

CHAPTER 6

Acquiring Online Data for Scientific Analysis

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Scientific inquiry, a component of scientific literacy targeted in the National Science Education Standards, allows us to explore nature and propose explanations based on evidence. The Standards define scientific inquiry as “a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena” (NRC 1996, p. 214). Inquiry includes posing questions, planning and conducting investigations, using tools to gather and analyze data, formulating data-based explanations, representing data, and communicating findings (see also *Science as Inquiry in the Secondary Setting*, by Luft, Bell, and Gess-Newsome).

As you seek to provide more opportunities for your students to engage in scientific inquiry, however, you may find data collection to be time consuming and expensive. The internet, which provides immediate access to numerous data sets from government agencies, global corporations, colleges and universities, and other institutions, can provide a solution.

The internet allows students to access existing data sets and explore phenomena beyond their classroom and school settings, like tracking migratory routes and identifying breeding areas of water birds in South Africa. Online data sets extend the possibilities of inquiry beyond the limitations and constraints of available equipment and geographic locations.

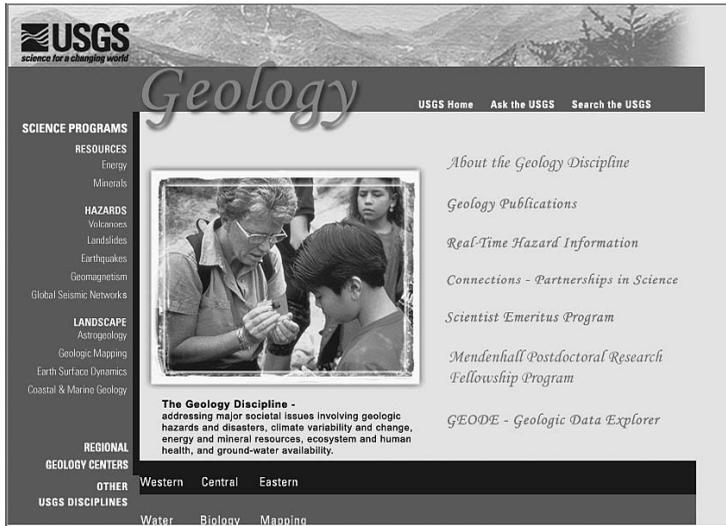
As researchers have increased their use of the internet for the dissemination of research results, many also have placed primary data sets online. Although the original intent probably was to make data available to other researchers, teachers can incorporate these free and easily accessible resources into their classroom instruction. Online data generally can be grouped into two broad categories, existing data sets and data collected collaboratively, like the GLOBE (Global Learning and Observations to Benefit the Environment) Program.

Data sets are available as raw data in spreadsheets, text files, aerial and satellite images, maps, and graphs. For example, the U.S. Geological Survey (USGS) website provides data on earthquakes, volcanic activity, and water quality. From

this website, teachers can access data on arsenic in the 31,350 ground-water samples collected in 1973–2001 by the USGS, available in spreadsheets or text files and including the state and site where the water sample was collected, the date and time of collection, the latitude and longitude of the well, the primary use of the water, and the depth of the well. Teachers can use this data set to have students plot the arsenic levels in their area and compare them to neighboring counties and states.

Figure 1.

U.S. Geological Survey Geology home page.



What the Research Says

Research findings indicate that using online data in inquiry-based instruction has many potential benefits, including gains in students' content knowledge and increases in student interest, engagement, motivation, and sense of control of learning.

A number of researchers have found that using online data to address authentic problems resulted in increased student motivation (Lenk 1992; Means and Olson 1995; Mistler-Jackson and Songer 2000; Songer 1996, 1998). The researchers attributed the increase in motivation to students viewing the learning experience as worthwhile and meaningful.

Windschitl (1998) found that the ability to access data on a wide range of topics can support inquiry by prompting student-generated inquiry questions. Since the available information is so diverse, students are likely to find topics aligned with their individual interests, which can spark interest and make the inquiry more personally relevant.

Other research has found that using the internet to access data about current events makes students feel empowered with their use of inquiry skills (Lenk 1992; Songer 1996, 1998), and students demonstrated statistically significant improvements in science content and inquiry skills (Mistler-Jackson and Songer 2000; Songer 1998;

Songer, Lee, and Kam 2002). For example, in two studies with inner-city students (Lee and Songer 2003; Songer, Lee, and Kam 2002), researchers studied students who were involved in a real-time weather forecasting project in which the students gathered and analyzed data from the internet on fronts and pressure systems. The results indicated that students (including students who were typically the lowest performing) increased their science content knowledge and improved their inquiry performance.

