A GIS PERSPECTIVE

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Introduction

I was asked to provide a GIS perspective on the issues being addressed at this conference. As an American, I will also try to provide a U.S. perspective, although I can't claim to speak either for GIS or for the U.S. Two comments are in order at this point. First, «geomatics» is not a common term in the U.S., and there is confusion about how to translate it. Recently, the University of Maine Department of Surveying Engineering, one of the members of the National Center for Geographic Information and Analysis (NCGIA) consortium, changed its name to the Department of Spatial Information Science and Engineering rather than Geomatics. Second, as a geographer I am a member of one of the «other» disciplines in David Coleman's excellent white paper draft. When I refer to «we» it is likely to be to geographers, or the GIS community, and whether the comments I make apply to geomatics I must leave largely to the reader.

I would like to make four major points, and this paper is organized into four major sections accordingly. The first deals with external forces affecting the world of GIS education, and the options available in responding to them. The second deals with changes occurring in GIS technology. The third addresses changes that I perceive to be occurring in the field of GIS research, and their implications for education. Finally, the fourth section proposes that in the long term the field of geographic information will be much larger than we have perceived to date, and that appropriate responses will be necessary as we educate for the future.

1. External forces

The white paper comments at length on society's changing notion of a career, and the introduction of a high degree of uncertainty into job prospects. A student in our programs can no longer hope to prepare for a long career in one agency or corporation, rising steadily through the ranks. This forces us to address a fundamental question - are we preparing students for their first entry into the labor market, where they will be lucky to spend the first decade of their careers, or giving them a foundation for their entire working life, which will last perhaps for four decades. The first suggests an emphasis on competitiveness, and probably on immediate skills - training rather than education, or «appliance» rather than «science».

The responsibility of the education community seems quite clear in this case - that society expects us (by «us» in this case I mean the university community in particular) to educate people for life, not for short-term skills. We must identify the lasting principles behind technology, so that graduates can move smoothly from today's technology to tomorrow's.

Other kinds of external forces are producing what seems to be an ever-increasing speed of technological change. Again, in these circumstances it makes no sense to train in today's technology - instead, we must identify its underlying principles, the fundamentals that must remain true in the long term.

Information technology is increasingly complex, and it is impossible for anyone to approach it from first principles. The days when a statistics professor could demand that his students perform all calculations by hand, so that they understood every aspect of the process before being allowed to use calculators and computers, are long gone. Equally, few scientists are able to sustain the traditional principle of scientific reporting that all experiments be reported in sufficient detail to allow the reader to replicate them exactly - too often, we simply do not know exactly what is going on inside the «black boxes» of our information technology.

Instead, we must educate our students to be critical users of technology. We should encourage them to be suspicious and skeptical about results, and develop ways of checking results, however crudely, so that errors become obvious. Our students should be critics of documentation, demanding the details of calculations. We should establish a tradition of critical reviews of commercial software, and encourage our students in it.

In the early days of computing, economies of scale demanded that universities provide computing facilities centrally. As costs have declined, so computing has become more dispersed, so that today many students are able to afford better computing facilities at home than the institution is willing to provide for them in its laboratories. I estimate that 50% of our undergraduate students now have at home computing hardware at least as powerful as the Pentiums and 486s in our undergraduate lab. Many have GIS software, and it is not uncommon for a student to ask to use a different - and possibly better - package, on a home computer, from the prescribed package in the lab. The traditional idea that the institution had to provide hardware and software in order to mount computer-based courses is eroding quickly.

It seems to me that this trend fits nicely with several others that are fashionable in education at this time. There is a trend away from teaching, as an authority-centered activity, towards student-centered learning. Similarly, there is a trend to group-based learning, and away from the individual. There is much interest in problem-solving as an educational paradigm, and in learning by discovery.

Taken together, all of these trends suggest a changing role for the educator, who is no longer the sole provider of technology and instruction, but instead something more akin to a facilitator of synthesis, helping the principles underlying the varied experiences of students to emerge through a variety of means that go well beyond the traditional lecture. At the same time, the institution becomes a mechanism for ensuring equity, by compensating for the uneven distribution of resources and access among its students.

Finally, the generation of students now entering university is the first to have had access to computing from an early age. Today's 18-year-old would have entered primary school just as the first round of PC's and Apples was beginning to enter the classroom. These students are computer-literate, with no fear of the WIMP interface, and with high expectations about the ease-of-use of software. They are intolerant of the command-line interfaces still found in many GIS's. Many are familiar with computer mapping, and see computers as tools, to be evaluated by what they make possible.

In the past, GIS education has occurred mostly at the upper-division level in universities. One might assume that this is because its concepts are understandable only by people in their early 20's. But one wonders whether it is not because the necessary computer technology was only available at this level. On closer examination, there seems little reason why the concepts of GIS should not be mastered by much younger students. Experience suggests that the concept of measuring latitude and longitude with a GPS receiver is quite understandable by a child of 10 or younger. It seems to me that the appropriate way to take advantage of the opportunity offered by increased computer literacy among our students is to move GIS

education down to earlier levels in the system, perhaps all the way to primary.

2. Changing technology of GIS

The previous section identified broader trends affecting GIS education. In this section, I focus on changes occurring in the technology itself, as GIS evolves continuously in response to changing market opportunities, new developments in technology, and new research.

