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Around the World with Geospatial Technologies

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"Research & Practice," established early in 2001, features educational research that is directly relevant to the work of classroom teachers. In this issue, teachers' use of geospatial technologies is featured. Adoption and adaptation has been slow in U.S. schools, but is gaining momentum in other nations. Milson and Kerski tell us why, and they provide five brief case studies that showcase how educators are mobilizing GIS and GPS in Asia, Latin America, and Africa.

—Walter C. Parker, "Research and Practice" Editor, University of Washington

The recent National Assessment of Educational Progress in Geography revealed that few American students can identify locations of current events, the scale of those events, or why those events are important.[1] Social studies educators have found that by incorporating emerging technologies into their classroom—such as Geographic Information Systems (GIS) and the Global Positioning System (GPS)—students can improve their geography engagement, content knowledge, and skills.[2] Adoption of geospatial technologies has been slow in the United States but is gaining momentum worldwide. In this article, we discuss where and why adoption has occurred and provide examples. We close with a summary of lessons learned through research and practice.

Australia

The landscape of geospatial technologies in Australian education is similar to that of the United States. Only certain states, such as South Australia and Queensland, have mandated the use of GIS for geography courses, yet pioneering Australian teachers have served as islands of innovation by implementing geospatial technologies without curricular mandates. Australian educators are currently transitioning from this uneven, state-based curricular system to a new national curriculum. The 2011 Australian curriculum provides an opportunity for more widespread use of geospatial technologies in classrooms. Australian geography teachers will likely look to innovative teachers, such as John Kinniburgh of The King's School in Sydney, as they seek effective strategies for employing geospatial technologies. Mr. Kinniburgh has developed successful projects for his students that require them to use GIS to investigate geographical issues within a problem-based learning context. In one such project, students investigated storm inundation and coastal erosion in the Narrabeen/Collaroy embayment on Sydney's northern beaches. Students conducted fieldwork using GPS to examine and map the area as they learned about the interaction of human activities and environmental processes along the coast. Using GIS software, students created hazard maps that simulated different inundation scenarios. Mr. Kinniburgh's work with his students provides a model of what is possible when an innovative teacher employs geospatial technologies in a country where adoption of these technologies for geography education has been limited.[3]

Taiwan

Formal education in Taiwan is centralized and guided by policies that promote the development of students' IT knowledge and skills. Geography is a required subject for Taiwanese high school students in grades 10 and 11. The Taiwanese government has encouraged the infusion of GIS into Taiwan's schools through curriculum standards, teacher professional development initiatives, curriculum development workshops, funds for selected "seed schools" to implement GIS, software and data kits, a nationwide online spatial data archive, national GIS competitions, teacher support teams, pre-service teacher training in universities, and the inclusion of GIS in standardized testing. One of the GIS seed schools selected by the Ministry of Education in 2005 was National Yilan Senior High School in Yilan City, Taiwan. Two geography teachers at this school, Shih-Yao Chou and Ming-Hung Hsu, have developed award-winning lessons that include developing a 3D map of the school campus, mapping an urban heat island, and conducting a GPS-enabled community survey. These teachers have also led student teams to national GIS competitions where the students have won awards for GIS projects such as mapping election results and assessing the vulnerability of communities to tsunamis. Che Ming Chen, a geography professor at National Taiwan Normal University, noted that challenges remain for Taiwanese educators when implementing GIS in the classroom, but predicts an expansion of GIS into lower grade levels as well as into history and civics courses.[4] Taiwan provides a model of what is possible when there is a strong policy and curricular infrastructure that promotes GIS in education.

Turkey

Geography is required in Turkish secondary schools for students from grades 9–12. In 2005, the Turkish national curriculum for geography included GIS for the first time. This addition to the curriculum sparked concern among many geography teachers in Turkey who doubted their knowledge, skills, and resources to implement GIS in the classroom.[5] In 2008, Ali Demirci, a geography professor at Fatih University in Istanbul, published a "GIS for Teachers" book that included GIS software in the Turkish language, GIS data, lesson plans, and an overview of GIS in education.[6] The book was organized according to the Turkish geography curriculum and each lesson involved a question for investigation, such as "Why do earthquakes occur frequently in Turkey?", "What are the most and least crowded cities and regions in the world?", and "Which Turkish province has the greatest population losses and gains due to migration?" In the earthquake lesson, students make predictions about earthquake risk in Turkey and then study actual earthquake data using GIS. Prior to using GIS, students predict where earthquakes and faults exist by placing dots and lines on a map of Turkey to represent recent earthquakes and fault lines. They also predict which provinces have high and low earthquake risk and speculate about why Turkey experiences earthquakes. Students compare their predictions to GIS data and maps showing earthquakes and faults to answer questions such as "What is the relationship between landforms, earthquakes, and fault lines in Turkey?" "Where is earthquake risk high and low?" and "How many people are living in cities with high earthquake risk?" Demirci has found that limited access to computer labs and inadequate hardware capacity have discouraged geography teachers in Turkey from implementing GIS. He has studied alternatives, such as teaching with GIS in a one-computer classroom, and found that this strategy can be effective.[7] The case of Turkey represents what can occur where the infrastructure for technology use in the geography classroom is limited, but where curricular and pedagogic support from university faculty can provide an avenue for successful implementation.

