Teaching Science Methods Courses With Web-Enhanced Activities

Alec M. Bodzin, Lehigh University

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Abstract

This session presented instructional approaches that utilize Web-based interactivities for learning science content and concepts in Lehigh University's elementary and secondary science methods courses.

Theoretical Background: Learning Science with the World Wide Web

Learning science in today's classroom does not have to be restricted to text-based curricular resources. Websites present learners with a wide range of science activities in various formats ranging from text-only information to providing authentic real-time data sets and interactive simulations. Owston (1997) contended that the World Wide Web is likely to bring new learning resources and opportunities into the classroom, provide teachers and students access to more resources, and promote improved learning. Many Web-based curricular resources have been developed for use in K-12 science classrooms. Some of these resources have been described in the literature (Alloway et al., 1996; Beaujardiere et al., 1997; Berenfeld, 1994; Bodzin, 1997; Bodzin, 2001; Bodzin & Mamlok, 2000; Bodzin & Park, 1999; Cohen, 1997; Coulter & Walters, 1997; Feldman, Konold, & Coulter, 2000; Friedman, Baron, and Addison, 1996; Gordin et al., 1996; Songer, 1996; Songer, 1998; Wallace & Kupperman, 1997).

The Web can encourage students to learn independently of a teacher. Materials can provide prompts for students to examine evidence (data), compare different viewpoints on issues, and analyze and synthesize existing data sets to formulate conclusions. The

Web also allows for the use of various instructional resource types to enhance student science learning. These resources include:

- Scientific visualizations - These are rich representations that present scientific relationships as visual patterns and provide data-intensive descriptions of phenomena.
- Simulations - Interactivities used to simulate and explore complex phenomena.
- Virtual Reality - This technology enables a user to interact with and explore a spatial environment through a computer.
- Animations or Video clips - Animations or video clips to illustrate science content, concepts, or processes.
- Still images - Still images to illustrate science content, concepts, or processes.
- Spreadsheets - Spreadsheets can be used in the instruction.
- Distributed information sources - Information sources are distributed among many sources including real-time data, peers, mentors in many locations.

The Web offers many advantages over traditional text-based instruction for individuals to learn science. These include:

1. Information is current - Many different kinds of science information can be found. New scientific discoveries are made each day and the Web provides learners with access to updated knowledge.
2. Access to data - Learners can access large amounts of current and archived scientific data. Data exists from scientists' labs as well as from scientific tools in the field such as drifter buoys in the ocean or seismic sensors placed in the earth. Learners can retrieve data from remote geographical distances. Web-based data is different than

data that is presented in curricular text materials. Data can take the form of a digital image or a 360 degree panorama that can be explored.

3. Access to scientific experts - Learners can use the Web to ask questions of scientific experts. The Web enables authentic student collaboration with scientists using Web-based discussions and group tasks.

4. Motivation - Materials may be presented to learners in a motivating form. Examples include the use of video and interactive simulations to engage learners in a task.

5. Communication - The Web can provide students with an authentic audience with which to communicate.

6. Remote explorations - The Web provides a way for students to explore remote geographic locations that they would otherwise not be able to view.

The Web can provide supports for learning processes that are infused with constructivist principles. Constructivist conceptions of teaching and learning assign primary importance to the way in which learners attempt to make sense of what they are learning (Krajcik et al., 1994). In a Web-based environment, learning can be an active process where learners explore ideas, compare and synthesize resources, and revise ideas. The Web may provide a context for authentic learning by presenting learners with authentic real world tasks that require problem solving and reasoning to achieve a collaborative goal (Bodzin, Cates, and Vollmer, 2001). Web-based conferencing and the sharing of student-created work can provide learners the opportunity to articulate their reasoning as they solve problems. Web-based activities can provide task structuring that requires learners to think about their own learning as they solve problems and seek out alternative explanations. Collaborative Web-based learning involves social interaction

and a sharing of collective knowledge in which the peer dialogue involves learners in the social construction of knowledge.

