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A Place for GIS in the Secondary Schools? Lessons from the NCGIA Secondary Education Project

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The National Center for Geographic Information and Analysis (NCGIA) has begun a project to encourage and support education about geographic information systems (GIS) technology in secondary schools. This article describes NCGIA's efforts to date and its ongoing role as a facilitator.

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The application areas for geographic information systems (GIS) are diverse and the specific uses are seemingly without limit. Because of that great potential, individuals with widely varying backgrounds are immersing themselves in a world of arcane GIS acronyms, familiarizing themselves with spatial analytical techniques, and even memorizing the command syntax for various GIS packages. In the past, many of these users — despite the aid of seminars, tutorials, and co-workers — were for the most part self-taught. That scenario has been changing as more and more universities offer GIS education as part of regular undergraduate and graduate studies or as extension courses. Various GIS firms and independent groups also offer extensive training seminars and short courses. In addition, universities and colleges are doing more than just training students to use GIS software or even teaching the underlying principles. They are beginning to use GIS as a mode of delivery for a variety of extra–GIS course concepts. In short, GIS is becoming established in our institutions of higher learning.

But what about the universal preparing ground for higher learning and the workplace: precollegiate education? Is there a role for GIS in educating the nation's youth? Can GIS provide improved learning opportunity for students who have struggled with traditional teaching methods? Does the technology have the potential for increasing the participation of traditionally disadvantaged minorities? As GIS technology becomes relatively ubiquitous in post-secondary education and the workplace, it may naturally trickle down to the high, middle, and elementary schools. However, some people may feel that without specific attention, trickle-down methods may perform no better than they have in the U.S. economy.

If we are to bring GIS to these realms of education, what will its purpose be and how should it be presented? Will GIS technology be introduced alongside the microscope as another of a school's science class tools, or will it be compared to complex technologies such as the scanning electron microscope? The former status implies that GIS software could be integrated into normal classroom activities; the latter restricts GIS to the category of a special topic. Would it be more profitable to educate pupils about the principles of geographic analysis (GIS concepts) rather than getting overwhelmed by the software? What about using forms of GIS software to elucidate existing topics in the curriculum?

Any of these uses are possible and reasonable, given the tremendous reduction in the price of powerful hardware, the increasing user-friendliness of the graphic user interfaces (GUIs), and the existence of limited-complexity GIS software.

Educational use of GIS software and concepts can be partitioned into two modes: GIS education and GIS *in* education. The former is a focus on the systems themselves. In this mode, students might learn about GIS use in the workplace and in research, investigate the basic data structures and analytical operations of a GIS, or attempt to perform a simple analysis based on GIS analytical models — perhaps even using GIS software.

GIS in education, however, deemphasizes the GIS. Instead, this mode uses GIS software or concepts to reinforce, and perhaps improve, learning of existing curricular objectives. For example, a biology class investigating the interconnected nature of ecosystems might use a GIS-based lesson to examine the effects of different inputs on the systems. Both modes can be found in the university setting, but questions remain about whether GIS education or education with GIS are necessary or plausible in the precollegiate setting.

NCGIA'S ROLE

The National Center for Geographic Information and Analysis (NCGIA) has been involved in GIS education at the collegiate level since its inception, making the center a natural contact point for individuals who are interested in GIS activities for schoolchildren. Sidebar 1 gives a brief history of the center. Following are some examples of existing activities that have come to our attention at the center:

- The Oregon State Department of Education in Salem, Oregon, USA, has begun a project titled Workforce 2000. The department is attempting to introduce high school juniors and seniors to the Global Positioning System (GPS) and GIS to prepare them for use of these technologies in natural resource management courses at community colleges.
- Reinhold Freibertshauser, a teacher at the private University School in Chagrin Falls, Ohio, USA, has students use GIS software to manage and study the 200-acre campus. He hopes to have his students expand their GIS activities to the surrounding state forest lands.
- Teachers at the Thomas Jefferson High School for Science and Technology, a public "magnet" school in Alexandria, Virginia, USA, are using GIS software in the school's Geosciences Department.
- Dr. Bill Huxhold at the University of Milwaukee, Wisconsin, USA, and Dr. Derek Thompson at the University of Maryland, College Park, Maryland, USA, both have run programs that have brought teachers and students into their GIS labs.

