

25. A Strategy for Integrating GIS

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Introduction

The teaching modules enabled middle and high school teachers in the Rockford public schools to explore the local community with geographic information systems (GIS) and global positioning systems (GPS). The modules, which were introduced to the teachers in workshops conducted between 2000 and 2003, required the purchase of GIS software and GPS hardware for five separate school buildings throughout Rockford. By the end of the project, more than 60 teachers from disciplines ranging from English to mathematics were trained in the use of GIS. The goal of the program was to illustrate a powerful tool for integrating spatial concepts and geographic principles across disciplines. This pedagogical goal is consistent with other approaches taken to train teachers on the use of GIS (Meyer, Butterick, Olkin & Zack, 1999).

What Are GIS and GPS?

A GIS is usually defined as a computer system for capturing, storing, and displaying geographically referenced information; however, many definitions have been proposed (see Clarke, 2003, p. 2). A GIS system is almost always described in terms of map layering, where the software allows the analysis of many maps of information about a place (Figure 1). The types of map layers vary as much as the many disciplines that employ GIS. For instance, health specialists might include a map of hospitals for a given region as a layer combined with a census block map that includes population counts. Such maps within a GIS could be used in an analysis of the number of hospital beds available to potential patients in a region and could even lead to the identification of underserved areas. In such a definition, a GIS is composed of features (like hospitals and census blocks) combined with attributes about those features (number of beds and people) and stored in a database table that is indexed to the features. Finally, the most critical component to the definition of a GIS is geographical referencing, which ties features to a common geographic coordinate system (latitude and longitude).

A GPS, on the other hand, is a satellite navigation system that allows a user who has a GPS receiver to pinpoint a precise geographic location from a constellation of satellites devoted to this purpose. The constellation of satellites is owned and operated by the U.S. Department of Defense (DOD). Nevertheless, the use of GPS for civilian uses has increased in recent years.

The relationship between GIS and GPS is strong in that they are both systems that rely on geographic coordinates. In most cases, GPS systems serve as an efficient method of acquiring data for a GIS; for instance, if one were interested in developing a map layer of trees for a neighborhood, one could derive their location (latitude and longitude) with a GPS receiver and transfer the coordinates into a GIS and generate the map layer. Alternatively, a GIS sometimes serves as input into a GPS; for instance, consider the case where a conservation organization wishes to send naturalists into the field to verify raccoon habitats it already has in its GIS. The

task is simple: feed the GIS coordinate locations into the GPS receiver and navigate to the locations with the GPS unit.

