ESIP Federation: Supplying Earth Observation Data to GIS Education

Tamara S. Ledley, Alan Buss, LuAnn Dahlman, Carol B. Meyer

Abstract

ESIP Federation: Supplying Earth Observation Data to GIS Education

The Federation of Earth Science Information Partners is a network of Earth science researchers who generate, analyze, disseminate and apply Earth observation information to scientific issues. Two partners have been working with educators to spread the use of GIS with geo-referenced Earth science data among the education community.

Educators from the Upper-Midwest Aerospace Consortium's nine institutions have provided professional development experiences for K-12 teachers in the use of GIS, GPS, and remote sensing for 8 years. Teachers have implemented a variety of projects involving these geospatial tools.

Eyes in the Sky (TERC) is an NSF-funded program that prepares science teachers to use geospatial information technologies. Participating teachers learn how to use ArcView GIS, GPS instruments, and image analysis software as research tools. Overviews of the Federation, especially its educational outreach, and both projects will be provided.

The Federation of Earth Science Information Partners ("Federation") is a dynamic network of Earth science data centers, science centers, and application centers, whose work focuses on the generation, analysis, or application of Earth science information. Included in this far-reaching network are NASA and NOAA's Earth observation data centers, many government-sponsored research laboratories, research universities, educational resource providers, information technology developers, and entrepreneurs. All are dedicated to bringing science-based information to users from many walks of life.

Created in 1997 by NASA, the Federation's core is its broad-based membership. Within a single organization, the Federation brings together more than 80 organizations that collect, analyze, interpret, and apply Earth science data. Together, these organizations leverage expertise across member types to enhance the individual products and services each provides (Figure 1).

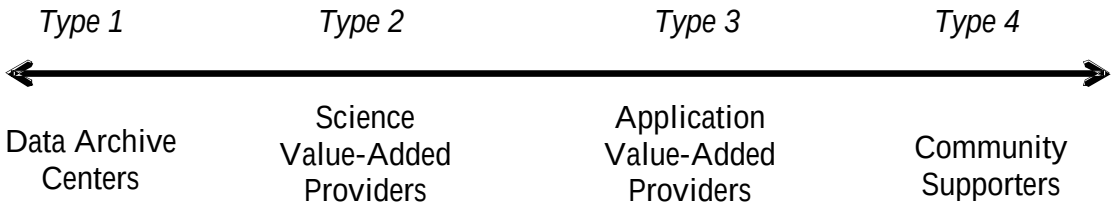

Figure 1. Continuum of Federation Members (producers)

The broad-based membership within the Federation fosters many opportunities for collaboration. This network provides an ideal forum for generating and sustaining collaborations that will lead to the discovery of new applications and create new users of products and services. The Federation's unique structure affords equal standing to data providers and educational product developers, as well as to all its other partner types. These collaborations lead to a far greater impact, than any one Federation partner could make alone.

The Federation recognizes that environmental change and sustainability are among the great challenges facing our world. Its uniquely crosscutting membership makes it well equipped to assemble the myriad technical and social components required to confront these challenges. The goals for realizing this vision have been articulated in the Federation's Strategic Plan, adopted in August 2004. Key elements of that plan are to:

- Expand public awareness about the importance and value of Earth science and Earth science information systems.
- Improve the quality and usability of Earth science data and information systems.
- Incorporate Earth science data into Earth system science education.
- Expand public awareness about the importance and value of Earth science.

The Strategic Plan calls for Federation members to work cooperatively among its partners and with outside collaborators—to deliver "the right data to the right people at the right time." Through its Education Committee, the Federation is working to make data available to educators and students in a form that is usable, useful and has impact. By providing data and tools to those who train the next generation's scientists and to those who inform the public about environmental issues, the Federation can make a lasting contribution to the goal of sustaining a hospitable world. As a consortium primarily made up of scientists, the Federation looks to forge partnerships that enable greater accessibility, usability and understanding of data. The GIS community offers context to scientific data that helps make the data more relevant to users across many fields. Combining scientific information with geo-referenced tools for education provides a powerful mechanism for improving public understanding of the changing environments on the

Earth.

The GIS-Federation connection continues to grow. In May 2005, ESRI provided support to the Federation to build a data portal, The *Earth Information Exchange*. One feature of the portal will be to provide users with science-based data using GIS tools. The Federation intends to continue to work closely with ESRI and others to assure that scientific data is increasingly compatible with GIS systems. Already, many Federation partners are successfully using Earth science data in GIS applications. Two such GIS educational initiatives are featured below.

