TEACHING AND RESEARCH PROGRAMS IN LAND AND GEOGRAPHIC INFORMATION SYSTEMS AT THE UNIVERSITY OF MELBOURNE, AUSTRALIA

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Abstract: As in many other parts of the world, Australia is experiencing a severe shortage of Land and Geographic Information System (LIS/GIS) specialists who possess appropriate tertiary education backgrounds. This shortage of qualified personnel is causing difficulties for public agencies trying to establish LIS/GIS which, having fought for approval of staff increases, are often in the embarrassing position of not being able to fill positions when finally allowed to do so. This shortage applies just as equally to the private and academic sectors.

In an effort to address this imbalance, The University of Melbourne has designed new LIS/GIS courses and subjects, at both the undergraduate and postgraduate levels, with the aim of catering for young professionals about to enter the LIS/GIS community, and current administrators, academics and practitioners who find they now need a stronger background in the science, technology and management issues surrounding LIS/GIS.

The paper outlines a multi-disciplinary strategy at The University of Melbourne for teaching and research in LIS/GIS. The paper, however, concentrates on the programs within the Department of Surveying and Land Information (A Centre of Excellence in Land Information Studies designated by the Institute of Land Information based in Washington, DC), and a new Graduate Diploma in Geographic Information Systems being introduced jointly by the above department and the School of Environmental Planning within the University.

INTRODUCTION

The rapid expansion of land and geographic information systems world-wide has also occurred in Australia, however the high level of interest and activity is causing major problems. Organisations in both the government and private sectors are having great difficulty getting people to build and manage systems, while system vendors are having the same problems obtaining qualified people to develop system software and structures and to sell them, and the education institutions are facing an almost impossible task in attempting to attract people to teach the theory and applications of LIS/GIS.

The result of all this activity is that the community urgently needs more people with various degrees of expertise in LIS/GIS.

However, while the lack of technical and professional personnel is a barrier to the growth of the information industries in general, the public and private sectors must show greater commitment and recognition of the need for better educated and trained people within the industry. This need was highlighted in a 1989 national study into education and research needs of LIS/GIS by the Australasian Urban and Regional Information Systems Association (AURISA) (1).

While this need creates obvious opportunities for the educational institutions, the response by such places has often been slower than expected because of the multi-disciplinary nature of LIS/GIS. Unfortunately,
educational institutions are usually not good at developing multi-disciplinary studies. In Australia the most activity has occurred in the surveying schools, with limited activity in the geography, computing, planning and landscape architecture schools. Ironically, the geography schools in Australia have been slow to adopt GIS and one leading geography school considers LIS/GIS not worthy of serious academic interest!

Many of the surveying departments in Australia consider that they have a broad mandate to teach and undertake research in the general area of science and management of spatial data. See for example the strategy to develop the surveying program at The University of Melbourne (2). In a similar manner, the development of courses and research in remote sensing in Australia has had a major base in surveying departments.

The Department of Surveying and Land Information at The University of Melbourne is an example of such a department which is committed to education and research in the science and management of spatial data in the broadest sense. As a consequence the Department has developed a broad range of programs from the undergraduate level through to postgraduate coursework and research degrees, as well as continuing education programs. The Department's activities are supplemented by consultancies and research contracts in LIS/GIS locally, interstate and internationally.

THE NEED

The major groups requiring personnel with expertise in LIS/GIS include:

- Organisations wishing to develop and maintain a LIS/GIS;
- System vendors who need personnel to develop, sell and maintain systems; and
- Educational institutions which require highly skilled personnel to run LIS/GIS courses and undertake research in the discipline.

Personnel in each of these groups must divide their expertise into several subsets, which include:

1. Land information systems. These are primarily land parcel-based systems, having a high integrity of data, are polygon or vector based and are usually large scale. Examples of such systems include state-wide LIS that are based on state land registration and cadastral mapping systems and often closely tied in with other state activities such as land tax and land valuation systems. Each state in Australia has such a system (3 and 4). Another example is at the local government level where local government organisations are increasingly developing such systems. Planning information systems also fall into this category, at both the state and local levels.

2. Facility information systems. Such systems have much in common with LIS, and while they often originate from a parcel-based system they are primarily network oriented. They have a high integrity of data and are large scale systems. These systems, often called AM/FM (Automated Mapping/Facilities Management) systems, have specific needs and requirements. Virtually all water, electricity, telephone, gas and sewerage utilities in Australia have or are developing AM/FM systems.