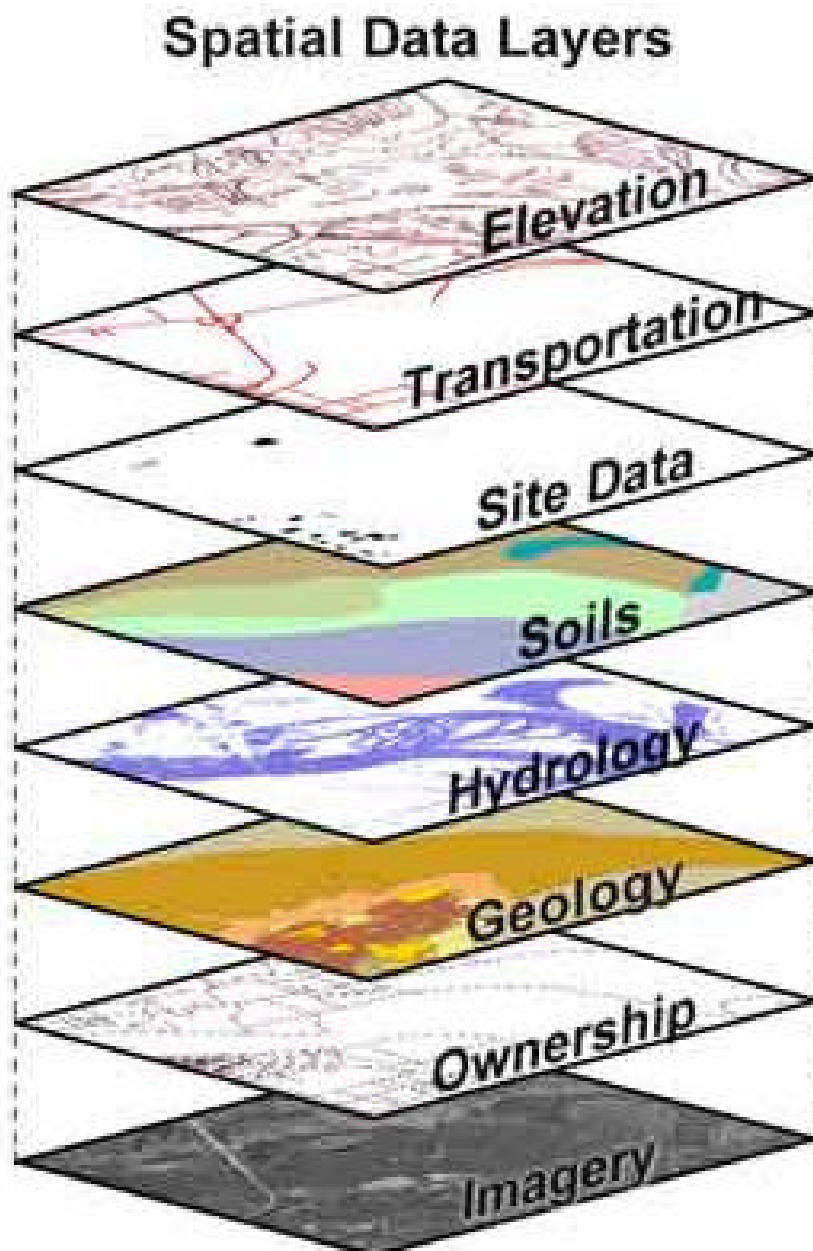


Figure 25.1 Concept of Map layering

Acquiring Hardware and Software for the Teachers

A number of studies have shown that access to hardware and software is a critical factor in the success of GIS teaching-preparation programs (Bednarz & Ludwig, 1997). Meyer, Butterick, Olkin, and Zack (1999) also note this problem by initiating two studies, one concentrated on teachers and the other concentrated on students. They specifically address the availability and

cost of hardware and software and find that the larger problem was with hardware, since many GIS software vendors offered discounts.

The Rockford project on GIS/GPS had funding to purchase laptop computers for each teacher. It also paid for the purchase of Environmental Systems Research Institute's (ESRI) ArcView 3.X site licenses for five schools (ESRI, 2003). ArcView is a GIS software package that has been adopted by many schools throughout the United States (Figure 2).

