GIS as a Theme or "Glue" in a Department

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Implementing GIS Programs

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Introduction: The Environmental Studies Department at UST

In 1990, the University of St. Thomas in Houston, Texas decided to establish an environmental program. They formed a faculty working group to explore the feasibility of such a program and commenced a search for a faculty member to establish and chair the department. The members of the committee felt that caring for the environment was both a scholarly endeavor and a religious imperative. With that in mind, they hired the author of this paper.

In 1991, I arrived at the University with a tight schedule to develop a university-level program that took into account the type of student attracted to the University of St. Thomas, industry standards, and standards in the field of environmental education. The last guiding principle, following "standards in the field of environmental education," proved to be the most difficult of the three. For indeed, there were almost no standards available for a relatively new area of study. This became very obvious when I attended a meeting of department chairs and directors at the Trinity University in San Antonio, Texas and the results of that meeting have been published.[1]

There were several models put forth, but no consensus arose as to what courses would be necessary for a degree in either environmental science or environmental studies. It was left up to the individual universities to determine the nature, or flavor, of their programs. There were several "themes" that were proposed, and these served as a model for the formation of the program at the University. In the spring of 1992, the University's Board approved a Bachelor of Arts and Bachelor of Science degree in environmental studies, with students being admitted to the program in the fall of that year. With the exception of a two-year hiatus for reevaluation, the department has been offering degrees in the environment field for 18 years.

A Change in Direction

The original degree programs, as proposed and approved, followed a pedagogically sound progression through introductory courses through the capstone experience. For the students receiving a Bachelor of Science degree, there were a number of supporting courses outside of the department in biology and chemistry. For the students in the Bachelor of Arts program, they were given the option of concentration areas in psychology, political science, international studies, communications and economics. The arts' students could "shape" their experience towards a particular concentration depending on what they were interested in doing after graduation. All students were required to complete a capstone experience by either completing a thesis or 250 hours of internship. These courses formed the "professional" spine of the program (Table 1).

Academic Year	Professional Spine
Freshman Year	Science of the Human Environment
	Science of the Earth Environment
Sophomore Year	Authentic Development and Sustainability
Junior Year	Urban Planning
	Field Studies in Ecology and Environmental Science

Senior Year	Urban Environmental Investigation Environmental Sampling and Analysis Research: Literature Search Research: Data Acquisition and Analysis Research: Thesis Writing Environmental Internship

Table 1. Environmental Science and Studies Professional Spine.

Another "spine" running through the courses required for the degree were courses and requirements related to evaluation and accreditation through the Southern Association of Colleges and Schools. Students were required to attend the fall colloquium, a one-hour course, from their first year in the program through graduation (Table 2). During the colloquium the students were introduced to the curriculum, curriculum changes, and each other (students from all classifications met together). They were asked to write their obituary (assuming that they lived a long life) and fill out applications for graduate school. In this way they could see where they were, where they were going, and how to get there. Students completed a journal during the semester and discussed that journal with faculty members. Key elements were included as evaluation within other classes to evaluate students' progress as well as whether the course was meeting the curricular needs of the program. A final piece to the evaluation "spine" was an exit exam tailored to the individual student's curriculum. The departmental evaluation plan was recognized by SACS during their University review process, one of only two recognitions given during that review period for the entire University.

Academic Year	Evaluation Spine

Freshman Year	Freshman Colloquium
Sophomore Year	Sophomore Colloquium
Junior Year	Junior Colloquium
Senior Year	Senior Colloquium

Table 2. Environmental Science and Studies Evaluation Spine.

Environmental Systems Research Institute, Inc. (ESRI) had a booth at the Geological Society of America National Meeting in Denver, Colorado in 1992. At that booth they were demonstrating their software on the Apple Macintosh platform. Having drawn geographic and geologic maps by hand for many years, Geographic Information Systems software seemed like a “miracle.” Although GIS software had been around in some form since the 1960’s[2], it was not widely known of outside of the geography community.

