BREADTH VERSUS DEPTH:
THE DILEMMA OF G.I.S. EDUCATION.

Christopher M. Gold
Department of Geography
Memorial University of Newfoundland
St. John's
Newfoundland A1B 3X9
BITNET: CGOLD@HUN

ABSTRACT

Space is a common concept: widely used in everyday life. No particular discipline has a monopoly on its use. The same is true to a lesser extent for computers. The combination causes problems. Universities and professions thrive on dividing knowledge into compartments, which then need to co-operate in regions of overlap. The maximum confusion can be created where the subject is of wide interest but little understood. G.I.S. has breadth because many groups have an interest in its use. Thus applications for the available computer techniques expand rapidly. G.I.S. has depth because the techniques available are primitive, expensive and need extensive development of both implementation and theory. Thus detailed knowledge of the techniques is required to prevent over-enthusiasm and mis-use. Combine these two and educational institutions must mass-produce "Renaissance Men" or take the consequences. They are - and not liking them.

The cost-of-entry into G.I.S. education is expensive, in two aspects. Firstly the capital costs of "real" G.I.S. systems are high. Secondly the influence of the marketplace is debilitating - students, faculty and ideas are gone to more expensive pastures without a backward look. The choice of depth or breadth becomes even more critical. Ideally both should be provided, but this requires co-operation between different specialities, and a curriculum requiring case-histories, computer science and cash. Not infrequently neither are provided, merely the half-hearted use of a miscellaneous selection of poorly-understood, poorly developed and cheap canned packages that happen to be available.

What is the moral? If interdisciplinary co-operation and resources are not available, concentrate on good case-histories, involvement. If computer software development is your thing, concentrate on that. For the long term, we are in trouble if we can not entice, and keep, those who will be needed to teach depth, or breadth, in the future.
INTRODUCTION

The motivation for a session such as this is not hard to find: there is a demand for GIS trainees that is not easily being satisfied. Several sessions or workshops have been held in the last few years on similar topics, but the problem has not yet been resolved. This paper will give a highly personal overview of the current state of concern.

At the CCA/OICC joint conference in Toronto in 1988 I organized a session on "What does Government/Industry want?". Two basic needs were expressed: for "engineers" to make systems work and for "applications specialists" to make them do useful things. A third category should be added - "academics", to both teach (future employees, as well as future teachers) and to have research ideas as to where the field should be going.

The session was organized as a follow-up to the Canadian National Report to the ICA on Cartographic Education, (Gold, 1987), based on a questionnaire the previous year. In this we found that the demand for "Cartography" was steady at best for traditional methods but expanding dramatically when computer applications (automated cartography or GIS) were included. With few exceptions the cry was that anyone with a plausible claim to any knowledge in these fields were being snapped up, students sensing a good thing wanted to get into whatever courses were offered, and there was not the manpower, expertise or equipment to do the job.

WANTED: ACADEMICS

This paper will then discuss these categories of GISers, and attempt to determine appropriate education strategies.

Because of the demand from below, it is becoming more and more apparent that the most critical category of all is the "academics". Without them there is no teaching, at least in the university pattern. The brutal truth is: they cannot satisfy the need imposed by society - if society needs these skills taught, then society must provide the resources to achieve its requirements. This is not happening now. Academics (but not necessarily each individual) must fulfill the needs for research, for in-depth programming experience, and for broad applications experience.

In order to perform research, the academic must be able to function as a useful contributor to the discipline. This is getting more difficult, as the commercial pressure is entirely to extract whatever ideas are put into the public forum, with little contribution of ideas or resources to permit the free development of new concepts. (It is true that tied research programs are on the increase, but these can have strong repercussions on the university responsibilities of the individual academic.) Government, at this time, in Canada, is not sufficiently sure of the directions required to provide strong leadership, but hopefully this will change. In addition, it must be admitted, many academics do not realize that the days of purely individual research are over, and that team-work is required to contribute meaningfully to the field. This is better understood in engineering than in the arts and sciences.