Many other institutions have demonstrated their GIS capabilities to teachers and students during open houses. During the past two years many individuals in the schools, the universities, and the workplace have contacted NCGIA about GIS use in schools.

Now that collegiate educational efforts are well under way, NCGIA management believe it would be appropriate to address the interest in GIS for the schools through a Secondary Education Project (SEP), described in Sidebar 2. Initially, the project focuses on the secondary level as a logical starting point in the schools for GIS technology and concepts.

SEP's first formal activity has been an information-gathering workshop, describ-

NCGIA AND GIS EDUCATION

The National Center for Geographic Information and Analysis (NCGIA) was established by the National Science Foundation in August 1988 as a consortium of the University of California at Santa Barbara, the State University of New York at Buffalo, and the University of Maine at Orono. In addition to basic research in GIS, the center's mission includes a concentrated effort to encourage GIS education. This focus on GIS education is intended to help meet the high demand for individuals educated in geographic information analysis and the use, design, and application of geographic information systems (GIS).

When NCGIA was created, few resources existed for teaching about GIS technology. One of NCGIA's first projects was to create a *Core Curriculum in GIS,* a year-long series of foundational courses in GIS for upper-division undergraduates and graduate students. More than 35 experts from the GIS community helped develop the curriculum, which is presently used in many educational institutions as the base for their GIS courses. Distribution of the *Core Curriculum* has topped 1,000 copies in its first two and one-half years.

Additional GIS education resources also have been created. To support the hands-on work necessary for a comprehensive GIS education, NCGIA has developed two sets of GIS lab exercises. A GIS lab resources guide has been compiled and a set of case studies on the development of facilities for lab work has been completed. The most recent addition to NCGIA GIS education materials is a report, compiled with help from the American Society for Planning and Remote Sensing (ASPRS), listing more than 100 videos on GIS and related topics.

In addition to the efforts geared toward colleges and universities, the center has begun to focus on other educational levels. NCGIA's primary thrust at this point is toward GIS awareness and use in the secondary schools. ■

THE SECONDARY EDUCATION PROJECT

The Secondary Education Project (SEP) began in 1991 as an extension of the NCGIA Educational Program. The initial objectives were

- to investigate appropriate roles for GIS software and concepts in the secondary school curriculum;
- to promote GIS within the secondary school community in the United States; and
- to develop NCGIA as a node connecting those in secondary education, higher education, government, and the business community with various GIS-related efforts for the secondary schools.

Activities to date include initial and extended contacts with a host of individuals and institutions interested in GIS for the schools and, in some cases, actual GIS activities. Those contacts are kept abreast of SEP and other activities for GIS in the schools through a quarterly progress report. SEP is identifying curriculum resources and software that are appropriate to GIS activities for the schools. An important early activity was to hold a workshop to introduce a group of secondary school teachers to GIS and receive important feedback from them. Based on the results of the workshop and the initial investigations and contacts, SEP is moving into a second stage, which will include a set of regional workshops for secondary school teachers and a concentrated effort to develop a set of GIS modules that will be intentionally designed to work in the secondary school curriculum. ■

ed in Sidebar 3. The prototype workshop was designed to serve the following objectives:

- to immerse secondary school teachers from a range of disciplines in GIS concepts, and to provide feedback for designing future workshops;
- to identify impediments to widespread acceptance of GIS in secondary schools;
- to develop prototype activities in GIS to be tested by the teachers in their fall classes;
- to explore the suitability of various software and hardware options; and
- to explore the various roles for GIS in the secondary school curriculum.

The workshop helped refine NCGIA preconceptions and also provided new information about potential obstacles to GIS in the schools.

WORKSHOP AND SEP FINDINGS

GIS benefits instruction. The teachers who participated in the workshop quickly noted GIS's potential for meeting some of their educational objectives. Teachers are being asked to provide their students with critical thinking activities. GIS technology was identified as an excellent medium for promoting this type of analytical problem solving. Another teaching technique for which GIS activities would be natural was student group work. The interdisciplinary nature of many GIS applications also would match a trend in the schools toward more integrated activities. GIS was seen as an excellent example of a real-world application of computer technology, which could help students see beyond the common function for computers in the schools: drill and practice — for example, math and spelling games and worksheets.

