How GIS Professionals Help School Teachers and Students Use GIS

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Abstract

Many GIS professionals want to help students and teachers use GIS in their local schools, but are uncertain about how the tools and their expertise might fit into classroom practice and curriculum. This paper guides effective efforts to assist schools, based upon experiences and opinions of 300 teachers across the U.S. in grades 7 – 12, in science, math, social studies and technology. Over three years in a National Science Foundation-supported project, teachers discussed which curriculum subjects and topics are best suited to using and teaching GIS; roles they see for GIS in teaching and learning in their classrooms; challenges they face as they incorporate GIS applications, techniques and data into their teaching practices; what assistance they need as they apply these tools in their teaching.

Introduction

A growing number of elementary and secondary school teachers wish to learn and apply Geospatial Information Systems (GIS) in their teaching and classroom practice. This paper is addressed to GIS professionals and teacher educators who want to assist teachers and students in this process. GIS professionals are sometimes uncertain about how the tools and their expertise might fit into classroom practice and curriculum. They can engage in more productive partnerships with schools to the extent that they understand purposes teachers have for applying GIS in their curricula and classrooms, challenges teachers encounter in learning GIS and applying it in their teaching practice with students, and types of assistance teachers need. In many cases, the GIS professional already has contact with a teacher or administrator who can help get the collaboration started. If not, the professional can contact a technology and/or curriculum coordinator or a building principal at a particular school of interest.

This paper is based on collaboration among classroom teachers, GIS professionals, and teacher leaders in project VISIT over the past four years. Project VISIT (Virtual Immersion in Science Inquiry for Teachers) is a professional development program for teachers in grades 5 – 12, supported by the National Science Foundation's Teacher Enhancement program. Between January 2000 and February 2004, about 300 teachers, 30 teacher leaders, and experts in GIS participated in the VISIT online Collaboratory. The purposes of this activity included the following:

- advancing teachers' understanding of geospatial data and information systems (GIS),
- applying these tools and applications in their classrooms and curricula, and
- conducting real-world investigations that take advantage of these technologies.

VISIT participants included teachers of chemistry, earth science, English, environmental science, geography, history, integrated natural science, library/media, life sciences, mathematics, physical education, physics, social studies, and technology. Participating teachers work in nearly all regions across the United States. Urban, suburban, and rural schools are all represented through the teachers involved in this study. Their teaching experience ranges from less than one to more than 30 years. They represent a wide range of technological skills and fluency, as well as the full range of teaching and classroom management styles. The information in this paper is derived from the discussions among teachers and leaders in online discussion forums. For more information about VISIT, and the products of VISIT, see http://ceita.emich.edu/visit A more detailed description of the VISIT model for professional development and the effectiveness of the online Collaboratory is provided in the report *Teachers Learning Online: Lessons from the VISIT Collaboratory* (Hunter, 2004).

What are Teachers' Interests in GIS?

In the VISIT program, teachers were encouraged to learn about GIS tools, techniques and applications and to discuss their interests in terms of project topics and instructional purposes. The GIS professional, as an outside consultant, can begin a productive partnership by both explaining some of the kinds of GIS applications they work with in the "real world" and discussing the teachers' topical and instructional interests as these may relate to GIS. An excellent starting point for such conversation is the book *Community Geography: GIS in Action (*English & Feaster, 2003). This book describes in detail seven case studies of community-based GIS projects conducted by students and teachers in partnership with companies, nonprofit organizations and government agencies. Examples include mapping crime data, mapping invasive plant species, tracking water quality, investigating point-source pollution, school bus assignments, inventorying trees, and managing wildlife areas. Other sources of information about school and community GIS projects and learning are available from the following:

- the VISIT web site (http://ceita.emich.edu/visit/getting_started/3.1_Resources.htm);
- ESRI's web site for schools and libraries (http://www.esri.com/industries/k-12/tocdetails.html#indepthschools); and
- the book *GIS in Schools (*Audet & Ludwig, 2000*).*

Topics

VISIT teachers expressed interest in hundreds of different topics for GIS-based investigations and subjects to be incorporated in lessons. Table 1 shows a sample of these, based on discussions in the online forums.

