Academic Geographic Information Systems Education: A Commentary

John M. Morgan, III
Department of Geography and Environmental Planning, Towson State University, Baltimore, MD 21204

INTRODUCTION

At the 1987 Annual Convention of the American Society for Photogrammetry and Remote Sensing and the American Congress on Surveying and Mapping held in Baltimore, Jack Dangermond (Environmental Systems Research Institute) remarked that his ability to market ARC/INFO is affected by a lack of individuals who are trained in the use of geographic information systems. The dramatic increase in the development and use of geographic information systems (GIS) has, without question, created a need for more people who are familiar with the collection, storage, analysis, and display of spatial data. The need is manifesting itself in several ways. The job descriptions of an increasing number of positions in government agencies and businesses are being rewritten to require employees to use a GIS. In addition, the increasing availability of a variety of digital map products requires that employees who use these maps understand how the maps were prepared if the maps are to be properly used. In all likelihood, this need will continue for some time into the future. As Bob Aangeenbrug (Executive Director, Association of American Geographers) noted in a May, 1987, letter to the Chairs of Geography Departments (Aangeenbrug, personal communication, 1987):

> "The emergence of geographic information systems as a component of our discipline provides a challenge and an opportunity. This is not a passing phenomenon, but a sign of the times. The capacity to gather information has eclipsed our capacity to evaluate the information. Geographers are expected to contribute in using the modern tools of GIS to evaluate the various spatial relationships of our resources on an ever crowded Earth."

In December, 1985, the author presented a paper on academic GIS education at the Geographic Information Systems in Government workshop in Springfield, Virginia (Morgan, 1986). The paper noted that the majority of those individuals who presently use GIS apparently received their education by means of either on-the-job training or vendor workshops. The paper also indentified and discussed the following questions regarding GIS education:

1. To what extent should both the theoretical and practical aspects of spatial data handling be included in academic courses on GIS?
2. Is the content of existing academic GIS courses appropriate to employer needs?
3. What types of GIS (hardware and software) are suitable for student use, affordable to academic departments, and yet representative of the state-of-the-art?
4. What types of reference materials on GIS are available for student, instructor, and library use?
5. What internship and job opportunities exist for students who have completed an academic GIS course as part of their undergraduate or graduate degree program?

The paper concluded that the only way these questions can be answered is by means of a survey of academic departments currently offering GIS courses, and a survey of government agencies and businesses currently using GIS.

GIS EDUCATION SURVEY

A survey of academic departments was conducted by the author during the period from June to August, 1986. The survey was designed to answer the following questions regarding academic GIS education:

1. What is the content of academic GIS courses?
2. Do GIS courses have prerequisites? If so, what courses are required?
3. What types of hardware and software are students being trained to use?
4. What textbooks and other course materials are being used?

The survey was sent to 409 geography departments and 46 landscape architecture departments in the United States and Canada. Although it is known that GIS courses are also offered by forestry, agronomy, wildlife biology, recreation, urban planning, and other departments, no attempt was made to survey these departments. It was assumed that there was a greater likelihood of geography and landscape architecture departments offering GIS courses than other academic departments.

A total of 233 departments (51.2 percent) responded to the survey. Of those geography and landscape architecture departments that responded, 127 (54.5 percent) currently offer a GIS course. The lack of staff and resources, rather than a lack of interest, was cited by the majority of the 116 departments that are not currently offering a GIS course.

Analysis of the survey data supports several conclusions regarding the nature of GIS education. These conclusions are discussed in the following sections.

Academic GIS Course Content

The content of academic GIS courses varies widely. From an educational perspective, the term "geographic information system" is apparently an omnibus term which incorporates the several types of GIS indentified by Dangermond (1983). These include: engineering mapping systems, property information systems, thematic mapping systems, bibliographic systems, geographic base file systems, and image processing systems. Nearly all of the GIS courses indentified in the survey are offered on a regular basis and include instruction in the theoretical and practical aspects of the collection, storage, analysis, and display of spatial data. Common aspects of course curricula include (1) the nature of geographic data (types and sources of analog and digital data); (2) geographic data collection (coordinate systems, cartographic data structures, and storage techniques); (3) geographic data analysis (polygon overlay, grid cell analysis, and digital terrain analysis); (4) geographic data display (cartographic and non-cartographic output formats); and (5) types and uses of GIS. A number of the courses are linked with other courses, notably computer-assisted mapping, remote sensing, and landscape architecture studios. Most courses require students to encode and digitize data and prepare maps using a GIS in a laboratory setting.