The geographic concepts that GIS would either demonstrate or help justify learning were another big draw. Geography is beginning a renaissance in the nation's schools, thanks in part to the National Geographic Society–sponsored Geographic Alliances found in almost every state. Each Geographic Alliance is a grass-roots organization that brings together the content expertise and classroom experience of academic geographers and classroom teachers. Alliances develop geography curriculum materials, coordinate geography-awareness activities, and offer workshops and multiweek summer institutes for teachers in their states.

The Geographic Alliance Network's efforts have been aided by the general public's recognition that we cannot afford to have the next generation enter the 21st century geographically illiterate. As geography begins to resurface in the curriculum of many schools, the Geographic Alliance Network and others are working to make its context contemporary. Therefore, digital maps, satellite imagery, and even GIS are emphasized, in addition to using hard-copy maps.

The workshop participants noted that they are already beginning to use electronic atlases and programs for calculating map routes. The use of map-making and projection programs is also on the horizon. All of these programs, although not as complex as GIS technology, provide a good introduction to geographic analysis and GIS software.

GIS fits into the curriculum. In addition to geography courses, the teachers saw a place for GIS in basic life, physical, and earth science courses. Like geography, environmental studies is also gaining favor in the curriculum, as either a part of the life or earth sciences, or in some cases as a stand-alone course. GIS is an excellent tool for teaching many environmental concepts and could serve as the basis for project work in these courses.

Certainly, computer courses could incorporate GIS. Simple GIS algorithms and routines — such as line intersection routines or geographic data base structures — could be used as examples in an advanced programming course.

Beyond those obvious subjects, the teachers suggested that GIS might be applied in history, economics, political science, and vocational education. Many vocational education classes could take advantage of the computer-assisted design (CAD) systems already in place to introduce GIS concepts. If nothing else, teach-

GIS IN THE SCHOOLS WORKSHOP

In July 1992, NCGIA at Santa Barbara hosted a seven-day GIS workshop for local high school teachers. The purposes of the workshop were to include teachers in the early stages of SEP planning and to test a prototype workshop that would help teachers gain access to university and college GIS expertise, software, and applications.

The 10 teachers who attended the workshop represented three disciplines: science (6), social studies (3), and computer studies (1). They were drawn from schools in the catchment area of the university, rather than from a larger region, to emphasize an ongoing relationship between the university's GIS personnel and the teachers.

To give the teachers a basis for evaluating the potential and drawbacks of introducing GIS technology in the schools, the workshop provided basic instruction and hands-on experience with GIS. The workshop included a 10-hour short course in GIS, a series of GIS application presentations by faculty and graduate students, and daily lab time using actual systems. The teachers used five software packages: HyperCard-based GISTutor (Dr. Jonathan Raper, Birbeck College, London, United Kingdom), MAPII for Macintosh (Think Space, London, Ontario, Canada), Atlas*GIS (Strategic Mapping, San Jose, California, USA), IDRISI (Clark University, Worcester, Massachusetts, USA), and ArcView (Environmental Systems Research Institute, Redlands, California, USA).

Additionally, the teachers acted in the role of consultants in various discussion sessions. Discussion topics included: appropriate subject areas for GIS activities, where specifically GIS software and concepts could be used in various courses, the state of computers in the classroom as they relate to GIS activities, modes of teaching, and general obstacles, and opportunities for GIS in the secondary school setting. During the last part of the workshop teachers planned specific activities relating to or using GIS that they could try in their fall classes.

In their final evaluation of GIS in the schools, the teachers were unanimously enthusiastic about the possibilities, but also clearly noted some of the difficulties that GIS activities may encounter. An NCGIA Technical Report on the workshop including lists of GIS resources for the schools is available from the NCGIA Publications Office. ■

ers saw GIS technology as an interesting topic of discussion about how computers and geographic information are used in modern society and as a potential career path for their students.

