EDUCATION EVENT REPORT AND RECOMMENDATIONS

Attendee's Name:
Joseph Kerski, Geographer:
Education/GIS, Denver, RMMC.

Location:
National Academy of Sciences
University of California, Irvine

Other USGS Attendees: None. I represented Barb Ryan and the USGS at this meeting.

Event Dates: 22-23 March 2001

Purpose of Event:

Meeting on "Thinking Spatially: The Incorporation of GIS Across the Curriculum."

(1) Conduct presentation on the implementation and effectiveness of GIS in the educational curriculum, and the role of the USGS in spatial literacy, education, and research.

(2) Contribute to group discussion and recommendations on the issue of GIS in education.

Background

National Academy of Sciences

The National Academy of Sciences (NAS) is a private, non-profit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to furthering science and technology for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce Alberts is the president of the National Academy of Sciences.

Members and foreign associates of the Academy are elected in recognition of their distinguished and continuing achievements in original research; election to the Academy is considered one of the highest honors that can be accorded a scientist or engineer. The Academy membership is comprised of approximately 1,900 members and 300 foreign
associates, of whom more than 170 have won

Nobel Prizes.

National Research Council

The study is being conducted by the National Research Council, Committee on Geography (COG). The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of further knowledge and advising the federal government. The NRC has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The NRC is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts is the NRC chairman.

A number of agencies provided funding to the COG for this study. USGS is one of the agencies, and the funding came from NMD. The study is one of several that COG is conducting. USGS is a major contributor to that committee.

These studies arise from an idea that comes either from a Federal agency or from the COG. A proposal is created and refined in a series of reviews and meetings among the Federal agencies and the COG. Once the proposal reaches a nearly final stage tentative pledges are given by the agencies. The proposal comes in as an unsolicited proposal from the NRC. The agencies perform a formal review and, if the study is appropriate to their mission, provide funding. *Thinking Spatially* was deemed to be valuable to the long-term health of the discipline, the long-term health of the nation, and the long-term use of the geographic information provided by the USGS.

Facility

This meeting was held at the Beckman Center of the NAS at the University of California, Irvine. This facility in Orange County is one of a few such centers operated by the NAS across the country. It certainly was a privilege to be in such an impressive facility. The walls of the center are adorned with very large, high-quality images of Ganymede, Mercury, and other planetary objects; I also noticed a Landsat scene of Boston.

Attendees

Researchers and practitioners interested in teaching *with* GIS, in a content area such as environmental science, geography, history, science, or mathematics, are still a small, close-knit community. Therefore, it is not difficult to understand why I already knew several people on the team. The meeting's attendees were comprised of the internal NAS group, and the external advisory group. The external group was comprised of federal agency and private company representatives.

Two federal agencies were represented: the USGS, represented by me, and the US Census Bureau, represented by Kimberley Crews, who is the "Census in Schools" coordinator. Members of the external group from ESRI included Bill Miller, Head of the Education Vertical Market, David Maguire, usually a keynote presenter on the first day of the ESRI User Conferences, and the K-12 Education team member whom I have worked with since 1994, Charlie Fitzpatrick. Evidently, other GIS software vendors were invited but declined, again highlighting the keen interest and support that ESRI has always demonstrated in the area of education.

Anthony de Souza, whom I met last summer at the GIS in Education conference at Cal State-San Bernardino. Dr de Souza was the first geographer on the National Academy of Sciences; now there are three members who are geographers. Another member on the internal team is Sarah Bednarz, with whom I have been acquainted with from NCGE, GENIP, and various GIS training events over

the past 7 years. Dr Bednarz was one of the key persons involved with writing the national geography standards. I was also pleased to see that Dr Reginald Golledge, UC Santa Barbara, is a part of this team. Dr Golledge, who was AAG President during 2000, gave an excellent talk at last month's 2001 AAG conference entitled "The Nature of Geographic Knowledge," and also wrote one of my all-time favorite columns, "Never Be Ashamed To Be A Geographer."

