Teaching environmental issues: Integrating field-based experiences and Web-based inquiry activities

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Environmental Issues Course

EDUC 394, *Special Topics in Environmental Education: Environmental Issues*, at Lehigh University takes advantage of using Web-based inquiry activities and GIS maps to promote learning. *Environmental Issues* was designed to meet Pennsylvania Department of Education program standards for environmental education (EE) certification and preparation competencies. The course primarily focuses on an in-depth study of environmental issues in the Lehigh River watershed. Course instruction uses a hybrid approach that includes field trips, Web-based learning modules and face-to-face instruction. In a face-to-face session, students are introduced to a variety of topics including EE learning theories, education standards and frameworks, GIS use in Earth and environmental science curricula, and data collection with Pasco probeware. Students then complete a series of Web-based modules and meet weekly for all-day field trips to areas of environmental concern. The Web-based modules consist of the following topics: teaching and learning about environmental issues; GIS in environmental education; implementing water quality curricular projects; environmental laws and regulations; environmental education essentials; and designing activities for environmental education. The Web-based modules take advantage of many instructional materials we have developed to promote the teaching and learning of environmental issues. These materials are housed on the

Lehigh Earth Observatory EnviroSci Inquiry Web site (http://www.leo.lehigh.edu/envirosci). Since these materials are interdisciplinary and Web-based, they are both flexible and portable to use in other disciplines in select secondary and college level courses that include geology, geography, environmental science, environmental studies, Earth system science, or ecology. Select materials include:

• *Stockertown Sinkhole Dilemma (*http://www.leo.lehigh.edu/envirosci/enviroissue/sinkholes)

In the intended use of this activity, students learn about the Stockertown sinkholes and decide who should be responsible for compensating property damage caused by a sinkhole. Students read a description of a stakeholder's role and access a variety of resources that they will use to develop a position statement about who should be responsible for the investigation and remediation of the sinkholes. They decide what should be done to solve the sinkhole problem, what might be causing the sinkholes, and what new policies should be created to protect the interest of homeowners affected by sinkholes. In this activity, students are responsible for presenting a long-term action plan to prevent and/or remediate sinkhole destruction in class during a simulated town hall meeting. The instructional use of this activity's materials and resources may be customized to emphasize the geologic occurrence of sinkholes and its implications for geoenvironmental engineering.

• *Abandoned Mine Drainage in Pennsylvania*

(http://www.leo.lehigh.edu/envirosci/enviroissue/amd/)

Abandoned Mine Drainage in Pennsylvania is a science-technology-society role-playing debate simulation. In this activity, learners investigate the abandoned mine drainage (AMD) issue from differing perspectives. In their investigation, they identify AMD problems, search for a solution, evaluate options, and decide on a course of action to treat and clean up AMD in Pennsylvania.

• *Lehigh River Photojournal* (http://www.leo.lehigh.edu/envirosci/watershed/pjournal/)

This virtual photojournal of the Lehigh River watershed contains digital images and panoramas to explore the watershed. Historical information is provided for many locations.

• Geology of the Lehigh Gorge (http://www.leo.lehigh.edu/envirosci/geology/gorge/)

This Web site includes interactive maps with picture links, surface and aerial pictures of the Lehigh River and its tributaries, a stratagraphic column, geologic map, digital shaded relief map and a 3D flyby through the Lehigh Gorge. The laboratory section contains several activities designed for learners to investigate the geologic formations of the Lehigh Gorge, relationships between rock types, topography, and river morphology.

The course field trips consist of site visits to abandon mine drainage and remediation sites to discuss issues pertaining to remediation efforts, a cement plant to discuss legislative issues involved in obtaining permits for recycling use in a manufacturing process, a state park to look at issues involved with land use planning and management practices, an area experiencing sinkhole problems to discuss who is responsible for the remediation of sinkholes, and a canoe trip through ten miles of the Lehigh River to gather water quality data and discuss pollution and water quality issues.

GIS for Lehigh Watershed Investigations

Given the emphasis on incorporating inquiry teaching and learning in Earth system science education, it is important that our students gain a theoretical and practical understanding about how to take advantage of Web-enhanced instructional materials and approaches to promote inquiry learning. 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, we have developed a series of Web-based GIS maps to use to promote scientific inquiry and environmental literacy using a watershed theme for use in the environmental issues course. The GIS maps are disseminated over the Web using an Arc IMS server. The Web-based interface is designed well and is intuitive to use. No special software is needed to view these maps other that a Web browser with an Internet connection.