Dominican Republic

Geospatial technologies are rare in the classrooms of the Dominican Republic. Quinta Ana Pérez of the Instituto Tecnológico de Las Américas (ITLA) and Victoria Castro of the Dominican Republic Ministry of Education, state that recent curriculum revisions and an increased emphasis on technology provide an opening for advancing geospatial technology integration in Dominican classrooms.[8] An ILTA research group developed a project for students in Boca Chica in the province of Santo Domingo that focused on a protected area of Española Island (Hispaniola) called Los Haitises. The lessons involved identifying the location of the island on Google Earth and mapping Los Haitises National Park using Esri's ArcGIS. The ITLA group is considering other GIS projects on environmental issues affecting Dominican Republic communities, such as places of high waste concentration and mosquito breeding grounds. An increasing interest in environmental education in the Dominican Republic has provided an opportunity for the expansion of geospatial technologies in education. The work of Pérez and Castro provides an excellent example of cooperation between government, higher education, and secondary schools. Their work advances geospatial technology implementation in classrooms by correlating the tool with the curriculum and providing real-world contexts for learning.

Rwanda

The people of Rwanda are overcoming incredible devastation as they rebuild their education system following the 1994 genocide. The Centre for Geographic Information Systems and Remote Sensing of the National University of Rwanda (CGIS-NUR) has developed award-winning programs for GIS education and research at the university. To build upon the work of CGIS-NUR and extend it to the secondary schools of Rwanda, Esri President Jack Dangermond granted GIS software to all secondary schools in the country. In 2007, the "GIS in Secondary Schools" project was launched as a cooperative effort between Esri Germany, CGIS-NUR, and the Rwandan Ministry of Education to provide GIS training for teachers, a GIS textbook for Rwandan students and teachers, and the support of a GIS specialist from Esri. One participating teacher who implemented GIS in his classroom was Theodore Burikoko of the École Technique Officiel (ETO) Gitarama, a technical secondary school with approximately 450 students who study fields such as construction, public works, and electronics. Mr. Burikoko teaches GIS at the school and applies it to the field of construction. His students have used GIS to map the school grounds including existing buildings, proposed buildings, green spaces, water pipelines, and septic tanks. They also employed GIS in a project involving the construction of domestic biogas digesters. The case of Rwanda is an inspiring example of collaboration between industry and education combined with resourceful and motivated teachers and a vocational context.[9]

Lessons Learned

Numerous additional examples of geospatial technology exist in classrooms around the world.[10] The cases summarized in this article illustrate the strategies that educators have adopted to overcome a variety of challenges to geospatial technology adoption. Many of the obstacles identified in surveys and case studies published since 1990 include the technological, pedagogical, administrative, and curricular hurdles that plague many educational technologies.[11] One unique barrier for geospatial technologies is that spatial thinking and analysis is a multidisciplinary and complex enterprise that does not fit neatly into one category of the standardized curricular structure in the United States and many other countries.[12] In a sense, spatial thinking and geospatial technologies are homeless in the curriculum. Nevertheless, geospatial technologies have been gaining ground in the U.S. and internationally due to a convergence of many factors:

1. the availability of curricular materials;[13]
2. the growing body of implementation and effectiveness research;[14]
3. funded professional development initiatives for teachers;
4. technological advancements such as increased Internet bandwidth, improved hardware capacity, and improved mobile computing;
5. the availability of easily accessible spatial data through government and university open data policies;[15]
6. the development of WebGIS applications that take advantage of advancements in online mapping, virtual globes, and cloud computing;[16]
7. the increased cohesiveness of the GIS education community;[17]
8. software licensing agreements for school use;
9. the rising sense of urgency about human-caused environmental change and increased attention to the role of geospatial technologies as a tool for environmental education and field work;[18]
10. increased recognition of the importance of visualization in learning;[19]
11. curriculum standards that emphasize the importance of learning through inquiry-oriented problem solving about authentic issues with real-world data;[20]
12. recognition of the importance of geospatial technologies for workforce preparation in the U.S. and internationally;[21]

At no time have geospatial technologies been so frequently used by the general public, and at no time have core issues of geography, such as natural hazards, human impact on the landscape, and climate change, been so ingrained in public discourse. Perhaps this is why the sense of urgency to engage students in using geotechnologies in an inquiry-driven educational environment has never been higher.

