

Development of the Interdisciplinary GIS Program at Weber State University: Its Growing Impact on Undergraduate Research

The use of Geographic Information Systems (GIS) to support student education and research at predominantly undergraduate institutions has steadily grown in recent years. However, resources at such institutions are limited and undergraduate research grants cannot typically support the management, hardware, and software requirements of department labs. Consequently, student needs outweigh adequate computer resources. To address this issue at Weber State University (WSU), an interdisciplinary GIS program was started so students, faculty and staff would have the necessary resources (educational opportunities, GIS software licensing, and adequate computer lab access) to utilize GIS in support of their research and teaching efforts. The three major stages that make up the core GIS program are described below, along with examples of how GIS is being used in undergraduate research.

Weber State University is a publicly supported university primarily committed to quality undergraduate education through superior teaching and undergraduate research (Weber State University, 2006). At WSU, GIS has been an important part of both undergraduate education and research in the geosciences and geography departments for many years. Students benefit from the strong job market in both the public and private sectors as well as the need in academic research for those with a solid foundation in GIS principles and techniques. As GIS matures in the marketplace, other disciplines discovered the powerful capabilities of geospatial analysis to support both education and research. The challenge for primarily undergraduate institutions is the ability to support the increased need for GIS education and software licensing for additional faculty and students outside the current department(s) using GIS. This article addresses how the Department of Geosciences is working with the Colleges of Science and Social and Behavioral Sciences, the Stewart Library, the Information Technology Division, and university administration at WSU to ensure a long-term funded GIS program is established to support the increased university GIS-related education and research needs. Experiences with using GIS in undergraduate research projects involving faculty in physics and geosciences is presented to highlight some of the issues and successes. Finally, we examine the challenges and opportunities related to the GIS program facing our institution in the future.



Some students from the Introduction to GIS course diligently working on lab assignments in the GEAR Lab at Weber State University (foreground left to background right: Margaret Harris, Jeanette Croft, Shaemus Yeiter, Don Coleman, Brian Teats, and Justin Quilter).

Development of a Sustainable GIS Program

The GIS program being implemented at WSU is loosely based on the guidelines proposed by ESRI in their white paper on developing higher education GIS programs (ESRI, 2002). However, this program is designed to support the institution's teaching and undergraduate research focus with the limited resources available. The proposed implementation plan calls for developing two separate phases of GIS programs: an initial, core (Phase 1) program which is active today, and a more comprehensive, long-range (Phase 2) program that will build on the solid foundation of Phase 1. The core GIS program (Phase 1) is a three-stage process. Details for each stage are addressed below.

Stage 1 (Planning). Stage 1 consisted of several steps. First, a single faculty member (Dr. Hernandez) was selected to oversee GIS planning and implementation (i.e., campus GIS administrator). It is critical that someone who has a vested interest in GIS education and research and understands both the technical and administrative issues is overseeing all aspects of the program. This individual is the single point of contact for GIS issues and will ensure that the GIS program is properly established and funded as well as prevent duplication of effort on campus.

Next, the requirements needed to develop the GIS core courses and a GIS lab were identified and prioritized. The assessment for the introduction of GIS on campus is typically done at the department level, as was the case at WSU. The third step focused on determining avenues for initial and long-term funding sources for the GIS program. In the past, because of the costs, external grants or gifts were needed to pay for the initial setup of many GIS labs. An external NASA grant awarded to a previous faculty member funded the construction and equipment for the Geospatial and Environmental Applied Research (GEAR) Lab at WSU. The final planning step looks to the future by developing an outline for expansion of the GIS program to address expected increase in student, faculty, and staff needs for education and research. This step is iterative, and the outline is continually under review as the interdisciplinary use of GIS matures on campus.

Stage 2 (Implementation). This stage is where the planning steps were realized and changes to plans occurred as needs and resources were prioritized resulting in the best possible outcome. Specific experiences with the GIS program implementation at WSU are discussed in detail here. The current GIS education component consists of two core GIS courses (Introduction to GIS and Technical and Applicational Issues in GIS) that are taught in the Department of Geosciences and two cartography courses (Cartography and Advanced Cartography) that use GIS software taught in the Department of Geography. Two courses, Remote Sensing and Advanced Digital Image Processing, that support the geospatial analysis minor and the Geomatics Certificate program, are also taught in the Department of Geosciences.

The GEAR Lab, a 15-seat student and faculty education and research lab housed in the Department of Geosciences, was created by a previous faculty member several years ago using funds from a NASA equipment external grant. The core GIS and remote sensing courses have lab components which are taught in the GEAR Lab.