Over the past decade, much of the benefit of faster processing has been realized in the form of more sophisticated user interfaces, that have made information technologies almost uniformly easier to use. In effect, these interfaces allow the user to interact at the level of the user's own conceptualization of a problem, instead of the level at which the designer chose to develop the command language. Dragging an icon from one location to another is a much closer imitation of the physical act of moving information than a command «copy». Today's word processors no longer force us to learn that f8 produces an underline - the appropriate icon is displayed unambiguously on the screen.

This trend toward less intrusive technology, and interaction at the level of conceptualization rather than implementation, is reflected in changes occurring in the GIS software industry. Today's software makes it possible to interact with curves rather than ordered sequences of points; areas rather than polygons; and continuous surfaces rather than the individual triangles of a TIN, or the sample points of a DEM. Interactions at the conceptual level are necessarily simpler, and as GIS software advances there is inevitably less to learn about it.

The concept of legacy reflects the tendency for concepts associated with an old technology to persist in the world of a new one. Concepts lag implementation, but they also provide familiar benchmarks and guideposts as we struggle to understand and make use of new technology. The classic example is the horseless carriage - the tendency for early generations of the automobile to be understood and described in the language of an earlier era. Today, of course, one would not think of describing a Honda by starting with a horse and carriage. But in GIS we are still in the earlier era - we still conceive of our GIS's as computerized collections of maps. This is helpful in many ways, but constraining in others. For example, paper maps had to be flat, because of the technologies associated with printing, distributing, and storing them. But the digital computer is not flat, and there is no obvious reason to flatten the world with projections in a digital era.

If we are to teach the lasting principles of GIS - principles that will still be valid 30 or even 40 years from now - we need to think beyond the legacy of older technologies - to think «outside the box» that is constrained by old ways of doing things. We need to anticipate how relevant the principles of the world of paper maps will be in the future, and what underlying principles will still be valid.

3. A changing field of geographic information

Both of the previous sections pointed in the direction of lasting principles as the foundation for education, so in this section it seems appropriate to attempt to identify them, or at least to make a stab in that direction. In June 1996 the University Consortium for Geographic Information Science, a consortium that now includes 34 universities, organizations, and national research laboratories with strong multidisciplinary programs in GIS research, held a conference to develop a research agenda. Although not ideal, the results do offer some guidance as to the nature of the lasting principles.

The UCGIS identified ten topics, each of which has been developed into a 5-page white paper. The set of papers is available on the UCGIS web site (http://www.ucgis.org), and a summary paper (also on the web site) will be appearing in a 1997 issue of the journal *Cartography and GIS*. The ten topics are as follows:

- Data acquisition and integration
- Distributed computing
- Interoperability
- Scale
- Spatial analysis
- Cognition
- Representation
- Uncertainty
- The future spatial data infrastructure
- GIS and society

The titles by themselves may not be very helpful, so the interested reader is invited to examine them in more detail via the web site.

In GIS, and in related fields concerned with geographic information, one often encounters the question «What is special about spatial ?» - in other words, is there something sufficiently special about geographic data that justifies its apparent isolation ? Conversely, do all forms of geographic data have enough in common to warrant studying them collectively ? If geographic data is defined as data referenced to the Earth's surface, does the presence of that reference alone justify special treatment for the data ?

These issues have become more complex recently, as we have come to recognize the existence of another information type, which I will call «geographically referenced». A data set is geographically referenced if the data set as a whole has a geographic footprint, whether its contents are strictly geographic or not. Clearly any geographic data set is geographically referenced, but so too are many reports, photographs, pieces of music, books - in fact, information of any type and in any medium can have this property. The significance of a geographic reference becomes apparent when one thinks of the problems of finding information on the web, or even in a conventional library. Today's web search engines are limited to text, since they work on the basis of key words. But geographic footprints open the possibility of answers to queries like «What information is available about this place ?» One can even go so far as to envision a digital «geolibrary», in which geographic footprints provide the primary search mechanism. If such a digital library could be built, what kinds of information would one choose to put in it, and who might use it ?

4. Education for a world of geodata

Our existing education programs and institutional arrangements are predicated on the assumption that geographic is the exception in data, rather than the rule. Although we have ample evidence of the preponderance of geographic data in local government, and in other areas such as resource management, there are abundant reasons why geographic data has been difficult and expensive to assemble, digitize, store, process, and use. But today's technology

makes geographic data much less problematic, and there is every reason to believe that this trend will continue. Moreover, the previous section suggested that the existence of a geographic footprint may have advantages even for non-geographic data. Finally, trends in society generally suggest that in the future the local and unique will be increasingly important.

Given these points, it seems worth thinking, if only for the purpose of discussion, of a future world in which geographic is the norm rather than the exception - a world in which virtually all information is georeferenced. This suggests that the future of GIS education lies in two directions rather than one - the general as well as the special. We need to ask what everyone will need to know, as well as what future specialists will need to know. In future, GIS may be part of general education programs, and part of every educated citizen's experience and skill set. To return to a point made earlier, we may find GIS being introduced at very early stages in the education system. What if, for example, the process of scientific measurement were introduced through latitude and GPS, rather than through temperature and the thermometer ?

As for specialist education, the trend today seems to be one of convergence between the various technical disciplines of geographic information - geomatics, GIS, photogrammetry, geography, geographic information science, geodesy, surveying, digital cartography, remote sensing. Although each may carry a distinct flavor and its own traditions, there seems less and less justification for distinguishing between them in a digital era. Educational institutions are inherently conservative, and it is not easy to think «outside the box», but meetings like the Atlantic Institute series can help immeasurably in bringing the various parts of the geoinformation consortium together, to address the difficult questions about the future of education and point us in the right directions.