Academic GIS Course Prerequisites

The survey attempted to identify the extent to which GIS courses require prerequisites such as mathematics or computer programming courses, or courses in cartography, remote sensing, or landscape architecture. There appears to be no concensus among educators regarding prerequisites for GIS courses. The majority (approximately 75 percent) of the departments surveyed do not require either mathematics courses or remote sensing courses as prerequisites for a GIS course. Also, only one-half

Photogrammetric Engineering and Remote Sensing,
Vol. 53, No. 10, October 1987, pp. 1443–1445.

0099-1112/87/5310–1443$02.25/0

of the departments surveyed required either computer programming courses or cartography courses as prerequisites.

Hardware and Software Used in Academic GIS Courses

A variety of hardware and software are used in academic GIS courses. Mainframe and microcomputer environments are used for GIS courses more frequently than minicomputer environments. Nearly all departments offering GIS courses have plotters and digitizers for student input and output of spatial data. The GIS software used most frequently is Dana Tomlin's (Harvard University) Map Analysis Package (MAP). (Tomlin, 1983). Although state-of-the-art software like ARC/INFO (Environmental Systems Research Institute) is used for several GIS courses, apparently only a few departments can afford the software for mainframe and minicomputer environments. Furthermore, a one-semester course may not provide a sufficient amount of time to instruct a student in the use of software like ARC/INFO, as well as to discuss the theoretical and practical aspects of spatial data handling.

The use of MAP by academic departments should come as no surprise. Available from Yale University School of Forestry and Environmental Studies, MAP (1) is very inexpensive; (2) has been adapted for use on a variety of mainframe and minicomputer environments by several hundred colleges and universities; (3) is easy for students to learn how to use because of its English-like command structure for interactive map storage, analysis, and display; and (4) is supplemented by a package of academic materials for both instructor and student use (student workbook, instructor notes, sample data base, and exercises and solutions). In addition to the use of MAP, the growing availability of low cost microcomputer software for IBM PCs and compatibles, such as aMAP (Yale University), pcARC/INFO (Environmental Systems Research Institute), ERDAS-PC (Earth Resources Data Analysis Systems), and AE-GIS (Aeronca Electronics, Inc.), was noted in the survey, and apparently is beginning to change the hardware and software used by geography and landscape architecture departments in GIS courses (Berry, 1986).

Textbooks and other Materials for Academic GIS Courses

Survey respondents noted the lack of textbooks and course materials to support GIS courses. While several departments use Carter (1984), MacDougall (1983), Marble and others (1984), and Monmonier (1982), most use GIS software documentation supplemented with selected articles and instructor handouts. Since the survey was conducted, textbooks by Burrough (1986) and Mutunayagam and Bahrami (1987) have been published. In addition, the American Society for Photogrammetry and Remote Sensing recently published a collection of papers on the use of GIS for resource management (Ripple, 1987). The author is aware of several departments that have adopted the new textbooks and the ASPRS book for use in their GIS courses.

Voluminous reference materials on GIS are available in the form of conference proceedings. These include the "Mapping Collection" of the Harvard Laboratory for Computer Graphics and Spatial Analysis (1979, 1981), the Auto-Carto symposia proceedings, the proceedings of the annual conferences of the Urban and Regional Information Systems Association, and the technical papers of the annual meetings of the American Society for Photogrammetry and Remote Sensing and American Congress on Surveying and Mapping. However, the "show-and-tell" nature of the papers on GIS presented at conferences are generally inappropriate for use in an introductory (undergraduate) GIS course.

CONCLUSIONS

The survey suggests that geography and landscape architecture departments are responding to the need for people who are trained in the use of a GIS. While the results of the survey point to progress in academic GIS education, the survey did not determine whether students who have taken GIS courses meet the needs of employers. It is known that the course content and prerequisites for the GIS courses offered by many of the departments surveyed would not be appropriate to the needs of at least one employer. According to Kalman and others (1985), the Defense Mapping Agency requires prior courses in differential and integral calculus, as well as knowledge of a high-level programming language (FORTRAN or Pascal), as prerequisites for its 15-week digital image processing program at Washington University (St. Louis). A dialog between educators and potential employers needs to be established as the development and use of GIS continues to increase.

