#### Using Web-based GIS to Promote Inquiry and Environmental Literacy Alec M. Bodzin, Lehigh University

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#### Abstract

This session demonstrates the use of Web-based interactive GIS map coverages to promote scientific inquiry and environmental literacy in science methods courses.

Since the post-Sputnik spike in our nation's commitment to science, math, and technology education, a chorus of committees and commissions has called for reform of science learning in our schools {1}. Most of these reform initiatives advocate a change in emphasis from students memorizing facts and terminology to students investigating science through active participation in inquiry-based approaches {2}. Research on learning supports what many science educators have always believed from experience: students understand and apply concepts better when they construct their own understandings than when they are passive recipients in the educational process {3}. In addition, students engaged in active scientific inquiry are more likely to have improved attitudes about science and to become lifelong learners and scientifically literate citizens. In 2001, an addendum to the *National Science Education Standards* developed by the National Research Council amplified the call for inquiry teaching and learning as a cornerstone of nationwide reform {4}.

Scientific inquiry is important to learning key components and skills of science disciplines. It helps students understand the nature of science and acquire the habits of mind that scientists employ. Further, scientific inquiry is a form of critical thinking; the skills it engenders support student thinking across other disciplines. Robust and well-designed inquiries address realistic problems scientists might well encounter, allow students to work with real data in authentic contexts, call for students to draw and justify conclusions using the same kind of reasoning scientists use, force students to examine and develop alternate viewpoints and interpretations and then interact with the larger community to justify and defend conclusions and test findings against the views and beliefs of others. This communication reinforces learning and assists in greater understanding of the problem. Robust inquiries can help students come to appreciate the richness and complexity of scientific problems.

Inquiry in today's science classrooms can take a variety of forms. It may be highly structured, with teachers and/or materials directing students towards known outcomes, or it may take the form of open-ended, learner-centered investigations. Current teaching and learning techniques that use inquiry include engaging students with authentic questions for local and global investigations {5}, project-based science instruction {6}, and role-playing debate simulations {7}. These techniques seek to engage students with meaningful questions about everyday experiences, emphasize using a method of investigation to evaluate some form of evidence critically, and engage learners in social discourse to promote the knowledge-construction process. Further, learning science in today's classroom does not have to be restricted to text-based curricular resources utilized solely under teacher guidance in the classroom. Owston {8} noted that the World Wide Web brings new learning resources and opportunities

into the classroom, providing teachers and students access to more resources and promoting improved learning. Today, the World Wide Web offers activities that provide opportunities to learn science through inquiry-based activities {9}.

#### Environmental Literacy

According to the NSF report, *Complex Environmental Systems*. *Synthesis for Earth, Life, and Society in the 21<sup>st</sup> Century* {10}, in the coming decades, the public will be called upon more frequently to understand complex environmental issues, evaluate proposed environmental plans, and understand how individual decisions affect the environment at local to global scales. The report calls for raising the environmental literacy of the general public by providing quality environmental education and training.

Learning about the environment and its implications for society is not a simple task. Environmental problems have multiple causes and multiple effects. Viewing any one portion of an environmental problem in isolation –without the other key components and points of view – may lead to simplistic understandings and unrealistic solutions. What learners require are rich and highly interrelated data sets that they can explore repeatedly, each time coming at the data from slightly different perspectives. This creates what is known as "cognitive flexibility" and helps reveal the true complexity of the problem under study {11}.

#### GIS use

Educational applications of Geographic Information Systems (GIS) are gaining attention and offer great potential for use in K-12 classrooms  $\{12\}$ . However, many teachers have difficulty using GIS in their classrooms due to inadequate training or not having time to develop GIS-based lesson modules  $\{13\}$ . Classroom adoption and implementation of GIS requires supplemental instruction to assist teachers with using GIS, as well as well-developed pedagogical and inquiry supports embedded within curricular activities.