That chance meeting with Charlie Johnson changed my life and the lives of my students since then. With the addition of GIS to the curriculum, the department now had a “technical spine.” And that is the focus of this paper, how GIS became a third “spine,” or glue in the department that flows through classes from the freshman to senior years (Table 3).

Academic Year	GIS Spine
Freshman Year	Modeling in Introductory Course
Sophomore Year	Introduction to GIS
Junior Year	GIS Supporting Course Assignments
Senior Year	Using GIS in Thesis/Internships

Table 3. Environmental Science and Studies GIS Spine.

Three Backbones in Departmental Program Development

One might ask if it is expecting too much to have three developmental threads within one program. Some university programs, inside the environmental science/studies field or in other fields, lack curricular coherence. Some environmental programs are administrated through a loose amalgam of faculty with only rudimentary "environmental" courses. A number of those kinds of departments have since failed or have been absorbed by other departments.[3] One key element of the proposal for the program at the University of St. Thomas was that it was a stand-alone program with its own, dedicated faculty. Having two faculty members, one for the BA degree and one for the BS degree made it easier to respond to concerns and shepherd students through the program with its diverse course requirements. The cooperation between the faculty members also meant that curricular goals could be met through the courses as they were developed for the program.

Curriculum development should include internal and external evaluation as part of the planning and implement process.[4] Whereas students are evaluated through papers, tests and other assignments, courses and programs should also be evaluated to see that they are achieving course goals, satisfying departmental needs and promoting the academic priorities of the school.

> "At the heart of the Commission's philosophy of accreditation, the concept of quality enhancement presumes each member institution to be engaged in an ongoing program of improvement and be able to demonstrate how well it fulfills its stated mission. Although evaluation of an institution's educational quality and its effectiveness in achieving its mission is a difficult talk requiring careful analysis and

> professional judgment, an institution is expected to document the duality and effectiveness of all its programs and services."[5]

Each spine provides stability to the program. Each spine is connected to the other by supporting the intertwined goals of instruction, evaluation and technological education. While this strengthens the program, it is also pedagogically efficient. If evaluation is built into a program from the beginning that also means that the goals have to be developed as the courses are developed. In this way the courses support their purpose within the overall development of the degree program and progression along Piaget's development towards the ultimate goal of "novel application" of information.[6] When that evaluation is also keyed through the program's professional development "spine" towards a capstone experience, the faculty members will know when and if students are going to be able to perform at the level needed to complete the capstone task. GIS, when woven into the fabric of instruction from the beginning of a student's formal education in college, becomes part of the toolkit that is used by the student to develop "novel application" skills, the ability to evaluate information within a geographic setting, and extend their work into the real world using real data from local, state or the federal governments.

Twenty-five years ago, who would have thought that word processing and the use of spreadsheets and database programs would denote "computer literacy" rather than the ability to program a computer? At that time people were programming computers in FORTRAN, storing their data on magnetic tapes, looking at monochrome monitors, no such thing as "high resolution" geographic information, and a megabyte was considered an impossible amount of information to store. Many GIS programs were pushing in the limits in the mid-1990's by requesting 2 gigabyte hard drives for their laptop computers, asking for networking of computers and file storage and distribution systems for student's use while the information technology departments felt that this was beyond what could have been considered a reasonable request.

Today, departments using GIS are requesting quad-core or better computers, highest resolution graphic cards, using data files in the gigabyte-range of sizes and need terabyte-sized storage devices. Distributive internet requirements have prompted schools to convert to fiber optic communication systems and rethink storage limits on campus computing systems for file storage. The use of GIS systems has necessitated that faculty members learn how to use computer systems beyond many of their peers so that students can be provided with the most efficient and stable systems available. Gone are the days where a student will tolerate beginning a layer-add command in the evening and waiting for four or five hours to see if the file will transfer and open, without the computer crashing or requiring the Arc View's version of exiting the program by using the "control-alt-delete" version of the exit command.