We 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, natural resources, populations, 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, 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, we have developed a series of specific GIS maps each organized to promote inquiry with driving investigative questions about a particular aspect of the Lehigh Valley watershed. We have designed our inquiry-based activities to incorporate two main properties: *scalability* and *portability*. Scalability refers to the need for the problems addressed by the learner to be small enough that they can derive conclusions in a reasonable length of time, but also of sufficient detail that in completing them will understand concepts that apply to larger and more complex environmental problems. Portability means the problems addressed in our activities should involve concepts and practices

that apply to diverse locations and situations, allowing learners to extrapolate their derived understandings to problems other than those to which they were exposed.

Select investigative questions and GIS maps are described below. The GIS maps are available online at: http://www.leo.lehigh.edu/envirosci/watershed/gis/investigations.html

Where have people concentrated their settlements and conducted their activities during human history in the Lehigh River watershed?

This GIS map (see Figure 1) enables learners to examine the location of cities, towns, and major industries in relation to the Lehigh River. A map that displays these data layers shows a pattern of settlements along the Lehigh River. With the addition of the *geology* layer to this map, learners may observe that many industries are located on carbonate rock more so than any other rock type in the watershed.

----------Insert Figure 1 about here----------

Which part of the Lehigh River watershed is the best place to build your new home?

This GIS map (see Figure 2) provides learners with a variety of different data layers one may wish to examine when selecting a site to build a new home. Learners can display land use types to determine locations of urban, forested, and agricultural areas in the watershed. Map layers of major, state, and local roads can be shown to determine transportation patterns throughout the watershed. The map also contains data about sites that may be prone to natural hazards. A *limestone* data layer may be displayed to consider locations that may be prone to sinkhole occurrences, and a *flood plains* data layer may be viewed to identify areas where flooding may occur. Industries that release regulated toxic chemicals into the environment can also be located.

The *toxic chemical release inventory* data layer provides the name, address, and location of the industry and a complete list of chemicals that the site discharges. Recreational and preserved land areas including County and PA State Parks and State Game Lands areas may also be displayed. Census data for each municipality in the watershed for the years 1990 and 2000 are included and can be explored to determine population growth trends in the area.

----------Insert Figure 2 about here----------

What are some natural processes in the Lehigh River watershed and how do human actions modify them?

The GIS map for this driving question provides learners with opportunities to see how people over time have altered the natural landscape of the watershed by establishing urban and agricultural areas, and building transportation routes that include roadways, railroads, and canals. For example, in the Little Lehigh Creek catchment, agricultural land cover decreased by 48% and urban land cover increased by 700% between 1947 and 1999. Differential effects of land cover change throughout the Lehigh River watershed provide a natural laboratory for GIS-based Earth system science research and education.

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?

This GIS map (see Figure 3) used in conjunction with the historical background provided on the LEO EnviroSci Web site (http://www.leo.lehigh.edu/envirosci/watershed/history/) provides

learners with the opportunity to understand the limitations of the use of a canal route to transport anthracite coal from the coal fields in the northwest area of the watershed to the confluence of the Lehigh River with the Delaware River. Displaying both inactive railroads and active railroads on the map illustrates the importance of using railroad transportation to connect cities and towns that contain major industries in the watershed area. The *zoning* layer (see Figure 4) illustrates how land is designated for use today. A careful examination of this portion of the watershed shows predominantly residential and commercial land uses located near the Lehigh River, especially in the southern areas of this map display. Agricultural areas surround this area to the north and west and a tract of land designated as open space is observed along the northern tract of this map section.

----------Insert Figure 3 about here----------

----------Insert Figure 4 about here----------

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. This driving question is an authentic issue that faces the Lehigh River watershed today. This GIS contains all map layers previously discussed. When examining these map layers, learners must consider the anthropogenic effects of a significant population increase in a watershed area. Issues of resource management and use of available space must be considered for environmental decision-making.

Sprawl in the Lehigh River Watershed activity

Land use and development in the form of urban or suburban sprawl has always been a problem in the minds of many people. We have developed an activity available online at http://www.leo.lehigh.edu/envirosci/enviroissue/sprawl/ that uses Web-based GIS maps to explore sprawl issues in the Lehigh River watershed. Learners are first introduced to historical population growth patterns in the Lehigh Valley watershed. Next, they are prompted to use a GIS map to explore trends in population change in the watershed area. The impacts of zoning laws created by multiple municipalities are then presented. Learners are prompted to use a GIS map to explore the effects of transportation infrastructure on land use. Information on the effects of sprawl on human and environmental health is then presented in the activity. Environmental issues that include pollution, effects of creating impervious surfaces, deforestation of riparian buffers, and the reduction of open spaces and farmlands are discussed. Learners are then guided to use GIS maps to examine patterns of land use and population centers. Best practices in land use including smart growth initiatives, brownfield redevelopment, and the creation of conservation easements are discussed. As a culminating activity, learners are presented with two differing viewpoints about creating a new highway extension in the area. They are prompted to select a viewpoint and write a position statement with supporting facts if the highway extension should be constructed or if the land should be preserved.