Recently, GIS has been incorporated in professional development activities of science educators {14}. In a two-week inservice professional development project, GIS was used with inservice elementary and middle school teachers to investigate salmon recovery issues using inquiry-based instruction {15}. Survey results from this project indicated that teachers improved their understandings of the nature of science and noted the importance of GIS technology in helping to develop scientific knowledge and thinking.

#### GIS for Lehigh Watershed Investigations

Given the emphasis on incorporating inquiry teaching and learning in science specified in current science education reform initiatives, preservice science teachers will want to gain a theoretical and practical understanding about how to take advantage of Web-enhanced instructional materials and approaches to promote inquiry learning with classroom students {16}. The Web can provide access to GIS maps, interactive images that are **information-rich** (they include layers representing various types of information) and **dynamic** (learners can explore them by observing spatial patterns and by selecting more or less detail). For this reason, I have developed a series of Web-based GIS map coverages to use to promote scientific inquiry and environmental literacy using a watershed theme for use in my science methods courses.

I use four main topic areas to help learners understand the complex networks of interactions and dependencies within watersheds: *underlying science, human resources, people centers,* and *human impacts.* **Underlying science** focuses on the interdisciplinary study of the

complex and interconnected issues of natural watershed processes, plant and animal populations, natural resources, and pollution. **Human resources** addresses materials consumed or reused by humans to meet their needs, including air, water, minerals, fuels, building materials, and open space. **People centers** deals with societal needs for human activities, including housing, transportation, agriculture, industry, education, and recreation; while **human impacts** attends to how human activities affect both biotic and abiotic conditions of the environment.

As a way of illuminating these interactions and complexities, I have developed GIS coverages each organized to address scientifically oriented questions. The questions and GIS map coverages are listed below:

*Question 1*: Why does the Lehigh River flow along the specific course that it does? Has its course or pattern of flow changed over time? (Underlying Science) http://128.180.10.97/website/activity1/viewer.htm

*Question 2*: Where have people concentrated their settlements and conducted their activities during human history in the Lehigh River watershed? (Human Resources) http://128.180.10.97/website/activity2/viewer.htm

*Question 3*: Which part of the Lehigh River watershed is the best place to build your new home? (Human Resources)

http://128.180.10.97/website/activity3/viewer.htm

*Question 4*: What are some natural processes in the Lehigh River watershed and how do human actions modify them? (Underlying Science & People Centers) http://128.180.10.97/website/activity4/viewer.htm

*Question 5*: What is sprawl and how has it affected the Lehigh River watershed? (People Centers)

http://128.180.10.97/website/sprawl1/viewer.htm http://128.180.10.97/website/sprawl2/viewer.htm http://128.180.10.97/website/sprawl3/viewer.htm

*Question 6*: In what ways are different parts of society in the Lehigh River watershed economically interdependent today? What role do science and technology play in this interdependence? How would this interdependence have been different 150 years ago? (People Centers)

#### http://128.180.10.97/website/activity6/viewer.htm

*Question 7*: What environmental issues should planners consider when designing and locating a site for a new information technology company that will create jobs for 7000 new workers in the Lehigh River watershed? Build a case for the site you think will do the least damage to the watershed. (Human Impacts)

http://128.180.10.97/website/activity7/viewer.htm

#### AETS session summary:

1. An overview of Web-based GIS and how it works was presented.

2. Session attendees received a handout listing the GIS coverages described above and a variety of other interactive mapping sites. The presenter modeled how one of the GIS maps was used in science methods course instruction.

3. The activity, Sprawl in the Lehigh River Watershed was presented.

#### http://www.leo.lehigh.edu/envirosci/enviroissue/sprawl/

This activity uses Web-based GIS maps to explore sprawl in the Lehigh River watershed. Learners are introduced to sprawl and its effects on human and environmental health. GIS maps are used to study patterns of land use and population centers. Learners form their own opinions and decide on best practice solutions to land use problems and explore some of the options that land owners have today as a result of changing practices.

4. Session attendees explored GIS and interactive map coverages.

5. Questions and discussions from the session attendees took place at the end of the session.

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