GIS teaching methods. The teachers pointed out that specific circumstances in each class would affect the level of GIS activity. The levels of use of GIS software and concepts were discussed and categorized in a hierarchy ranging from simple show and tell to full-blown GIS projects, as shown in Figure 1. The base level, *mentioning* GIS where contextually appropriate, was seen as a common denominator. The next level — describing the technology and its applications in more detail using slides, videos, hard-copy GIS output, and case studies — was seen as viable in most classrooms.

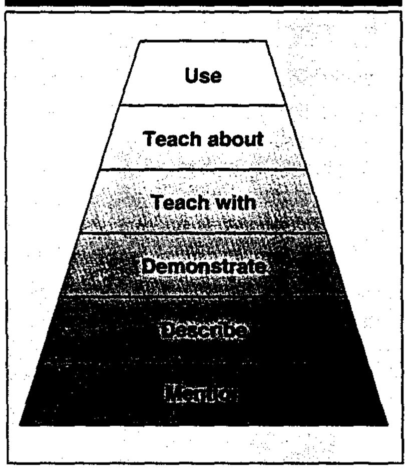

Figure 1. Continuum of activities

GIS software could be *demonstrated* by the teacher or by a guest speaker. If practical, GIS demo packages or prepackaged modules could be demonstrated. Moving to a level at which GIS begins to play a significant role in instruction are *teach with* and *teach about.* Those categories reflect the two modes of GIS-based educational activities: GIS in education and GIS education. It would be necessary to *teach about* GIS to realize the highest level of GIS activity, actually *using* GIS software to work through a particular problem.

Within each level of GIS activity on the continuum, greatly varying amounts of GIS-based learning could take place. For example, in the case of *teaching with* GIS, a teacher might tentatively try a GIS-based lesson once or use GIS-based materials as a regular part of the course to enhance the existing curricular objectives.

Technology issues. One of the difficulties noted was the unavailability of hardware. As Figure 2 points out, most GIS software operates on platforms above or near the peak of what is available in schools. They would be more likely to use less sophisticated GIS software, which in general would operate on the platforms more common in schools. However, less sophisticated GIS packages exist that operate on the platforms more common in the schools. Further development of that type of package and other nontraditional software that incorporates some GIS capabilities makes it reasonable to assume that some classroom GIS activities may get beyond the lower levels of the hierarchy.

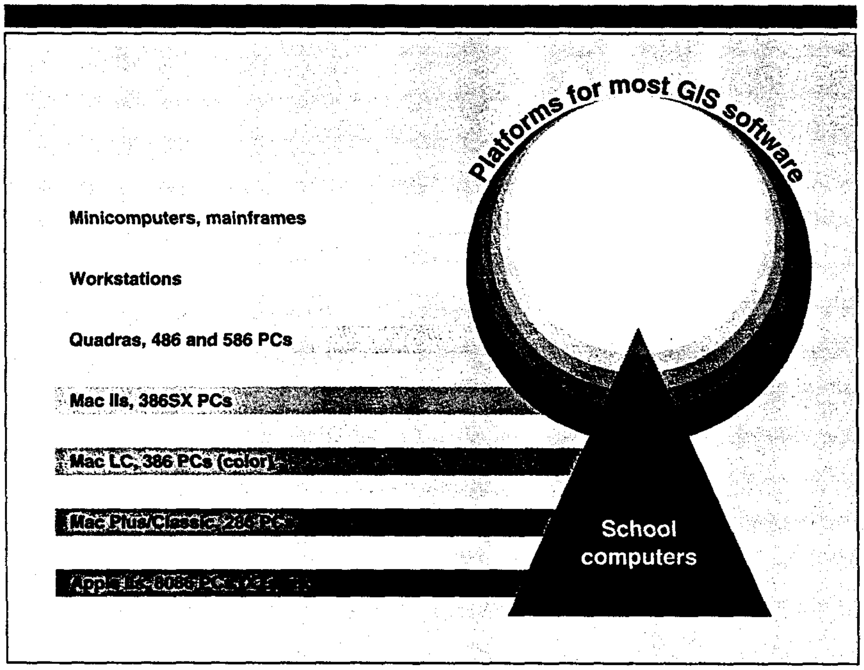

Figure 2. Most GIS software operates on platforms above or near the peak of what is available in schools.

