Data Tools for Real-World Learning

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Many teachers want their students to have opportunities to learn in the context of real problems of meaningful complexity, particularly in the local community of students' personal experience and interest. However, a teacher encounters many barriers to such contextual or project-based learning.

In addition to institutional and logistical obstacles, there are cognitive challenges in addressing complex, real problems. And real problems lead learners into territory beyond the knowledge base of any one teacher. Teamwork among people within and outside of school is essential in real-world projects.

Teachers, students, and others in a community can take advantage of a combination of technologies to help overcome some of these barriers. We provide an introduction and examples of ways in which teachers and students and their local communities are using geo-referenced data and geographic information systems (GIS) technologies to work on real phenomena.

Combining Community, Internet, Data, and GIS

Local, state, and national government agencies and nongovernmental organizations are making data and other information increasingly accessible on the Internet to allow people working on a common problem to share data and information and help each other learn. Local organizations are taking advantage of the Internet and shared data to reach out to students and teachers. For instance, the Thornton Creek Project near Seattle, Washington, is a collaboration of networking students, teachers, residents, and other decision makers all working together to understand and actively care for their watershed. (See Resources for projects and programs mentioned in this article.) Figure 1 shows a portion of their Web site that provides tools for sharing information.

![Figure 1. Community-based data collection in Thornton Creek Project.](image)

When data include a geographic reference—latitude and longitude or a street address—that data can be represented not only numerically, graphically, or verbally, but also spatially. When data are geo-referenced, we can manipulate the data using a collection of technologies called GIS or geo-spatial information technologies (GIT). Using the geographic reference as a key, we can analyze relationships among data from different sources, such as roads, population density, rivers, and land use patterns. The Thornton Creek Project supports mapping projects in Thornton Creek watershed schools. Students learn to connect social and natural phenomena to the geographical space in which they live. By viewing information in a spatial context, students can begin to connect their actions and those of community members to the quality of life in the watershed.
GIS combined with Internetwork-ing provides the “glue” to help us bring together the following elements:

- cognitive as well as technical access to large amounts of data and information,
- ability to mine that data to extract relevant subsets,
- ability of both subject-matter experts and nonspecialist students and interested citizens to manipulate and visualize patterns and relationships in data,
- multidisciplinary perspectives on complex situations involving the natural, sociopolitical, and human-built environments, and
- ways of representing and sharing results of an investigation in visually appealing and approachable forms such as thematic maps.

Accessing Large Data Sets

We are often told vast amounts of data are available on the Internet. Although this is technically true, it is not always cognitively true. That is, a learner can go on the Internet (or to the library) and find a lot of data, but the data may not be understandable to that person in the form in which he or she finds it.

For instance, a student wanting to learn about hazardous chemicals in his or her environment might find a chart listing the total annual volumes of various chemicals released into the atmosphere by industries in his or her state. To a nonspecialist in this subject, such data have little or no meaning. However, suppose that same student uses the U.S. Environmental Protection Agency’s EnviroMapper to look at a map of toxic release sites near his or her own school (Figure 2).

![Figure 2. Visual data mining with EPA’s EnviroMapper.](image)

A student may know little about either the companies or the chemicals they release. This visual presentation provides enough cues (“that’s our school there on Main Street”) to motivate the next logical questions, “What are these places?” and “What are these chemicals?” With some guidance, the student using EnviroMapper can retrieve information on a company and the chemicals it releases, then go directly to a different database that explains the nature of that chemical’s effects on humans and the environment.

EnviroMapper is one of a growing number of GIS tools and data collections you can use interactively on the Internet as a first step in developing skills and knowledge in the use of GIT. The Geography Network is a new Internet service providing links to such application service providers in a wide range of subject areas.

Visual and Spatial Aids for Data Mining

Federal government agencies (e.g., U.S. Environmental Protection Agency, http://www.epa.gov/; the U.S. Census Bureau, www.census.gov; and the U.S. Geological Survey, http://www.usgs.gov/) provide numerous data sets about our natural and human-made world online. Examples include data about our waterways, air, toxic chemicals, highways, land use, and populations. State and local government agencies, such as
departments of natural resources and economic development, also are increasingly making their data accessible online.

An expert in a given subject area has a broad repertoire of techniques for zeroing in on the particular subset of data he or she needs from large collections of data because he or she has a rich base of knowledge by which to interpret the data and their interrelationships. Someone new to the subject, on the other hand, has few associations to aid in data mining. Geographic and other visual and spatial cues can help to bridge this gap.

The EnviroMapper example in Figure 2 illustrates several GIS techniques to aid the intuition: zoom, scale, layers, visual cues, and hypertext. First, the learner can zoom in on a particular geographic location through visual inspection of geographic locations and repeated pointing and clicking of the mouse. Second, as one zooms in to maps of increasingly larger scale, more detail is automatically revealed. On a map of the United States, only the state outlines are visible; at the state level, the county outlines are revealed; within a city, named streets become visible. This revealing of successively greater levels of detail at larger scales of the map is a function of the software tool itself and does not require the learner to (yet) understand how to choose appropriate levels of detail for particular scales of representation. Third, different kinds of information (schools, waterways) are stored in separate layers, which can be turned off and on at a click of the mouse. Thus it takes less than a second to select or deselect an entire collection of information as a beginner explores the relevance of a particular parameter. Fourth, colorful icons represent data points in a layer, so there is both a shape and a color for visual cues to associate with a particular layer or type of data. Notice also in the EnviroMapper example how hypertext makes it easy for a novice to access more detailed explanations of the meaning of these abstract icons—such as “hazardous waste.”