Concluding Remarks

In the activities and ideas described in this article, students learn spatial concepts and data analysis skills essential for disciplinary science and Earth system science education using inquiry-based instructional methods. In the course, environment and ecology content and EE

pedagogy are integrated and interdisciplinary. Investigating driving questions about one's immediate environment promotes a sense of personal involvement in understanding authentic issues in one's geographical area. When learners critically examine a local environmental issue with inquiry-based methods, they develop conceptual understandings and practices that can be transferred to related issues in different geographical areas. The use of the materials and activities described in this article are portable; they can be used by other instructors at universities and in secondary school settings in different geographic locations to understand associated issues. For example, the concepts and understandings one learns from the *Stockertown Sinkhole Dilemma* can be transferred to understand geoenvironmental engineering and policy issues in other areas of the United States that contain limestone geology that might be prone to sinkhole occurrences.

Instructional activities that incorporate GIS maps can be effective for learning about interdisciplinary connections among the Earth and environmental sciences, providing a broader systems view of an area under study. Using Web-based GIS provides learners with opportunities to explore spatial concepts and participate in real-world environmental problem solving.

Figure 1. GIS map of the Lehigh River watershed showing land cover patterns, the location of population centers and industries along the Lehigh River and its major tributaries. Shaded colors illustrate the different geology types.