3. Geographic information systems. These are typically small scale which can be either polygon/vector and/or raster based. The major applications in Australia are for environmental or natural resource management, or for socio-economic analyses which often use census data sets.

In addition, each subset also requires a range of personnel with different skills. This range includes:

1. Personnel who have a general understanding of the complete LIS/GIS environment. These people can undertake user needs studies, design conceptual LIS/GIS models and establish the administrative structures required to develop and maintain a LIS/GIS. In this group there are also specialists in cadastral, environmental, AM/FM and planning systems.

2. Personnel who have a detailed understanding of how systems work (built on a good computing
background), but are not pure computer scientists. Such people can design a data model, integrate different data sets and develop user menus for a range of systems. These staff have a good appreciation of the various system strengths and weaknesses, and are in a good position to undertake benchmarking of different systems. In this group there are also specialists in databases, spatial analysis, statistical software, digital mapping, data standards and data interchange. In addition, this group usually comprises people who have expertise in one or two systems such as Intergraph or Arc/Info. The surveying profession plays a major role in this activity in Australia.

3. Personnel who can manage a LIS/GIS in an organisation. Such people do not require the same depth of LIS/GIS understanding as the two groups above, but instead need a good general grasp of the subject. Generally, an organisation needs at least one LIS/GIS manager and one technical/computer systems person for such management tasks.

4. The final major category includes the people who operate the systems and input data. They do not necessarily need a detailed understanding of the system, but they are certainly much more skilled than keyboard operators and play a major role in the development of LIS/GIS. At the minimum, they must have an appreciation of maps and spatial data. They are often retrained drafting officers.

While the above overview is not complete, it does highlight the dilemma facing the educator in attempting to introduce LIS/GIS into an educational institution. Simply put, there are many different forms of education needed to be incorporated in a comprehensive strategy of LIS/GIS education, albeit there is certainly a lot of basic education in the discipline common to all areas. However, introducing an education program for LIS/GIS is certainly not a matter of simply adding a few appropriate subjects to an existing geography, surveying or planning program.

**PROBLEMS AND ISSUES**

There are many problems and issues facing an educational institution if it wants to make a major commitment to the education of LIS/GIS. Some of these problems and issues are:

1. Recognising that LIS/GIS is multi-disciplinary, deciding which department/s should be the major player/s in an institution. Once a department has made a major commitment to LIS/GIS, how does the institution ensure the multi-disciplinary nature of LIS/GIS is maintained? Obviously, duplication of resources is discouraged in an educational institution.

2. Where does the institution get the suitable personnel to teach and research in the LIS/GIS program? Usually, universities demand lecturers with a PhD, but in most cases they are simply not available in LIS/GIS. The few that are being trained, are offered high salaries in industry and are not very interested in an academic career. As an example, the Department of Surveying and Land Information at The University of Melbourne received a government grant in 1988 of about $0.4 million over three years to support two new academic staff in LIS/GIS. The first was appointed in early 1990 and the Department hopes to appoint the other before the end of the year. These appointments are the result of a major effort world-wide over two years to find suitable applicants.

3. In a technological environment which is changing rapidly, how does an educational institution acquire the hardware and software to run a LIS/GIS course, recognising a simple laboratory with about 30 suitable personal computers costs about $0.25 million to establish. Then, once the department has got its initial system/s, how does it keep the technology up-to-date?

4. Having acquired personnel and systems, the educational institution has to develop courses and programs and in some cases new degrees or diplomas in a multi-disciplinary area. This often takes at least two years of hard work and political manoeuvring. This can often be very difficult because the expansion into LIS/GIS usually means a decrease in emphasis in other well-established areas. At the same time that a department wishes to move into LIS/GIS, it is essential however that the department does not undermine its traditional student base, but in fact strengthens it. This applies in the disciplines of surveying, geography, planning and forestry, for example.

**THE STRATEGY AT THE UNIVERSITY OF MELBOURNE**
Overview

The Department of Surveying and Land Information decided in 1985 that it wished to make a major move into LIS/GIS, and it set down a strategy which it is still implementing. The Department recognised that surveying was an excellent base discipline on which to build a LIS/GIS program by providing the broad environment of the science and management of spatial data. However, the Department lacked the computer science base on which to build as well as lacking strength in environmental and natural resource management and planning. To a lesser extent, it also required input from the geography, agriculture and forestry disciplines.

At the same time, the Department did not wish to diminish its excellence in precision measurement and the whole surveying discipline. It was essential to maintain this expertise since the Department believes that measurement science and its related disciplines are fundamental to programs in LIS/GIS. It is becoming increasingly obvious that the strengths of surveying and LIS/GIS are complementary and synergistic.