Conclusion

Educators and citizens around the world are seeking solutions to the challenges of educating digital natives in an era of globalization, while also narrowing the digital divide. In many countries, geospatial technologies have become an important tool for addressing this issue because spatial questions such as "where?" and "why there?" are fundamental to an understanding of 21st Century globalization. Investigating these spatial questions is made easier with geospatial technologies, but these technologies do not substitute for users' spatial thinking skills. On the contrary, these technologies require skills of spatial thinking that too often have been neglected in formal schooling. Fortunately, the spatial thinking skills that are vital for understanding the world can be taught and strengthened through the use of GIS and related technologies.[22] Students and teachers around the globe are using geospatial technologies to investigate the whys-of-where as they study social and scientific concepts and processes, engage in problem-solving and decision-making about local and global issues, and broaden their skills in using this emerging technology. These technologies have an important role to play in the education of digital natives for global citizenship, and in the shrinking of the global digital divide.

Notes

1. National Assessment of Educational Progress (NAEP), *The Nation's Report Card: Geography 2010*, http://nces.ed.gov/nationsreportcard/pubs/main 2010/2011467.asp (Washington, D.C.: National Center for Education Statistics, 2010).
2. Articles in *Social Education* include: Marsha Alibrandi et al., "Reconstructing a School's Past using Oral Histories and GIS Mapping," *Social Education* 64, no. 3 (April 2000): 134-140; Daniel P. Donaldson, "With a Little Help from Our Friends: Implementing Geographic Information Systems (GIS) in K-12 Schools," *Social Education* 65, no. 3 (April 2001): 147–150; Marsha Alibrandi and Hershel Sarnoff, "Using GIS to Answer the 'whys' of 'where' in Social Studies," *Social Education* 70, no. 3 (April 2006): 138–143; Andrew J. Milson, Kathleen M. Gilbert, and Brian D. Earle, "Discovering Africa through Internet-based Geographic Information Systems: A Pan-African Summit Simulation," *Social Education* 71, no. 3 (April 2007):140–145; Andrew J. Milson and Mary Curtis, "Where and Why there? Spatial Thinking with Geographic Information Systems," *Social Education* 73, no. 3 (April 2009): 113–118; Megan Webster and Andrew J. Milson, "Visualizing Economic Development with ArcGIS Explorer," *Social Education* 75, no. 2 (April 2011): 114-118.
3. John C. Kinniburgh, "An Investigation of the Impediments to using Geographical Information Systems (GIS) to Enhance Teaching and Learning in Mandatory Stage 5 Geography in New South Wales," *Geographical Education* 21, (2008): 20–38; John C. Kinniburgh, "Australia: Inquiry Learning with GIS to Simulate Coastal Storm Inundation," in *International Perspectives on Teaching and Learning with GIS in Secondary Schools*, eds. Andrew J. Milson, Ali Demirci, and Joseph J. Kerski (New York: Springer, In Press).
4. Che Ming Chen, "Taiwan: The Seed of GIS Falls Onto Good Ground," in *International Perspectives on Teaching and Learning with GIS in Secondary Schools*, eds. Andrew J. Milson, Ali Demirci, and Joseph J. Kerski (New York: Springer, 2012).
5. Ali Demirci, "How do Teachers Approach New Technologies: Geography Teachers' Attitudes towards Geographic Information Systems (GIS)," *European Journal of Educational Studies* 1, no. 1 (2009): 57-67.
6. Ali Demirci, *Ögretmenler için CBS: Cografi Bilgi Sistemleri.* (Istanbul: Fatih University, 2008).
7. Demirci, "Using Geographic Information Systems (GIS) at Schools Without a Computer Laboratory," *Journal of Geography* 110, no. 2 (March-April 2011): 49-59.
8. Quinta Ana Pérez Sierra and Victoria Castro De la Rosa, "Dominican Republic: Prospects for the Incorporation of GIS into the School Curriculum," in *International Perspectives on Teaching and Learning with GIS in Secondary Schools*.
9. Martina Forster, Theodore Burikoko, and Albert Nsengiyumva, "Rwanda: Socioeconomic Transformation to a Knowledge-based Economy through the Integration of GIS in Secondary Schools," in *International Perspectives on Teaching and Learning with GIS in Secondary Schools*.
10. Thirty-three countries are profiled in *International Perspectives on Teaching and Learning with GIS in Secondary Schools*, eds. Andrew J. Milson, Ali Demirci, and Joseph J. Kerski (New York: Springer, 2012).