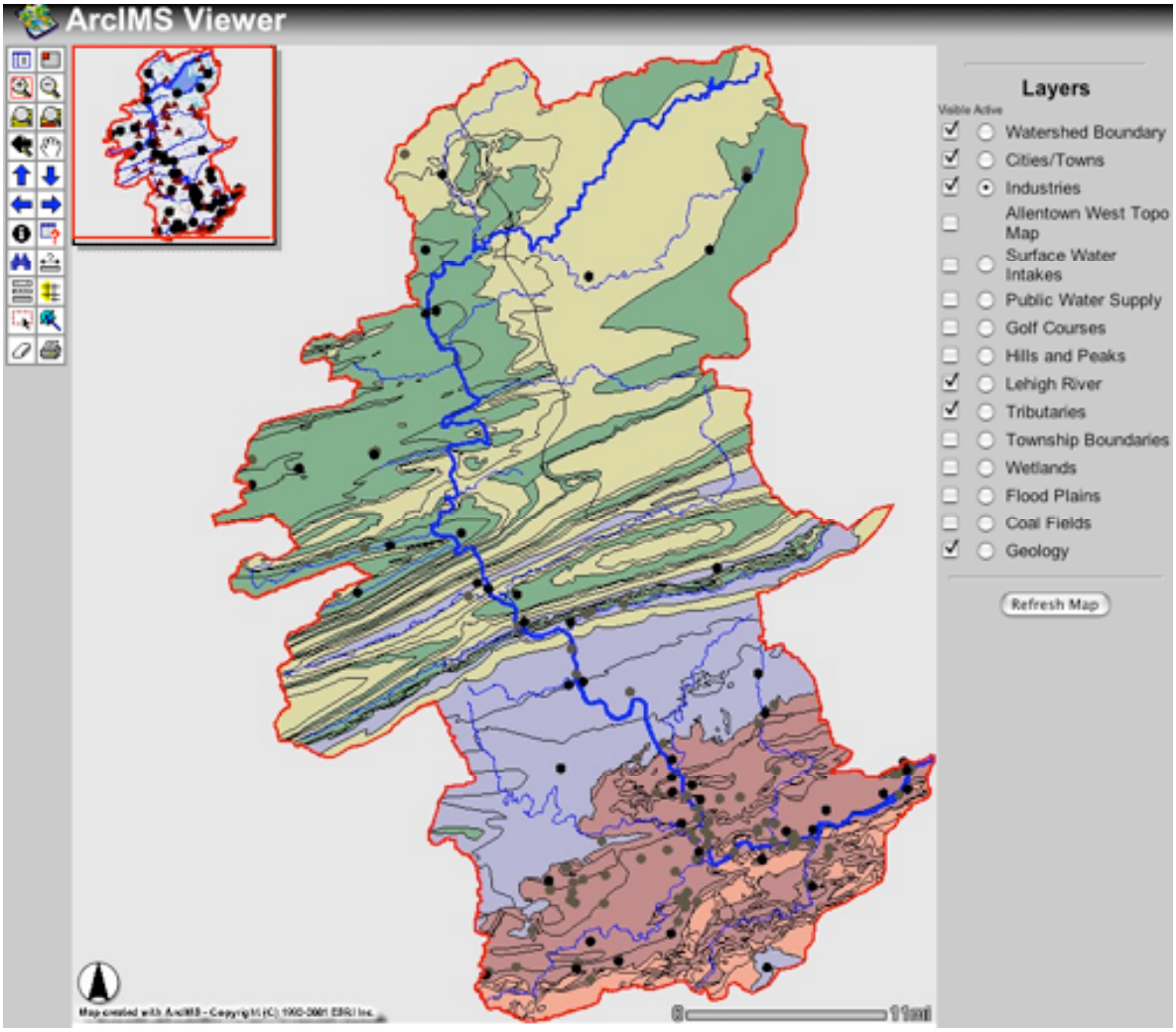

Figure 2. GIS map of the Lehigh River watershed displaying the location of recreational and preserved lands, limestone areas, and industries discharging toxic chemicals.

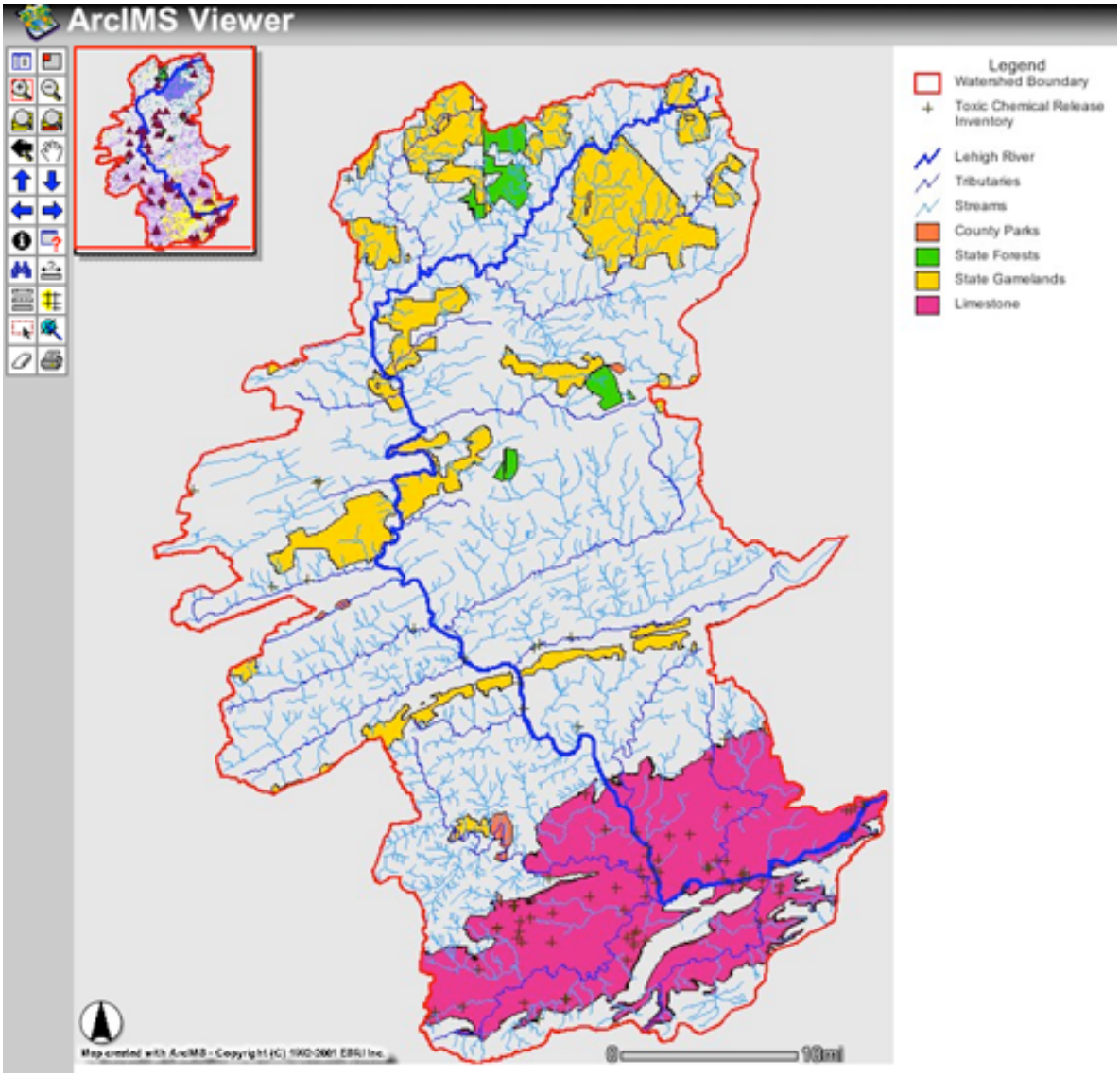

Figure 3. GIS map of the Lehigh River watershed displaying the location of canal and railroad transportation routes from coal fields to cities.