ABIOTIC	ALLIANCE	AMISH	ANATOMY
ARCHAEOLOGY	ARTHROPOD	ARTS	AXIS
BAROMETRIC	BASIN	BAY	BEDROCK
BOGS	BUTTERFLY	CALIFORNIA	CANADA
CANCER	CHEMIST	CLOUD	COMMUNITY
CREEKS	DARWINIAN	DEMOGRAPHY	DERIVATION
DISSIPATE	DYNAMIC	ECLIPSE	ECOSYSTEM
ENTOMOLOGY	ETHNIC	FAULT	FISH
FLOOD	FRACTION	FROG	GDP
GEOLOGIC	GOVERNMENT	GROUND	GYPSY
HERPETOLOGY	HIGHWAYS	HYDROLOGY	IGNEOUS
INCOME	INEQUITY	INFRARED	JAPAN
JOURNEY	KOREA	LAKE	LANGUAGE
LIMESTONE	MACROINVERTEBRATE	MAGMA	MICROBE
MOON	NINO	NUCLEAR	NUTRIENT
OLIGOTROPHIC	OTTER	PATHOGEN	RACE
REGION	REPTILE	RIPARIAN	SALAMANDER
SEISMOLOGIST	SIMULATION	SPECIES	SURFACE
TEMPERATURE	TRACKING	TURBIDITY	UPWELLING
VOLCANO	WAR	WATERSHED	WEATHER
WETLAND	WINDS	WINTER	

Table 1: Example topics of teachers' GIS projects and lessons.

From a curriculum standpoint, topics in earth science, environmental science, and history are easiest for science and social studies teachers new to GIS to visualize and infuse into existing curricula. Interdisciplinary studies are also a motivation for using GIS, especially when teachers of different subjects are able to work as a team. Initially, teachers are most interested in applications that fit directly into topics they already teach in those subjects. For example, world-wide patterns of volcanoes and earthquakes in relation to tectonic plate boundaries is a topic commonly taught in earth science and is easy to visualize using GIS. GIS applications in high school physics, chemistry, and biology curriculum were present but less common in VISIT discussions. Connections with geography curriculum would seem obvious as well, but relatively few teachers of geography participated in VISIT.

Local phenomena and issues play a major role in teachers' topical interests in applying GIS. "Watershed" was one of the most frequently discussed topics, as were other water-related terms, such as "water", "stream", "water quality", "river", and "lake". Terms such as "purple loosestrife" and "frogs" were used in

the context of issues of importance in teachers' localities. Other frequently-cited topics included land use policies, epidemiology, water pollution, local history, and school bus routes.

The following are a few examples of projects and lessons that teachers developed. These and others are available at the VISIT web site: http://ceita.emich.edu/visit/investigation/Investigations.htm:

- Rouge River Watershed
- Water Chemistry a spatial Viewpoint
- Michigan Bedrocks
- Michigan Ski Relief
- Plate Tectonics using ArcView
- Comparing and Contrasting Climates using ArcVoyager
- EI Nino
- Evolution
- Is Global prosperity and Ecological Sustainability Possible: An Environmental Justice Lesson.
- Michigan Glaciers
- National Park Geology Research
- Race and Ethnicity of the United States
- Headed Toward Midnight: The Underground Railroad in Wayne County,
- Spatial Analysis in Environmental Studies: Habitat, Watershed, Forestry
- Toxics in Our Neighborhood
- Learning About Chemicals and Their Use In Our Community

Instructional interests

As they became familiar with the tools, data, techniques, and applications of GIS, teachers defined the instructional purposes for which they wanted to use GIS with their students. In general, teachers discussed using GIS in their teaching practice to enable their students to:

1. work with real data and real-world problems in the context of the curriculum and their standards of learning
2. map field data they have collected, often in combination with other data from their field study area
3. perform open-ended investigations, inquiry processes, and project-based or problem-based learning experiences.
4. visualize and understand complex phenomena and data.

Since GIS professionals engage in such activities on a daily basis, they can provide invaluable assistance to teachers and students by giving examples of how they perform and think about the tasks involved.

Working with real-world problems and data.

