

GIS in the Undergraduate Curriculum: Embraced or Ignored?

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Abstract

While a wide range of disciplines has embraced spatial analysis, the majority of those employed in GIS positions have been trained in geography departments or have completed specialized GIS certificates. To what extent, then, is GIS being incorporated into other academic disciplines? This paper will provide results of a major survey of GIS teaching across the undergraduate disciplines. For faculty who are incorporating GIS, the survey explores how it is included in the curriculum and what kinds of problems GIS is being used to solve. For faculty who are not using GIS, the survey explores what they thought the future role of GIS might be in the curriculum and any impediments to including GIS. While earlier studies have examined the teaching of GIS, we believe this is the first to explore not only current usage, but also reasons why GIS is not being included in some curricula.

Introduction

The analysis of geographic data has gained substantial acceptance across a wide spectrum of disciplines – including marketing, health science, environmental science and criminal justice among many other areas. Companies using GIS are nationally recognized firms such as Sears, Staples, Office Max, Best Buy and Chase Manhattan. Among government agencies GIS is embraced by the U.S. military, the Department of Health and the Department of Justice. Much has been written about the flood of spatial data available for analysis. According to Dr. Duane Marble (2006), the growth in the use of GIS tools is “explosive in every sector of the global economy.” It takes little effort to identify many job opportunities that require some GIS skill – sites such as Monster.com and the GIS Jobs Clearinghouse (www.gjc.com) list hundreds of such career opportunities. The GeoSpatial sector is among 14 areas identified by the Department of Labor as ‘high growth job areas’ (U.S. Dept Labor, 2004).

Along with the establishment of GIS as a legitimate tool in so many industries, one would expect a concomitant level of activity in the academic world. Students in geography departments are being provided opportunities to explore GIS in-depth. However, are students in criminal justice, marketing, public health, political science and environmental science being exposed to spatial analysis – are they being trained in the use of GIS software? This question has been addressed by a number of surveys in recent years. Fisher and Conrad (1998) examined the use of GIS among fisheries departments in 42 U.S. universities and found that an average of 21-40% of faculty and students occasionally use GIS in their research and that students were getting their GIS training in earth science or natural resource departments. A survey by Essa, Li and Shi (1998) of civil engineering departments in Canada found that faculty incorporated GIS into their classes via demonstrations and hands-on assignments. According to their survey, 53% of Canadian civil engineering departments reported having GIS courses or courses in which GIS concepts were included. Thirty percent of the respondents expected to include GIS

in a future curriculum. More recently, Tas (2003) examined GIS within geography departments, comparing GIS use against the institution's Carnegie classification. Not unexpected, he found greater GIS use among PhD granting institutions.

In addition to these focused surveys that probed the inclusion of GIS into the curricula of specific departments, there have been surveys examining GIS use across the curriculum. Among these studies, Morgan and Fleury (1993) identified a number of departments that were using GIS – but the focus was clearly on geography departments. Most notably missing among the disciplines identified as using GIS are marketing, public health and criminal justice. Given the time period of the early 90s, this is understandable – it has taken advances in the availability of data, more user-friendly software and more powerful computers to encourage various disciplines to explore the use of GIS. Morgan's research found that cost and training were impediments to GIS being included in the curriculum. Phoenix (2004) explored the inclusion of GIS in international schools.

THE STUDY

What is missing from this stream of research is a study that explores the use of GIS *across* the undergraduate curriculum. This paper begins this process by providing results from four academic disciplines – with a number of additional disciplines currently being surveyed. Results from these additional surveys will be reported shortly.

The present study details our findings from the marketing, environmental science, criminal justice and political science disciplines. In addition to identifying the level of GIS inclusion in each curriculum, we identify the kinds of problems GIS is being applied to, how GIS is being addressed in textbooks and what obstacles there are to its broader acceptance.

The above mentioned availability of both data and technology coupled with the growing use of GIS by corporations and governmental organizations suggests that universities may be falling behind. Thus, we need to understand where GIS is successfully being incorporated into the undergraduate curriculum as well as what the impediments are to the increased use of GIS.

METHODOLOGY

The Sample

Our study seeks to understand the use of GIS across the undergraduate curriculum, requiring a survey of a wide range of faculty, from those with significant GIS knowledge and expertise to those with no knowledge or experience. For this reason, we could not use GIS-oriented list serves for our sample frame and turned to a commercial list vendor that specializes in the education market.

Using a research grant from our school, Roger Williams University, we contracted with MDR, a list vendor, to send an email invitation to randomly selected faculty. Table 1 identifies the disciplines and the number of emails sent. The breadth of sub-disciplines in

both marketing and environmental science led us to increase our sample size in an attempt to capture the diversity of fields in these two disciplines.

