THE CHALLENGE TO EDUCATIONAL ESTABLISHMENTS: PREPARING STUDENTS FOR A FUTURE IN LIS/GIS

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ABSTRACT

Basic considerations arise from the requirements for education and training in spatial information systems. They are the implications of the terminology; the levels and categories of staff needed and the educational preparation desired; aspects of the educational challenge; and the importance of defining objectives in such teachng. Several conclusions resulted from ITC's evaluation of the needs for educational programmes in land information systems. The perception of need for such systems is expanding rapidly, and personnel qualified to manage their design, implementation, operation and maintenance will be in critical demand. There will be a variety of disciplines for which the educational programme must cater, and heterogeneous backgrounds will be encountered. Although a single course will not suffice for this one functional level of personnel, a common structure based on the concepts of systems engineering will be an advantage. An outline is given of the curriculum for the first specialisation, and the essential differences between it and the other two specialisations are noted. The paper concludes with points for discussion: the need to identify completed manpower forecasts, the value of a 'clearing house' for exchanging information on programmes and courses, ensuring there is full coverage of the educational needs, and developing an informal referral system for student applicants.

INTRODUCTION

Educational establishments are increasingly challenged by society, and by governments acting on its behalf, to provide programmes which are relevant to society's needs. One such need is for personnel able to function creatively, effectively and efficiently in the many land and geographic information systems which exist in, are undergoing development, or are proposed for, the public and private sectors. An assessment of the size and segmentation of the market for digital spatial data in the USA, including GIS applications, has been provided recently by McDermott (1984). Satisfying the personnel requirements of this and similar expanding markets, and overcoming the lag between the recognition of need and the initiation of appropriate programmes which often occurs in academia, is a major challenge. It is also a growth centre for the educational world, to which the small number of responses thus far range from three day "crash courses" as a function of continuing education to a four

year undergraduate baccalaureate degree programme. The purpose of this paper is to identify and consider matters which arise from the requirements for education and training in spatial information systems.

BASIC CONSIDERATIONS

Terminology and implications for education

The purpose of raising the subject of terminology is not to add to, discuss, or modify existing definitions of LIS and GIS; nor to argue whether one is a subset of the other. Recent contributions, including papers by Hamilton and Williamson (1984) and Marble (1984), will provide the semantic purist with ample material for consideration. Rather it is intended to recognise key aspects of the discussion and terminology which have implications for educators.

1. Spatially-referenced land-related information systems demand inter-disciplinary cooperation. The disciplines which should be represented will vary with the questions which a system should help answer in order to facilitate planning and decision-making.
2. Such systems should be strongly user orientated. This requires a thorough understanding by those who will design and manage the system of the political, legal, economic and social factors which may influence the development; and a commitment to investigating, understanding and responding to user requirements.
3. The land parcel is clearly the basis of some information systems, and the legal or fiscal attributes of the parcel are vital to specific parcel-based systems. Equally clear is that there are systems for which the parcel is not relevant, and for which other polygons or grid cells represent the basic element.
4. Procedures and techniques of data collection, structuring, manipulation, presentation, management and maintenance are central to spatially-referenced information systems, whether in manual, automated or hybrid forms; and sound knowledge of possible techniques which might be employed is important. The degree of importance will, however, depend upon the level at which the individual is expected to function.
5. Information systems will have consequences for staffing and funding, and these must be understood by those responsible for design and management.

Levels and categories of staff for which education and training is needed

The purposes, design and components of a specific information system will determine the level, categories and numbers of staff needed to ensure its proper functioning. Each solution will be unique, and the nomenclature and responsibilities of the personnel will be decided accordingly. Given the theme of this paper, however, an attempt will be made to identify appropriate levels of staff, suggest generic categories, and describe functions.

The levels of staff are A. Management; B. Technical Support; and C. Operation. The categories of staff, and their functions, are shown below.

Level	Category	Functions
A	System Manager	To assemble and analyse user needs, develop design concepts, oversee procurement and installation, manage the system, maintain contact with users, and define necessary changes to the system
A	Data Base Manager	To design data structures and formats, and to manage the creation, utilisation, maintenance and expansion of the data base(s)
B	System Analyst/Designer	To transform concepts into detailed system design, evaluate proposals, undertake benchmark tests, supervise installation, conduct problem analysis, and design changes to the system
B	Programmer	To programme utilities, algorithms and interfaces
B	System Engineer	To ensure the smooth running and maintenance of the components of the system
C	System Operator	To operate the individual components of the system for data collection, processing and presentation
C	Terminal Operator	To input high volume text data (where appropriate)

Education or training, and work experience, desired

For each category of staff which has been identified an outline will be given of the academic preparation and work experience considered desirable.