The NAS committee is led by Roger M. Downs, Chair, Department of Geography. Other members included Peter B. Dow, First Hand Learning, Inc., Kenneth E. Foote, Department of Geography, University of Colorado, J. Freeman Gilbert, Institute of Geophysics and Planetary Physics, University of California, San Diego, Kim A. Kastens, Earth and Environmental Science Journalism Program, Lamont-Doherty Earth Observatory, Columbia University, Marcia C. Linn, Graduate School of Education, University of California at Berkeley, Gerald M Stokes, Joint Global Change Research Institute, Pacific Northwest National Laboratory, and Gaea Leinhardt, Learning Research and Development Center, University of Pittsburgh.

Because one of the main purposes of this research initiative is to explore the cognitive aspects of what students are actually learning when they use GIS, the group is represented by several leading psychologists, including Lynn S. Liben, Department of Psychology, The Pennsylvania State University, Robert A. Bjork, Department of Psychology, University of California, Los Angeles, and John J. Rieser, Department of Psychology and Human Development, Vanderbilt University.

Why GIS in Education?

Many factors are encouraging the use of GIS in education, such as:

- Technological innovation
- Constructivism
- Integrated, authentic practice
- Authentic assessment
- School-to-career movement and funding
- School-to-community emphasis
- Active, student-centered learning
- National, state, and district content standards [see warning above].
- Public accountability demands for education
- Globalization
- Inquiry emphasis
- Information literacy
- Computer literacy
- Professional societies.
- Universities.
- Private companies, especially GIS companies, particularly ESRI.
- Government agencies' outreach staffs such as the USGS.
- Research groups (CIPE, TERC, UMAC).
- Advances in data availability and usability.
- Advances in hardware capability.
- Advances in software capability.

My Presentation at the Meeting

My presentation was based on (1) a five-year research project on GIS in education from 1995-2000, (2) conducting approximately 50 geography and GIS-related workshops and training events for data users each year, the bulk of which are educators, and (3) information I received from the USGS (see acknowledgements).

With a computer presentation accompanied by handouts, I addressed the group with three major themes.

Mission Theme. The first theme was, "how does the GIS in education research theme fit into the goals and mission of the USGS, and how can the USGS contribute to such a research theme?" I pointed to our "Future Science Directions" and our USGS strategic plan, pointing out how GIS in education ties into our mission. I pointed out, thanks to notes from Barb Ryan, that our emphasis is integrated information for societal needs. I

pointed to our revision effort, Gateway to the Earth, and research projects where we need scientists who can analyze data from a variety of disciplines. Integrated studies are recommended by education scholars in K-12 curricula also, rather than the traditional model of separate subjects that do not overlap. I also listed the eight most critical world environmental themes that another NRC study identified last year, and 6 of them require spatial data and a populace that can interpret such data.

I also included the results of the Customer Satisfaction/Outcome Survey, where a group of USGS staff (Steve Gillespie) surveyed 18 different science products, and received 332 useful responses from customers. One question they asked was what they used the product for--whether for research, resource management, hazard mitigation, or education. Across the 18 products, an average of 55% of the customers reported using our products for educational use.

Research Theme. The second theme of my presentation highlighted results of my own five-year study of the implementation and effectiveness of GIS technology and methods in education. I surveyed 1,520 high school teachers who own GIS software, to discover the benefits and constraints to the use of GIS in the classroom. I also conducted 87 experiments involving 300 students in three high schools over an entire academic year, to determine how effective GIS is in influencing students' knowledge of patterns and processes and skills in geographic analysis.

Recommendations Theme. The third theme of my presentation included recommendations needed in order to take advantage of the advantages afforded by the use of GIS in the curriculum.

My handouts included (1) a 15-page version of my research results on GIS in education, (2) sample lessons on studying *Stipa comata* (needle grass) and *Earthquakes Everyday t*hat I have written based on USGS data and GIS technology and methods, and (3) article reprints that I have written that highlights work that students and teachers have accomplished with GIS.