Table 1. Emails sent by discipline

Discipline	Emails Sent
Marketing	3,979
Environmental Science	3,167
Criminal Justice	2,153
Political Science	2,500

The Questionnaire

We constructed a two-part survey that addresses issues common to every discipline as well as discipline-specific issues. All respondents were asked a series of questions about the “state of GIS” across the undergraduate curriculum. The survey also branched into a series of discipline-specific questions about the kinds of problems GIS is being applied to, as mentioned above. We elicited the assistance of faculty from environmental science, criminal justice and political science to help frame these discipline-specific survey questions. Dr. Micken provided questions for the marketing discipline. An example of a discipline specific question would be one that asks a marketing faculty about their use of segmentation data. Thus, criminal justice faculty were asked about using GIS to identify crime “hot spots” and political science faculty were asked about using GIS to identify voting patterns.

The survey was approved to the Roger Williams University Human Subjects Review Board; an appropriate consent form is presented on the first page of the survey.

Data Collection

The study was conducted via an online survey, using Qualtrix survey software which allows for sophisticated branching and skip patterns. Emails with a link to our online survey were sent to a random sample of faculty in each discipline in the spring of 2007. As already noted, other surveys are currently in the field.

RESULTS

Respondents

Of the nearly 12,000 emails sent, 965 surveys were completed by faculty from the four target disciplines. An additional 142 surveys were completed by faculty in other disciplines (they received the emails “in error” from the list vendor, but were willing to participate). Thus, 1,107 respondents completed surveys for a return rate of 9%. Table 2 provides the returns by discipline.

Table 2. Surveys completed by discipline.

Criminal Justice	Environmental Science	Marketing	Political Science
136	265	270	294

GIS Software Knowledge

When asked if faculty were familiar with GIS software, there were two surprises. One is the strong level of familiarity with GIS by environmental science faculty – the other surprise is the low level of familiarity among marketing faculty (Table 3).

Table 3. Faculty ‘familiar’ with GIS software at some level (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
Yes	52	80	31	51
No	48	20	69	49

Those familiar with GIS software were asked to specify which GIS software they had some familiarity with (Table 4). As expected, faculty were familiar with the major GIS packages such as ArcGIS and MapInfo. Criminal Justice faculty mentioned CrimeStat and GeoDa. CrimeStat addresses specific needs of criminal justice faculty to perform crime analysis. GeoDa is a free software program from the Spatial Analysis Lab at the University of Illinois, Urbana-Champaign; it is designed for use by non-GIS specialists. Political Science faculty identified two additional packages, GeoVista and TerraSeer; GeoVista is an open source project of Penn State’s department of geography. TerraSeer’s strength is the ability to analyze space-time problems.

Table 4. Which GIS software are you familiar with? (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
ArcGIS	79	98	56	74
MapInfo	32	18	44	26
MapPoint	5	8	40	21
GeoMedia	2	3	12	4
CrimeStat	52			
GeoDa	10			14
GeoVista				9
TerraSeer				6

* Percents exceed 100 due to multiple responses

GIS in the Curriculum

Given that many faculty are familiar with GIS, we asked about the role of GIS in their curriculum (Table 5). Faculty from three of the four disciplines, criminal justice, environmental science, and political science, expressed a strong interest in GIS being covered at some level in their curricula. Marketing faculty, however, are not embracing GIS as a component in their curriculum. This finding is in keeping the low level of familiarity with GIS that marketing faculty reported (Table 3).

Table 5. Might GIS have a Role in your Curriculum? (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
Yes	84	87	56	66
No	14	13	44	34

The next logical step is to learn what role GIS could play in the curriculum. Would it be a stand-alone GIS course? In general, the answer is ‘NO’ for most disciplines (Table 6). Perhaps it isn’t surprising for environmental science faculty to show more interest in a stand-alone course, since many departments of natural resources and forestry have included GIS courses for a number of years. One interpretation that reconciles the responses to these two questions is that a GIS course could be taught in some other department, such as geography, and thereby satisfy the desire for incorporating GIS in the curriculum without needing to add to the course offerings.

Table 6. Would you want a stand-alone GIS course in your department? (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
Yes	24	51	4	12
No	76	49	96	88

Textbook coverage of GIS/mapping

One indicator that GIS is being discussed in the curriculum is its inclusion in textbooks. We asked faculty to provide feedback as to the level of GIS coverage in both the introductory texts and the ‘research methods’ texts in their field (Table 7 and Table 8). Given the widespread use of maps to analyze national elections it is somewhat surprising that political science texts provide little coverage of mapping. Only environmental science shows strong levels of mapping coverage – with some expanded mapping examples and, in several cases, entire chapters that present mapping.

One would expect expanded coverage of GIS/mapping in the research methods texts – once again, it is environmental science that appears to provide this material (Table 8).