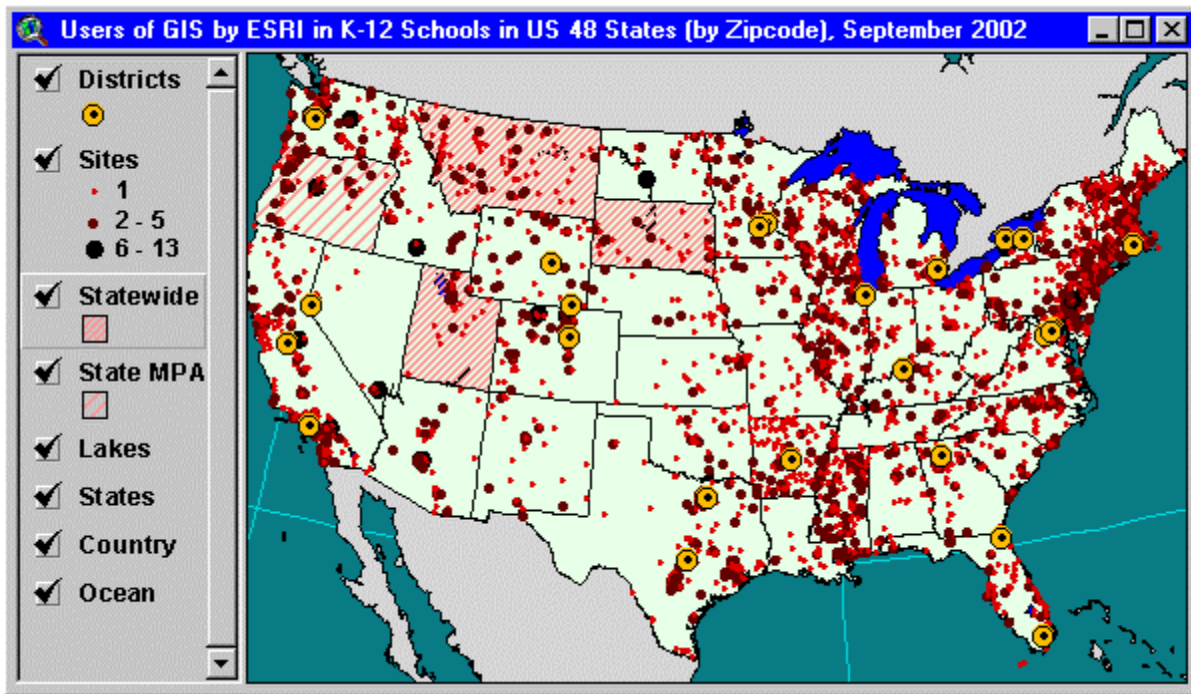


Figure 25.2 Schools Using ArcView GIS (ESRI, 2003)

In addition, the project bought Navman GPS units bundled with Rand McNally's Street Finder software for each teacher who participated in the GIS/GPS workshops.

Workshops

The project offered a two-day workshop for GIS and a one-day workshop for GPS, structured around modules developed for studying the Rockford community. The GIS module consisted of 12 lesson plans, with discussions on how teachers could use or modify them for their own subject areas. The GPS module consisted of 11 sequential and cumulative lesson plans. Unlike the GIS lesson plans, which could be taught in any sequence, the GPS lesson plans were part of one large project.

The principal educational goal of the GIS/GPS modules was to help students understand their local community and how geography has helped shape the society in which they live. A secondary goal was to introduce students to mapping and the associated concepts of map projections, map scale, and cartographic generalization. A tertiary technology goal was to develop proficient use of GIS and GPS and to understand the database structure underlying these technologies.

These goals were consistent with those developed by *Geography for Life: The National Geography Standards 1994* (Geography Education Standards Project, 1994). The GIS module was most consistent with Illinois and district learning standards, where a clear link could be made to: (1) social studies, grades 6-8, goal 17, geography, standards A-D; and (2) social studies and environmental sciences, grades 9-12, geography.

It was important to tie the GIS module to these standards, but it was emphasized that the content could be incorporated into geography, history, sociology, economics, environmental science, and technology.

In addition to drawing links to the state learning standards, industrial partnership activities were proposed. For instance, the module handout mentioned the use of GIS by the Rockford Police Department for crime analysis and suggested that a fieldtrip to the police department could be organized to demonstrate the use of GIS in the operation of city functions.

Description of the GIS Instructional Module

The first lesson in the module was the definition of GIS. Teachers were asked to go to the site www.gis.com and evaluate it in terms of how their students would respond. The lesson activity then instructed them to visit the following portions of the page and answer these questions:

- 1) Click on *What is GIS?*
What is the definition of GIS?
- 2) Click on *GIS for your Specialty.*
How many specialties use GIS?
Click on one specialty and summarize how GIS is used.
Can you think of a specialty that could use GIS but is not listed?
- 3) Click on *Try GIS for Yourself.*
Which mapping applications did you like best and why?
- 4) Click on *GIS-Software.*
What is GIS software?
List the variety of software options available.
- 5) Click on *Data for your GIS.*
What makes GIS data unique?
List some sources of GIS data.
- 6) Click on *Education and Training.*
What types of educational programs are available for GIS?
- 7) Click on *News/Events/Trends*
List some examples of GIS in the News.

The teachers especially liked the active learning aspect of this lesson.

Lesson 2 introduced the principal elements of GIS through an activity that started the teachers with the ArcView GIS software. They practiced turning map layers on and off and learned how to access attribute tables associated with each layer. Initially, they found some of the functions difficult, for instance the difference between a polygon layer (state boundaries) and

a line layer (rivers) and how the drawing order was important for their display (lines on top of polygons). Most teachers felt that the students would have very little difficulty with the lesson.

Lesson 3 introduced the teachers to downloading a community map layer of roads from a website that makes U.S. Census Bureau GIS files available. A slight deviation from GIS was necessary because most map layers on the Internet are archived and require software to unzip the archives. An additional activity of the lesson was to perform a geo-coding service, sometimes referred to as address matching as it compares two addresses to determine whether they are the same. To match addresses, ArcView looks at the components of addresses in both the tabular data file and the feature data source. Then ArcView looks for certain standards and makes a decision about whether addresses match. The Census Bureau's street maps have four street address numbers, ranging from low to high, for each side of a street segment. The range indicates the possible numbers that could fall within a particular block, and the numbers are divided into even on one side of the street and odd on the other. The address components for this type of street are typically represented as:

Left_from	Left_to	Right_from	Right_to	Street_name	Type
201	299	200	298	SUNSET	ST

The teachers were instructed to assume that the Rockford Public Library had asked them to make a quick map of the locations of three patrons who visited the library that morning. They were given the following addresses:

ID	Address
1	100 Rockton Rd.
2	152 Auburn St.
3	27 Blossom Rd.

