On Using GIS to Teach in the Social Sciences

by Jill S. Harris

In higher education, teaching is required but learning is optional. For those with a true passion for learning, it is almost unbearable when students do not seem to "get it." Yet, as the rising tide of outcomes assessment rolls in, learning communities must come to grips with the fruit of their labor. If we are honest, sometimes the harvest is plentiful, sometimes the pickings are slim, and sometimes we sow apple seeds and get squash!

While this experience is not limited to any one discipline, in liberal arts programs the fruit basket can be quite the cornucopia. Why? Increasingly we draw students to our lower-level courses who have aspirations in business or other fields. Our content is foundational, but not core to their degree programs. Alternatively, our economics, history, and humanities courses also attract undeclared underclassmen because they fulfill certain requirements. But without long-term interest in these fields, students will often disconnect and become frustrated with our content. They sometimes lament our subject matter does not equip them with marketable skills. After all, it is easier for students to associate the practice of chemistry in the "real world" with the study of chemistry in college than, say, to associate the practice of law in the real world with the study of economics or history or English. So, how can a professor of "the dismal science"—or any other social science—engage a group of skeptical students who may be just passing

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through on the way to their final destination? The professor can harness the power of Geographic Information Systems (GIS).

At its core, GIS produces maps with layers of information that tell a story about relationships. All social sciences study relationships on some level: prices and quantities, political parties and campaign contributions, musical genres and cultural diversity are a few examples. Because GIS deftly reveals these relationships while harnessing the power of visual intuition, showing patterns, providing for experimentation, and leveraging creativity in the teaching and learning processes, it seems natural that GIS should make its way into social science

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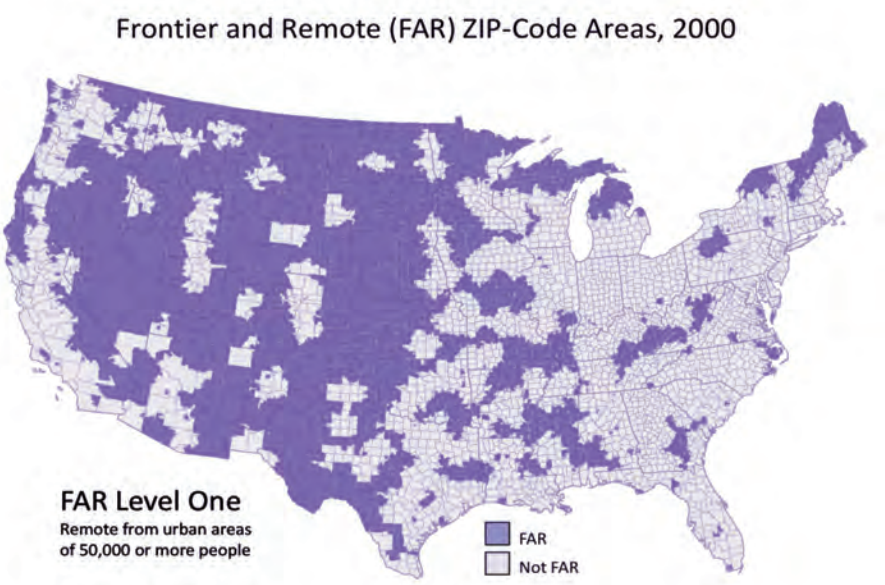
research methods in grand fashion. Yet, a brief search with the engine of your choice will reveal that this is not the case.[1] This is a revolutionary resource, but revolutions can be messy and most of us resist change. Still, my own conversion to GIS—while not completely tidy—was certainly not as chaotic as you might imagine. I have found the pain of change to be far smaller than the pain of regret when it comes to reaching more students and teaching more effectively.

In this article, I show examples of how GIS can illustrate concepts during lecture or discussion, and provide two specific GIS assignments: one for undergraduate students and the other for graduate students. In addition, I provide some basic guidelines regarding pre-requisites and resource requirements for the interested reader. The technology of GIS is dramatically changing the way the world does business; in my view, those of us in education could dramatically change the world if we harness this technology.

In my own classroom, GIS permeates all of my teaching, and adds dimension to theoretical concepts. In macroeconomics, for example, I could simply report to students that unemployment has increased from five percent to 10 percent—or, I could show them a thematic map of the U.S. that uses geocoded data, or data that has a spatial reference like an address or ZIP code,to convey not only the rise in unemployment, but also the way it varies by county across the country. (For an example of a ZIP code map, see the map on the opposite page, which shows the shrinking American frontier.)

Students who grew up on Super Mario Brothers (versus Captain Kangaroo) are already equipped with the skills to make sense of animated visual experiences. Thematic maps seem familiar to this generation of students (though they might intimidate mine). They use GIS on their phones to find the closest Starbucks, figure out how many fast food choices exist around campus, or get directions to the party this weekend. Why not



FAR level one includes ZIP Code areas with majority populations living 60 minutes or more from urban areas of 50,000 or more people.

Source: Economic Research Service, U.S. Department of Agriculture, using data from the U.S. Census Bureau, the Center for International Earth Science Information Network, and ESRI.

meet them where they are and take them a step further?