Other pressures exist: please note that the academic GIS "expert" is a rare species, especially in Canada, and due to low resources may well be tempted to leave either the university or the country: it is very hard to refuse an opportunity that provides facilities that are not mere
dreams in a university context. At the research level these academics are few; at the teaching level there may be more, but they are not necessarily very experienced in the field. One of the more pathetic sights is the job advertisement for an assistant professor, entry level, Ph.D. preferred, capable of teaching GIS, remote sensing and regional studies or equivalent. If such a candidate exists (with a private income) it is certain that he will be the only such person in the department, will be teaching introductory courses and will, at best, have experience of use of an existing system rather than program development.

BREADTH VS. DEPTH

Which brings us to the next point. It is clear that a scenario of this type will only be capable of training students in the use of GIS systems in support of regional studies, planning, etc. Note however that this fits our model of an "applications specialist" in general terms - but without the knowledge of the nuts and bolts. Does this last point matter? I personally believe it does - recent history is replete with examples of techniques (especially computer ones) that were massively oversold and *misused*, primarily because the user was encouraged to consume rather than to understand. Contouring techniques and multivariate statistics come to mind as examples. It still seems desirable to include familiarity with basic algorithms and computer techniques (data-base, data structures, efficiency of operations) in order to reduce the grotesque misuse of this particular tool. To put it another way: the applications expert knows his data, but does he understand the appropriate GIS methods for his problem?

So much for the misuse of the tools; what about misuse of the data? Here the "applications specialist" should come into his own. The very purpose of his specialization is to understand what his data consists of, what its accuracy is, what procedures it is fit for, what problems need to be solved. Well-known applications areas include forestry, surveying, regional planning, transportation. Training inevitably includes an understanding of these issues; it should also include an understanding of the appropriate data manipulation techniques, whether network analysis or coordinate accuracy.

How about the "engineer" type? How should he be trained? There is an obvious advantage if his experience comes from an "engineering" discipline: the most obvious possibilities are computing science and surveying engineering. The basic mathematical and computing skills will thus readily be addressed. It is perhaps ungrateful to mention that computing science has, in general, shown no excitement about being dragged onto this new bandwagon. Nevertheless, maths, computing and spatial data handling skills are readily available in this environment. The weakness lies in the frequent absence of experience with defining and solving particular real-world problems with the tools developed. (This is less true of surveying, where cadastral data is well understood, but where regional economic analysis would be somewhat out of context.) Here again, we see the breakdown into knowledge of tools but not necessarily knowledge of the specialized data - depth, but not necessarily breadth.

Out of this discussion emerges the idea that "GIS education" is not just one goal but several - applications expert, engineer, training of future academics - involving university and college students and those already in industry or government. How do the existing education opportunities fit the bill?
GIS PROGRAMS - STRENGTHS AND WEAKNESSES

The College style program appears to have a well defined objective, and can meet those needs given the equipment and staff/student ratio. These resources are sometimes available from government/industry as the payoff (employees for vacant jobs) is obvious. The short-term intensive nature is good for providing value-added skills to students with some pre-existing applications experience. The skills tend to be of the technical/engineering type, as sufficient of these can be conveyed once a background of "what do I want to do this for?" has been obtained.

The Graduate Degree program (in applications) is very similar to the College program in emphasis, except that the equipment resources are less readily available. Course and practical requirements are less likely to be provided by a picked suite of instructors, but instead on the more eclectic basis of what pre-existing courses in other departments are available, and what the thesis supervisor's interests and skills are. Given the university desire for some level of originality, there is less interest in experience with commercial systems for their own sake, and more emphasis on "find out for yourself how to use it, and then come back to talk about your thesis area". Thus the emphasis is more on the application, and the system is merely a tool. Consequently the resulting training takes longer and covers less of the "commercial" GIS skills. This is a "data-driven" program, in a discipline such as geography, geology or forestry.

The Graduate Degree program (in "engineering") concentrates on the tools more than the applications, and assumes previous experience in the mathematical and computing skills. This is an appropriate environment for system and algorithm development. Limiting factors are the possible lack of an overview of a wide range of spatial problems and applications. The environments where this program is appropriate include surveying engineering and computing science. Surveyors, due to their strong interest in spatial coordinates, are currently very active at this level. Computing science, although the natural source for much system development expertise, has not perceived the importance of spatial data processes for GIS - with a few honourable exceptions.