Category	Academic preparation	Work experience desired
System Manager	BSc or MSc in discipline appropriate to the type and functions of the system; and post-graduate course in LIS/GIS or image processing	In the discipline, and in the applications of computing within the discipline
Data Base Manager	BSc or MSc in appropriate discipline and post-graduate course in LIS/GIS; or MSc in Computing Science	In the discipline, and preferably with spatially-related data base

System Analyst/Designer	BSc, Computing Science	Analysis of user requirements and system design
Programmer	BSc, Computing Science (for senior level); post-secondary diploma in computing (for junior level)	Programming for spatially related data
System Engineer	BSc, Computing Science or Electrical Engineering	In computer installation, operation and maintenance
System Operator	BSc and/or diploma in land surveying, photogrammetry, cartography, remote sensing, or computing	In digital mapping, computer-assisted cartography, digital image processing or computing
Terminal Operator	Secondary schooling completed, and preferably diploma in computing	

Tentative conclusions on the educational challenge

A wide range of spatially-referenced, land-related information systems already exists at various stages of implementation and with differing degrees of sophistication. They serve the needs of legal and fiscal cadastres, utilities management, local authority and municipal planning and management, land use in its many manifestations, or combinations of interests. Others will surely follow, and continued attempts will be made to develop functioning linkages between systems and data bases. In the light of this situation, and the functional levels and categories of staff which have been recognised, the following tentative conclusions are reached on the challenge facing educators.

a) Management level

1. Knowledge of the appropriate user discipline, and a thorough grounding in the concepts and techniques of LIS/GIS, are equally important to system managers so that the relevance and proper functioning of an information system can be assured.
   There is, then, the question of whether a single course offering in LIS/GIS can deal adequately with the range of disciplines and applications which can be anticipated.
2. Managers of spatially-related data bases with a first or higher degree in Computing Science would be better prepared for an LIS/GIS environment if the curriculum in Computing Science permitted insights into the earth sciences, and perhaps carefully selected social sciences.
3. The role of Geography as an integrative discipline warrants careful consideration when education in LIS/GIS is under discussion.

b) Technical support level

The conclusion noted in 2. above could also be applied to the category of System Analyst/Designer.

c) Operational level

The curricula of those disciplines traditionally concerned with spatial data collection, processing and presentation should be reviewed to ensure proper emphasis is placed on the requirements and use of spatial information, and the appropriate methods of collecting data and converting it into the information needed.

Teaching in LIS/GIS

Educational theorists consider it highly desirable, if not essential, to define with precision and clarity a small number of objectives for each programme, course, and teaching unit; and to express the objectives as a graded series of practical and intellectual tasks. The subject matter of the programme, course or unit, and the choice of teaching method(s), should be such as to contribute to the fulfilment of one or more of the defined objectives. Whether such theory is applied in practice will depend largely upon the teacher's own knowledge and understanding of the processes of learning, and methods by which to achieve success. For prospective managers of land information systems, there is an interdependence of disciplinary interests and techniques of data collection, organisation, processing, storage, extraction and presentation. The former are reflected in the questions "why", "for whom", "what", and "when", and in other contextual factors. The latter consists of a wide variety of technologies, processes, and their applications. Reflecting this interdependence of interests and techniques, and achieving an appropriate balance between these two major components, are judged to be particular and difficult challenges to the designers of an educational programme in LIS/GIS which is intended for present or future management level personnel. Given this context it would seem that the carefully structured statement of objectives, and accompanying steps in curriculum planning, are highly desirable means to the end required.