11. Jay D. Gatrell, "Structural, Technical, and Definitional Issues: The Case of Geography, GIS, and K-12 Classrooms in the United States," *Journal of Educational Technology Systems* 29, no. 3 (2001): 237-249; Joseph J. Kerski, "The Implementation and Effectiveness of Geographic Information Systems Technology and Methods in Secondary Education," *Journal of Geography* 102 (2003):128-137; Thomas R. Baker, "Internet-based GIS Mapping in Support of K-12 Education," The *Professional Geographer* 57, no. I (2005): 44–50; P.A. McClurg and A. Buss, "Professional Development: Teachers use of GIS to Enhance Student Learning," *Journal of Geography* 106 (2007): 79–87; Andrew J. Milson and Jennifer A. Roberts, "The Status of Geospatial Technologies in State Geography Standards in the United States," in *Digital Geography: Geospatial Technologies in the Social Studies Classroom*, eds. Andrew J. Milson and Marsha Alibrandi (Charlotte, N.C.: Information Age, 2008), 39–59; Thomas R. Baker, Anita Palmer, and Joseph J. Kerski, "A National Survey to Examine Teacher Professional Development and Implementation of Desktop GIS," *Journal of Geography* 108 (2009):174–185.
12. National Research Council, *Learning to Think Spatially—GIS as a Support System in the K-12 Curriculum* (Washington, D.C., National Academies Press, 2006); Sarah W. Bednarz and Robert S. Bednarz, "Spatial Thinking: The Key to Success in Using Geospatial Technologies in the Social Studies Classroom," in *Digital Geography: Geospatial Technologies in the Social Studies Classroom*, eds. Andrew J. Milson and Marsha Alibrandi (Charlotte, N.C.: Information Age, 2008), 249–270.
13. In the United States: Lynn Malone, Anita Palmer, and Christine Voigt, *Mapping Our World: GIS Lessons for Educators*, ArcGIS desktop edition, *(Redlands*, Calif.: Esri, 2005); In Switzerland: Raymond Treier, Carmen Treuthardt Bieri, and Michael Wüthrich, Julie Robitaille with art, *Geografische informationssysteme (GIS) - Grundlagen und Übungsaufgaben für die Sekundarstufe II* (Bern, Switzerland: Verlag, 2006); In Turkey: Ali Demirci, *Ögretmenler için CBS: Cografi Bilgi Sistemleri* (Istanbul, Turkey: Fatih University, 2008).
14. Thomas R. Baker and S.H. White, "The Effects of GIS on Students' Attitudes, Self-Efficacy, and Achievement in Middle School Classrooms," *Journal of Geography* 102, (2003), 243-254; Patrick Wiegand, "School Students' Understanding of Choropleth Maps: Evidence from Collaborative Mapmaking using GIS," *Journal of Geography* 102, (2003): 234–242; Eui-Kyung Shin, "Using Geographic Information System (GIS) to Improve Fourth Graders' Geographic Content Knowledge and Map Skills," *Journal of Geography* 105, no.3 (2006):109-120; Andrew J. Milson and Brian D. Earle, "Internet-based GIS in an Inductive Learning Environment: A Case Study of Ninth Grade Geography Students," *Journal of Geography* 106, (2007): 227–237.
15. International examples of open data initiatives include: USA Geospatial One Stop (www.geodata.gov); Open Data from the UK Ordnance Survey (www.ordnancesurvey.co.uk/oswebsite/opendata/viewer/); Geonetwork from the UN FAO (www.fao.org/geonetwork); Instituto Brasileiro de Geografia e Estatistica (www.ibge.gov.br/home/).
16. Megan Webster and Andrew J. Milson, "Visualizing Economic Development with ArcGIS Explorer," *Social Education* 75, no. 2 (April 2011): 114–118; Richard B. Schultz, Joseph J. Kerski, and T. Patterson, "The Use of Virtual Globes as a Spatial Teaching Tool with Suggestions for Metadata Standards," *Journal of Geography* 107 (2008): 27–34; Joseph J. Kerski, "The World at the Student's Fingertips: Internet-based GIS Education Opportunities," in *Digital Geography: Geospatial Technologies in the Social Studies* Classroom, 119–134.
17. Joseph J. Kerski, "Toward an International Geospatial Education Community," in *Digital Geography: Geospatial Technologies* in the Social Studies Classroom, 61–74.
18. Richard Louv, *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder* (Chapel Hill, N.C.: Algonquin, 2005).
19. Michael D. Piburn et al. "The Role of Visualization in Learning from Computer-based Images" *International Journal of Science Education* 27, no. 5 (April 2005): 513–527.
20. National Geography Education Standards Project. *Geography for Life: National Geography Standards*, 1994 (Washington, D.C.: National Geographic Research & Exploration, 1994).
21. For example, the U.S. Department of Labor recognizes geospatial technologies as a "high growth industry" See www.doleta.gov/BRG/pdf/Geospatial.pdf
22. Jong Won Lee and Robert S. Bednarz, "Effect of GIS Learning on Spatial Thinking," *Journal of Geography in Higher Education* 33, no. 2, (2009): 183-198.

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