Why do teachers want their students to work with real-world data, what kinds of data are they looking for, and what assistance do they need in taking advantage of available data sources? In some cases, teachers are working with their students on particular projects and want to use GIS tools for modeling and analysis of the data. Some teachers feel students will be more motivated if they are working on real problems or problems relevant to their local community, rather than textbook or "canned" problems. Some teachers like their students to learn how data is collected using contemporary instrumentation such as remote sensing and GPS. The following are some examples of the reasons teachers gave:

- "The application of a real world analysis is always a challenging but important goal in the classroom."
- "I like to have my students take data and analyze it to develop critical thinking skills.
- "The great thing about this real-time data site is that students can very easily envision how the data is collected (by remote sensing underwater submersible devices). They benefit directly from the collection technology and spend most of their time manipulating and assessing data to study specific problems."

- "…the program doesn't "prepare" the kids for some unknown future; rather, it involves them in important work as part of their learning. It's more of an apprenticeship in data analysis, digital imaging, and social science."

Locating data sources. VISIT teachers spent a substantial proportion of their conversation on questions of how to locate sources of data for the particular topics of their interest, and in sharing the sources they had located. The following are just a few examples of the sorts of data teachers were looking for:

- Our next step is to locate data needed to make maps. We would like to map the geologic features of the ocean floor over time…
- I have been looking for annual historical data for CO2 and/or methane emissions in table form.
- Looking for land use and roads data for Maine
- To begin the Nile River project, we are looking for a topo map of this region with contour lines.
- I'm looking for spatial data on numbers of amphibians present in ponds of southeastern Michigan (Especially members of following genera: Ambystoma, Notophthalmus).

Mapping field data

Teachers who have their students collect data in a field study or project want to use GIS so that the students can map their data for purposes of analysis and visualization. In addition, they would like the students to be able to combine their own field data with other data sources from the study area. The following are examples of projects VISIT teachers cited:

- "We have had some success having freshmen carry out vegetation transects that compare forest floor species richness to percent cover canopy...I think this could be done using GIS if you can get the GPS units to work in the forest (our problem)."
- "I am planning on having my Aquatic Biology students place their fish presence data into GIS maps."
- "My students test water quality within a watershed and evaluate water quality in relation to land use patterns."
- "Our students conducted a field study survey of trees in the neighborhood around the school. We recorded location (street address), girth of trunk, estimated height, type, and comments of condition. My goals related to this project are to: 1. Access local data available from the Rutland Regional Planning Commission and the City of Rutland that could provide base maps for property, streets, etc. Also gather available information concerning planting information on specific trees. 2. Improve understanding and experience with software to better understand how this technology can support and enrich the project 3. Review and refine data collection process and forms to improve field study."
- "I believe that use of GIS technology could enrich science field studies considerably. In order to achieve best results, it would be important to develop geographic thinking and geographic perspectives in the science teachers….very strong field studies could be developed and completed using mapping technology."

Student inquiry, open-ended investigations, and project-based learning

The following are some examples of teachers' interests in inquiry or in conducting investigations or projects:

- "When emphasizing the inquiry approach to teaching and learning, students are responsible for forming a research question, gathering background data, establishing a protocol or methodology for answering the question, analyzing the results of data collected, and finally drawing conclusions based upon those experiments.

- "I know that from a pedagogical standpoint teaching through inquiry is rewarding for both teacher and student. GIS makes this a reality. Students and teachers learn together."
- "One of my goals is to have Aquatic Biology students use local GIS data bases to carry out scientific inquiry regarding ecology and distributions."

We selected from the discussions a set of 450 words that might be considered to be part of an inquiry process.—words such as "ask", "persevere", "solve", and "variable." We then analyzed discussion forums to determine the frequency with which these inquiry terms were used.
Table 2 shows 30 inquiry-related terms most frequently used in a forum in 2003, in descending order of frequency.

Term……Freq.		REAL.....87
LEARN.....402		*EXPLORE..... …...80*
PROJECT.....327		*RESEARCH.....80*
QUESTION.....296		EXAMPLE.....78
INFORMATION.....239		SKILLS.....77
IDEA.....234		CONCEPT.....75
DEVELOP.....187		FIELD.....75
ACTIVITY.....171		STEP.....74
AREA.....162		WHY.....73
THOUGHT.....158		ADD.....72
CREATE.....148		*DESIGN.....71*
APPLICATION.....110		CONNECTION.....70
UNDERSTAND.....102		STUDY.....70
ANALYSIS.....101		SELECT.....66
GROUP.....100		TOPIC.....63
ASK.....90		

Table 2: Most frequently used inquiry terms

The following are some examples of the things teachers said they were creating or wanted their students to create:

