Internet-Based GIS Mapping in Support of K-12 Education

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Internet-based mapping provides a powerful alternative for successfully establishing GIS technology in the K-12 education community, while simultaneously avoiding the traditional barriers associated with desktop GIS. Internet-based GIS can support standards-based inquiry methods of teaching and learning while providing basic analysis tools for studying and exploring geographic or scientific data in the classroom. Key Words: GIS Education, Internet-based GIS, K-12 GIS.

Introduction

In the last decade, the use of geographic information systems (GIS) in K-12 classrooms has grown very little (Donaldson 2000; Kerski 2000). Of the approximately 1,900 U.S. high school classrooms that have a desktop GIS, less than 15 percent report ever using it for instructional purposes (Kerski 2000). While researchers have gone to great lengths to identify barriers to GIS use at the K-12 level (Audet and Paris 1997; Crechiolo 1997; Donaldson 2000; Kerski 2000; Olsen 2000), these identifications are largely parallel to those presented at the time of the first conference on Educational Applications of GIS [EDGIS] in 1994 (EDGIS 1994; Palladino 1994). Chief among these barriers is a lack of time. Desktop GIS requires a substantial commitment of time from educators to learn the software, the intricacies of data, and the development or modification of instructional materials supported by GIS. A formative review of K-12 GIS training workshops in the United States during 2002 revealed that a high proportion of GIS teacher-training workshops exceeded forty hours and focused on the development of desktop GIS skills (KanGIS 2002). For widespread K-12 adoption of computer-based mapping, the required commitment of time and resources is simply unacceptable (Gatrell 2001). Secondly, schools are plagued with variety of patchwork-style computing and network systems, frequently incapable of meeting the robust demands of desktop GIS. Additionally, school district demands for computing security and the typical need of GIS to leverage the most current operating system software can leave an impassable maze of technical requirements. Finally, the organization of schools in the United States, the rigidity of the school-day bell schedule, the separation of subject disciplines (especially at the high school level), and a lack of administrative support often characterize barriers to implementing desktop GIS in the K-12 setting.

These barriers are significant for professional geographers, as many are engaged in the development of programs that train K-12 educators in the adoption and implementation of GIS technologies. The prevalence of these geographer-led training programs was recently made clear when nearly half of the articles submitted to a special issue of the Journal of Geography, titled “Research on GIS in Education” were submitted by professional geographers attempting to train K-12 teachers in GIS technologies (Baker and Bednarz 2003). This article explores the nexus of standards-based K-12 instruction, desktop GIS barriers, and the resulting role for Internet-based mapping in K-12 education.

A Context for K-12 Classroom GIS

The national standards in science, geography, and technology education call for the extensive use of inquiry-based instructional models in K-12 education. These models are intended to teach disciplinary content through the development of higher-order, inquiry-process skills (i.e., formulating research questions, designing or implementing systematic data collection, analyzing and synthesizing data, and so on). Within this vein of standards-based instruction, GIS is emerging as an instructional technology for supporting contextually rich student learning.
GIS, modeling applications, and image analysis technologies seem to extend students’ abilities to do inquiry as envisioned by the National Science Education Standards (NRC 1996), the Benchmarks for Science Literacy (AAAS 1993), the National Educational Technology Standards (ISTE 2000), and the National Geography Standards (GESP 1994). The standards emphasize meaningful, problem-driven inquiries, situated in a rich context of learning with data collection, analysis, and interpretation. It has been suggested that the use of these technologies has the potential to promote in-depth data explorations, giving greater meaning to the work of student researchers (NRC 2000). These technology-supported learning experiences expand both the data available for student use and the scale of their explorations, allowing for infinite variations in their search for explanations.