LIS AT ITC

Photogrammetry was the founding discipline at the Institute. It was joined later by disciplines which utilised aerial photography for data collection and interpretation: Natural Resources (soils, forestry, rural surveys and integrated surveys), Earth Sciences (geomorphology, geology, geophysics and mineral exploitation), and Urban Surveys. Cartography and the Image Processing Laboratory were added in the 'Seventies. The majority of courses are offered to post-graduate and MSc students, though in three departments students may follow technologist or technician courses. In 1985 there were 389 students in residence. Post-graduate diplomas and MSc degrees were awarded to 230 and 31 students respectively. Several factors prompted an evaluation in 1984 of the needs for educational programmes in land information systems, and the following conclusions were reached.

1. The perception of need for such systems is expanding rapidly. This is in response to reports in the technical literature; conference discussion; the singular or combined efforts of consultants, software houses, and equipment manufacturers; and the interest of the World Bank in seeing improvements to land registration, property assessment, the collection of taxes upon land, and the upkeep of urban infrastructure.
2. There will be an early and critical need for personnel qualified to define and analyse the requirements for and functions of such systems, and to manage their design, inplementation, operation and maintenance. It was accepted that other levels and categories of staff will also be required. In the first instance, however, the need for managerial staff will be pressing. The planning group decided, therefore, that the initial focus should be upon an educational programme for actual or potential management level personnel possessing university degrees; and that the programme should have a strong user or demand orientation.
3. There are three main problem areas in which spatially-related land and geographic information plays a key role:
   a) A legal and/or a fiscal cadastre which can serve as the foundation for a multi-purpose cadastre
   b) Municipal information requirements for planning, decision-making and management
   c) Project, rural, regional or national development planning, decision-making, management and monitoring of change
4. The educational programme should attempt to cater to a range of professional interests in land information systems - representing the survey and earth sciences, natural resource disciplines, and urban and regional planning - and to respond to the needs of the problem areas identified above. As a consequence it could be expected that the programme would have to accommodate heterogeneous academic backgrounds and work experiences.
5. Given the considerations noted above, the extreme position of there being a single course dealing with the whole spectrum simultaneously would not be acceptable. It would of course be impossible to provide a tailor-made course for each participant. The compromise should consist of a small number of specialisations. In order to avoid unnecessary duplication in teaching, the curriculum should be planned in such a way that there would be elements common to the several specialisations.
6. The specialisations would require a common structure within which to operate, combining where appropriate and diverging where necessary to reflect the professional interests and problem areas of relevance to the students. The common structure should be founded upon the concepts of systems engineering, and take the following form:
   a) Defining the functional problem of the information user to be solved, and the processes on which a solution depends

b) Analysing the specific environment of the problem, and the conditions and constraints it imposes
c) Specifying the information needed for the solution of the problem
d) Defining the data required to derive the information needed
e) Examining and assessing the means of collecting, structuring, storing and processing data into the information required
f) Solving the functional problem

Planning proceeded with the intention of offering a one year post-graduate course in the first specialisation (or problem area), the Cadastre/Land Registration, to commence in October 1985. An outline of this specialisation is given in Table 1. Though the Institute has a firm base in disciplines concerned with data gathering, manipulation, analysis, presentation, and utilisation for problem solving, to realise the full scope of the first specialisation has necessitated cooperation with other institutions. The substantial contributions of colleagues from the Department of Geodesy, Technical University of Delft and The Netherlands Cadastral Office have demonstrated the importance of "networking" between institutions. Other specialists are also participating. Such "networking" may prove to be necessary for other educational institutions embarking upon a course or programme in LIS/GIS unless, of course, the variety of disciplines required are already represented in the individual institution. "Networking" does, however, demand careful coordination in course planning and execution, a lesson which has been learned by ITC and its collaborators. The first specialisation is underway at ITC with 10 students selected from 55 applicants. All ten have degree qualifications in surveying and previous work experience.

Planning is underway so that the other two specialisations may be offered in 1986, in Municipal Data Management Systems and Rural Data Management Systems respectively. Much of the content of subject groups 1-4 (inclusive), as outlined in Table 1, will differ substantially from that of the Cadastre/Land Registration specialisation; and will be offered by the three departments at ITC concerned with Natural Resources, Earth Sciences and Urban Surveys. The section on data gathering techniques (6.2 of Table 1) will be modified to reflect the relevance to the two specialisations of small-format aerial photography, air-photo interpretation, and remote sensing; and the reduced roles of land survey, photogrammetry and valuation. Common subjects will account for approximately one-third of the time available; and in each of the additional specialisations emphasis will be placed upon practical projects related to the student's home country or to a project on which ITC staff are working overseas.