In the near future, GIS will be added to the list as a form of computer competency that all students will need to operate in a more complex world.[7] The success and spread of GIS into the modern workplace is making it an invaluable tool for any student wishing to advance in the world. The Department of Labor has identified GIS as a "high-demand" skill within the technology workforce only third behind biotechnology and nanotechnology. By including GIS within a department curriculum, faculty members are preparing their students to enter the workforce not only of today, but the workforce and workplace of tomorrow. As the current generation of students become more familiar with GIS and expects to use GIS technology in their education, universities will have to provide GIS instruction to a broader scope of customers.

The success of GIS has not come without problems, though. Along with an increase in geographic literacy (which is much needed in the United States[8]) and an increased use of geography-dependent information, GIS has blurred the distinction of geography for the sake of geographic knowledge and the use of geology as a data display methodology. Before GIS, professors and students would either have to trace maps from pre-existing sources or construct their own maps using plane tables and alidades as well as theodolites and transits.[9] These methods were extremely time consuming and often resulted in maps that were geographically "flawed" in some respect. Today students gather map information from the Internet, project on the fly, and sometimes misrepresent information because of a lack of the geographic and cartographic knowledge. GIS, as with any other technology, has sometimes been viewed as the answer and not a tool to work towards an “answer” to the questions that face us.

It is important that faculty members present information using appropriate styles and display methods. By modeling the proper application of the technology from the beginning of instruction, the students will grow to expect certain information from their maps and the appropriate use of the technology. Instead of offering a computer competency course in the use of GIS our Introduction to GIS course teaches about data, geographic principles and the use of the GIS. Students complete exercises from a workbook as they develop competency in the software **AND** as they support course instruction in GIS as an area of study. Although we do not expect that our students will obtain a degree in GIS, they need to understand the system and not become merely users of the technology.

GIS Throughout the Curriculum

We started adding GIS as a degree requirement in 1994 with one course, Introduction to GIS. This course had as a prerequisite our introductory sequence of science classes. It was positioned during the student’s sophomore (or early junior) year when they were also taking supporting courses principally outside of the department. Sophomores, with our introductory sequence of classes, would have at least a rudimentary knowledge of environmental date and an introduction to geography from the map interpretation portion of the Science of the Earth Environment course. By positioning the class between this sequence and the upper division courses, we could then require the use of GIS as an analytic and display tool by the students for class assignments and tests. By the senior year, GIS could be used by students to conduct or complete their senior thesis research or use the technology in support of their internships. Many potential internship providers have noted our students knowledge of GIS as a key in hiring our students over those students from other universities.

The development and more widespread use of extensions within GIS brought about an increase in our GIS course requirements with the addition of Advanced GIS. In this class our students took online courses from ESRI in 3-D and Spatial Analyst and an additional course in the application of GIS. Students commonly take their third course in urban planning, natural resources and/or hydrology. As a capstone to the online courses, students then prepare a set of maps using the new tools that the extensions brought to the program using local data, or at least data pertinent to their concentration within the major. Many students used this course to prepare them to conduct their senior research. In at least one case, the use of GIS to analyze a local problem became a thesis. We have also offered independent research in GIS to some students where they use GIS as a tool to examine the use of large-scale data sets to solve problems of a more regional nature. One such student has prepared a database to analyze the successes and failures within the Bureau of Indian Education’s schools for Native Americans.

At levels of instruction above the sophomore year, students are expected to know how to use GIS as a tool for display and eventually the use of GIS for the analysis of environmental data. To support the use of GIS the department has purchased datasets, aerial photography and maintains an up to date set of shapefile data for the Houston area. The University has recognized the importance of GIS within the program and supports it through funding to attend and present at the ESRI conference, maintaining a dedicated GIS lab within the department, providing a dedicated financial line to pay for program licenses, and the University pays for the continual upgrading of the computers used in the department's lab.