An alternative course is therefore proposed, one that is intended to address the imperative need of supporting standards-based inquiry, yet circumventing many of the traditional barriers associated with desktop GIS in K-12 education. The use of Internet-based mapping (or Web-maps) can help meet these requirements, while presenting educators with geographic solutions for the needs of students. Technically, Internet-based mapping requires both a server and client to produce a map view and geographic tools (zoom, pan, identify, etc.), often rendered through a common Web browser. Internet-based maps can vary greatly, providing thematic, street, scientific, or historical data. Over the past three years, the development of Internet-based map services has enabled new opportunities, both for technical and pedagogical outcomes. The release of ESRI’s Geography Network in 2000 (http://geographynetwork.com), the USGS National Atlas in 1998 (http://nationalatlas.gov/), and the U.S. GeoData Web in 2003 (http://geodata.gov) all epitomize the rapidly advancing developments in Webmapping as a viable tool for K-12 education. In each of these cases, atlas-style, Internet-based maps are created for viewing and exploring archived or real-time geographic data. While these Webmaps are often invaluable tools for many classroom activities, they do not serve an explicit and well-defined K-12 curriculum or specific curricular project. The tools and data are broad, providing a relevant and powerful way to expand any number of instructional activities.

A second type of Internet-based map has also evolved in support of K-12 education. The use of collaborative, Internet-based mapping places an emphasis on data submitted to the mapping system by multiple, geographically dispersed participants in an educational network. Unlike atlas-style Webmaps, collaborative Webmaps tend to focus on a particular curricular issue or project, applicable to large numbers of K-12 classrooms across the nation or world. In these collaborative Webmaps, a student may, for example, contribute a piece of scientific or social data collected as a part of a larger class project, perhaps directed in part by protocols established elsewhere on the Webmapping site. This student-generated data is submitted via the Web, and rendered back to the student via an Internet-based map service, along with data from any number of other students participating in the project. Organizations such as Cornell’s FeederWatch (http://birds.cornell.edu/pfw/), The GLOBE Project (http://www.globe.gov), and PathFinder Science (http://pathfinderscience.net) have all created such collaborative Webmap applications, many available since the mid-1990s. These collaborative Internet-based map applications, like atlas-style Webmaps, provide a unique and powerful tool for extending K-12 standards-based inquiry, while simultaneously avoiding the traditional barriers of desktop GIS implementation.

Choosing the Right Tool for the Job

Even when K-12 classrooms have access to desktop GIS, teachers and students do not generally tax the capabilities that make desktop GIS a powerful data-analysis tool (O’Dea 2002). Based on data from a national implementation survey, about seventy-seven respondents from an initial survey of over nineteen hundred teachers reported using desktop GIS in more than one class on more than one occasion (Keriski 2000). Therefore, it is unlikely that substantial numbers of classrooms not included in this group are regularly using sophisticated features of a desktop GIS. For many classrooms, particularly at the elementary and middle school level, Internet-based mapping provides enough spatial and database query tools to extend classroom learning to include greater emphasis on analysis. Fitzpatrick and McGuire (2001, 64) have argued that “the vast majority of [GIS]
tasks that schools wish to accomplish can be handled with a reasonable number of basic operations. Students and teachers generally need just the basic features of the software.” By using Internet-based mapping, the added and unused complexities of desktop GIS can be cut, making the software easier to learn and use. This kind of browser-based GIS is ideal for a majority of classrooms that are not interested in the time, commitment, and energy required of desktop GIS. Many online learning networks are using atlas-style, Internet-based mapping to encourage the classroom use of geospatial technologies. The University of Montana’s Lewis and Clark Education Center (2002) is one instance of sophisticated Internet-based mapping applications supporting students as they learn about the past and present environmental and anthropocentric conditions surrounding the Lewis and Clark trail (http://www.lewisandclarkeducationcenter.com). In another way, the Cornell FeederWatch Project uses collaborative Internet-based mapping to display and explore participant-submitted bird data from across North America. Bird Web-maps can be generated based on user-submitted criteria, such as year of observation, bird species, and geographic extent.