Educational Public Access Resource Center (EdPARC)

EdPARC is one of three Public Access Resource Centers established within the Upper Midwest Aerospace Consortium (UMAC). Supported by NASA, the consortium, which consists of nine institutions of higher education in Montana, North and South Dakota, Idaho, and Wyoming, is one of the founding Federation partners. UMAC's fundamental philosophy is that people make proper decisions if given appropriate, accurate, and timely information. Primary activities of the consortium have centered on creating and sharing an array of data and information products that can both educate the next generation of scientists through a unified Earth Systems approach and raise public awareness about the current status of the planet's health.

EdPARC's mission is to form, support and maintain a collaborative partnership among K-12 educators, teacher educators and scientists to provide students with authentic learning experiences in Earth system science. Specific objectives include:

- Develop teaching/learning activities that reflect recent advances in understanding how people learn—actively, collaboratively, conceptually, constructively, contextually, and multisensorily—and are consistent with ongoing work in national reform efforts.
- Utilize remote sensing, GPS and GIS as tools to inspire students and teachers to think systemically about the Earth.
- Distribute relevant data and information in formats usable in schools.

Teacher Workshops
In 1996, when the original PARC project was developed, few schools were incorporating courses or technologies for investigating Earth system science. Science content was segregated into the traditional disciplinary areas of Earth, life, and physical science, without connections among the content areas or to other disciplines. Geographic Information Systems software was beginning to make its way into educational settings, and few educators were aware of the power and potential for using these technologies for studying systems. Additionally, data sets which were user-friendly for novice learners such as K-12 teachers and students were non-existent. In order for such new technologies to be incorporated into the 5^{th}-12^{th} grade classroom environment, extensive training experiences and ready-made data sets were required.

The *EdPARC* team of public school teachers, agricultural producers, and university faculty have worked collaboratively to provide educational experiences for 5^{th}-12^{th} grade teachers in the use of spatial technologies and data sets to study Earth system science. These experiences included intensive summer institutes, three 2-day professional development workshops, and short introductory seminars. Content of the experiences focused on the implementation of geospatial tools and data, such as ArcView GIS, image processing software, satellite imagery, GPS, and the regional data set *Prairie to Mountain Explorer*, to solve real-world problems involving science, geography, mathematics, agriculture, art, and technology concepts. As a result, the teachers selected for participation represented several disciplines.

Participating teachers were required to adopt these technologies and strategies in their classrooms, and extend their learning to fit the goals and objectives related to their state and local content standards. They learned how to use the Internet and the *EdPARC* web site to access additional data and to network with other educators in planning, implementing, and assessing instruction using the data and technologies.

Evaluations were conducted to determine the effect of the GIS training on teacher skills and attitudes toward using the technologies in the classroom. Teachers were given a pre-workshop survey to determine abilities and attitudes on a number of aspects related to using GIS. A follow-up survey was administered at the end of each workshop. Results showed significant gains in the teachers' self-reported ability to manipulate the technologies and incorporate them in the classroom. Results of this research have been presented at the National Science Teachers Association national conference, the International Conference on Mathematics/Science & Technology, and the ESRI Education Users Conference. Results from workshops have been presented at multiple state-level conferences, and several articles have been published or submitted.

Data and Curricular Materials

One of the products created from the efforts of *EdPARC* is the *Prairie to Mountain Explorer* (PTME) data set. PTME is a CD-ROM set of spatial data specifically designed for use in the classroom. GIS data were assembled and modified for Idaho, Montana, North Dakota, South Dakota, and Wyoming for themes such as: bedrock geology, roads, boundaries, cities, demographics, climate, land cover, land ownership, species occurrences or habitats, rivers, watersheds and elevation. Using a specialized PTME ArcView project file to simplify complex software processes, students can explore these data layers from local to regional scales. Students can investigate relationships among these data such as the specific climates most suitable for growing corn, or the elevations and vegetation types that certain animal species prefer.

A second product is the *Leafy Spurge Invasion: A Rangeland Management Case Study and Role Play* material set. This case study uses the concepts of GIS and remote sensing to investigate issues surrounding the management of Leafy Spurge, an invasive weed species which causes problems with cattle and wildlife. Students research issues from multiple perspectives surrounding weed management and then participate in a Coordinated Resource Management role play to determine a suitable course of action. While non-technical in nature, the case study introduces key concepts for using technology to grapple with real-world problems.

GIS Showcase for Teachers and Students

As more teachers and students became comfortable with GIS and GPS, it became evident that there were opportunities for sharing these successes in the classroom on a regional scale. To honor the work of teachers and students, and to promote further use of spatial tools in the classroom, *EdPARC* organized the Annual GIS for Educators Showcase. The first showcase was held in Bozeman, Montana in October 2001, then in Rapid City, South Dakota in October 2002, and the third in Sioux Falls, South Dakota as part of the Technology Innovations in Education Conference in April 2004. The showcases were conducted to highlight outstanding student and teacher activities using ArcView and/or GPS, and to share how schools are incorporating the use of GIS into their instructional programs. Each of the five states selected up to three outstanding educational activities to be showcased at the conferences. Teams of students (some as young as 4th grade) and their teachers set up displays and made presentations to those in attendance. The two-day events also included presentations by scientists, field trips to museums and planetariums, and demonstrations by graduate students on uses of technology in science.