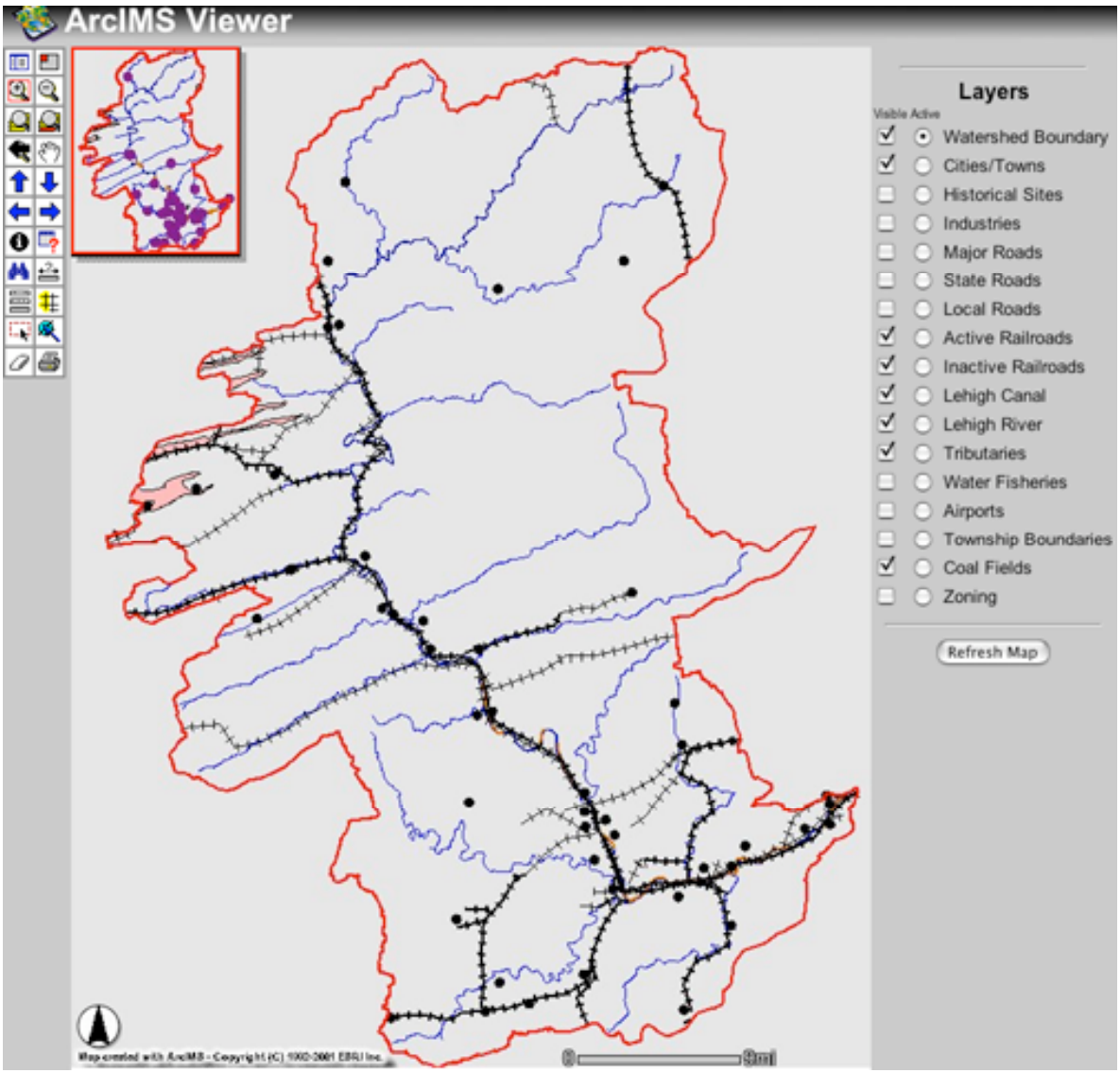

Figure 4. GIS map displaying land use zoning in a subsection of the Lehigh River watershed.