Extending GIS to Other Department's Curricula

The environmental science and studies program has been contacted by faculty members in the education and business schools as well as members of the international studies and political science departments about their students taking our GIS courses. It began with faculty members in those departments asking if students could take the introductory course as an elective. For those students, we have let the class project be a way for those students to focus the course towards the kinds of uses that they may have for their own majors. All students must construct a "novel" data layer (shapefile) as well as collect layers from online sources with authority in the chosen field. Some examples of the projects completed by those students include (Figure 1 a - c):

Attributes of EPA Superfund Sites in Harris County – Austin Taylor.
Global Protected Lands – Junior Oirike.
A Representation of Greenhouse Gas Emission Levels and Related Characteristics for Asian Countries using ArcView GIS – Maritza Aguirre.
Galveston Bay Project – Submerged Lands of Texas: West Bay – Yvonne McKeon.
Comparative Analysis of 421 Rancho Baur, Harris County, Texas using GIS – Brian Carlile.
Environmental Analysis of Europe – Brian Lowe.
Tectonic Plates – Jamie Bonilla.
Buffalo Bayou Stormsheds: Stanford Outfall – Carlos Trujillo.
East Side Parks and Public Lands, Harris County, Texas – Tang Dao.
Harris County Superfund Site Analysis – Matthew Toomey.
University of St. Thomas Campus Features – Karen Wong.
Europe Using Overlay Analysis of Factors – Yolanda Garcia.
African Countries – Anne Aviles.

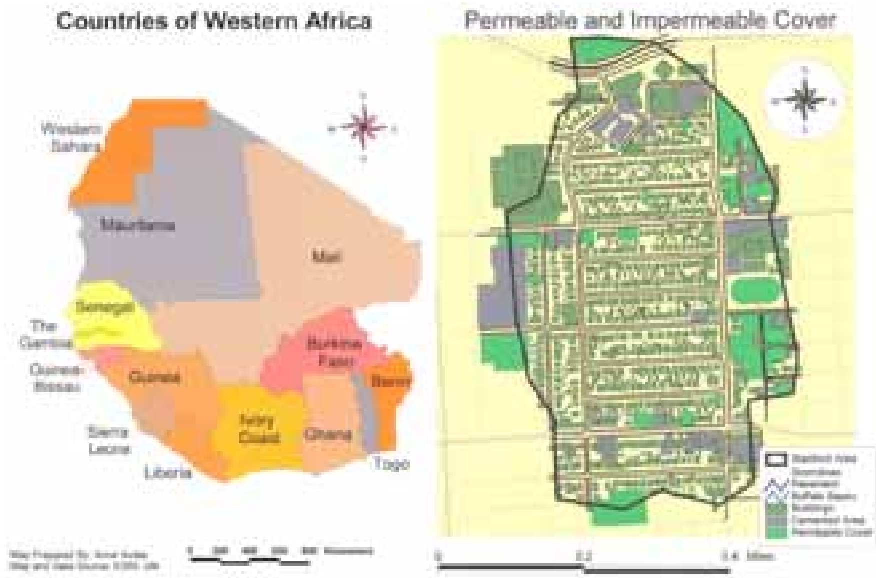

Figure 2a. Introduction to GIS Class Projects: Anne (Left), Carlos (Right).