More than 700 teachers have been impacted by the introductory and intensive workshops, presentations, and showcases that *EdPARC* has offered. Students have been able to use GIS, GPS, and remote sensing in a wide range of activities, including:

- Managing and evaluating prescribed burns;
- Mapping historic cemeteries, trails, and communities;
- Evaluating safe walking routes to school for students;
- Investigating the environmental impact of coal-bed methane wells on raptor and sage grouse;
- Using beetles to control invasive species;
- Studying watersheds, rivers, and streams.

Currently, *EdPARC* teams are working to modify training and data sets to take advantage of recent developments in GIS, GPS, and remote sensing, such as Internet Mapping Services, precision agriculture, geocaching, and widespread access to inexpensive GPS units. Follow-up and support for teachers, in an increasingly demanding atmosphere of standards and high-stakes testing, is a high priority as well. For more information about *EdPARC*, visit http://smtc.uwyo.edu/edparc/.

Eyes in the Sky: Applied Geospatial Information Technology

Eyes in the Sky is a professional development program that prepares middle and high school teachers in Arizona to use geospatial information technologies for community-based research. Administered by Federation member TERC, a not-for-profit educational research and development firm in Cambridge, Massachusetts, the project is one of 32 two- or three-year projects funded by the National Science Foundation's Information Technology Experiences for Students and Teachers (ITEST) program. The project encourages use of GIS by providing software, data, and training coupled with authentic scientific research pedagogy—this combination results in teachers and students who are as motivated to use technological tools as research scientists.

The Professional Development Program
For successful teacher applicants, the four-part program begins with a 12-week distance learning course. A two-week face-to-face workshop, a school-year implementation phase, and a culminating Research Showcase round out the program. Program participants learn to use ArcView 3.0 GIS, ImageJ—a public domain image analysis program, and GPS units. They also learn about the difference between simple experiments done in school situations and authentic scientific research projects that model how scientists work. Additionally, teachers develop an awareness of careers that utilize geospatial information technologies (GIT).

Eyes in the Sky staff developed their own introductory GIS lessons and built the online course, drawing on published materials from the Center for Image Processing in Education and the SAGUARO group at University of Arizona. The four-hour graduate-level course is offered through Northern Arizona University. Each week, participants explore websites or read material to provide context for their learning, then follow step-by-step instructions to learn and practice GIS and image analysis skills. Participants submit screen shots of their completed work to demonstrate their mastery of technical skills. In addition, they discuss ideas for using specific capabilities of the programs for learning activities in their existing science and mathematics courses. The continual focus on using new technology to improve teaching and learning of existing content gives participants a real sense of the possibilities and potential for GIT. Though most participants consider the distance learning course to be a challenge, they emerge with strong foundational skills and apply them effectively in new situations.

The second part of the program is a two-week face-to-face workshop that includes a student institute. During the first week, teachers apply the principles they learned in the distance learning course to example research projects. They get hands-on experience with each project by collecting data and walking through data organization and analysis procedures. *Eyes in the Sky* staff worked with local scientists to develop or adapt several projects that provide teachers and

students with opportunities to engage in authentic research. Example projects include a light mapping project to quantify and analyze light pollution around Arizona's metropolitan areas, a food mapping project in which students map urban food resources and assist in collecting and redistributing them to economically disadvantaged families, and a project to investigate the nesting patterns of birds in urban and suburban saguaro cacti. The first two of these projects have the potential to be implemented as service learning projects, making them attractive to a wide range of schools that are now focusing on this aspect of learning. Rich datasets, the ability to gather new data in their own communities, and the opportunity to ask and answer new questions through geospatial analysis are key features of all projects featured by the program.

The Summer Institute for Students
During the second week of the teacher workshop, students attend every morning for a summer institute that provides them with an introduction to GIT and careers that use them. Student attendees are recruited from schools with large populations of historically underrepresented groups. In small teams, teachers prepare and present introductory lessons on using ArcView GIS, ImageJ, and GPS units. This arrangement of involving students in the workshop gives teachers the opportunity for direct practice in teaching their new technology skills. Teacher success with these lessons also serves to boost confidence for introducing the technology to their own students in the fall.