Relevance to Science Teacher Education

Recent science and technology education reform initiatives (American Association for the Advancement of Science, 1993; ISTE, 2000; NRC, 1996) emphasize incorporating instructional technologies into classroom science curricular contexts and provide guidelines for the preparation of science teachers. The World Wide Web is changing the way science education content is being delivered in K-12 classrooms. The Web is accessible worldwide, relatively easy to update (compared to traditional delivery systems such as textbooks and CD-ROMs), and adds new capabilities almost daily. Teachers and students in science education classrooms today can access many Websites that purport to provide "science education." Websites present learners with a wide range of science content in various formats ranging from text-only to authentic real-time data sets and interactive simulations. With the simplification of Web-publishing software, one no longer needs to have strong technical skills to publish a Website. Almost anyone -- K-12 students, science educators, scientists, members of special interest groups, and for-profit commercial enterprises-- can become a content provider for a science education site.

A variety of instructional practices can be used to integrate the Web in elementary and secondary science methods courses. The Technology-Based Teacher Education program at Lehigh University has designed and developed Web-based interactivities and instructional systems to support learning science. These materials have been an intricate part of the science education methods courses during the past two years. These Web-based interactivities are used to model how visual instructional technologies can be used

to address students' naïve conceptions of science, how science teachers can help students perceive knowledge as constructed, provide students with an effective model to develop critical thinking skills, and meet standards for inquiry-based teaching and learning.

Web-Enhanced Activities

This demonstration session illustrated how Web-enhanced activities are used in the elementary and secondary science methods courses at Lehigh University. The Web-enhanced activities and related course resources are available online at:

- Science Education at Lehigh University: http://www.lehigh.edu/~amb4
- Science Education Courses at Lehigh University: http://www.lehigh.edu/~amb4/courses
- Web-based Inquiry for Learning Science manual and instrument: http://www.lehigh.edu/~amb4/wbi/

Specific examples that were highlighted in the session included using data collection activities located on the LEO EnviroSci Inquiry Website, Science-Technology-Society role playing simulations, activities that allows students to develop skills in understanding location by exploring a variety of unique geological formations using QuickTime Virtual Reality (QTVR) panoramas and topographic maps, and virtual photojournals to explore watershed features and societal issues. The use of the Web-based Inquiry for Learning Science (WBI) manual and instrument in the science methods courses was also described. Below is a more detailed description of the activities in the LEO EnviroSci Inquiry Website.

LEO EnviroSci Inquiry

LEO EnviroSci Inquiry (http://www.leo.lehigh.edu/envirosci/) is indexed into five interconnected areas: Lehigh River Watershed Explorations, Environmental Issues, Geology, Weather, and Data Collection Activities. Curricular activities actively engage learners in data collection, analyzing data, working with Web-based Global Information Systems (GIS) databases, and learning in interdisciplinary contexts. The Website enables classroom teachers to implement science teaching strategies that incorporate Web-based and other technologies into the classroom. Curricular activities emphasize student-directed scientific discovery of their local environment.

Lehigh River Watershed Explorations

The main goal of Lehigh River Watershed Explorations area (http://www.leo.lehigh.edu/envirosci/watershed/curricular/) is to present science to K-12 learners in a historical perspective by engaging them in a detailed study of the Lehigh River watershed. This watershed has a very rich history that presents learners with a unique opportunity to observe how the American industrial revolution has impacted a watershed over time. Stories are presented in the *History of the Lehigh Watershed* section that enable learners to explore science from a historical perspective and to observe how science and technology may impact society over time.

The *Lehigh River Watershed Photojournal* provides learners with the opportunity to virtually explore the Lehigh River watershed. The photojournal contains MPEG movie watershed flybys that provide the learner with a graphical overview of the topography of the area. GPS (Global Positioning) coordinates index the photojournal. In addition to digital images of the area, the photojournal Web pages contain short MPEG

video clips and QuickTime Virtual Reality panoramas that allow learners to zoom in on specific physical features.

The *Water Quality* section contains background information and protocols that assist learners using Vernier CBL (Calculator-Based Laboratory) units and graphing calculators to collect water quality data. Data reporting forms are provided on the Website that enable learners to submit collected data to the LEO water quality database. This data can then be compared to other water quality data located on the Website. Web-based data links to the Lehigh River's USGS (US Geologic Survey) monitoring stations provide river flow data and real-time discharge data.