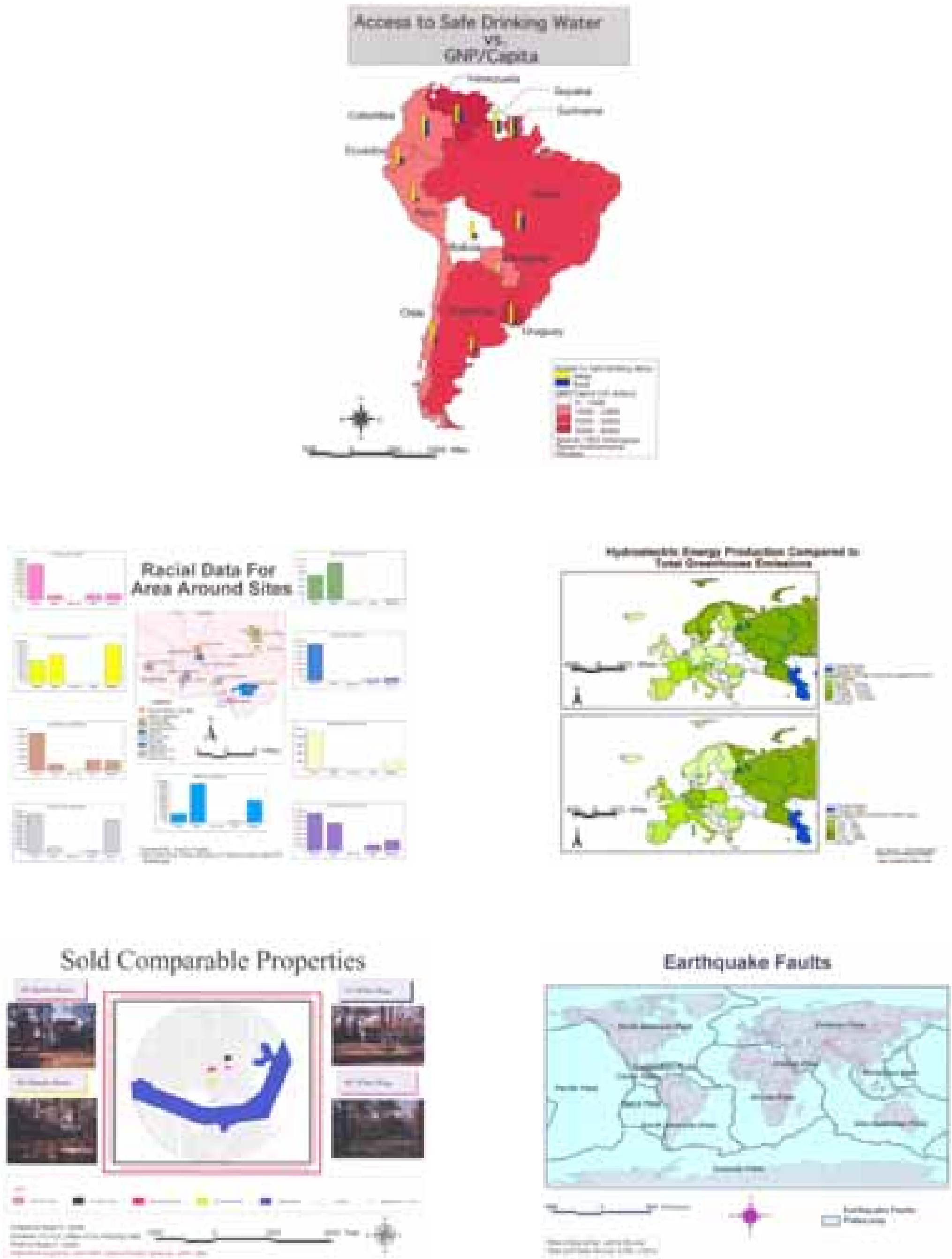

Figure 2b. Introduction to GIS Class Projects: Sarah (Top), Austin (Middle Left), Brian (Middle Right), Bryan (Lower Left), Jamie (Lower Right).