- I'm especially interested in landform and structural geology. I also want to learn how to create isoline maps.
- I am trying to learn ArcGis 8.2 so I can create georeferenced historical maps for any time period. Just think of the data you could add and the analysis that would be possible.
- I think that it would be beneficial for students to look at their route through the maps that they could create with the GIS software. I am especially interested in having students observe the terrain…
- With 3d extension, .you can basically create a view where you are "looking under the surface" and can view (in addition to the 2d features plotted ON the surface - including fault lines and continental boundaries, etc.) what is going on underneath.
- With the ability to create multiple views in one project, one could develop a base map with embedded data and links that could be used to open the door and invite students into the topic, and then further exploration could be introduced to them as they develop their own maps and charts.

Visualization and spatial reasoning

Teachers are interested in using GIS because the technology can assist students to:

- visualize patterns in data or places,
- incorporate spatial reasoning in their analysis,
- use the visualizations to help learn complex concepts from the curriculum.

The following are examples of teachers' comments about visualization and spatial thinking.

- "I really liked the way we can change the fills of polygons (federal lands) to transparent so the underlying topography can be viewed in association with the types of lands."

- "Data visualization tools embedded in the web site allow students to see and explore relationships that may be missed when the data appears as just arrays of numbers."
- "Through GIS, this lesson encourages students to explore whether the canal could have been dug along a more preferable route in terms of topography.
- My students tend to NOT be very active, in an outdoor sense, or well-traveled, so they really struggle to visualize different types of landscapes.
- My first goal was to use ArcView with its 3D Analyst extension to create 3D contour maps using DEMs from USGS to create virtual field trips to understand the standard topos we use.
- Your idea of visually displaying "continental drift" is a good one, I particularly like the idea of having students using the coastlines as puzzle pieces."
- The GIS application is great because students can begin with historical data and then extrapolate information into the future to create a series of maps that can be displayed in time-sequence.
- I like this lesson because it gives the opportunity for discovery, the "Aha." Comparing the temperature and precipitation charts by cascading them is beautiful, and the fact that you can change from chart to chart by simply clicking on the city is amazing. It leads to asking "Why?" about the differences that are so apparent on the charts. I could see using this type of activity with the Great Lakes region where we live and then applying the understanding to areas of the eastern hemisphere that we are studying .

As they developed their own lessons or investigations, teachers used words related to place, visualization, or spatial thinking in more than 11 percent of their discourse. The most frequently used of the spatial terms in one "projects forum" are shown in Table 3.

Spatial term.....freq
MAP*.....650
WATERSHED.....475
AREA*.....366
WHERE.....327
IMAGE*.....267
POINT*.....250
UNDER..... .182
BASE.....175
VIEW.....137

LAYER*.....130
MAPPING.....100
LINE.....88
SCALE*..... .80
BACKGROUND.....80
LARGE*.....73
LANDFORM*.....66
REGION*.....62
COLOR*.....50
GEOGRAPHIC.....28

Table 3: Frequently used terms related to spatial reasoning and visualization

What are teachers' classroom and curricular challenges?

As an "outsider" to the school system, the GIS professional will not be able to change many of the challenging conditions the teacher faces. However, by developing awareness of these challenges, the consultant may be able to help the teacher work around some of the barriers to innovation. Teachers described the challenges they face in their schools and curricula as they tried out lessons that use GIS tools, techniques, and data, wrote critical reviews of existing GIS-based lessons, developed their own lessons or projects, and read articles about GIS-related projects in other schools. The main obstacles they discussed include the following:

- Time management
- Making changes from one's current pedagogy
- Classroom management
- Interpreting data accurately, and other quality issues
- Providing students with access to equipment, and creating alternatives to machine access.

Time management challenges
As is the case with any new classroom activity involving inquiry, project-based learning, or use of new technologies, teachers' first concern is allocating their own professional work time and their students' classroom time in relation to what already fills that time. Teachers discussed many of these challenges, including their own challenge in finding time to develop new lessons that fit their curriculum. The following excerpts focus on just one of these time-management challenges; the competition with classroom time needed for preparing students for standardized tests.

