GEOGRAPHIC INFORMATION SYSTEM TEACHING AT ITC

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ABSTRACT

ITC was founded in 1951 as a photogrammetric training centre, but now has five departments: Aerospace Data Acquisition and Photogrammetry (ADAP); Cartography; Land Resource Surveys and Rural Development; Earth Resource Surveys; and Urban Surveys and Human Settlement Analysis. ITC students are mostly from developing countries, and already have professional expertise; they arrive with specific needs which must be met by our education program.

By the mid 1980's GIS teaching was established in all departments, and for example, graduate Cartography students will learn map design and production only within the GIS environment and graduate Photogrammetry students have as a central theme the capture and processing of photogrammetric data within the GIS context. Beyond this evolution, a specific LIS course, having three streams: multipurpose cadastre; urban applications; and rural applications, began in 1985. LIS Coourse participants usually come from cadastral, legal, rural planning, or urban planning professions and the course aims to "prepare participants to manage the design, implementation, and maintenance of geographic or cadastre based Land Information Systems".

ITC LIS Course participants often lack computer skills when they arrive in Enschede - so these are taught via GIS problems. Because course participants often return to organisations with low funding levels, much coursework uses microcomputers. Finally contact is maintained on returning home through the ITC JOURNAL and joint projects between ITC Staff and former course participants.

1.0 A WORKING DEFINITION OF GEOGRAPHIC INFORMATION SYSTEMS

In a recent paper by an ITC staffmember, which approached the problem of establishing a GIS from the viewpoint of information utilization [De Man,1988] it was stressed that GIS systems are similar to information systems in general in that they accept, process, present, update, modify, and combine data from a variety of sources - but that in the case of GIS the data has a locational attribute. It was also stressed that there are general feelings of scepticism towards all information systems in that they do not provide useful results automatically; this scepticism is not ignored at ITC, but is alleviated by the fact that good presentation of locational data has been achieved for many years through the techniques of Computer Assisted Cartography (CAC), and these techniques are easily incorporated into GIS. Both conceptually and practically a

GIS may be the superstructure on a CAC system, and this bottom-up approach finds some favour at ITC because of its practical usefulness. Negative characteristics of the bottom-up approach include the conflicting locational, attribute, and quality objectives of data gatherers resulting in data sets which cannot be combined; the conflicting time requirements of users who need 'their' data immediately and cannot wait for them to be prepared for general access in an information system; and institutional barriers which prevent the flow of data between information system users.

The top-down approach, which may be the ideal approach, also has its advocates at ITC [Jerie,Kure,Larsen,1980]. The top-down approach begins with a decision by the political masters of the information users, the data gatherers, or both, to integrate their efforts. From this political decision will eventually flow consistencies in software, hardware, and data standards. Unfortunatly the political will may not be there, or may not be there for long enough to ensure the establishment of a good GIS.

In 1984 when ITC's GIS Working Group established the syllabus for its LIS/GIS Course it was realised that the political environment within which a GIS is to be established has considerable bearing on whether or not the top-down or bottom-up approach is adopted. As our course participants, or students, come from countries representing the complete political spectrum (and no one political system dominates), then participants have to be aware of both approaches. ITC course participants are usually mid-career professionals, generally in their thirties or forties so they are keenly aware of the importance of compromise. The success of GIS in Burnaby, B.C., Canada, which began as a bottom-up development, achieved eye-catching success, and subsequently received top-down enhancement is a model with which many of our course participants identify.

In terms of organisational structure there is no LIS/GIS department in ITC. Taking the view that LIS/GIS is a coordinated collection of tools and technologies for geoinformation production, a GIS working group involving a wide variety of earth science disciplines was created instead. The common working basis of the working group finds its terms of reference within the following conventional definition:

"A Geo Information System is a system for capturing, storing, checking, integrating, manipulating, analysing, and displaying data which are spatially referenced to the Earth. This is normally considered to involve a spatially referenced computer database and appropriate applications software. A GIS contains the following major components: a data input subsystem, a data storage and retrieval subsystem, a data manipulation and analysis subsytem and a data reporting subsystem."

This definition is a foundation of the ITC LIS Diploma courses.

It should be noted that although the term LIS often refers more specifically to cadastre related information, the terms LIS and GIS are used quite interchangeably at ITC.

2.0 THE NEED FOR GIS EDUCATION

In the industrialised countries if an organisation does not possess staff with the right skills it must either:

(i) recruit new staff from schools;
(ii) poach staff employed in other organisations; or,
(iii) have existing staff retrained.

But, in industrialised countries there is a general shortage of personnel with the skills to develop and manage GIS, thus schools have to establish courses to provide or retrain staff. It is because schools realise "large sums of money are spent by Government, commerce and industry, the utilities, the armed forces, and others in collecting and using it" (i.e. geographic information), "...much human activity depends on the effective handling of such information.." and, "it is the ability of....Geographic Information Systems...to integrate these functions and to deal with the locational character of geographic information" [CHORLEY,1987] that they are beginning to establish GIS courses. At the moment these courses are directed towards the development and management of GIS; they are essentially postgraduate courses.

In the industrialised countries technician level training is essentially on-the-job, however GIS skills are so removed from other skills acquired in secondary education that technician level training may be important as a foundation for GIS operators to further develop their skills on-the-job.

For GIS in non-industrialised or less developed countries (LDC's) staff hardly exist yet to be hired directly from schools or poached, so only the third option exists, namely staff retraining. Furthermore the training has almost always to be away from the home country.