Some research has examined networked science projects in which students, teachers, or scientists shared online data and collaborated about shared problems or current events. An example of this type of project is the GLOBE Program. Findings from the research on these types of projects indicated an increase in student interest and accountability, an increase in student engagement (including by students who were not usually interested or successful in science), and a decrease in absenteeism during the projects (Lenk 1992; Songer 1996, 1998).

Guidelines for Best Practice

Although using online data in inquiry-based lessons is a fairly new field, a synthesis of the work of the teachers and researchers who have explored this area yields some helpful guidelines to make the practice easier and more effective.

(1) Limit student searches to targeted websites and simplified data sets.

The volume of accessible data can be overwhelming for teachers and students, and real data sets can be messy. Also, some principals and school administrators may limit student access to the internet out of fear that students may access inappropriate material such as pornography. To address these issues teachers can copy and paste URLs into a word processing document or develop class or subject homepages that contain links to specific websites (Lynch and Walton 1998). Teachers can also use web pages that are configured without search capabilities, or they can capture all targeted pages and create an off-line browsing site on the school's computer. One easy way to develop a web page for student use is through the online system TrackStar (<http://trackstar.4teachers.org/trackstar>), which allows you to collect URLs, enter them into the TrackStar system, and add annotations for your students.

(2) Make the learning relevant.

You can integrate data into authentic tasks that address problems faced by scientists, such as mapping earthquake activity, forecasting the weather, or monitoring air quality (Hunter and Xie 2001; Means and Olson 1995; Slater and Fixen 1998). Also, you can use data from the school community to increase student interest in the project. According to Lee and Songer (2003) authentic problems use real-world problems faced by scientists, have students seek solutions to problems in their own

lives, and/or link students and scientists through data sharing. Authentic tasks or problems help students see an activity as being worthwhile and meaningful. By making assignments relevant, students who are not typically interested in science may find science learning more engaging. Finally, using online data sources facilitates teaching students about multicultural aspects of science by exposing them to the efforts of researchers from other countries.

(3) Integrate data into inquiry that reflect the science process.

The National Science Education Standards call for teaching science concepts through scientific inquiry. Inquiry includes identifying important questions, observing, recording data, classifying, looking for patterns, analyzing data, verifying results, and communicating findings to others. To help students develop their inquiry skills, Windschitl (1998) recommended the following for use with online data:

- ▶ **Develop questions:** Help students understand what constitutes an inquiry-based question and frame a driving investigative question around the data. Often students are not skilled at asking questions that can be answered with data. Teachers and students must work together to develop appropriate questions and allow students to reframe their questions if the data indicate their questions are unclear or inappropriate.
- ▶ **Analyze data:** Allow students to develop their own strategies for analyzing data and interpreting evidence. Provide a scaffold for working with outliers in the data.
- ▶ **Communicate findings:** Emphasize the role of argument to support claims or assertions, and engage students in discussions about the validity of their findings.

(4) Contact education centers to request help.

Many teachers may not have the time to filter the large volume of existing data for the most usable subsets. Many of the organizations that generate and store data also have an educational resource person on staff to work with teachers. Teachers who wish to use online data may contact the centers to request help in meeting their instructional needs (Lynch and Walton 1998).

Examples of Best Practice

Science educators recommend incorporating web-based data into inquiry activities, and many such activities have been published. Online data are available in all areas

of science (e.g., life, physical, and Earth and space science) and in various formats. Examples for each content area follow.

Earth and Space Science

In Earth and space science, students can discover tidal patterns by using online data sources and spreadsheets for data analysis. They can import data into spreadsheets, cull data, calculate daily tidal ranges, create and interpret line graphs of tides and tidal ranges, correlate Moon phase data with tidal range data, and describe relationships between phenomena. (See Tidal Data below for more specific details about this activity.)

TIDAL DATA

In a class of ninth-grade Earth science students, a colleague and I limited students' access to data to one site, the Center for Operational Oceanographic Products and Services, Verified/Historic (Tides) Water Level Data retrieval page (http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Tide+Data). We also initially limited the geographic location to one place, FPF Pier, in Duck, North Carolina, and to the same time period so that all students were using the same data set. This gave all students the same initial point of reference and comparison for additional analyses. Also, we were better able to quickly identify any problems when a student's graph did not fit the expected pattern.