Reducing the Time Constraints of K-12 GIS

Many of today’s computing applications have been described as “so encrusted with features that users are confounded by the bewildering array of features, few of which are used effectively, or at all. Meanwhile, the myriad of marginal features crowd out the few really useful ones” (Cooper 1999, 29). As a result, the complexities of desktop GIS mandate time for initial and ongoing teacher training (Bednarz 1999; Bednarz and Audet 1999; Alibrandi and Palmer-Moloney 2001). Internet-based mapping interfaces can be substantially less complex to the user; while these technologies do not often have the analytical power of a desktop GIS, they have a variety of functionality, likely better suited to the K-12 classroom. With decreased technical and cartographic complexity, the need for teacher training becomes substantially less or can be refocused on the larger educational goals of supporting instructional and assessment strategies when using geotechnologies. In similar ways, others have documented the ease of use and simplicity of operation by teachers and students trained with Internet-based GIS applications (Cheung and Brown 2001; O’Dea 2002).

When teachers are trained to use a technology, the mind of the instructor is divided between the mechanics of the software and the integration of the software into the classroom curricula. While learning the mechanics of a GIS can be challenging for any novice, the addition of strategizing, planning, and organizing good instruction and practical assessment is substantial. In this way, the integration of the software reflects a more complex understanding of the technology and its place in the classroom; this kind of understanding is the descriptor that epitomizes the postmodern notion of learning (Mayer 2001). As teachers acquire the skills to use the software, they are simultaneously asking, “How can I use this in the classroom?” For some instructors, an inquiry-based instructional model is already available, making GIS inclusion a timely, natural fit (Bednarz 2000). For the instructor not yet teaching with these standards-based strategies (AAAS 1993; GESP 1994; NRC 1996), the technical skill development may be more difficult and time-consuming since there are fewer well-defined needs for the software in the teacher’s conceptions of curriculum and instruction. As a result, the teacher not using inquiry methods in the class may have fewer places in the curriculum to legitimately integrate GIS. This idea of teachers primarily as technology integrators, rather than software experts, is not new. The GenY program attempted to infuse technology into the K-12 classroom by teaching students the mechanics of the software and teaching instructors how to integrate the software. Faculty and students were then paired as members of a collaborative team—designing, implementing, and assessing technology enriched classroom activity (Coe and Campbell 2001).

Of the GIS training events identified for K-12 educators in the United States, very few included substantial components that focused on integrating GIS technology into instruction. By and large, such training events were mechanistic in nature and seemed to lack a standards-based educational context for the use of technology. In some training events,
prepackaged instructional units may have been identified that tied GIS technology to national curriculum standards, but in few cases were these events fully rounded, so that they included elaborations on appropriate instruction or classroom assessment. One possible solution to such an issue is the modeling of pedagogical practices that better support the uses of teaching with GIS and not limiting K-12 GIS teacher training to teaching about GIS.

The traditional use of desktop GIS in the classroom also requires substantial instructional time for its successful planning, implementation, and assessment (Crechiolo 1997; Kerski 2000). The technical aspects of integrating GIS into the curricula can be daunting, given the myriad of possible points of collapse and technical diversity in school computers, networks, and software. Opponents and even proponents often contend that GIS takes too much time for widespread inclusion in classrooms (Meyer et al. 1999; Cheung and Brown 2001). While Internet-based mapping does not lessen the instructional time for integrating technology into the classroom, it does substantially shorten the technical preparation time (i.e., loading datasets, installing supporting software, ensuring printers are online, and student permissions are in place, and so on) required for integration (Cheung and Brown 2001). The technical preparation time that is now required of teachers could be largely shifted back to focusing on instruction. Using Internet-based mapping, the technical GIS work can be returned to curricular and technical developers, allowing teachers and students to more fully focus on learning with GIS.

**Overcoming School Technology**

For most of the 1990s, data were considered a chief barrier to the proliferation of GIS in K-12 classrooms. Data barriers became sizable in American K-12 education, despite relatively plentiful and free access to existing geographic data. The barriers related to data in the classroom were generally recognized in one of two forms: data for a particular topic were simply said not to exist or data were inaccessible to relatively novice users, perhaps because of data projection or format issues.