Availability of data also could limit the use of GIS. Although data issues are common to all GIS applications, schools have an advantage in that they do not necessarily need specific data sets and could make do with a very limited subset of a typical GIS data base. They would not usually require hundreds or even tens of megabytes of data.

What's needed. The technological and curriculum requirement issues discussed here led to the suggestion that GIS would gain entry and give the greatest benefit to the secondary school classroom if specific modules were developed for a GIS software package or, if possible, as a subset of that package. The modules would come with clear documentation, lesson plans, and relevant data sets. In some cases the demos or tutorials provided with existing packages would be adequate if modified slightly. Ideally, a GIS or GIS-like package will be developed with the needs of schools in mind.

Even if such materials were prepared, teachers would not be likely to adopt them if they were not made aware of the uses of GIS in society and the potential benefits GIS activities could provide to their students. Making teachers aware of GIS was identified by the workshop participants as a high priority.

SEP PHASE II

To address these two main needs — teacher awareness and GIS materials designed to work within the existing curriculum — NCGIA has outlined a second phase of SEP. This phase will include a series of regional "GIS in the Schools" workshops to further refine the model; institutions having GIS expertise and equipment will use the model in their outreach to local schools. The regional workshops also will strategically involve representatives of some of the state Geographic Alliances.

Alliance members will be able to take the information gained about GIS back to their summer institutes, and indirectly to hundreds of teachers, through in-service presentations. The local teachers who attend the workshops will also offer in-service presentations in their schools. This round of workshops and future workshops based on the model, along with Geographic Alliance Network efforts, will multiply the outreach and increase GIS awareness significantly within just a few years.

The second key activity of phase II will be a series of GIS modules developed by teams consisting of a GIS expert and a trained curriculum developer. The modules will be designed using existing, proven geographic educational materials. This will allow teachers to add a computer-based component when teaching with those materials. Module development will take place in the year following the regional workshops and will provide materials to meet the demand created by the workshops and ensuing in-service presentations.

THE FUTURE

It seems reasonable to assume that powerful hardware will get cheaper, GIS software will become easier to use, data sets will become more widely available, and the use of more sophisticated computer applications will gain favor in the schools. The growing market for low-end, general purpose, easy-to-use GIS software on readily available platforms will provide a much more accessible resource for applications in secondary schools. As GIS software grows and evolves, it seems likely that many products will be designed for special purposes. These more highly specialized and advanced systems may not come anywhere near the classroom, but users of such systems will necessarily be drawn from those who have put in their hours of mandatory education. Any organization using a GIS would benefit from individuals who had been exposed to GIS in their early education and had acquired some skills in geographic analysis.

AS *GIS software grows and evolves, it seems likely that many products will be designed for special purposes.*

Based on our experience to date, NCGIA's answer to the question Does GIS have a place in secondary education? is a solid *yes*. Many issues remain to be resolved, but we can all play a part in improving the education system we so often decry by applying our expertise: making ourselves available for classroom presentations, sharing data sets with interested educators, and encouraging the development of educationally oriented software and the accompanying instructional materials.

For more information about GIS educational resources, contact the Publications Office, NCGIA/Geography Department, University of California, Santa Barbara, California 93106-4060, USA; telephone (805) 893-8224; fax (805) 893-8617; email: ncgiapub@ncgia.ucsb.edu.

For information about SEP and the NCGIA Education Program, or to be added to the SEP mailing list, contact Steve Palladino, Education Projects Manager, NCGIA; email: spalladi@ncgia.ucsb.edu or palladi@voodoo.bitnet. ■

PROFESSIONALS *continued from page 45*

increasing professionalism in the GIS industry.

A route to continued professional development through the institutions is not clear. In the United Kingdom, unresolved difficulties exist between the roles of the professional institutions and the Association for Geographic Information, as well as a concern that a gap may appear that prevents the GIS community from being effectively serviced. AGI is not a professional institution and therefore cannot provide the services and regulatory functions that might be expected of such a body. However, the existing professional institutions — primarily BCS and RICS — that associate themselves with GIS do not cover the entire spectrum.

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