The biggest issue faced by the department was the limited number of GIS software licenses available to run on student workstations. At WSU, we have chosen to use ESRI as the software vendor to support GIS activities on our campus. Prior to the summer of 2004, there were only four full ESRI ArcGIS license seats available for a negotiated yearly higher education licensing and maintenance fee of \$3200. These licenses were shared among the students and faculty. This limited our ability to both teach students and use GIS in undergraduate research (20 – 30 students taking the courses or doing independent research). Other important software extensions (e.g., Geostatistical Analyst)

were not part of the license, so students and faculty were not getting access to some specialized tools that would be useful in courses or research. The major goal for advancing the GIS program was to provide more GIS capability and interdepartmental cooperation based on both our needs for more licenses and increased faculty and staff interest in using GIS. A critical step was to acquire a higher education ArcGIS site license agreement that would provide the appropriate GIS software products and virtually unlimited number of licenses to meet the expanding user needs.

A consortium of Utah universities had negotiated a Utah statewide higher education ESRI ArcGIS site license, which provided participants with unlimited use of the majority of ESRI software applications and extensions, ESRI-authored virtual campus training courses, at a significantly reduced cost in license and annual maintenance fees than the standard higher education site license program. At WSU, institutional support was built with several targeted organizations (stakeholders) on campus to get the necessary funding so WSU could join the consortium. These organizations had faculty and staff proponents already using some form of GIS software or had expressed an interest in GIS (Colleges of Science and Social and Behavioral Sciences, Stewart Library, and Facilities Management). With the help of the proponents, the organizational leaders each agreed to fund a portion of the license and maintenance fee (~\$5,200/year for the Utah regional universities and colleges) for a three-year period requested to ensure there was enough time to gain further support for GIS and seek a longer term funding solution.

Stage 3 (Sustainment). Sustainment is critical to ensure long-term viability of the WSU GIS program. This involves both maintaining current institutional support and garnering new support through constant marketing and communication by the GIS administrator as to what GIS can do to help the university community. To maintain support for GIS at WSU, faculty and staff proponents take an active role in discussing their GIS-related activities with their respective colleagues, chairs, and deans. A yearly campus GIS activity report is sent out summarizing the GIS program activities for the previous year. Publicizing GIS to the campus community has expanded support for GIS at WSU. A campus-wide GIS roll-out seminar was held where ESRI representatives gave an introductory presentation about GIS and attendees learned about what software and training options were available through the campus site license agreement. Additional GIS seminars were also held in some of the colleges. The seminars and informal discussions have gen-



Rich Emerson is shown in the Avian Ecology Lab at Weber State University, reviewing bird nesting locations in ArcMap®. He is an undergraduate research student working with Dr. John Cavitt (Zoology) using GIS to help examine factors affecting nesting success of coexisting shorebirds around the Great Salt Lake, Utah.

erated significant interest in GIS applications from faculty in the computer science, health administration services, criminal justice and political science departments.

Sustainment is also supported by bringing together the GIS user community. Recently, WSU had its inaugural GIS users group meeting attended by 18 people from both the campus community and invited GIS professionals from surrounding local government agencies. The meetings provide a forum for users of all experience levels to learn about various GIS-related topics such as software issues, discussions on how to accomplish tasks using GIS or getting help on some GIS-related task, generating research ideas, and GIS community news. The group meets every two months.

There are several challenges to an effective GIS program facing WSU. First, is the establishment of long-term funding for the Utah statewide higher education ESRI ArcGIS site license. This will provide GIS users the stability and confidence needed that this important tool will be available for the long term. Details about our funding plan are addressed in the last section of this article.

Next, those using GIS need to have access to PC workstations capable of running the newer releases of the software. Several options are available at WSU. A modern three-workstation GIS lab in the library created by grants awarded to JaNae Kinikin, the science librarian, is available to the students, faculty, and staff. Our IT Division also maintains a state-of-the-art computer classroom that can be scheduled for GIS lab instruction as needed. This is an important asset for those departments that want to teach a GIS-related lab but do not have a

sufficient computer lab in their department or college. One of the great reasons to have unlimited GIS software licensing is that the GIS applications can be loaded on any university-owned computer capable of supporting the software, including the open student labs, giving students multiple access points.

The third challenge to sustainability is how to keep those interested in learning GIS engaged since the learning curve is steep. Involvement is the key. The GIS users group meetings and an associated email listing give them a way to communicate with other GIS users to get help with their problems. GIS education and training is also very important. These options and challenges are addressed in the next section.