- I think the biggest challenge here is getting those in positions of power within the educational system to understand that this type of learning is worthy of the time and resources! The kids who go through this program may or may not be able to apply what they learn to a standardized test, but that doesn't mean that valuable learning has not taken place.
- I have often sounded off about the struggles I face in dealing with a limited, high-stakes statewide curriculum (the only thing that matters is how many of our students pass the statewide final exam, whether it is Earth Science, or Biology, etc.)
- Our curriculum is jammed packed with standards and benchmarks. It is important that anything new we incorporate must slide right into place.

Pedagogical and classroom management challenges
Using powerful tools and complex data sets for any of the educational purposes teachers envision, requires changes in classroom management such as teamwork, sharing computers, differentiated roles, project scheduling, field trips, and other activities that are more challenging to manage than individual work or whole-class lectures or discussions.

- "Since different learning styles, abilities and behaviors can influence the success or failure of an activity that is less structured than sitting in a classroom, the teacher must have reachable goals clearly defined for every person on the team. Each team member must have an important role or those that love to lead will take over.
- We had hoped to do larger group maps, but coordinating the groups between our 2 classes is a problem. We decided that we would have to do individual maps this year. We have been working with our administrator to have back-to-back groups of students next year to facilitate groups work between our two classes."

Data quality issues
In contrast with using a textbook or some other well-reviewed, authoritative source of curriculum content, using source materials and raw data introduces the requirement for a higher level of attention to quality assurance. Students and teachers need to learn, for example, to look for metadata that explains the source, date, and other aspects of the data and how to interpret the data. They need to become aware of "how to lie with maps" and how the necessary distortions of mapping convey misconceptions about facts and patterns.

- One of the main challenges for the teacher in managing this type of investigation is QUALITY CONTROL! This might be in any of the following areas: accurate recording of data, correct interpretation of events or accurate identification of species.
- Some of the thoughts raised so far spark on the where, what and how to measure water quality.
- How can the data we collect measure both a norm and a variance in water quality?
- What kinds of measuring tools will give us the accuracy, reliability, economics and ease we seek?
- How can we build in quality assurance measures that don't wrap us up in red tape but provide the level of quality our audience needs?

Student access to equipment
Often an outside consultant will be shown excellent computer laboratory facilities in the school, with the implication that student access to appropriately configured computers and networks is well provided in the school. However, such facilities are usually tightly scheduled. A particular teacher's class may have access to these facilities very infrequently. In planning a project, limitations on student access to equipment must be taken into account. The best situation is where a teacher has appropriately configured computers in his or her classroom. Students working in teams can take on differentiated roles in working on the project. In this way, not every student needs to have access to a machine at all times in the project.

What kinds of assistance do teachers need?

The most frequently requested support teachers asked for included the following:

- general technical support,
- assistance in using GIS software,
- assistance in locating and using data,
- assistance in planning and implementing classroom lessons and activities.

General technical support

The most common kinds of technical assistance teachers needed, particularly at the beginning of their work with GIS, were in the following areas:

- Installing software and trouble-shooting software installations
- Downloading and unzipping lessons and data
- Locating lessons and data on CD or hard drive
- Managing files and file directories
- Apple/Mac memory problems
- School network firewall issues
- Making Screen Captures
- Uploading files

There are two critical factors in providing successful technical assistance– timeliness and diagnostics.

First, the assistance must be timely. Typically a teacher schedules a certain period of time, to perform a specific task related to his or her GIS work – for example, installing software or downloading a data set. If the teacher did not get the needed assistance within that window of time, his overall participation might be delayed by several weeks or cancelled altogether. In the VISIT program, there were always one or more leaders checking the HELP forums seven days a week, so there was a good likelihood of identifying a teacher's need quickly. However, identifying the need is just the first step.

Secondly, the providers of technical assistance need to be skilled diagnosticians. Most teachers are not experienced in discussing technical matters. Therefore, their difficulties need to be probed by people skilled in diagnosing a technical problem based on few verbal clues. Some aids to the diagnostic process included teaching teachers very early how to make screenshots and upload these so that a support person could see exactly what the teacher was seeing on their own screen. Direct verbal communication via telephone is ideal, but teachers rarely have access to a telephone while they are online on the computer.