The complete results of the 1986 survey have recently been published along with a directory of geography and landscape architecture departments currently offering GIS courses (Morgan, 1987). The survey results and directory provide employers with information on the location of geography and landscape architecture departments offering GIS courses that could be used for employee in-service training, or that could be sources of student interns and potential employees. The results of the survey also provide useful information to academic departments that are considering either offering a GIS course or expanding their GIS course offerings.[1]

Plans are underway to conduct another survey of academic departments in January, 1988. The 1988 survey will make a concerted effort to include other departments that offer GIS courses, in addition to geography and landscape architecture departments. Also, the survey will attempt: (1) to determine the extent to which departments are using microcomputer hardware and software in their GIS courses; (2) to identify departments offering short-courses and workshops on GIS; and (3) to document internships and job opportunities available to students who have completed a GIS course. Academic departments or employers who are interested in participating in the survey are encouraged to contact the author.

ACKNOWLEDGMENTS

The author wishes to thank William D. Gillespie and Ruth G. Sadler for their assistance in tabulating the survey results.

REFERENCES

Berry, J., 1986. A Microcomputer Package for Instruction in Computer-Assisted Map Analysis. *Proceedings of the Geographic Information Systems Workshop*, Atlanta, 1–4 April, p. 320–324.

Burrough, P. A., 1986. *Principles of Geographical Information Systems for Land Resources Assessment*, Monographs on Soil and Resources Survey No. 12, Oxford University Press, Oxford, England.

Carter, J. R., 1984. *Computer Mapping, Progress in the '80s*, Resource Publications in Geography, Association of American Geographers, Washington, D.C.

Dangermond, J., 1983. A Classification of Software Components Commonly Used in Geographic Information Systems, *Design and Implementation of Computer-Based Geographic Information Systems*, D. Peuquet and J. O'Callaghan (eds.), IGU Commission of Geographical Data Sensing and Processing, Amherst, New York.

Kalman, B. L., J. L. Posdamer, S. V. Pollack, A. F. Laine, and S. Reichenbach, 1985. Defense Mapping Goes to School, New Program Paves the Way for Automation, *Computer Graphics World*, December, p. 27–30.

Laboratory for Computer Graphics and Spatial Analysis, 1979. *Harvard Library of Computer Graphics, 1979 Mapping Collection*, Harvard University, Cambridge, Massachusetts.

[1]For information regarding the availability of the survey results and directory, contact the author in care of: Department of Geography and Environmental Planning, Towson State University, Linthicum Hall Room 30, Baltimore, Maryland 21204, (301) 321–2964 (Bitnet: E7G4MOR @ TOWSONVX).

———, 1981. *Harvard Library of Computer Graphics, 1981 Mapping Collection*, Harvard University, Cambridge, Massachusetts.

MacDougall, E. B., 1983. *Microcomputers in Landscape Architecture*,, Elsevier Science Publishing Co., Inc., New York, New York.

Marble, D. F., H. W. Calkins, and D. J. Peuquet, 1984. *Basic Readings in Geographic Information Systems*, SPAD Systems, Ltd., Williamsville, New York.

Monmonier, M. S., 1982. *Computer-Assisted Cartography, Principles and Prospects*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Morgan, J. M. III, 1986. Academic Geographic Information Systems Education: Addressing Unanswered Questions, *Geographic Information Systems in Government*, B. K. Optiz (ed.), Vol. 2, pp. 887–893, A. Deepak Publishing (Science and Technology Corporation), Hampton, Virginia, Vol. 2, p. 887–893.

———, 1987. *Academic Geographic Information Systems Education: A Directory and Resource Guide*, The Morgan Group, Inc., Baltimore, Maryland.

Mutunayagam, N. B., and A. Bahrami, 1987. *Cartography and Site Analysis With Microcomputers, A Programming Guide for Physical Planning, Urban Design, and Landscape Architecture*, Van Nostrand Reinhold Company, New York, New York.

Ripple, W. J., ed., 1987. *Geographic Information Systems for Resource Management: A Compendium*, American Society for Photogrammetry and Remote Sensing and American Congress on Surveying and Mapping, Falls Church, Virginia.

Tomlin, C. D., 1983. *Digital Cartographic Modeling Techniques in Environmental Planning*, Unpublished Doctoral Dissertation, Yale University School of Forestry and Environmental Studies, New Haven, Connecticut.