The *GIS* (Geographical Information Systems) section contains a variety of interactive maps of the Lehigh watershed. GIS mapping provides a spatial framework for analyzing environmental data such as water quality data and relating it to the characteristics of the land around it. Unlike static maps (such as the road maps you get at the gas station), GIS not only lets you view a map, but also lets you query the map for information that is not displayed. Figure 1 is an example of a land use map from the watershed.

The *River Explorations* and *Curricular Activities* sections provide innovative inquiry-based water quality and watershed studies activities developed by our research group and partner organizations.

Environmental Issues

The Environmental Issues area (http://www.leo.lehigh.edu/envirosci/enviroissue/) contains links to Science-Technology-Society (STS) issues-based approach simulations developed by our research group and partner organizations. These simulations provide

learners with the experience of learning science and technology in the context of human experience involving real-life controversial issues. Engaging in an authentic issues makes environmental science instruction current and part of the real world. In these simulations, learners investigate a real-world controversial issue from different perspectives. After they complete their investigation, a public forum or debate is conducted to determine the next course of action on the issue. Classroom debates on STS issues offer learners a forum to think critically about the role that science plays in societal issues. These simulations acknowledge the connection between science and the decisions individuals make about social issues.

Weather

The Weather area (http://www.leo.lehigh.edu/envirosci/weather/) contains two distinct curricular resources for learners to explore weather phenomena. The first resource, *Phenomenal Weather Explorations,* is a series of guided Web-based Explorations of unique weather phenomena designed for learners in grades 4-8. In these explorations, students learn the science of hurricanes, tornadoes, lightning, and the Green House effect. The second resource, *Bits of Biomes,* provides a learning environment that uses a guided inquiry-based approach for learners to investigate characteristics of biomes including climatic differences, populations, and ecosystems in terrestrial biomes. In *Bits of Biomes*, learners investigate the driving question: "Do selected cities in our study really exhibit the characteristic climatic conditions of their defined biome?" Learners work in groups to collect climatic data on selected cities that characterize different biomes. They use spreadsheets to explore patterns in their climatic data. Climatic data in different biomes are compared. The groups research characteristics of a particular biome

that includes people and culture, animal life (vertebrates and invertebrates), plant life, and economic conditions. Each group contributes a section to a class "World Travel Book." The "World Travel Book" can be a class Website, a hypermedia artifact, or a traditional paper artifact. Throughout the implementation of the unit, students participate in hands-on experiments that focus their learning on topics that include habitats, predator/prey relationships, adaptations to environments, and food chains.

Geology

The Geology area (http://www.leo.lehigh.edu/envirosci/geology/) contains interactivities for learners to use virtual reality in their science investigations. "Which Way Is North?" is an activity that allows learners to develop skills in understanding location by exploring a variety of unique geological formations using QuickTime Virtual Reality (QTVR) panoramas and topographic maps (Figure 2). "Dino Inquiry" allows learners to explore a variety of dinosaur fossil bones from the Dinosaur National Monument quarry using panoramas and digital still imagery. "Geologic Explorations" allows one to explore a variety of unique geological formations through the use of QTVR.

Data Collection Activities

The Data Collection Activities area (http://www.leo.lehigh.edu/envirosci/data/) connects learners to a variety of earth and environmental science data sets and collection activities currently underway at LEO (Lehigh Earth Observatory). The *LEO WeatherNet* is an electronic network of weather and water monitoring stations. Learners can access real-time and archived weather data from weather and water monitoring stations near the Lehigh University Campus and from lake monitoring stations on the Pocono Plateau.

The *LEO hydroprobe* area contains a database of water quality data taken from a hydroprobe located on the lower reaches of the Lehigh River. The probe measures a variety of water quality parameters and is logged on an hourly basis. Classroom learners use this data to examine temporal patterns of the health of the river. *The LEO Seismic Station* area contains data from a broadband seismic station located on South Mountain at Lehigh University. Data collected from the seismic station provides information on active seismicity in northeastern Pennsylvania. This station is a part of the Northeastern Regional Seismic Network, which monitors earthquake activity in the eastern U.S. In addition to learning about earthquakes, learners can link to the GSN (Global Seismic Network) maintained and operated jointly by IRIS (Incorporated Research Institutes in Seismology) and the US Geological Survey. *The Salamander Response to Climate Change project (SRCC)* focuses on the use of salamanders as a natural indicator of changes in environmental conditions. Learners can access current research being conducted in Northeast Pennsylvania at South Mountain, Hawk Mountain, and the Lacawac Sanctuary to examine salamander activity in relation to environmental conditions. Environmental data, recorded on data loggers in the field, can be compared with salamander activity levels to predict salamander response to climate change.