Leveraging the familiar— the students' attraction to interactive virtual experiences—creates a bridge for students to cross over into less familiar areas of our disciplines. In *Understanding Place: GIS and Mapping Across the Curriculum*, Sinton and Lund showcase a variety of these bridges. In one, students studying French language and culture use GIS to explore the migration of peasants toward the densely populated city of Paris. In another, an art historian uses demographic maps to examine the emergence of the modern art gallery in 19th century London. Meanwhile, an instructor of Latin American music encourages students to map neighborhoods where they are likely to find Latin American music and draws on those discoveries to extend discussion about the relationship between genre and cultural diversity. Similarly, in my economics classes, I have used maps to teach the concept of a negative externality—or spillover effect. Using a data-imposed map, I can direct students to known graffiti sites within a five-mile radius of campus. Next, a layer of recent criminal activity can be imposed. And then, still other layers with median home values, disposable income, or other census-level data can be added on top. In this application of GIS, students dive into familiar geography and discover just how much they do not know about their surroundings. These maps facilitate a search for meaning and prompt critical thought and exploration.

YOU CAN BE A CARTOGRAPHER TOO

To create your own maps for use during lecture and discussion, try a free

online open-source site such as *ArcGISonline.com*. First select a base map from a drop-down menu, then choose from prepared "layers" of data on the site's online server. With just three clicks of a mouse, a thematic map can be created. Arranging maps ahead of time and storing them as screen shots within a PowerPoint or keynote presentation can help to avoid the pitfalls of using technology in real time. Other more sophisticated and proprietary programs exist to be sure, but these open source resources perform beautifully for illustrative purposes.[2] Learning management systems like Moodle or Blackboard support external link features, and maps from a variety of open sources can be linked for classroom use and student review. A network of online educational forums are developing within the GIS community; these forums bubble over with sample lesson plans and resources.[3]

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Teaching political science during an election year? How about introducing an interactive map that shows campaign funds spent on advertising, layered over the electoral votes of each state? Teaching Native American studies? Why not show a map of tribal population changes after key events in history? Or, how about English composition? Create a map illustrating the origins of the Chicago Manual of Style, APA, and MLA to tell the story of why style, structure and form are essential to good writing. And, for Ethics, Religion, or Philosophy, a team from Kansas State University has created a fascinating map illustrating the Seven Deadly Sins.[4] This map always stirs discussion about crime trends, per capita income distribution, overconsumption, and population density when I show it to students. However, in a lab where students also are able to use computers, students can—with very minimal instruction—create their own maps. This method harnesses not just the power of familiarity but also the power of kinesthetic learning. Students investigate, explore, challenge, and create all with the ability to repeat experiments and share with other students what they are learning.

In my upper-level undergraduate and graduate-level courses, I go deeper into GIS and incorporate a GIS-related assignment. The undergraduate course is taught in a computer lab where each student has access to a desktop computer and monitor. Students are shown a variety of maps, as I've described above, and then introduced to an open-source program like *ArcGISonline.com* or *explorer.ArcGIS.com.* After one day of classroom instruction, students can import a text file of geocoded data (e.g., ZIP codes) into a base map, add layers of demographic information, add notes of interest, and even create a slideshow of their

analysis. These skills are then used to evaluate local neighborhoods for a healthy neighborhood assessment, an assignment that has them populating a map with the addresses of recent graffiti sites, plus layers of data that indicate the additional presence of schools and public recreation areas. It usually takes three to four class periods for me to model and monitor the tasks, and assess learning. Some students do take longer than others to master the basics. However, by fostering a collaborative environment where students work together and help one another, plus teaching by wandering around the lab, everyone crosses the assessment finish line together. Students comment frequently on their course evalutions and during informal conversations that the GIS assignment is among their favorites because of the way it helped them to learn.

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THE LATTE FACTOR: IMPROVING LEARNING

But it was the remarkable—and measurable—improvement by two cohorts of graduate-level business students that inspired me to use GIS in my other courses. These students, who were in an accelerated MBA program (eight-week courses with four hours of instruction per class meeting), had been assigned a "location decision" case study: they had to choose between two known locations for a new coffeehouse/bookstore. To do so, they were encouraged (but not required) to utilize GIS in the analysis, and also encouraged (but not required) to work together. During this time, a GIS program called Business Analyst Online (BAO) was made available for our use, and students were provided with a 30-minute orientation to BAO, an additional hour of question-and-answer sessions regarding its application to the assignment, and also an hour with an independent GIS professional. BAO was made accessible from any laptop or PC; in other words, educational output was not restricted by resource limits.

Immediately, the students took to the case with enthusiasm. In economic jargon, the introduction of GIS appeared to create increasing "returns to scale" in learning. (Returns to scale describes how output changes as the scale of production changes. For example, suppose your output is coffee lattes. The input to produce them includes, among other ingredients, coffee beans and espresso machines. Now assume the initial production relationship was such that one hundred pounds of beans and one espresso machine resulted in one hundred lattes produced. If the scale of operation is increased by some factor, say two, so that two hundred pounds of beans and two espresso machines are employed in production, the resulting

change in output indicates whether decreasing, constant, or increasing returns to scale are present. If exactly two hundred lattes are produced, then constant returns are present. If fewer than two hundred are produced, decreasing returns are present, and if more than two hundred lattes are produced, increasing returns are present. With these cohorts, we got far more than two hundred lattes!)