At Boulder (Colorado) High School, students making maps by hand to analyze a neighborhood problem using demographic data were able to analyze only four or five variables related to a particular problem, so the teacher would provide the data for those most relevant variables. With the use of GIS, students themselves were able to select, from more than 60 variables, the ones that supported their analysis of the problem. Because the students selected their own variables, they had more ownership of the project with the GIS component added. There was a marked increase in the frequency of referring to the maps as analytical tools after GIS was used (Wanner & Kerski, 1999).

**Analyzing Spatial Patterns in Data**

GIS tools provide a variety of methods for analyzing spatial patterns within and among layers of georeferenced data. Examples of such methods include thematic mapping, spatial interpolation, proximity analysis, network analysis, and image processing.

High school and junior high students in Detroit, Michigan, conducted a survey of safety hazards in their school neighborhoods as part of a Safe Schools program. Using a rubric they helped to develop, the students rated the buildings around their schools as to whether they posed a safety hazard. They entered their ratings for each building into a GIS system that already included street addresses for all parcels of land in the city. Using color-coding for each category of building rating, they easily produced a series of thematic maps that show the patterns of unsafe conditions and neighborhoods by colors. School and law enforcement officials, using these thematic maps, were easily able to prioritize areas needing immediate safety attention and remediation.

In their Community Atlas project, Northern High School students in Port Huron, Michigan, obtained an iso-surface map from the Globe Program Web site (Figure 3). In the students’ analysis of this map, notice their references to what “you can see” and other spatial cues. (See Student Map Analysis on this page.)
The GIS technique to produce temperature iso-surface maps is called spatial interpolation. Because a limited number of observation stations exist, temperatures between those stations (known points) are interpolated at certain distances by applying a mathematical function. In this instance, the students obtained the iso-surface map from the Globe Web site and made their own interpretations.

Analyzing Multidisciplinary Perspectives

The central reason for using GIS tools for real-world problems is our capability to analyze and visualize the interaction of natural, social, and built environments (Figure 4).

Here, students at Chelsea (Massachusetts) High School, under direction of teacher Walter Paul, analyzed the predicted atmospheric dispersion plume of a hazardous chemical (indicated by the shaded area) accidentally spilled into the Chelsea River at Gulf Oil (center).

In a simulation of an emergency hazardous materials incident, they analyzed this plume in relation to the location of vulnerable populations such as a nearby elementary school. Based on this geographic analysis plus information the students retrieved about the characteristics and effects of this particular chemical, the students made recommendations to the police and emergency medical teams regarding areas to evacuate (Paul & Hamilton, 2000).

Sharing an Investigation

GIS tools enable students to share the results of their investigations with diverse audiences. These visually appealing products share and build data, information, and ideas among people of different backgrounds and knowledge. Ambitious endeavors involving analysis of data gathered by thousands of people are imaginable only with the tools of GIS. Washington State’s Nature Mapping program promotes biodiversity studies through citizens’ and school-based data collection and research. Students and others make field observations of thousands of species of birds, mammals, fish, insects, amphibians, and plants. Their georeferenced observations are mapped using GIS. The analysis involves the use of satellite imagery to create vegetation maps of the state. Additional information is mapped in layers that can be overlaid on each other. These map layers include the distribution of species, water and geological features, soil types, land use and land ownership, and roadways and topography. Areas important to individual species, groups of species, or of high biological diversity can then be identified and the degree of protection assessed.

In the Work/Site Alliance (W/SA) in southeastern Michigan, teachers from high schools, a community college, and a regional university learn to apply GIS to community-sponsored projects such as those listed in Table 1.
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<thead>
<tr>
<th>Communities/ Clients</th>
<th>GIS Project Topics</th>
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<tr>
<td>Ypsilanti Meals on Wheels; History of</td>
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<td>Transportation Course</td>
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<td>Ypsilanti City</td>
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<td>Wayne County Office of Economic Development</td>
<td>Brownfields inventory</td>
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<td>Wayne County</td>
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<td>Detroit Public Schools</td>
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<td>Novi City; Taylor City</td>
<td>Parks and recreation</td>
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<td>Detroit 300; Goodison MI; Corktown Redevelopment</td>
<td>Historic neighborhoods</td>
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<td>W/SA-sponsored case study</td>
<td>Agricultural lands</td>
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<td>Classroom project</td>
<td>Natural disasters</td>
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Table 1. Work/Site Alliance GIS projects and their client organizations.

W/SA projects are documented as case studies to aid other teachers who wish to conduct similar projects in their own classrooms and communities. The case study data, analysis procedures, and associated maps are provided in a format that you can analyze with ArcView, a commonly available GIS program. Therefore, teachers and students can manipulate and analyze the same data, producing their own variations of the projects as they learn the techniques for doing the study.

**Summary**

Student learning in real-world projects requires teamwork and shared data. The combination of GIS and the Internet enable people to work together on common problems and projects by sharing and building on each other’s data and knowledge. Novices can begin to understand complex phenomena through visual and spatial representations and techniques for data manipulation and analysis.

**Resources**


Educator’s introduction to GIS: [www.gis.com/specialty/educators/k12.html](http://www.gis.com/specialty/educators/k12.html)

EnviroMapper: [http://maps.epa.gov/enviromapper](http://maps.epa.gov/enviromapper)


Nature Mapping: [www.fish.washington.edu/naturemapping](http://www.fish.washington.edu/naturemapping)

Thornton River Project: http://nsccux.sccd.ctc.edu/~tcp

Work/Site Alliance case studies: http://ceita.acad.emich.edu/

References


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