The broad educational and research strategy for LIS/GIS in the Department of Surveying and Land Information is based on a balance between science, measurement science, land management, environmental management and associated applications. This requires a strong base in mathematics, physics and computer science, linked to an in-depth understanding of land and the environment. The strategy, in simple terms, is set out below:

1. A four-year undergraduate degree in surveying with a heavy emphasis on mathematics and science, computer studies, surveying science, LIS/GIS, land management and professional studies.
2. A five-year double degree program resulting in a degree in surveying and a degree in computer science. This program builds on the above course, but includes a range of computer science subjects provided by the Department of Computer Science, directed at LIS/GIS, which together with the surveying degree is sufficient to obtain a full computer science qualification.
3. A (primarily) coursework Graduate Diploma in Geographic Information Systems conducted jointly with the School of Environmental Planning within the University.
4. Research masters and doctoral programs in LIS/GIS.
5. Short courses.
6. A strategic research program, both pure and applied in LIS/GIS.
7. Specialist consulting in LIS/GIS.

As a consequence of the Department's initiatives in LIS/GIS, it was designated as a Centre of Excellence in 1988 by the international Institute of Land Information based in Washington DC.

The Undergraduate Programs

During 1987/88 the Department undertook a major review of the four-year Bachelor of Surveying degree. The new course is based around six streams reflecting the major thrusts of the program. The streams and the percentage of time allocated to each one are as follows:

- Mathematics and Science 20%
- Computer Studies 14%
- Surveying Science 27%
- Land Information Technology 10%
- Land Management 16%
"Mathematics and Science" comprises mathematics, physics, statistics and electronics. "Computer studies" comprises basic computer science subjects, computer systems for surveyors and computer graphics subjects. "Surveying science" comprises plane, engineering and hydrographic surveying, geodesy, use of GPS, photogrammetry and geodetic surveying. "Land information technology" comprises cartography, spatial analysis, remote sensing, and land and geographic information systems. "Land management" comprises land law, cadastral surveying, land development, and aspects of land management, land administration, land economy, town planning, ecology, geology, and environmental assessment. "Professional studies" comprise written, verbal and graphic communication, introduction to engineering, economics, project planning and a minor thesis.

The combined surveying/computer science degree program over five years has basically the same program as above with some reorganisation, however it has a strong computer science stream through the first four years with Year 5 being mainly advanced computer science subjects aimed at information technology and the management of spatial data.

The Department believes the new courses achieve their objectives by providing a sound basis in the sciences, a good balance between surveying science and land management, provide flexibility and options for employment and serve the present and future needs of the surveying and land and geographic information industry.

The Graduate Diploma in GIS

In 1989 the Department, together with the School of Environmental Planning at The University of Melbourne, received a combined grant of approximately $0.8 million over three years from government and industry to establish a new Centre for Geographic Information Systems and Modelling. The Centre will coordinate the new Graduate Diploma in GIS and will support a research thrust into environmental visualisation based on GIS, as well as undertake specialist consulting in GIS.

The Graduate Diploma in Geographic Information Systems is primarily designed to fill the need for graduates presently active in the disciplines associated with land administration, natural resource management, facility information management, environmental management, urban planning and conservation, who wish to gain a working knowledge of the theory, technology and applications of geographic information systems (GIS) as a subset of the broader discipline of the management of spatial data.

These are likely to be graduates (both recent and of some years standing) in engineering, surveying, geography, planning, environmental science, agriculture and forestry. Thus, the course structure has been designed to accommodate people of diverse academic backgrounds who wish to gain both a broad working knowledge of GIS and some specialised skills in perhaps one of the many applications of both land and geographic information systems technology.

The Graduate Diploma in Geographic Information Systems aims to develop in students an understanding of the underlying science, the design, the operation and application of geographic information systems as part of the broader discipline of the management of spatial data. On completion of the course, students should have acquired knowledge on the operation of geographic information systems and have the technical proficiency and competence to design and develop geographic information systems.

The course will be administered through the new Centre which for administrative purposes resides in the Department of Surveying and Land Information. The Faculty of Agriculture and Forestry and the Department of Geography are co-operating by providing subjects which are directly relevant to the discipline of geographic information systems.

The course (commencing in 1991) will normally take two semesters of full-time study over a period of
approximately nine months, although students can undertake the course part-time over a two year period. It is structured to be equivalent to about 500 contact hours and consists of three components: a core of 225 hours; streams consisting of about 130 hours; and a project of 125 hours.