The most notable improvement, compared to previous studies done without the benefit of GIS, was the demonstrated understanding by students of key concepts like demand tastes and preferences, market disequilibrium, and competition. Their GIS-enhanced maps painted a multi-dimensional picture of the number of

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suppliers in the proposed market area, as well as the number of potential customers. This brought enhanced analytic factors, such as traffic flow, income- and age-demographic data, and consumer drive-times, into their decision-making process. Without GIS these learning opportunities would not have occurred.

At the same time, student performance on the case studies was remarkably improved. Of course, these results could be attributed to other factors (e.g., varying individual aptitudes, degree of collaboration between students, etc.) However, the only difference in the syllabus and course was the introduction of GIS, and the increased performance was significant enough for me to ask: Is GIS helping the students to learn? The answer could only come from repeated experiments, but based on student performance in the first trial, I have been inspired to map, teach, and repeat. Through repetition I have discovered that, in the beginning, less is more. If you are in need of a pedagogical pick-me-up and the idea of thematic maps attracts, begin by searching an online source of prepared maps like *ArcGISonline.com* or exploring *www.edcommunity.esri.com* for maps and lesson plan inspiration. Add just a map or two next semester and let the revolution begin! With the two sites previously mentioned, you can also begin creating your own maps and saving them to a free database where they are catalogued and easily accessible by you and your students.

STIR THE PRIMORDIAL SOUP OF TEACHING

To incorporate GIS assignments into your curriculum, examine your existing repertoire for potential opportunities. Your modification could be as simple as directing students to a map you have saved online and having them pinpoint where they last filled their gas tanks and what they paid per gallon. Once completed, you can use this student-generated map to invite discussion on location and price,

commuting patterns, or the political economy of our fossil-fuel dependence. Or, you could have students search and identify the number of public libraries compared to retail booksellers in your area. This could lead to a discussion about public services, books versus e-readers, or the future of the publishing industry. If you are teaching about ethnicity and religion, have students search and identify the worship centers in your community and then add a census tract layer including ethnicity. Assignments like this require no pre-requisites and simple access to the Internet (for more involved assignments where sustained use of network databases is involved, coordination with your campus or department IT specialists may be

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necessary). Courses requiring advanced mapping or precision shapes and figures will more than likely require proprietary software. Site licenses are costly and might be prohibitive for smaller institutions, however it is worth asking the geography department on your campus (or nearby!) what they have in place before completely giving up on the possibility. In fact, a conversation like this could result in collaboration: while a GIS professional teaches your students some mapping how-to, you teach their geography students how to apply mapping skills to interesting social issues.

Adventures with GIS stirred the primordial soup of my teaching. Evolution continues as I learn from mistakes, build on successes, and celebrate the rebirth of excitement in the classroom. As students—once disconnected and frustrated—enthusiastically embrace learning, they go deeper in their understanding of key concepts and also wider in the scope of social issues. They leave the course mastering the learning objectives I've always had in place, plus gain one more: the power of translating the story to a larger audience through spatial narrative. The evidence thus far is encouraging, but perhaps not convincing on its own. Formal research on these improved learning outcomes is necessary. A scholarly investigation would require the cooperation and support of institutional review boards and students. In my view, it is essential to pursue these opportunities to make GIS more widely available across all disciplines. Strategic partnerships between the academic and professional worlds could reduce the costs of GIS as an input in the learning production process.While no single technology is going to guarantee a bumper crop of learning outcomes, this particular innovation has proven to be consistently fertile. And, though we may never be able to control all the variables involved in student learning, we can certainly control the tools we use to sow our seeds. Imagine the relative ease of outcomes assessment in a world where compar-

ative learning technologies are tested rigorously and adopted widely. I believe Geographic Information Systems can improve teaching, learning and the assessment of learning. Venti Latte, anyone? nea

ENDNOTES

1. There is a literature growing within the GIS community about the usefulness of GIS in the social sciences. See Sinton and Lund, "Understanding Place: GIS and Mapping Across the Curriculum," for example. However, the literature connecting GIS and its use in economics is quite sparse. Peterson 2000 discusses this lack while Walstad, et al., address technology in general.

2. The author gratefully acknowledges ESRI for its cooperation in making BAO accessible to two cohorts of MBA students during the fall of 2008. Many of the features and benefits of BAO discussed in this paper are now available at **www.communityanalyst.esri.com** and **www.ArcGISonline.com**

3. Check out **http://edcommunity.esri.com/blog**, for example.

4. The Seven Deadly Sins map has been featured several places in the mainstream media and may be found on Kansas State University's media archive at: **www.lasvegassun.com/news/2009/mar/26/one-nation-seven-sins/**

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