The perceived lack of data is not only a GIS issue, but also a pedagogical one. Data availability often dictates the nature or direction of classroom inquiry. This is particularly problematic when students are designing and directing the inquiry. For GIS novices, steps can be taken to substantially reduce the need for new or unique data in classrooms. Initially, classrooms wishing to work with GIS could consider joining established online networks that use collaborative Internet-based mapping applications to explore and/or analyze data (i.e., Cornell’s Project FeederWatch, The GLOBE Project, Wisconsin Nature Mapping, The Great Lakes Information Center, Water on the Web, and so on). For instance, the PathFinder Science network (http://pathfinderscience.net) supports several online inquiry units, many with collaborative Webmaps providing real-time representation of data, collected and submitted by students via the Web. Through the PathFinder Science Web site, students can study, record, and analyze the geographic distribution of tree lichen as a relative indicator of atmospheric quality. In this collaborative research, students and teachers are able to use online learning environments for doing science in the classroom. As an integral piece of science, students must analyze data they have collected and consider it in the context of other students’ data. In this study, students collect data around their homes and school and upload their results into the Web site’s geospatial database. Student-collected data is then mapped in real time, resulting in a collaborative Internet-based map of their town with supporting base data. Geographic analysis activities can begin on the Web, allowing students to identify distributions, create targeted searches, reclassify data, construct buffer zones, gauge proximities and bounding regions, and launch queries. The Internet-based environment is ideal for instigating geographic analysis in classrooms where such activities would have otherwise not occurred at all.

School-based hardware, software, and networking-related issues are no less daunting. Largely driven by influential reports (e.g., U.S. Department of Education 1995, 1996; PCAST 1997) to introduce technology into every classroom, U.S. government efforts have, in many cases, left a patchwork of computer technology in schools across the country. Some classrooms have the latest and greatest, while others have what might be mistaken as corporate hand-me-downs, commonly able to handle only
minimal tasks such as word processing or Internet-browsing.

The National Center for Educational Statistics (NCES; 2003) reports that Internet access is ubiquitous in K-12 education; access is present in 99 percent of schools and 92 percent of instructional classrooms across the United States. These conditions set the stage where demanding technologies, such as GIS, can turn to the most common denominator to reach the majority of schools. GIS must be taken to the Internet in order to avoid this technical patchwork that comprises school technology. Using Internet-based mapping, classrooms with a Web browser can load, query, and display reasonably sophisticated online GIS applications. And at a time when GIS manufacturers seem to be steering away from out-of-the-box solutions for the Macintosh, a major shareholder in school operating systems, Internet-based mapping continues to provide suitable geospatial capabilities. As a first step in using GIS, while avoiding data, hardware, and software issues, instructors should consider using established online networks, where base data has already been collected, formatted, and integrated with student data for exploration. This allows the teacher and students to immediately focus on the more important issues of inquiry process and analysis of the data.

Teaching and Learning with GIS

Currently, no national K-12 content standards explicitly call for the use of GIS in schools. The Geography Education Standards Project [GESP] mentions the technology in an appendix, suggesting that “the standards were written with GIS in mind, but not yet in sight” (1994). Largely because learning about this technology is not identified within any of the standards, it is an inappropriate goal. Furthermore, teaching about GIS is, at best, a vulnerable proposition, with new releases of GIS software emerging frequently. Ultimately, the rapid pace of technological innovation makes teaching about GIS all the more difficult (Heywood and Kemp 1997). Finally, many will argue that the aim of K-12 education is the preparation of critical thinkers and lifelong learners, goals better met by focusing on the science of geographic information (Gatrell 2001). Instruction with GIS, instruction that fosters critical thinking aided by technology, is far more in tune with the goals and objectives of current educational reform movements in the United States. Teaching about Internet-based mapping to students is little more than a minimal concern, as interfaces, data, and other functionality can be reduced and tailored to the classroom inquiry in question.