Observations and Recommendations:

This group is an excellent one to address this issue, with its combination academics from education, psychology, science and geography. I do hope they will keep the external advisory group involved, and in particular, people who have trained educators and worked with students in GIS technology and methods. The group is a high-level research team, and rightly so, for this is what we need as an ingredient in long-term change, the group still needs to concern itself with several key practical issues. The group's national statements about this topic are needed to pull this effort together from a variety of individual efforts by others and myself. However, I also hope that they can make some concrete recommendations on the use of GIS in the curriculum.

I pointed out the fundamental differences between teaching *with* GIS versus teaching about GIS. This committee is largely addressing the former--how to use GIS in teaching history, geography, chemistry, and so on.

Implementing a GIS is not primarily about hardware or software! Technology is a "process; a systematic blend of people, materials, methods, and machines" (Ely et al. 1992). GIS is both a technology and *a set of methods*! There are challenges in teaching with GIS--GIS is a system! Costs exist, the user is confronted with a blank screen, and the user must decide which data to use, find data, manipulate data, present data in a usable format, and then design a lesson around these data. Integrating GIS into classroom practice is a complex process. Educators must match the computers and software with instructional goals, subject

matter, the students, and the context of instruction.

Guided inquiry entails changes in the technology, curriculum, social organization, and management of the classroom, teaching approach, and in basic beliefs about the nature of knowledge and the roles of teachers and learners. For example:

• unpredictable results
• student-directed learning
• broad vs deep learning

Students and teachers may have confusion about the fundamental representational and spatial concepts upon which an understanding
of GIS rests. This is something that the USGS can directly assist with changing.

Geo-technology in education must be done within context of reform for long-term impact.

Standards

Content standards, which specify what students should know and be able to do, in technology, science, geography, social studies, and history, repeatedly emphasize hands-on exploration.
"The power of a GIS is that it allows us to ask questions of data."
--Geography Education Standards Project, 1994, p. 256.

However, the current manner in which standards are being assessed is a serious danger to the use of exploratory tools. The current assessment instruments are emphasizing memorizing facts, directly opposite to what is desired with the use of GIS and other spatial tools in the curriculum! This is a serious issue that needs to be addressed by the NRC.

Use GIS in the Right Way

I believe that we need to use GIS in the right way.

1) Don't use it to exchange one form of time-consuming, rote tasks for another.--for example, entering data into tables or making the perfect map. These use only technical skills.
2) Don't use GIS just to add more information, but to use information more effectively to arrive at a decision. Use GIS to emphasize generative knowledge, not inert knowledge (Dede, 1995).

3) Use GIS to make decisions given incomplete information, inconsistent objectives, and uncertain consequences--just like the situation in the world outside of the classroom.

4) Design modules that can be directly used or easily modified and transferred--sustainable projects.

Benefits and Challenges

From a learning perspective, GIS is highly praised. Lessons around the country illustrate community-based, fieldwork based, interdisciplinary, open-ended projects involving ill-structured problems with real-world data. These projects help students use the same tool as is used in research and business to enhance motivation and learning, explore the world, and provide real employment skills.

From a teaching perspective, challenges exist, such as the traditional dominance of Macintosh computers, while most GIS software is written for Windows operating systems. ArcView, for example, runs on Macs, but only the 1997 version of the software. A lack of training in GIS and the perceived and real complexity of GIS tools is another challenge. The lack of preservice training means that the future implementation

rate will continue to be slow. Other challenges are that:

• GIS is a complex, open-ended tool.
• Teachers must process data as well as develop lessons.
• Increases complexity of teachers' jobs.
• A lack of geographic training and thinking in both teachers and students.
• Inadequate time to learn software.
• Few lesson plans.
• Lack of training, funds, and technical support.
• Insufficient openings in curriculum for GIS.
• Few incentives for teachers.