One of the first GIT experiences for students is to look for their own schools, homes, and other familiar places on high resolution aerial photos (Digital Orthophoto Quarter Quadrangles or DOQQs). These photos and other satellite images are provided by Federation member, Arizona Regional Image Archive (ARIA). In looking for familiar features, students are quick to ask for orienting information such as street names. As soon as they realize they can turn on themes in ArcView, they understand the value of layering in a GIS, and proceed to exploring, analyzing, and eventually mapping geospatial information of the workshop site. Students also use GPS units in a simplified geocaching exercise and complete another GPS activity in which they attain surprisingly accurate results for Earth's polar circumference. Students also learn to use digital cameras as data collection instruments, including applying image analysis techniques for making measurements from photographs.

The summer institute for students also features activities led by GIT-using professionals from local businesses and municipal agencies. Each presenter describes their career and how they use GIT in it, then walks students through a hands-on computer activity to illustrate what they do. These activities give students the chance to see how an eyes-in-the-sky perspective is applied to a broad range of issues and the experience provides them with evidence that skills in GIT are increasingly important for many careers. At the end of each career activity, students create screen shots and write a short reflection about the experience. These records become part of the students' *Eyes in the Sky* portfolio, which they are encouraged to bring along to job interviews. In some cases, *Eyes in the Sky* staff worked with the professionals to craft activities that would be appropriate for middle and high school students. In all cases, teachers take the data and activities back to their classrooms so that they can use them with their own students.

Staff from Federation member ARIA in Tucson volunteered to make one of the guest presentations and also helped *Eyes in the Sky* staff connect with other qualified professionals who would do the same. People with an exciting range of careers made a positive impression on the students. Fire department personnel demonstrated the technology they use to help them locate and respond to emergencies. A member of the police force showed how GIT are used to understand patterns of repeated crimes so they can predict where and when the next crime might be committed. Natural resource managers showed how satellite imagery is used to monitor the threat of wildfires. A marine biologist explained how radio signals from marked whales and turtles help biologists understand migration patterns and threats to marine mammals. Students also made and digitized an inventory of facilities around a school to

understand how geo-referenced databases can facilitate day-to-day management of an organization's assets.

Taking GIT Back to the Classroom

During afternoons of week 2, teachers reflect on how well the introductory lessons and career activities worked with students, and they create detailed lesson plans for how they might present the materials to their own students in the fall. They also choose one of the exemplary research projects (or develop their own with assistance from project staff) and gather background materials to help them implement it during the following school year. Participants are encouraged to consider a range of possible implementation strategies and identify their own best chance for running a successful project in a classroom, independent study, or club situation. The freedom to try out the new pedagogy and technology skills in a club was useful to several teachers. Because they didn't have to focus on meeting specific content standards, they were able to successfully implement the technology and inquiry skills, and build excitement among students. This experience serves as a positive foundation, encouraging teachers to try other projects and cover more standards-specific content in future years. Other teachers found that they could use the exemplary projects as presented, simply focusing on the specific scientific and technological skills that covered the standards they needed to teach. In all cases, *Eyes in the Sky* staff offered support in the form of extra information, classroom visits, or communications with district technology offices to facilitate installation of software and data files. Unfortunately, the issue of technological support at the district or school level remains the most frequently encountered obstacle for teachers implementing this project.

The Research Showcase

The culminating event of the 18-month long professional development program is a GIT Research Showcase. The Showcase highlights student research in oral and poster presentations, a format that closely models traditional scientific meetings. Teachers, students, parents, school administrators, school board members, guest speakers, and members of the media are invited to attend. A plenary speaker and student oral presentations are followed by a less formal student poster- and computer-demonstration session. The community-wide event offers students the opportunity to disseminate their results to the GIT community as they participate in this realistic model of how science advances.

One particularly successful implementation of an *Eyes in the Sky* project was in a 6th grade mathematics classroom in Tucson, Arizona. The teacher led a series of Saturday field trips to Sabino Canyon, a local recreation area, and students collected data on more than 80 saguaro cacti. They gathered the GPS location, counted the number of arms, classified and counted wounds and bird nesting cavities, and photographed each cactus and used ImageJ to measure its height. Students downloaded aerial photographs and wrote WorldFiles to bring the images into ArcView at the correct scale and location. Using their GPS data, they plotted saguaro locations and completed a series of analysis procedures to characterize the population. Students worked cooperatively to write their report and develop an effective oral presentation of their work. Additionally, they entered and won an award at a science fair competition and were invited to display their work at the Sabino Canyon Visitor Center. During the oral and poster presentations, these students enthusiastically described the mathematical basis of their work as well as the science they had learned and the questions they wanted to research further. One female student proudly reported that she would never look at a saguaro cactus as a "normal person" again.

Eyes in the Sky is funded by the National Science Foundation's Information Technology Experiences (ITEST) program and is supported in part by ESRI, Inc. For more information about *Eyes in the Sky*, visit http://eyesinthesky.terc.edu/toplevel/home.cfm.

To learn more about the Federation or to find out about other available GIS resources, visit http://www.esipfed.org.