To make the learning relevant, we asked students to select another time period for the same geographic location, and many students selected their birthdates. We also asked students to select a different geographic location to compare to the analysis for Duck, North Carolina. Many students selected coastal locations where their families had vacationed or areas near where extended family members lived.

Students used data and modeling to answer the question "What causes tides?" Through their work, students were interested to see what happened in these areas during hurricane seasons, and they also came up with additional questions such as, "How do tides compare during different seasons?"

Students were provided a model for importing data into a spreadsheet and for analyzing and representing the data in graphs. However, students were encouraged to think of subsequent questions and come up with their own strategies for analyzing data to answer their questions.

Students looked for anomalies in the patterns in their data. For example, some students found an extreme peak in their tidal range that did not correspond with springtides. The students inferred that a storm could have caused the extreme fluctuation in the tidal range. Using the internet, the students looked at newspaper reports from the targeted areas and found that a hurricane had struck during the time period in question.

Other data that may be used in Earth and space science include earthquake and volcano data related to plate boundaries, latitude and longitude of specific cities to

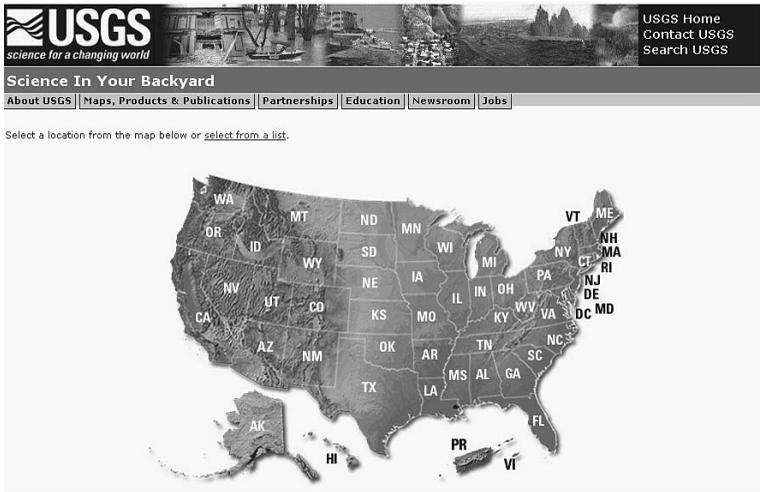
access plate motion data and calculate the directions and rates of plate movements, temperature data from different geographic locations to describe climates and climate changes, hurricane impacts on landforms and geographic features, oceanography (e.g., sea floor spreading), river patterns, and volcanic ash and weather patterns.

Some websites that provide data for Earth and space science lessons include the following:

- ▶ **Science in Your Backyard, U.S. Geological Survey:** State-specific water data, streamflow, floods and high water data, groundwater levels, earthquake activity. www.usgs.gov/state

Figure 2.

The USGS “Science In Your Backyard” web page.



- ▶ **National Oceanic and Atmospheric Administration, Center for Operational Oceanographic Products and Services:** Verified/historic (Tides) Water Level Data retrieval page. http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Tide+Data
- ▶ **Plate Motion Calculator, UNAVCO:** Calculate tectonic plate motion at any location on Earth. http://sps.unavco.org/crustal_motion/dxdt/mnrcalc
- ▶ **Surfing for Earthquakes and Volcanoes (Coe and Merrick, UC Berkeley):** Earthquake and volcano data with lessons. <http://cse.ssl.berkeley.edu/lessons/indiv/coe/details.html>

- ▶ **EPA Envirofacts Data Warehouse, U.S. Environmental Protection Agency:** A national information system that provides an integrated single point of access to data extracted from six major EPA databases.
www.epa.gov/enviro
- ▶ **Air Quality System Database, U.S. Environmental Protection Agency:** Database contains measurements of air pollutant concentrations in the 50 states.
www.epa.gov/air/data/aqfdb.html
- ▶ **Search Your Community, U.S. Environmental Protection Agency:** Get specific environmental information about your neighborhood by entering your zip code on this site.
www.epa.gov/epahome/commsearch.htm

Physical Science

Students also can access and use data in physical science classes. They can use an interactive periodic table (*www.chemicool.com*) to access data about different elements, including atomic radii, electronegativity, and first ionization energy to describe periodic trends and explain the organizational principles for the periodic table. Students can use sports speed records to plot record speeds over time and infer explanations for speed trends. Also, most teenagers are interested in driving and cars. Students can access automobile performance test data to calculate time, velocity, and mass for the accelerating automobile. They can calculate kinetic energy versus time data and graph it, and they can graph time versus speed.