The Undergraduate Degree program, in various disciplines, causes more problems. The biggest uncertainty concerns whether the course emphasis is on the data (applications speciality) or on the tools (engineering). In addition, a specialization in GIS has appeared premature in some experiments, as the student has little knowledge of his interests or of the potential applications until the senior years. This gives little time to give skills both in the applications field and in the understanding of the tools, especially in the normal university context of a larger emphasis on the lecture-and-reading format than the hands-on-laboratory format. Thus there are intrinsic difficulties with the accessibility of hands-on software and hardware for the first or second year students (hence the success of the elementary "MAP" package), even if a graphics laboratory is available. The problem is one of "when to specialize?", and affects some disciplines more than others. Thus students entering a well-defined program, such as surveying engineering or the Applied Geography program at Ryerson may be able to proceed further due to the intrinsic specialization. This may in part explain the difficulty encountered in emphasizing GIS within a general Geography degree, since the wide general education deemed desirable leaves little time for the development of the specific skills required for GIS training suitable for government or industry employment.
Thus the "GIS education" problem appears really to be a "GIS in geography" problem. College-based programs, where available, seem to meet the market needs very well. Graduate programs in an applications discipline appear valuable where deep thinking about the fundamentals of the problem and the tools required is essential. Undergraduate and graduate programs in the "engineering" disciplines appear to work well, although a greater interest by computing science would be beneficial. Undergraduate programs in specific application disciplines, if present, will usually be limited to one course. This leaves geography. In principle it should be the ideal place for the study of a wide range of spatial applications, and it has a long history of development of spatial concepts and methods. In practice, the wide range of faculty interests is becoming a handicap in this era when cooperative teamwork is necessary for significant systems research. Indeed, the assumption by an outsider that geography was concerned fundamentally with spatial data would not be accepted by a significant proportion of faculty. Hence the development of a geography program built on the foundation of an early introduction to spatial data types, properties and processes, as suggested by (Goodchild, 1985) has not yet found much favour, although (Ranting, 1987) describes such a program. In the Canadian context GIS is often uncomfortably positioned within the curriculum. For a variety of reasons this appears not to be the situation in either the U.S. or the U.K. Thus either geography will become a minor player in the field - which would be a pity because it has both the wide availability and the interests to disseminate the basic concepts widely - or else some revision of the role of spatial processing in general in the geography curriculum must take hold. Firstly however we must obtain a clearer picture of what constitutes a core curriculum in spatial data management.  

SPATIAL DATA - A CORE CURRICULUM

Over all of this discussion there hangs a question about GIS techniques in general: are they unique to the trade, or are they merely a particular collection of skills from existing disciplines? For individual applications a particular set of tools, both computational and logical, can be taught: the issue here is to see the individual application as one part of a whole, with some techniques common to several areas of specialization. As an example, network analysis should be taught in transportation geography, but it is of use in other fields as well. In addition, if the overall goal is to use and understand modern tools, there is a requirement to see the understanding of this tool as a part of the comprehension of the whole of spatial data processing, or GIS, and fit it into this framework as it is taught.

The engineering side also has its selection of available skills. Computing science can offer programming, network analysis, data structures, data base management, computer graphics, Mathematics can offer conventional statistics, linear algebra (an important one, this), graph theory, computational geometry. Geography might offer cartography and map transformations. What then is left?

The unresolved issues both involve integration. First, the integration of individual applications-specific or computer-specific knowledge into a complete systems approach - GIS. Second, the integration of the ideas about spatial data and data processing into a coherent whole. This would permit judgement between raster and vector modes for a particular
problem, about logical overlay of superimposed data coverages to provide solutions to questions, about point versus area sampling, interpolation versus polygon data, coordinate versus topological information, graph-theoretic versus geometric techniques, Voronoi adjacency and dual graphs - and many more.

Any program desiring to add the GIS label may mix and match available applications and engineering style courses, as described above. Who, however, will provide the integration required to form a coherent whole from the disparate parts (or, to be honest, to create that coherent whole that we think may be there)? I believe we are getting closer to achieving this, but the tools, the expertise and the vision do not yet exist within any available organization.

ACKNOWLEDGEMENTS

The Author would like to thank Dr. Douglas Banting of the Applied Geography Program of Ryerson Polytechnic Institute for several valuable and enjoyable discussions about the ways, means and objectives of GIS education.

The funding for this work was provided in part by an operating grant from the Natural Sciences and Engineering Research Council of Canada, and in part from the Energy, Mines and Resources Canada Research Agreement Program.

REFERENCES