Assistance in using GIS software

Whether they learn the rudiments of using GIS software through workshops or prepared lessons such as those provided in the VISIT program, ESRI's ArcLessons, or those in the *Community Geography* book mentioned above, teachers and students will always encounter need for assistance with particular procedures and tools. In response to teachers' requests for assistance in using GIS software, VISIT facilitators tried whenever possible to refer teachers to existing instruction related to the request. Also, VISIT staff took the most frequently asked questions and prepared a set of reference guides called "Tech

Tips" to address these questions. Tech Tips can be viewed at
http://ceita.emich.edu/visit/Resource/tech_tips.htm

Assistance in locating and using data

Helping to locate and use data is one of the most valuable contributions a GIS professional can make to a school/community project. Commonly in the VISIT project, a teacher would receive several replies to a call for help in locating data sources. GIS professionals who work in the same locality, state, or region as the school can provide a most valuable service by showing teachers how to locate sources of data relevant to their geographic area. One source of links to state GIS data sources is available at
http://libinfo.uark.edu/GIS/us.asp

Deciding what data sets are appropriate for the purpose, making needed file conversions, and understanding how to use that data technically and pedagogically, are more challenging than just finding the data sources. Web sites often post pictures of maps that can be downloaded, but these are not georeferenced; often the spatial metadata are available but difficult to locate on a web site; files may be available in formats the teacher does not know how to use.

The following are some examples of teachers' reports on their quest for usable data for their projects:

- I have found an enormous number of really interesting geo-referenced data sets to include in the project. The problem will be in deciding which ones to include.
- Attached please find a screen print showing the Arcview project that I've created. It contains the tif files to be used in the lesson. I want to also include various satellite images of the area and an historic map that I obtained from the Library of Congress, however they are screen dumps in Microsoft Word. How can I include them in my project?
- Attached are the files I am working with. I downloaded the map and info from a site called Clary-Meuser Research. I also located the original info in a comma delimited text format, but I am not sure how to change it into a format I can use. If you can offer any guidance on how to convert the text, I can try and see if it will fix my problem.
- The problem is that the data are too specific. We started with 18,000 points, reduced it to 8,000 points and the editing process continues. I took about 200 points and plotted them against the older data to see how they compare. We would like a general pattern of granitic where continental crust is melting, basaltic with oceanic crust and andesitic with both. We also would like to include some volcanics that aren't at plate boundaries as well.
- I don't know how to layer pH, Nitrate, Phosphate, and water & air Temperature into an .apr project that has Census data imported as Themes.
- I found a tar file in my search for topo maps of Egypt before Christmas. I sent it to Al Lew after I got totally frustrated trying to work with it. He gave me some ideas on working with it, but I am afraid I am in over my head.

Working with complex data may require assistance in interpreting the data. For instance, a teacher leader teamed with a teacher in an analysis of volcanic magma. The following is an excerpt from his commentary:

"This is a complicated task to simplify such a complex data set. I think the best way to consider this is that it is not just one rock type found at a certain geologic but relative percentages of rock types. With a volcanic eruption, the volcanic magma differentiates as it flows out in stages due to temperatures, you could conceivably have Basalt ,Andesite and Rhyloite come out of the same volcanic pipe over geologic time due to the relative temperatures of the cooling magma body. Minerals that make up Basalt are created (crystallizes) at hotter temperatures, Andesite second and Rhyolite third (lowest)."

GIS professionals can assist in interpretation of data by helping teachers locate and use the metadata for datasets.

Providing Tech Tips for data

In response to teachers' requests for assistance with data sources, VISIT staff took the most frequently-asked questions and prepared a set of reference guides called "Tech Tips" to address these questions. One way to assist teachers with some of these questions is to provide them with the Tech Tips, which can be viewed at http://ceita.emich.edu/visit/Resource/tech_tips.htm

The topics of these Tips with regard to data preparation include the following:

- File extensions for GIS data
- Bringing images into GIS software
- Converting file formats
- Combining field data with other sources
- Joining tabular data
- Working with tabular data

Creating a base map for a project

Many teachers expressed the need for assistance in creating a base map for their project or lesson. In fact, many of the VISIT participants had little or no concept of either the nature or purpose of a base map. For the purposes of the project we defined a base map as a set of GIS reference data layers, such as topography, road network, or streams, to which all other layers are referenced. It is the base upon which one then adds the additional data needed for the project. A base map provides spatial orientation for other data to be used in the study. The base map establishes the geographic extent, scale, and projection of data for the study. Below are a set of questions used to help participants develop a base map:
What is the geographic extent of my study area?
How do I describe the geographic extent of my base map?
What kinds of information should I include in my base map?
What scale, or resolution, should I use in my base map data?
Where shall I obtain the data for the base map?
What data formats should I look for?

