with data via the World Wide Web: (a) through accessing data sets constructed by science projects or agencies, and (b) through collaboration with other school groups to produce data sets (network science projects).

ACCESSING DATA SETS

The increased use of the World Wide Web for information dissemination by research groups has led to many research findings being placed online, including primary sources such as data sets. Though not originally developed for educational use, diverse data sets allow students around the world to analyze authentic data in pursuing questions they may formulate about natural phenomena. There are many more resources than can be listed here, so what follows is a sampling of the resources available online. Following the listing of data sources are links to useful tools for managing and interpreting data, along with suggestions for finding additional resources.

U.S. Environmental Protection Agency (USEPA)

http://www.epa.gov/

The U.S. EPA offers many resources of value to science teachers in addition to data sources, from background information to classroom activities. Following are selected Web pages that serve as good starting points for locating useful data sources.

EPA Envirofacts Data Warehouse

http://www.epa.gov/enviro/index_java.html

This is the best single point for locating USEPA environmental data. This Web site provides access to databases with information about environmental activities that affect air, water, and land.

Environmental Atlas

http://www.epa.gov/ceisweb1/ceishome/atlas/

This site offers an online environmental map collection, links to other important collections, and information about environmental quality maps and mapping, including maps of air quality, maps of landscape and land use features, and maps of watershed, groundwater, drinking water and water quality.

Surf Your Watershed

http://www.epa.gov/surf/

This search page provides access to data about the condition and vulnerability of aquatic systems in each of the 2,262 watersheds in the 50 states and Puerto Rico.

EPA's Environmental Education Center

http://www.epa.gov/teachers/

This Web site provides background information and resources of particular interest to teachers.

National Oceanic and Atmospheric Administration (NOAA)

http://www.noaa.gov/

This Web site provides the general gateway to the vast informational network of NOAA, including resources relating to weather, climate, air quality, oceans, fisheries, and remote sensing. The following selected Web pages provide direct access to various data sources.

NOAAServer

http://www.esdim.noaa.gov/noaaserver-bin/NOAAServer?stype=home

This is the general gateway to all NOAA data distributed across many Web sites, so this Web site can be used to:

* Search for environmental information on multiple NOAA computers

* Retrieve data from NOAA's electronic archives

* View graphics

* Download or order data

National Oceanographic Data Center

http://www.nodc.noaa.gov/

This is one of three NOAA environmental data centers, and it serves as a national repository and dissemination facility for global ocean data.

National Climatic Data Center

http://lwf.ncdc.noaa.gov/oa/ncdc.html

This NOAA data center is the world's largest archive of weather data.

National Geophysical Data Center

http://www.ngdc.noaa.gov/

This NOAA data center provides access to data on glaciology, marine geology, paleoclimatology, solar-terrestrial physics, and solid earth geophysics.

NOAA Education Resources

http://www.education.noaa.gov/

This is the general portal to resources specifically designed for educational use.

Specially for Teachers

http://www.education.noaa.gov/teachers.html

These resources are designed for the teacher to use in the classroom or as background or reference material.

NOAA Research

http://www.oar.noaa.gov/k12/

This web page provides middle school science students and teachers with research and investigation experiences using online resources. This is a good place for teachers with little experience in using Web-based resources to begin; the directions are easy to follow.

United States Geological Survey (USGS)

http://www.usgs.gov/

The USGS offers a wide range of data sources related to geography and geophysics, earthquakes, volcanoes, floods, storms, and related topics. Following are selected Web pages that provide access to data and educational resources.

Water Resources in the United States

http://water.usgs.gov/

USGS Human Health Database

http://www.usgs.gov/themes/health_database.html

USGS Learning Web

http://www.usgs.gov/education/index.html

OTHER DATA SOURCES

National Space Science Data Center

http://nssdc.gsfc.nasa.gov/

The National Space Science Data Center (NSSDC) archives and provides access to a wide variety of astrophysics, space physics, solar physics, lunar and planetary data from NASA space flight missions. The NSSDC General Public Page (http://nssdc.gsfc.nasa.gov/nssdc/gen_public.html) is intended to guide non-specialists to data and services most likely to be of general interest.

Surfing the Internet for Earthquake Data (Directory)

http://www.geophys.washington.edu/seismosurfing.html

Real-Time Internet Data for Teaching Science (Directory)

http://www.physics.montana.edu/physed/papers/real-time/four.htm

Real-Time Science Data Access Page (Directory)

http://solar.physics.montana.edu/tslater/real-time/

NETWORK SCIENCE PROJECTS

Teachers who prefer focusing on databases to which their own students have contributed should consider network science projects that enable collaborative investigations. The most extensive collaborative program involving school groups is the Global Learning and Observations to Benefit the Environment (GLOBE) Program (http://www.globe.gov/). The following articles describe aspects of the GLOBE program:

Berglund, K. (2000). Exploring science through the GLOBE Program. "ENC Focus: A Magazine for Classroom Innovators," 7 (3). [ED 443 691]

Means, B. (1998, March). Melding authentic science, technology, and inquiry-based teaching: Experiences of the GLOBE Program. "Journal of Science Education and Technology," 7 (1), 97-105.

Mims,F. M. (1999, July). "An international haze-monitoring network for students. Bulletin of the American Meteorological Society," 80 (7), 1421-31.

Other online science projects include the following:

The Global Water Sampling Project

http://k12science.stevens-tech.edu/curriculum/waterproj/index.html

Frogwatch USA

http://www.mp2-pwrc.usgs.gov/FrogWatch/

Cornell Lab of Ornithology Citizen Science

http://birds.cornell.edu/whatwedo_citizenscience.html

Education Place Project Center: Science Projects

http://www.eduplace.com/projects/scproj.html

All About Online Projects

http://www.accessexcellence.org/21st/TE/AO/

TOOLS & TECHNIQUES

Following are online resources that provide tools or techniques for managing or interpreting data sets.

Spreadsheets in Education

http://sunsite.univie.ac.at/Spreadsite/

Modeling for Understanding in Science Education

http://www.wcer.wisc.edu/ncisla/muse/

Digstats

http://www.cvgs.k12.va.us/digstats/

TILT: Teaching Inquiry With the Latest Technology

http://www.icsrc.org/TILT/Index.html

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Olson, S. & Loucks-Horsley, S. (Eds.). (2000). "Inquiry and thee National Science Education Standards: A guide for teaching and learning." Washington, DC: National

Academy Press. (Available online at: http://www.nap.edu/books/0309064767/html/ or http://books.nap.edu/html/inquiry_addendum/)

Wallace,R. M., Kupperman,J., Krajcik,J., & Soloway,E. (2000). Science on the Web: Students online in a sixth-grade classroom. "Journal of the Learning Sciences," 9 (1), 75-104.

Walters, J. M. (1997). "Working with data in network science." Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-28). [ED409216]

Windschitl,M. (1998, March). Independent Student Inquiry: Unlocking the Resources of the World Wide Web. "NASSP Bulletin," 82 (596), 93-98.

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