Learning GIS – Resources for Undergraduate Students and Faculty/Staff at WSU

The core GIS courses taught in the Department of Geosciences form the backbone for GIS education on campus. These courses are taught mostly from an interdisciplinary perspective because many of the students come from outside the department. The only prerequisite is an elementary statistics course. The courses introduce students to the fundamental geographic concepts and techniques that form the framework of GIS. Through a series of lab assignments and a final project in both courses, they systematically learn basic to advanced GIS tasks, taking advantage of the ArcGIS applications and extensions. Their GIS knowledge and skills reach a level where they can work effectively with faculty on GIS-based research and community service projects. In some cases, the students assist faculty with understanding the capabilities and limitations of the GIS software to support research tasks and analyses. The basic and advanced cartography courses use ArcGIS to teach students how to create accurate and effective maps based on cartographic concepts and rules. Students are encouraged to take at least both the introductory GIS and cartography courses.

A major problem is the inability for certain students, faculty and staff to take the GIS courses. Some students have few elective hours in their curriculum (e.g., pre-med) to take additional classes or have schedule conflicts. Faculty and staff have conflicting schedules with the courses or simply do not have the time. Fortunately, they have several training pathways available at WSU at no cost. Independent, self-paced training is the most common option. Students, faculty and staff can choose to use the ESRI educational GIS resources to learn how to operate software applications and perform GIS-based analysis.



Undergraduate research student Stanton Nielson is shown observing laser altimeter and passive radiometric imagery derived from Mars Orbiter Laser Altimeter data that he is using to perform topographical analyses of Martian polar crater forms. Stan is working with Dr. John Armstrong (lead researcher) and Dr. Michael Hernandez (GIS mentor) on this interdisciplinary research project.

Several students, faculty and staff have taken online Virtual Campus training courses (<http://training.esri.com>) which provide excellent introductions to GIS software and applications. Those online courses authored by ESRI are free as part of the site license. The company also provides online lessons and exercises for the classroom designed by GIS software users (<http://www.esri.com/arclessons>). Another option is to review GIS textbooks, lab manuals, and professional and trade journals to learn about different aspects of GIS (e.g., software, applications, industry news, etc.). Many of these resources are available in the campus library, either in hard copy or electronic versions. Some publications, like *ArcUser* (an ESRI quarterly publication that provides useful applications, tips and tricks, and reviews on their software) are free (<http://www.esri.com/news/arcuser/index.html>). An introductory GIS lab manual is an excellent way to begin learning GIS. One is used in the basic GIS course. There are many other online GIS resources. A good portal for GIS data and information can be found at GIS.com (<http://www.gis.com/>).

One of the best ways to learn GIS is through personal interaction with other users on campus. Our GIS users group provides a great forum to develop ideas and potential collaborations and discuss GIS-related

issues involving undergraduate research. There are also many informal discussions amongst GIS users on campus, who help each other better utilize GIS in their teaching and research. Collaborations with other faculty experienced using GIS is another great situation. Other faculty and undergraduate students learn how to best utilize GIS to support the research project. This situation is reflected in the current Mars polar ice research project collaboration between the two co-authors and an undergraduate student.

Undergraduate GIS-Based Research: Examples from Weber State University

Each year a pool of 10 to 20 students take the core GIS courses. Faculty in other departments are encouraged to enroll their students who need GIS skills to support undergraduate research in the courses. Therefore, it has been a priority to make faculty aware of the GIS program because they can reach a larger student pool that could benefit from learning GIS for their future careers. Usually two or three students in this pool show the level of interest and commitment needed to participate in undergraduate research. Faculty interested in using GIS to support their research and involving students with GIS experi-

ence normally contact the GIS instructor to identify any qualified students interested in doing research. They typically will be offered an opportunity to work on a faculty research project. In a few cases, students with the internal drive and maturity develop their own research projects under a faculty mentor, as either their final project in the advanced GIS course, as an independent study course, or as a Capstone project as part of the honors program.

Examples: Zoology and Geosciences undergraduate research projects. The College of Science has a long record of faculty supporting undergraduate GIS-based research. For example, Rich Emerson, a geosciences senior currently enrolled in the GIS core course sequence, is working on a zoology research grant with Dr. John Cavitt (Zoology) using GIS to map bird nest locations in the wetlands surrounding the western shorelines of the Great Salt Lake. He is analyzing their distances from levees, which predators use to search for the nests. Dr. Cavitt, who has an appreciation of the value of GIS, directs the research activities, teaching Rich about the avian species in question and their predators looking for food. Conversely, Rich (with mentoring by Dr. Hernandez) demonstrates how GIS is used to determine spatial relationships between the bird nests and levees. Most importantly, both faculty mentor and student are learning how GIS-based mapping and analysis enhances research.