On completion of the lesson, teachers displayed the location of each library patron on a map superimposed on the street map layer. The teachers then discussed the possible scenarios they could create for students to learn the technique of address matching within a GIS.

Lesson 4 introduced the concept of map projection. Participants were asked to change the map projection of one of their map layers. Map projections involve a mathematical transformation of the coordinates (the map being a two-dimensional representation of a three-dimensional Earth). The lesson demonstrated the concept by transforming the Census Bureau road-map layer from geographic coordinates (latitude and longitude) to the UTM coordinates that were shown on a topographic map downloaded from the United States Geological Survey (USGS) Web page.

An equally important concept is map scale, a concept that the teachers could more easily appreciate. Lesson 5 demonstrated the concept of large-scale maps (more geographic detail) versus small-scale maps (less detail) through GIS by using the zoom in and zoom out function. Scale was also demonstrated by overlaying map layers collected at different scales in order to illustrate the concept of map generalization. The teachers understood the importance of scale and thought that the concept would be easier to communicate than map projections.

Lesson 6 taught the teachers how to integrate points collected from a GPS unit into the GIS. Prior to the workshop, some GPS points were collected within Rockford, and the teachers later added the points into a database table and translated them into the GIS. Not all participants would be taking the subsequent workshop on GPS, so it was important to illustrate to all of them how the two technologies were integrated. The teachers thought the students would like the fieldwork component of this activity.

Lesson 7 illustrated how an aerial photograph is used as a layer in a GIS and often as the base for referencing all other layers (see Figure 1). Teachers downloaded a USGS digital aerial photograph of the site of the high school and zoomed into the various parts (such as the parking lot). They thought the students would especially like this activity. Lesson 8 involved downloading a census block map and overlaying it on the aerial photograph to show differences in spatial precision.

Lessons 9, 10, and 11 emphasized the attribute-table side of GIS. The activities involved creating tables, adding fields to tables, updating data cells, and examining the resulting changes to the map features. Lesson 12 introduced the principles of thematic mapping with two specific types: choropleth (shaded area) mapping and dot density mapping. The activity in this exercise involved mapping several demographic variables for the Rockford area. The teachers were asked to map the 2000 African American population, first using a choropleth technique with five equal intervals. Next they were asked to use a dot map for the same population and to overlay the two and discuss differences in spatial patterns. Many of the teachers saw this as a powerful tool for mathematics applications and for visualizing patterns.

Conclusion

The project was an effective model for disseminating GIS into middle and high schools. Many of the teachers have adopted some of the module lesson plans and others expect to modify them for their own specific areas. We can expect more teachers to adopt GIS and GPS into middle and high school curricula as teachers come into the system with backgrounds in this growing area. Bednarz and Audet (1999, p. 61) note the following:

Throughout this decade efforts to implement GIS have been directed at in-service teachers. Thus, most teachers who use GIS in their classrooms have learned the technology while on the job. However, experts in GIS and education recommend pre-service as well as in-service education (EDGIS 1995, 1996). In-service teachers have a limited amount of time to acquire the skills needed to use GIS to teach geography and, as Brownell (1997) notes, the quality, methodology, and effectiveness of such training is in question. In contrast, pre-service teachers have both the time to become technologically proficient and access to training at university facilities by GIS-literate professors.

Nevertheless, in-service training programs such ours will be of great benefit as schools make the transition to hiring teachers trained in GIS.

Echoing findings by Meyer, Butterick, Olkin, and Zack (1999), most of our teachers felt that they needed additional hands-on practice beyond the initial workshops. One of the

mathematics teachers invited me to his classroom following his first GIS workshop, and I gave a presentation to the students and had them complete one of the lesson plan activities. After that visit, the teacher attended my GPS workshop, where I learned he was integrating GIS, GPS, and CAD into a project for the students. Follow-up communications showed that he was working through many of the difficulties that one encounters when developing an activity from scratch. In addition, I offered a follow-up review session at the beginning of the upcoming school year after the workshop to provide review and support for those who were going to implement GPS/GIS in their modules.

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