TABLE 1

LIS SPECIALISATION IN THE CADASTRE/LAND REGISTRATION

SUBJECT GROUP	SUBJECTS	HOURS LECT/PRACT
0 Preparatory Subjects	Maths, Statistics, Programming, Surveying, Photogrammetry, Cartography	133/74
1 Introduction to LIS	Definitions, theory, applications, models	32/-
2 Defining the problem area	Land, the economy, transfer, security, planning	36/-
3 Environmental characteristics	Political, cultural, legal, socio-economic, technological, institutional	50/38
4 Info required by problem area	Cadastres, parcels, identifiers, linkages, confidenticality	20/-
5 Data required to derive information	Data types and quality, technical and legal	26/-
6 Technology		
6.1 Georeferencing	Systems and conversions	8/-
6.2 Data gathering	Land Survey; Valuation; Photogrammetry; Photo-interpretation; Remote Sensing; Socio-economic, admin. and environmental data; digitizing existing graphics	157/98
6.3 Mapping Techniques	Metric and semantic data, standards, methods of presentation	64/70
6.4 Data Base Technology	Requirements, data systems, models, DBMS	50/50
6.5 Data to Information Processing	Data types and sets, editing, manipulation, analysis, modelling	28/34
6.6 Functional design	Admin. and graphic parts of cadastral data base	10/30
7 Resources required	System specification, selection, personnel needs, education, re-training	26/-
8 Existing systems	Overview of selected systems	10/8
9 Systems engineering	Applied to design/implementation of LIS	15/-
10 Case Studies	Case study and computer simulation	25/20
11 Final Project	Project to integrate all subject matter	-/240
		690/662
	TOTAL	1352
	Directed studies	302
	Technical visits	80
	Assessment	40
	Statutory and other holidays	120

CONCLUSION: POINTS FOR DISCUSSION

Whether one shares Humphries' (1984) view that "hopefully, the educational problem is a passing one....." will reflect one's optimism or otherwise. Perhaps few would question his statement that "a concerted effort and the fullest possible cooperation between the tertiary institutes, employee and employer" will be needed. In the broader international context the second part could, however, be expanded to include the multilateral and bilateral funding agencies which support external educational studies. What follows here is the author's perception of points which warrant discussion between educators in LIS/GIS.

1. The signs suggest that the market for personnel educated or trained to fulfil specific functions in LIS/GIS will grow in the coming ten years at a rate in excess of the supply from educational institutions. The author is aware of a forecast of personnel requirements which has been made in one country. Presumably there are other forecasts. Knowledge of their existence and contents would assist the planning of new programmes and courses; and would help prevent the serious imbalances between demand and supply which have been experienced in some disciplines. What is needed, then, is the identification of national manpower forecasts which have been completed, and initiation of such in other places.
2. A workable mechanism must be devised for the exchange of information on current and proposed programmes and courses in LIS/GIS. Word of mouth, the occasional paper on an educational matter, and the chance sight of an announcement in a journal or brochure, are unreliable forms of communication. For the purpose of exchange a 'clearing house' is desirable, which might be the responsibility of an educational institution or association, or a professional body. It could, of course, be at national level; and in the larger developed countries this might be appropriate. But for many developing nations the needs for specialised education or training in LIS/GIS will have to be met externally. This suggests that an international 'clearing house' would be useful.
3. It is the jealously guarded prerogative of educational institutions to devise and offer programmes. This the author defends, particularly in the face of a growing tendency for governments to influence - and even direct - what will be taught. Yet the 'clearing house' suggested above could play a valuable role in helping to ensure that full coverage of educational needs in LIS/GIS is provided for the levels and categories of staff proposed in this paper. Being able to determine easily what courses are offered, where, and to whom, could help identify potentially serious gaps in coverage and, equally, substantial overlaps.
4. Finally, enrolment in an LIS/GIS programme will be influenced by many factors, both student-centred and institutional. The latter will include staff and equipment constraints, and could lead to qualified applicants not being admitted to a specific course. Knowledge of alternative programmes, and of

the availability of places, would be an advantage to those responsible for admissions. For this purpose an informal referral system would be useful, particularly in the context of the limited number of programmes and places to satisfy what is clearly a growing international demand.

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