Another example involved Mike Waltermann, an experienced computer programmer and photographer, who came to WSU to earn the Geomatics Certificate. In the advanced GIS course Mike's final project resulted in the development of a GIS-based method to properly georegister his unique spherical 360° panoramic images to Digital Elevation Models (DEMs) so the panoramic three-dimensional image mosaics could be accurately displayed in perspective maps and animations. By minimizing location error throughout the panoramic scene, these ground-based images can be used as ground reference data for correction of airborne and satellite imagery. Mike's results were presented at Weber State's second annual undergraduate research symposium in Spring 2005. Mike's successful efforts were a direct result of the knowledge he gained about map projections, coordinate systems, and datums, and how geospatial data spatial reference information is created and changed in the GIS software.

Example: Interdisciplinary research in planetary science. One of the benefits of strong courses and an integrated facility for GIS is the ability to study topics outside of the geosciences that can take advantage

of the software. Typically, at small teaching-focused universities, planetary sciences are the realm of physics, or perhaps a joint collaboration between physics and geology. However, many of the planetary science faculty and students have limited access to GIS tools, even though these tools are wide-spread in planetary research. With access to the GIS lab, support courses, and online resources, research programs have an avenue for student training.

This type of collaboration often approaches GIS from the opposite direction. Students involved in astronomy and planetary science coursework become involved in research that requires GIS experience, but are not on track to take these courses. In that sense, they become much like the faculty and staff that need to learn GIS, and can take advantage of the many paths in place to learn the tools and apply this knowledge to their specific problem.

Recently, one of our undergraduate students, Stan Nielson, became interested in a project to study craters in Mars' polar regions. This project takes advantage of several datasets, from high-resolution multi-spectral imagery to global data sets in topography and thermal spectra. Stan's twin interests in geography and physics allowed him access to the GIS software through the GEAR Lab, and he used on-line courses to take advantage of the software in his research before he was able to take the courses. Stan represents a class of mature, highly motivated students that we see frequently at Weber State, who can benefit from multiple training paths, especially in tools like ArcGIS. Having multiple access points to GIS training satisfies a range of needs, from faculty with specific research goals, to students just getting started in GIS analysis.

Another helpful aspect of the University-wide GIS program is the mentoring provided by faculty experienced in using the tools and software. A scientific advisor can help students with aspects of the Martian science, but without the help of GIS mentoring, the student could struggle needlessly or have to postpone research until courses are available. This strategy also leverages GIS expertise. While the GIS mentor may not be able to support the number of students interested in projects involving GIS, that person can act as a point of contact for students and faculty who are interested in expanding their research through the use of GIS tools. Eventually, more faculty (and students) become well versed in GIS technology, and can become mentors in their own right.

The challenge of this approach, however, is to find a way to support the expanded GIS program through lab computers and software main-

tenance costs. It is easy for faculty to take advantage of an expanded GIS program. However, faculty outside of the geosciences often find it difficult to allocate resources to GIS (they may be the only faculty member in a given department that uses it, for example), and since their research students often do not take the GIS courses, lab fees are not available to maintain the GIS lab or other computing facilities that may use the software.

The solution to these challenges is an integrated program that provides University support for software licensing as well as support for laboratory computing. In the end, such GIS software can be included in a campus distribution (such as site licenses for symbolic mathematics or word processing) so that all faculty, staff, and students have automatic access. As the tools become more familiar and used in more research, generating excitement for GIS becomes easier.

What Next? The Future of WSU's GIS Program

The immediate need is to secure long-term funding for the program. We are currently in discussions with the IT Division about how best to structure the budget based on future administration support and increased users. The GIS program will continue to mature and we will provide increased opportunities for student, faculty and staff involvement with GIS. An instructor-led workshop is expected to be offered on campus next summer. The workshop will introduce fundamental geospatial concepts and provide hands-on basic instruction on using ESRI ArcGIS desktop software. The need for a more comprehensive introductory GIS course similar to first core GIS course will also be evaluated and potentially offered through continuing education in the future.

An exciting interdisciplinary movement that will provide students from computer science, physics, and geosciences the opportunity to integrate class experiences and work together on real-world applications is under development at WSU. The Scientific Analysis and Visualization Initiative (SAVI) involves faculty and lab facilities from the three departments. As part of the initiative, the faculty members are planning to develop a new course on scientific visualization that incorporates curricula from the three departments, including GIS, so students get hands-on experience using high-performance computing to analyze and visualize data from an interdisciplinary perspective. Other faculty will be able to take advantage of the skills students have devel-

oped through SAVI to support their research needs. Several companies including ESRI are looking for qualified students who have the necessary computing and GIS background along with teamwork skills to meet dynamic industry needs that cross disciplines. To support the growth involving the GIS program, a qualified GIS coordinator will hopefully be hired in the near future to provide the day-to-day technical support (software installation and problems) and assist with other GIS activities on campus.

References

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