In response to teachers' questions, the VISIT project developed a guide to creating a base map for a project. (http://ceita.emich.edu/visit/Resource/guide/basemap.htm)

Using online help and tutorials for data sources

For some data sources such as the US EPA, USGS, and the Census Bureau, there are tutorials that help in learning how to use the site to identify, download, and use the data in GIS. The VISIT Guide to online sources of georeferenced data (http://ceita.emich.edu/visit/Resource/data_source.htm) includes links to such tutorials. However, the sites do change from time to time and so the tutorials and links need to be updated.

Assistance in Designing and Implementing Project and Classroom Lessons and Activities

The VISIT professional development program for teachers includes a sequence of guidance and assignments in which the teacher develops a lesson for their classroom. At each stage in the development, the participants in the collaboratory assist each other with the decisions they are making about the design and implementation of their lessons. These conversations have focused on many different dimensions of the lessons, but three of the most commonly requested kinds of help are in the following areas:

- defining a feasible project
- creating a pedagogically meaningful lesson

- integrating with existing curriculum.

Helping to define a feasible project

One of the most challenging tasks for a GIS professional assisting teachers, as it was for VISIT's Teacher Leaders, is in helping teachers to define the scope and nature of their projects. The most creative teachers in VISIT had exciting ideas for projects they want their students to engage in. Due to their lack of experience in carrying out the various steps in building a project, they had difficulty in defining the scope and complexity of a project in such a way that they could actually implement it in a reasonable amount of time, skill, and effort. Assisting teachers in this process is tricky. The facilitator does not want to discourage the teacher at the outset, but needs to ask appropriate questions in order to learn a lot about the teacher's situation and objectives in order to provide timely and appropriate suggestions for scaling down the project to something feasible as a first start. For example, instead of starting with a project to test the pH level of every lake in Maine, students might sample several different locations along one local lake or stream. Feasibility is also affected by the available tools, including devices such as color printers, GPS units, digital cameras, student time in the computer lab, and skill with using software and hardware.

The following are excerpts of discussion about a too-complicated project that the teachers scaled to something they could accomplish, both technically and pedagogically.

August, 2003. Subject: Ski Relief Project. Attached is a draft of our lesson exploring topographic maps (and other objectives) using ArcView. This started out as a project about the Nile River watershed, but moved closer to home after many interesting problems! The acquisition of the Africa Data CD and the knowledge learned while doing this smaller local project will make creating the Nile Watershed project much easier. I think the Nile project will have much more meaning to the students after they work on this local project, because they will be able to compare the topography in their own area with that of the Nile River watershed. Many thanks to all the VISIT leaders and teachers who offered assistance on this project!

Together, students will be creating a large cardboard relief map of elevation in the ski areas of Emmet County in which our school system is located. Groups of students will use ArcView to create a section of a colored contour map of this region to use as a pattern. Pieces of cardboard will be cut for each contour. The cardboard pieces will be glued on top of each other to form a 3-D contour map. When all individual maps are assembled together, the large relief map of the ski areas will be completed.

Students will write a summary statement illustrating their understanding of the information shown on the group map as well as answer guided questions about their observations.
The large cardboard map can also form the basis on which students can illustrate other information they will research and map throughout the year such as weather, population density, vegetation, land use, soil type, and resources. This will provide opportunities to make more connections between computer created maps, print maps, and their 3D map, deepening their understanding of *our* region and regions in general.

In this case, the original project idea was scaled down technically, geographically, and pedagogically. The teachers changed the following aspects of their project from their original idea by:

- changing the study location from Africa to a local U.S. site that is familiar to the students and for which data are easier to obtain,
- reducing the geographic extent of the study area, thereby simplifying the printing tasks from a technical standpoint;
- choosing a geographic location that offers better opportunities to explore the objectives of the lesson (in this case, greater topographical variety),
- reducing the number of new concepts being introduced to students simultaneously.

Helping to create a pedagogically meaningful lesson

When one is working with many new ideas and tools, plus incredibly rich data sets, it is challenging to integrate and package these together into a sequence of learning activities that has intellectual coherence for the learner. The following is one of many examples of teacher leaders' efforts to assist teachers in creating a pedagogically meaningful lesson plan.