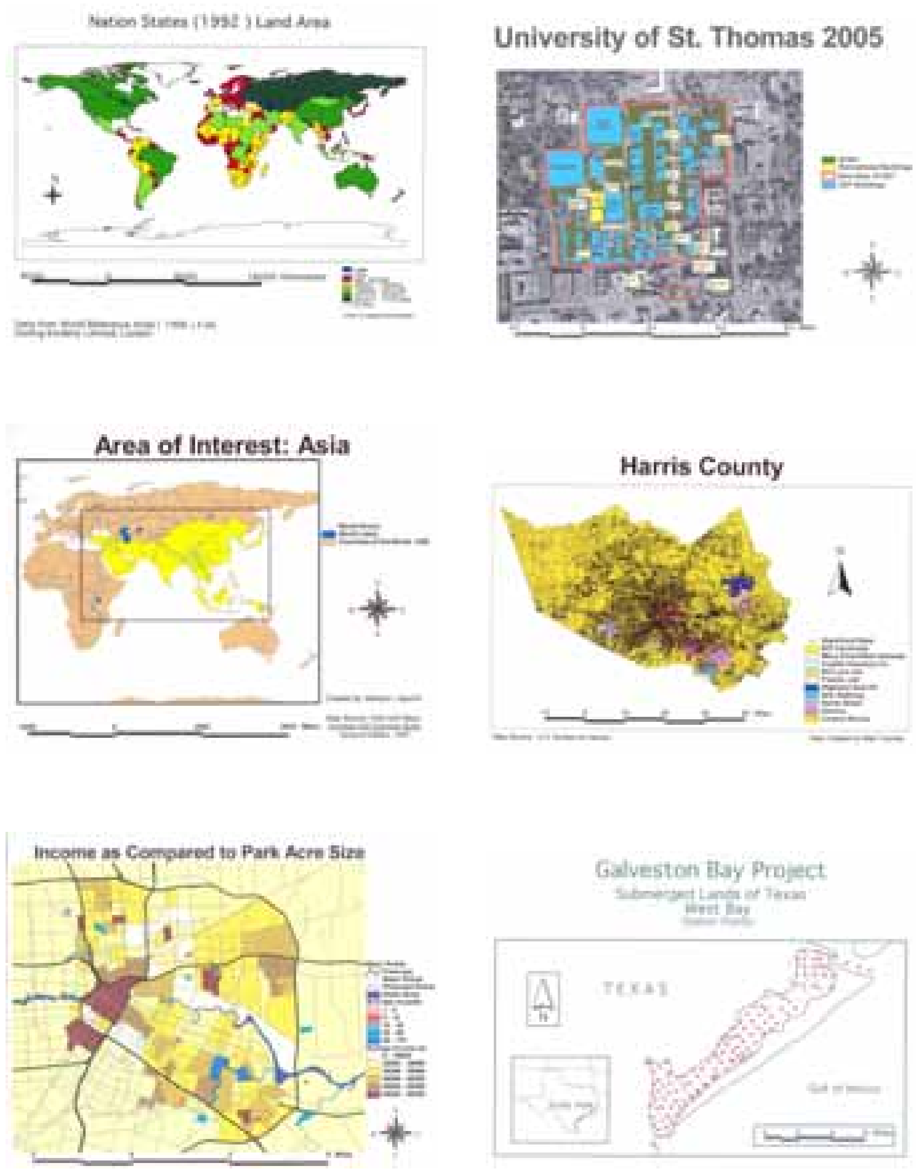

Figure 2c. Introduction to GIS Class Projects: Junior (Top Left), Karen (Top Right), Maritza (Middle Left), Matthew (Middle Right), Tang (Lower Left), Yvonne (Lower Right).

One of the best projects turned in one year was put together by a bilingual education major. This individual worked hard all semester to figure out how the whole thing worked and was often frustrated because he could not remember the commands and/or the computer would crash just when he had finished a complicated map (but before he had saved it). One day, while working on his project, this student had an epiphany about the program and how it worked. Instead of the four or five maps that he had felt he could create, he produced sixteen maps. Each of them was almost letter perfect, displayed the data correctly, and used a good range of colors to best display the data within the geographic framework. This student went on to take other environmental classes and used his mapping skills to complete his projects in those other classes.

When the University was considering a new urban studies minor, it was assumed that the Introduction to GIS course would be included. In addition to the GIS course, our course in Earth Science and Urban Planning (which has a substantial GIS component) was also to be added into the list of courses students could elect from for the minor. During the negotiations for the minor (which broke down for non-GIS reasons), the Introduction to GIS course was going to be a required course and not an elective course as most of the other classes were going to be listed.

Plans are already being made to offer a course in the use of GIS with the census and redistricting (this course will be topical because 2010 is a census year for the United States). Students in this course will take census projections (the actual data will only be available in a very preliminary form) and see how the redistricting process works by applying redistricting models to the numbers. This will be compared to the possible redistricting solutions that were available based upon the 2000 census data. Faculty members from the political science department will offer instruction in the politics of redistricting while faculty members from the environmental science and studies department will provide a short course in using GIS and the use of the redistricting models. Both faculty members will work with the students for their course projects.