References

Alloway, G., Bos, N., Hamel, K., Hammerman, T., Klann, E., Krajcik, J., Lyons, D., Madden, T., Margerum-Leys, J., Reed, J., Scala, N., Soloway, E., Vekiri, I., & Wallace, R. (1996). *Creating an inquiry-learning environment using the World Wide Web.* Paper presented at the International Conference on the Learning Sciences, Northwestern University.

American Association for the Advancement of Science (1993). *Benchmarks for Scientific Literacy: Project 2061*. New York: Oxford University Press.

Beaujardiere, J.-F. d. L., Cavallo, J., Hasler, A. F., Mitchell, H., O'Handley, C., Shiri, R. & White, R. (1997). The GLOBE Visualization Project: Using WWW in the classroom. *Journal of Science Education and Technology, 6*(1), 15-22.

Berenfeld, B. (1994). Technology and the new model of science education: The Global Lab experience. *Machine-Mediated Learning, 4*(2-3), 203-227.

Bodzin, A. (1997). Incorporating the World Wide Web in the science classroom. *Electronic Journal of Science Education, 1(3),* 1997. [Online]. Available: http://unr.edu/homepage/jcannon/ejse/bodzin.html**.**

Bodzin, A. (2001). Designing Web-based inquiry simulations: Carolina Coastal Science. *Proceedings of the Society for Information Technology and Teacher Education (SITE) 12th Annual Conference in Orlando, FL*. Charlottesville, VA: Association for the Advancement of Computing in Education (AACE).

Bodzin, A., Cates, W., and Vollmer, V. (2001, March). Codifying Web-based inquiry activities: Preliminary instrument development. Paper presented at the National Association for Research in Science Teaching Annual Meeting in St. Louis, MO.

Bodzin, A. and Mamlok, R. (2000). STS issues-based approach simulations. *The Science Teacher, 67*(9) 36-39.

Bodzin, A. M., & Park, J. C. (1999). An online inquiry instructional system for environmental issues. *Meridian, 2*(2).

Cohen, K. C. (Ed.). (1997). *Internet Links for Science Education: Student-Scientist Partnerships*. New York: Plenum Press.

Coulter, B., & Walters, J. (1997, March, 1997). *The promise and perils of network science: Experiences in the Testbed for Telecollaboration.* Paper presented at the National Association for Research in Science Teaching, Chicago, Ilinois.

Feldman, A., Konold, C., & Coulter, B. (2000). *Network science, a decade later: the internet and classroom learning*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Friedman, E. A., Baron, J. D., & Addison, C. J. (1996). Universal access to science study via Internet. *T.H.E. Journal, 23*(11), 83-86.

Gordin, D. N., Gomez, L. M., Pea, R. D., & Fishman, B. J. (1996). Using the WWW to build learning communities in K-12. *Journal of Computer-Mediated Communication, 2*(3).

International Society for Technology in Education. (2000). *National educational technology standards for teachers*. Eugene, OR: International Society for Technology in Education.

Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., & Soloway, E. (1994). A collaborative model for helping middle grade science teachers learn project-based instruction. *Elementary School Journal, 94*(5), 483-497.

National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press.

Owston, R. D. (1997). The World Wide Web: A technology to enhance learning and teaching? *Educational Researcher, 26*(2), 27-33.

Songer, N. B. (1996). Exploring learning opportunities in coordinated network-enhanced classrooms: A case of Kids as Global Scientists. *The Journal of the Learning Sciences, 5*(4), 297-327.

Songer, N. B. (1998). Can technology bring students closer to science? In B. J. Frasier & K. G. Tobin (Eds.), *International Handbook of Science Education* (Vol. Volume 2, pp. 333-347). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Wallace, R., & Kupperman, J. (1997). *On-line searching in the science classroom: benefits and possibilities.* Paper presented at the American Education Research Association, Chicago, IL.