Teachers ideally need to be paired with at least one other teacher in the school for increased likelihood that these methods will "take root," and they need some start-up lesson plans, and training. In my survey of 1,520 teachers, training was cited as the number one need.

GIS alters communication patterns and traditional roles of students and teachers, for example:
• Coaching
• Small group instruction
• Working more closely with weaker students
• Assessment based on products and progress
• Cooperation

GIS appears to be effective with non-traditional learners.

Students with GIS may learn at different rates and not all learned the same content or skills. With GIS, there is a shift from *covering* material to *sampling* material. There is a shift from unilaterally *declaring* what is worth knowing to *discovering* what is important. Students are examining processes over space and time.

In Binko's (1989) 4 stages of learning: awareness, understanding, guided practice, implementation, GIS is barely in the awareness phase for most teachers. In the diffusion literature (championed by Everett Rogers), GIS is in use by the "early adopters"--there could be a big wave to come, but we must be bold in considering these comments and those of the NRC.

GIS implementation will be slow because it relies on inservice training. Therefore, the USGS and others need to address what future teachers are learning in colleges of education in universities.

There is value in requiring students to "dig out" information, rather than handing it to them. GIS involves data management skills and a whole host of other skills besides spatial analysis. It is one of the few tools to take advantage of many computer skills, relational skills, and content skills.

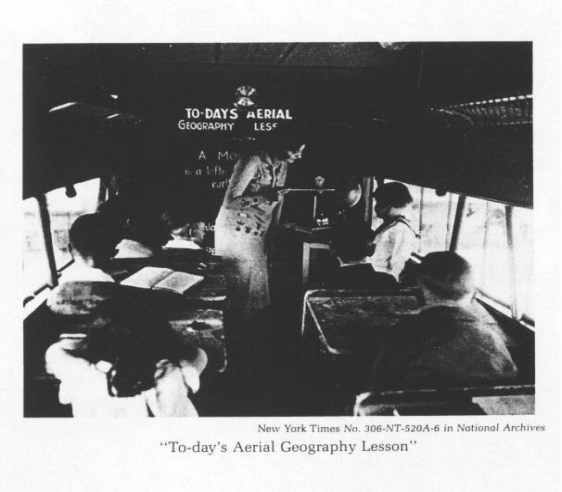
The teacher's role is still critical to learning with GIS, and training teachers needs to be emphasized. Teachers are more likely to adopt GIS if they have previous computer experience, a problem-solving approach, a geographic perspective, a positive attitude toward work change, and active networking and communication skills.

GIS implementation cannot be effective without educational reform. This group can help instigate such reforms.

Our approach should not be: "How can we get GIS into the curriculum?" But: "How can GIS help meet curricular goals?"

I would like to summarize a recommendation with the following photograph. This photograph illustrates the use of technology inappropriately. Here, a class is using the latest technology of 1927, flying in an airplane, high over Los Angeles. However, this new technology is used within an outdated model of education—all eyes are on the teacher, instead of looking at the terrain below, noting patterns of human impact, land use, physical environment, and so on. Even

the old desks have been brought on board and arranged in the old educational paradigm: teacher as dispenser of knowledge. Let's not make the same mistake with GIS!



New York Times No. 306-NT-520A-6 in National Archives

"To-day's Aerial Geography Lesson"

Reproduced with permission from Cuban, Larry. 1986. Teachers and Machines: The Classroom Use of Technology Since 1920. New York: Columbia University, Teachers College.

"The trouble with education…is that the best teaching methods are in fact the most difficult."
--Piaget, Jean. 1929. *The Child's Conception of the World.* London: Routledge.
Despite the challenges, GIS is too important a tool and method to ignore.

Another NRC Study

I recommend that everyone interested in this topic review the recently published study by the National Research Council of the National Academy of Sciences, on the future of the USGS. The report is available online from the National Academy Press at:
www.nap.edu/books/0309072646/html/

This report, by extension, can help us design our education program so that it more fully embraces societal needs.