Within the next year, a course will be developed based upon the book "Digital City"[10] for Masters of Liberal Arts students who are completing a concentration in public administration, undergraduates in the political science department and students in the business school. This course will require the Introduction to GIS course as a prerequisite and will look at the implementation, maintenance and use of GIS by city planners in a wide range of situations. Students will focus on the needs of smaller, intermediate and larger cities and how GIS can be used at each of these levels to maximize the potential for smart growth[11], brownfields[12] and to avoid the problems of sprawl.[13]

Although the environmental science and studies program will probably continue to undergo changes throughout its existence at the University, undoubtedly GIS will continue to serve a pivotal role for our students and university community.

How Do You Introduce GIS as a "Spine" to Your Department

If you are in a program where your data has a geographic component, then GIS can help your students and provide them training in a tool that has almost unlimited potential. To begin with, though, you must ask yourself the question, "How can we use

GIS to promote the use and analysis of geographic data within out area of study?" If you can't answer that question, then it doesn't make sense to add GIS to your program. Here are some examples of department that could readily introduce the use of GIS software most easily into their departments:

Political Science	Geography	Public Health
International Studies	Geology	Public Administration
Business	Ecology	History.

Once you decide that GIS is a viable tool for your students, you have to determine the level of GIS involvement that you are going to want. Is it necessary to only use GIS as a tool? If so, a simple class at the sophomore level that serves as a technology course in the use of something like ArcGIS would be appropriate. In this way students could be introduced to the software and its basic capabilities and the appropriate construction of maps to provide information. On the other hand, if you intend to use GIS software as a high end technical tool, then you may be looking at either a more involved, upper division course or a sequence of courses. The obvious question at that point is whether you can afford to add six or more hours to your degree plan.

Another question to ask would be "is there anyone in your department, or at your university, that knows how to use GIS software and does your school already have a site license for the software?" These are real, financial considerations. If you do not have a GIS "expert" or are not able to hire one, you can't just buy the software and read a book in order to begin teaching it. To become proficient with the software and to be able to know how to use it enough to teach a course a faculty member will need several years of working with the program. There are some online courses available to help you begin to use GIS software, but nothing takes the place of putting it on your computer and using it for yourself. It may turn out that bringing GIS into your program may be cost prohibitive. If you do not have a dedicated lab, printers and computers, a software budget, data sets or a professor who knows how to use the software, then you may not be able to easily bring GIS into your department.

If you have the opportunity to bring GIS into your program, then you need to ask yourself where in the curriculum will this fit. Can it be used across the curriculum in your department, or are there specific times and classes where introducing the use of GIS would be appropriate? Environmental data is inherently geographic, so integrating GIS into our program wasn't as much of a problem for us as it could have been for others. You need to have at least one faculty member who will be given the designation as the "GIS professor" for the department and they will need to be supported for what they have to do to use GIS within the program. Tasks such as license management, installing updates and computer lab maintenance are time consuming and require a comfort with the program that goes beyond just being comfortable using a computer.

One thing that we found with the introductory course projects is that students will spend upwards of 10 hours working on their projects. The ten hours of work includes looking for data, trying to reprojecting data and setting up the map elements. Many students need help at all stages of project development and some of that will be hand-holding. This isn’t a course where you can answer questions over e-mails and the professor will have to be available for a significant period of time during the latter part of the semester.

Summary

At the University of St. Thomas, the department of environmental science and studies has offered courses in GIS as part of the course requirements for degrees within the program since 1994. The faculty members decided to make GIS an integral part of the program, with the use of GIS software serving as one of three programmatic "spines"; professional development, program evaluation and technology.

Students begin by working with maps constructed using GIS in the freshman classes, learn to use the program their sophomore year, and then are required to use the software to prepare projects in the upper division courses. By requiring the use of GIS in projects in the upper division courses, the faculty can evaluate how much of that instruction is retained throughout the remainder of the student's undergraduate career. The use of GIS allows for the "novel application" level of work at the upper division level. Our students graduate with an appreciation of the place of GIS in data display and analysis and a valuable skill that gives them an advantage when applying for jobs.

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