The core comprises the following subjects:

- *Land and Geographic Information Systems 1;*
- *Land and Geographic Information Systems 2;*
- *Remote Sensing Principles;*
- *Remote Sensing Applications; and*
- *Environmental Information and Monitoring.*

While the subjects in the three streams are as follows:

- *Land Information and Management*
- *Land Administration and Cadastre;*
- *Landscape Simulation and Perception; and*
- *Cartography.*
- *Landscape Assessment and Planning*
- *Landscape Simulation and Perception; and*
- *Regional landscape planning and design.*
- *Geographic Information Systems Principles*
- *Spatial Analysis; and*

**Masters and Doctoral Program**

The department offers masters and doctoral postgraduate degrees by research and thesis. At present about ten masters students (almost all have returned to full-time study with complete financial support from their employers) are involved in research which is equally divided between measurement science and LIS/GIS topics. The five doctoral students are conducting research in the areas of human/computer interaction; the integration of simulation models and GIS; propagation of positional error in spatial data processes; data upgrading in digital map bases; and computer based methods for evaluating the efficiency of LIS/GIS structures.

**Short Courses**

Over the past few years the department has regularly sponsored conferences in the fields of land and geographic information systems (particularly at the local government level), cadastral reform, surveillance and monitoring surveys, and close range analytical photogrammetry. In addition, shorter and more detailed technical workshops are held in these areas. The department also hosts free seminars featuring local and overseas speakers in the measurement science and LIS/GIS disciplines.
Research Program

The department is actively involved in research programs with Intergraph, Digital Equipment Corporation and Tektronix, as part of its general research effort in Land and Geographic Information Systems. Research in the department encompasses topics such as policy, administrative and economic considerations in the design of LIS/GIS; telecommunications forecasting with GIS; design of facilities information systems; application of GIS techniques to archaeology; cadastral studies; geodetic adjustment techniques; global positioning systems; close range analytical photogrammetry; digital terrain models; and other allied fields.

Consulting and Industry Interaction

A major activity of the department is to undertake joint projects and consultancies with industry, however it is a department objective that only projects with a specialist or strong research component will be undertaken, so as not to compete with industry. Departmental staff are involved in consulting for the design and development of Land Information Systems for numerous local, state, federal and overseas agencies; as well as being actively involved in precision measurement of engineering structures.

In addition, the department sees one of its roles as being to transfer technology to industry, and therefore encourages both the government and private sector to place their own staff in the department to work on research projects within the University environment.

Equipment and Resources

Major equipment and resources of the department include multi-workstation Intergraph facilities operating TIGRIS and Microstation GIS software; ARC/INFO software on DEC MicroVax hardware, various IBM-PC/AT compatible microcomputers and Macintosh II computers for smaller vector/raster GIS packages; use of the Faculty of Engineering's laboratory with 60 SUN workstations and 120 terminals for CAD teaching and general programming; image analysis software and hardware; fibre optic access to University-wide computing facilities; analytical and analogue photogrammetric plotting equipment; high precision metric cameras; total survey stations; hydrographic survey systems; and GPS equipment. The Department's facilities emphasise an overall process from the full range of data collection methodologies through to the analysis and output within a LIS/GIS environment.

CONCLUSION

The land and geographic information industry has many and varied educational needs. In order to serve these needs, an institution cannot simply introduce several courses in LIS/GIS at either the undergraduate or postgraduate levels, without carefully determining what market the program/s are aimed at and the design of an appropriate offering.

Gaining in-depth understanding of LIS/GIS is not simply a matter of taking a couple of courses. It is the expectation of The University of Melbourne that students wishing to enter this discipline at the technical and scientific level, should ideally undertake either the single surveying degree or preferably the combined surveying/computer science degree. For people with a first degree in a related discipline, the appropriate course would be the Graduate Diploma in GIS, recognising that this does not give a broad background in computing and the science and management of spatial data.

For students with a first degree and a desire to gain some expertise in LIS/GIS, they would initially undertake the Graduate Diploma in GIS. They could stop there or, after having satisfactorily completed the coursework at the desired level, could convert to a research masters or doctoral program. If required, the masters or doctoral program could be undertaken jointly with Environmental Planning, Landscape Architecture, Geography, Forestry or Agriculture departments or faculties in the University.
The Department of Surveying and Land Information also believes it is essential to maintain close contact with industry through applied research contracts and specialist consultancies, in order to keep in touch with industry's concerns and issues of importance.

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