Ideally, when a K-12 educator employs GIS in the classroom, the technology is used to extend classroom learning about a central concept or topic, not about a particular GIS technique. Whereas K-12 instructors aim to guide students through authentic learning experiences with the aid of technology tools, the goal of many higher education professors is to teach the skills and technologies of GIS. This dichotomy reflects the very heart of what Sui (1995) identifies when describing teaching with GIS technology versus teaching about GIS technology. Similarly, two-year community colleges tend to focus GIS inclusion in the classroom at certification and technical competency programs, such as the Core Curriculum for Technical Programs from the National Center for Geographic Information and Analysis (NCGIA 1996).

Many university geography programs now teach about GIS, all too often reducing instruction time with GIS as an analysis tool (Goodchild 2002). Surprisingly, this trend is not necessarily shared across university programs, as schools of architecture, business, and engineering are increasingly using GIS as a tool in ways more amenable to the pedagogy of K-12 education. Departments outside of geography are often likely to teach with GIS, as an integrative tool, rather than about GIS. Ironically, the use of GIS as a core, integrative technology is, in part, leading to a call for the decoupling of GIS from its traditional associations with the K-12 geography classroom. Alibrandi (2002, 36) describes the potential for GIS across disciplines, “Because this swift uptake [in GIS use] has permeated traditional disciplinary boundaries, it may be time to reconsider the positioning of GIS in the K-12 curriculum as part of instructional technology.”

In the 2000 national survey of GIS implementation at the K-12 level, Kerski reported that twice as many science educators use the technology as social science educators. More specifically, he argued that veteran, high-achieving science teachers hold the market share of K-12 teachers using GIS. Some suggest that K-12
science teachers have a somewhat different perspective toward education and are more frequently trained in inquiry pedagogies and the use of technology to extend student learning (Kerski 2000). Still others have contended that current trends in GIS usage are based on access to classroom technology; it is argued that science teachers have better access to computers than their counterparts in the social sciences (Wardley 1997). Whether such arguments are correct or not, it is reasonably clear that science and social science classrooms initially access and use the technology for different reasons.

Another way to differentiate between the uses of GIS in K-12 science and social sciences can be derived from the approaches to pedagogy used by each academic domain. Science teachers, increasingly attempting to model classroom activity in the form of scientific investigation, foster environments where collection and analysis of data by students is commonplace (AAAS 1993; NRC 1996). Laboratories and field studies are typical in science, and logical progressions of such activities often require some form of data analysis (KanGIS 2001). Conversely, social studies educators are frequently trained with an emphasis in history and are often lacking robust experiences in research methodology and design, a potential disadvantage for inquiry-oriented instruction and resulting analytical needs for GIS use. The prospects for using GIS as a tool of scientific analysis and visualization in the science classroom have been noted and distinguished from the use of GIS in other academic disciplines (Edelson et al. 1999; Edelson 2001). In many respects, science teachers are less likely to teach about GIS, viewing the technology as a tool of data analysis, much akin to the use of spreadsheets for mathematical analysis. For those teachers, who are less interested in learning the specifics of desktop GIS, Internet-based mapping provides a powerful outlet for viewing data and beginning basic analysis.

**Conclusion**

The use of Internet-based GIS can provide a powerful method for collecting, exploring, and analyzing geographic and scientific data. Using Internet-based tools as a first exposure to GIS, many educators will find the value of this technology for extending student inquiries and will seek increasingly more advanced GIS solutions. As professional geographers, we can take advantage of this interest in and availability of Web-based technologies and Internet-based GIS to stimulate geographic awareness across precollegiate education. This early exposure will likely provide greater success for future classroom GIS applications at all levels. Internet-based mapping will not meet the analytical needs of every K-12 classroom, but it has great potential for introducing every classroom to geography and GIS while supporting meaningful, authentic learning.

**Literature Cited**


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