Table 7. Do the Introductory Texts in your discipline discuss mapping? (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
No mention	13	31	29	75
Brief paragraph or two	41	33	31	9
Expanded mapping example	3	14	5	0
Chapter on mapping	0	6	1	0
Not certain	42	16	34	16

Table 8. Do the Research Methods Texts in your discipline mention mapping? (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
No mention	28	23	23	47
Brief paragraph or two	21	15	19	13
Expanded mapping example	6	15	8	2
Chapter on mapping	3	19	2	1
Not certain	43	27	48	37

Problems/Topics Addressed by GIS in the Classroom

As illustrated in Table 9, a wide variety of topics is being addressed by GIS, ranging from hot spot analysis of crime locations in a city to mapping vegetation patterns. While there is some overlap across disciplines, for example in the mapping of socio-demographic patterns, the predominant use is very discipline-specific.

Table 9. What kinds of problems do you use GIS to solve in the classroom? (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
Hot spot analysis	90			15
Voting/election/innovation patterns				58
Wars/terrorist events				25
Political/social/demographic trends	53			78
Location of parolees	26			
Location of sex offenders	44			
Lifestyle segmentation *			92	
Trading area analysis *			34	
Sales force territory assignments *			15	
Real estate site selection/mkt analysis *			23	
Spatial analysis of soil samples/animal sightings/vegetation patterns		81		
Spatial analysis of data gathered via remote sensing		51		
Other	13		6	24
* Percents exceed 100 due to multiple responses				

Impediments to GIS in the Undergraduate Curriculum

Since, except for environmental science faculty, respondents overwhelmingly said that there was no room for a GIS course in their department, we wanted to learn what the reasons for that belief were (Table 10). Concern about additional required or elective courses was a common response across all four disciplines, as was the lack of faculty

preparation to teach GIS. A final theme seemed to be that GIS was more appropriate for graduate than undergraduate students.

Table 10. Why GIS Is Not Taught in your Major/Department (percent)

	Criminal Justice	Environmental Science	Marketing	Political Science
Not relevant to my discipline	3	21	5	7
More appropriate for grad students	14	6	6	11
Faculty not familiar w/ GIS concepts	11	13	15	23
Faculty not familiar w/ GIS SW	14	17	17	24
No room for more required courses	20	21	18	15
No room for more electives	14	10	16	6
Few jobs for new college grads	6	4	7	4
HW & SW too expensive	14	6	10	6
Data too hard to find	0	0	1	1
Data too expensive	3	2	5	3
* Percents exceed 100 due to multiple responses				

DISCUSSION

The results presented here demonstrate that for three of the four disciplines, faculty are interested to incorporate GIS topics into the undergraduate curriculum. So why is that not happening? The problem seems to be two pronged: the cost of setting up GIS labs and the preparation of faculty to teach the courses. An additional issue is the paucity of GIS material in textbooks across disciplines. Perhaps this is a chicken-or-the-egg type of problem, in that textbook publishers are reluctant to include discussion of GIS until schools have the requisite technology and schools may be waiting on the development of GIS labs (or the purchase of GIS software) until more texts address the topic.

Comments on the surveys also reveal that across almost all disciplines, departments that do incorporate GIS seem to have a “GIS champion” on the faculty. To the extent that this person is successful in garnering resources and is willing to take on extra work, GIS offerings for students become available. Once that person either tires of the effort or moves to another institution, however, the GIS offerings seem to disappear.

Faculty preparation also is an issue addressed in the comments. Younger faculty seem to be the ones who get the GIS training in their degree programs. But tenure requirements seem to preclude them from the efforts necessary to start a GIS program. Thus, it would seem that the penetration of GIS will require efforts on the part of administrators and software publishers to offer incentives and courses to other faculty to take on this work.

REFERENCES

- Essa, Said M., Songnian Li, and Yaoyu Shi (1998), "GIS Technology for Civil Engineering Education," *Journal of Professional Issues in Engineering Education and Practice*, Vol. 124 (2), 40-47.
- Fisher, William L. and Conrad S. Toepfer (1998), "Recent Trends in Geographic Information Systems Education and Fisheries Research Applications at U.S. Universities," *Fisheries*, Vol. 23, 10-13.
- Harder, Christian (1997). *ArcVIEW GIS Means Business*. ESRI Press.
- Marble, Duane F. (2006), "Defining the Components of the Geospatial Workforce—Who Are We?" <http://www.esri.com/news/arcnews/winter0506articles/defining1of2.html>, accessed on February 27, 2006.
- Morgan, J. M., III and B. B. Fleury (1993), "Academic GIS Education: Assessing the State of the Art," *Geo Info Systems*, Vol. 3, 33-40.
- Phoenix, Michael (2004), "GIS Education: A Global Summary," Fourth European GIS Education Seminar.
- Tas, Halil I. (2003), Status of GIS Education at 4-year Colleges and Universities in the United States, unpublished dissertation, Oklahoma State University.
- U.S. Department of Labor, Education and Training Administration (2004), The President's High Growth Job Training Initiative, from the Web: <http://www.doleta.gov/BRG/JobTrainInitiative/>, accessed October 11, 2006

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