Dave,

I am soooo excited about your project. Congratulations on getting the data layers.

In your message you had an e-mail from your data source, the town herpetologist. He said, "Perhaps one component you could explore is where we have frogs and where we don't. Why this would be and what can they do to change or prevent this from occurring. Habitat conservation is critical in maintaining populations of frogs and toads."

Perhaps you could take this big idea of habitat conservation as the focus of your lesson. When I looked at your Table of Contents you did a great job identifying the activities and the concepts you were going to work towards. As I read it I wanted to chat with you to see what you would say the overarching idea was that you were teaching. Two possible suggestions for finding this idea depend on whether you work from part to whole or whole to part in designing lessons.

To work from whole to part, you could start by identifying the state education standards that are targeted for the 7th grade level. There must be one that addresses either ecosystem interactions or wildlife populations and carrying capacity. When you review the standard list some of the key pieces of information that make up the concept in the standard. You could use the frog life history as the background for the learning about this larger concept. When students had some solid understanding of the general concepts they could apply them to their regional herp population.

To go from parts to whole in planning, review all the concepts you have identified. Try to construct a question that would drive students to answer all the pieces you have put together.

Keep us posted!!!

Helping to integrate with existing curriculum

Whether teachers choose to adapt an existing lesson to their own practice or to create a new lesson, they need to analyze how that new activity will fit into their existing curriculum. In the Collaboratory, participants assisted each other in conducting this analysis and then shaping the lesson as a result. The following is one example in which a teacher leader is responding to a teacher's initial idea about a project involving purple loosestrife, an invasive species.

Lets start by taking one reasonable first step. To do this, we best need to focus on what will best integrate with our existing curriculum.

So, if we chose the wetlands/purple loosestrife project how about answering these questions:

1) Will your students have had any experience with wetlands before you start this unit?

2) Will this unit be their first exposure to GIS?

3) Will they be communicating with any other classrooms?

4) Will they have any background on "invasives", botany, or ecology?

5) Will that background support their understanding why one species can out compete another?

6) How much time will you have for this unit?

7) What will the access to computers and software be? 1:1, 1:24 etc?
I ask all of these because it will outline what precursor knowledge may need to be included in the lesson in order for them to make sense of what they are doing in the GIS program.

Summary

GIS professionals can provide valuable assistance to schools, teachers and students as they learn to use and apply GIS techniques to their classroom studies and community mapping projects. To make the partnership most effective and productive, the professional can begin by discussing with teachers and students their interests. Teachers' interests in using GIS are driven by both school curricula and issues of importance in their local geographic area or community. Topics most often are in earth science, environmental science, and social studies.

The primary purposes teachers have for using GIS in the classroom include enabling and helping their students to:

- work with real data and real-world problems in the context of the curriculum and their standards of learning
- map field data they have collected, in combination with other data from their study area
- conduct inquiry, open-ended investigations, and project-based learning
- visualize and understand complex phenomena and data

It is useful for the professional to develop some understanding of the constraints and challenges the teachers face as they initiate the use of new tools and techniques. Teachers' classroom and curricular challenges include:

- Time management, such as competing with standardized tests for classroom time
- Making changes from one's current pedagogy
- Classroom management
- Interpreting data accurately, and other quality issues
- Designing lessons to work around limitations in students' access to equipment

Professionals can provide effective assistance to the teacher by providing a combination of their own expertise and materials already available on the web and in books.

Teachers need assistance in the following areas:

- general technical support,
- using GIS software,
- locating and using data,
- planning and implementing classroom lessons and activities.

Professional development programs for teachers wishing to take advantage of GIS in their classrooms and curricula can benefit from the VISIT teachers' experiences by designing a program that addresses these teachers' interests, challenges and needs and by building upon the materials and strategies employed in the VISIT program and in other materials available for schools such as the *Community Geography* book.

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References

Audet, Richard & Ludwig, Gail (2000). *GIS in Schools.* Redlands, CA: ESRI Press

English, Kim Z. & Feaster, Laura S. (2003). *Community Geography: GIS in Action.* Redlands, CA: ESRI Press

Hunter, Beverly (2004). Teachers learning online: Lessons from the VISIT Collaboratory. Draft report available: http://www.piedmontresearch.org/PDF/tlo_visit.pdf

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