Some websites that provide data for Physical Science lessons include the following:

- ▶ **ChemiCool Periodic Table:**
www.chemicool.com
- ▶ **USA Rollersports Speed Skating Records:**
www.usarollersports.org/vnews/display.v/ART/40046cf801d44
- ▶ **International Skiing History Association World Speed Skiing Records 1874–1999:**
<http://skiinghistory.org/Speed.html>
- ▶ **Physics Factbook—Speed of the Fastest Human, Running:**
<http://hypertextbook.com/facts/2000/KatarzynaJanuszkiewicz.shtml>

▶ **Road Test Data—Automobile Magazine:**

www.caranddriver.com/newreviewsroad

Life Science

In life science, students can identify migratory routes and breeding areas for various animals, including sea turtles, water birds, great apes, and arctic animals. They can access data about different animals' migratory routes and/or breeding areas, plot the data onto maps, and compare the data for different time periods to see how the patterns have changed over time.

Other life science topics include analyzing global tap water, human population trends, human census data over time, types and amounts of marine debris, and water monitoring.

Some websites that provide data for life science lessons include the following:

▶ **U.S. Geological Survey—Water use in the United States:** 50 years of data.

http://water.usgs.gov/watuse

▶ **U.S. Geological Survey—National Water Quality Assessment Data Warehouse:** Chemical, biological, and physical water quality data from 42 basins across the nation.

http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:4072984908919821

▶ **National Oceanic and Atmospheric Administration National Ocean Service:** Includes data on coral reef conservation, coastal ecosystem science, natural hazards assessment, and oil and chemical spills.

http://oceanservice.noaa.gov/dataexplorer/data_topics/welcome.html

▶ **Marine Turtle Interactive Mapping System, UNEP World Conservation Monitoring Centre:**

http://stort.unep-wcmc.org/imaps/indturtles/viewer.htm

▶ **Great Apes Survival Project, UNEP World Conservation Monitoring:**

http://stort.unep-wcmc.org/imaps/grasp/viewer.htm

▶ **Migratory Waterbirds, African Eurasian Migratory Waterbird Agreement, UNEP World Conservation Monitoring:**

http://stort.unepwcmc.org/imaps/AEWA/viewer.htm?Title=AEWA

▶ **World Atlas of Biodiversity, UNEP World Conservation Monitoring:**

http://stort.unep-wcmc.org/imaps/gb2002/book/viewer.htm

- ▶ **U.S. Census Bureau Lessons Using Census 2000 Data:**

www.census.gov/dmd/www/schoolessons.html

- ▶ **U.S. Geological Survey: Wandering Wildlife:** Satellite and Radio Telemetry Tracking Wildlife Across the Arctic: Includes polar bears, loons, sockeye salmon, brant, common eider, and long-tailed ducks.

http://alaska.usgs.gov/science/biology/wandering_wildlife

- ▶ **National Cancer Institute, State Cancer Profiles:** Dynamic views of cancer statistics.

<http://statecancerprofiles.cancer.gov>

Figure 3.

“Wandering Wildlife” web page.



In addition to the websites that provide access to data, several resources are available that offer lesson plans and instructional ideas about how to access data through the internet. One example is the Network Montana Project, a site funded by the National Science Foundation that offers instructional materials on the atmosphere, geosphere, hydrosphere, and mountain environments (Slater and Beaudrie 1998). The website can be accessed at *www.math.montana.edu/~nmp*.

Conclusion

By using online data, students can ask questions about scientific phenomena and develop methods for answering their questions. They can collect data by accessing existing data sets and they can organize their data. They can use the data to make inferences, they can represent their data in graphs, and they can communicate the findings to their teachers and classmates. By integrating online data into inquiry-based lessons, teachers can help students develop their inquiry skills as they develop their science content knowledge. As an added bonus, students also will develop important technology skills as they use online databases to import data sets into spreadsheets, construct data tables, make graphs, and produce presentations.