Why Should the USGS Be Involved?

By participating in this meeting, we demonstrated the leadership that the USGS has in national science literacy. We are the largest producer and one of the largest users of digital spatial geographic data. These are data sets not only used by geographers, but by anyone interested in solving a project that has to do with space—hydrologists, biologists, demographers, seismologists, geologists, sociologists, psychologists, environmental planners, public works officials, marketers, business analysts, and others. Someone has stated that if physics was *the* science of the 20th Century, then earth science will be *the* science of the 21st.

This wealth of data that we create at the USGS will be worthless unless we proactively create a scientifically literate populace.

One reason for attending this meeting was to illustrate USGS strength in integrated technology and science. The explosion in geographic technology presents an excellent opportunity for the USGS to get our data and products into the hands of students and educators across the country. Students familiar with our data will form an expanded future USGS customer base. We also sought to inform the educational and scientific community that our strength does not end with maps and digital cartographic data, but it includes hazards, water resources, energy, and biological research, for example. These are all fields that rely on spatial data, the focal point of this study.

By working with educators, the publicity generated for the USGS could be enormous, particularly with increasing media attention on both the need for geographic and science skills as well as the need for geographic and environmental research. Teachers are a powerful voice for the USGS and represent the largest single professional group in the country.

Furthermore, I believe the USGS will benefit

from participating in this initiative because we will learn from the committee members about how to package our data for the educational community. This is a current question before the Director's Education Team, of which I am a member. We have all of the pieces, but need to write the interfaces, links, and guidelines.

Thinking Spatially Working Group, 23 March 2001. Not Pictured: Dr Reginald Golledge, UCSB.

Teacher Training

Several of us mentioned the topic of teacher training. I believe that the use of GIS has been slow because GIS training, conducted by myself and others, has primarily targeted inservice teachers – teachers who are already practicing in their profession. One exception was a one-week training at Roger Williams University that ESRI education staff and I conducted in January 1999, which was geared toward faculty in departments of education who are training students to become teachers. This *inservice* training needs to be more fully embraced. Teachers teach in large degree, and follow the practices of, how they themselves were first taught in their preservice days.

Technology is changing rapidly—GIS is no exception. However, the pace of change in institutions of higher learning oftentimes is too slow to meet the changing demands of teachers, students, and the needs of society. I hope the group can make recommendations quickly and then follow through on these recommendations.

Teachers and schools are under pressure today as never before, such as being forced to adhere to district, state, and national content standards. These standards specify what students should know and be able to do in science, technology, math, geography, history, social studies, and other areas. Schools are also pressured to perform alternative means of assessment that includes portfolios, field work, computer-based presentations, and other means, in addition to standardized written tests.

During the next five years, schools will be faced with a massive retirement in the system. These new teachers need to be trained in a wide range of technology and methods. I believe that the USGS should capitalize by this massive turnover by emphasizing preservice training for the new teachers coming on board. Schools are also pressured to reduce class sizes, and provide alternative pathways for students, such as educational vouchers. They are expected to recruit and retain high-caliber individuals who must work long hours all during the year, but whose salaries are lower than most other professionals.

At the same time, national and state budgets are constrained, and the likelihood that teachers' salaries will be increased is low. At the same time, growing national population requires a massive number of new teachers over the next decade. In light of the teacher shortage, some areas are lowering the requirements that teachers must have. These individuals who are not required to have a teaching degree also represent wide-open territory for the USGS, for they will be even less aware of our products and services than teachers who have at least had a science methods or social studies methods course.

Acknowledgements

I thank Barb Ryan for appointing me to be the USGS representative at this meeting, for her insights, and for funding the trip, Steve Gillespie for the survey results, and John Kelmelis for sharing his knowledge about this initiative. I am thankful to the NAS for welcoming me at the meeting, which again was a privilege for me and for the USGS to be involved in. I look forward to being involved in the group in the future.

*** End of Thinking Spatially March 2001 Report ***