In LDC's there may not yet be the same mass of geographic information in computer compatible form which is available in industrialised countries, but due mostly to rapidly expanding populations, there is the need to strengthen the managerial functions of government. These functions include planning, decision making, inventorying, and monitoring; all these functions are functions of GIS.

As well as the need to strengthen the managerial functions of government most LDC's lack assets, and may look to international bodies such as the World Bank to develop these. Although most LDC's lack assets, two assets which they have are the land and the people on it, and these are ideally suited to management by a GIS - and especially a Cadastral GIS. There is now a trend in organisations such as the World Bank to assist in asset development if an LDC demonstrates an intention or capability to manage its existing assets.

Under the type of pressure outlined in the preceeding paragraphs, LDC's are now considering GIS training. This must usually take the form of staff secondment for one year to a training course in an industrialised country. Such staff are almost invariably graduate, but their most distinguishing characteristics are that they are already experienced professionals, usually in mid-managerial ranks, in secure employment, and often have a very good grasp of what their own country needs. It is these professionals who

form the core of ITC's LIS/GIS student body.

3.0 ITC's LIS/GIS COURSES

There are three groups of LIS/GIS courses at ITC:

1. Degree Courses (Ph.D. or M.Sc.);
2. Interdepartmental LIS Diploma courses; and,
3. GIS modules within other Diploma courses.

3.1 Degree Courses

Dutch Universities are closely monotored by the Dutch government, and so for administrative reasons the doctoral courses have to be given in conjunction with a traditional Dutch university and not by a Dutch International Institute (such as ITC) on its own. In practice this means a student will have a supervisor (or promoter - to use the Dutch terminology) from a university such as Utrecht, Wageningen, or Delft as well as a supervisor in ITC. Several ITC Ph.D. candidates are now preparing theses in the GIS domain.

The M.Sc.'s need not, legally, be given in conjunction with a Dutch university, however ITC has established a cadastre-based M.Sc. course jointly with the Geodesy Department of Delft University, for students who typically already have an ITC LIS Diploma with the cadastral specialisation. Students wishing to specialise in urban or rural applications of GIS, and who typically have already completed the LIS Diploma with urban or rural specialisation, may carry out their M.Sc. work within the ITC departments of Urban Surveys and Human Settlement Analysis or Land Resource Surveys and Rural Development. Students not having an ITC LIS diploma, but instead typically one in Cartography, Photogrammetry, Urban Surveys, etc., may also chose as a thesis title a topic clearly within the LIS/GIS sphere (and at the moment most do!), but on completion of their M.Sc. their knowledge of LIS/GIS is likely to be shallower than that of a student who has completed the ITC LIS diploma course. At ITC an M.Sc. course lasts about twelve months, and usually immediately follows a twelve month diploma course. The diploma course is not a prerequisite for the M.Sc. course, but very few students are accepted for direct entry to the M.Sc. The M.Sc. course consists of 500 hours of coursework, followed by thesis work taking about eight months.

3.2 LIS Diploma Course

The ITC Interdepartmental LIS Diploma course began in 1985. Its syllabus was the product of interdepartmental deliberation. It consists of three streams:

cadastral;
rural; and,
urban.

The aim of the cadastral stream course is to enable participants to establish a cadastral GIS at national or municipal level, for legal, fiscal and other purposes; to upgrade cadastral GIS; to expand an existing cadastral system into a multi-purpose cadastre or large-scale cadastral GIS to be used for title registration, valuation, and assessment, administration and social services, and the development of utilities, services, and transportation.

The aim of the rural stream course is to make participants familiar with available hard and software for spatial analysis and survey and the potential uses of these systems for resource management, development, and conservation; and, to enable students to evaluate techniques of data collection, processing, analysis, and presentation.

The aim of the urban stream course is to familiarize participants with the application of GIS as a vital tool to a city's strategy to improve the quality and control of urban planning and management; and, to familiarize participants with physical urban planning, traffic planning, education planning, and land management. [LINDEN,1988]

The course can accomodate 35 participants, and at the moment about half of them are in the cadastral stream. The course consists of 3 blocks.

3.2.1 ITC LIS Diploma First Block. The first block covers some fundamentals (including the nature and purpose of GIS in different applications; microcomputer operating systems; wordprocessing; BASIC programming; use of SQL; conceptual database design; data capture verification and storage; data structures for map production; data analysis and spatial modelling processes; georeferencing; geometric transformations; economic role of land; land valuation; legal aspects of cadastre) which are taught to all three streams, and others taught only to specific streams (including airphoto interpretation; geometric transformations; relational databases; computer graphics; FORTRAN; point determination systems; ecology; agronomy; land evaluation).

It can be seen that basic computer science is covered in this block. This reflects the present educational level of most of our course participants, and might be unnecessary for students from industrialised countries. With the advent of low-cost microcomputers students from all countries will soon have these basic computer skills, and the First Block will have to be rethought. At the moment participants who already possess these skills (a tiny minority) can replace this coursework with a personal study topic.

3.2.2 ITC LIS Diploma Second Block. In the Second Block the participants specialise. For the cadastral stream coursework is designed with the objectives of enabling students to compare the appropriateness of one cadastral system to another; to design an efficient system of land registration; to design a computerised land information system in a well known environment (such as Intergraph, Igos, Sysscan, or Arc-Info); and to establish criteria for the effective implementation and management of a cadastral and municipal information system. For the rural and urban streams the objectives are to strengthen the participants' understanding of the analytical processes which have to be applied in geographic problem solving; and to increase their operational familiarity with a large number of mainly micro-computer based GIS.

A rather fundamental difference between the streams emerges in Block 2. To some extent a cadastral LIS is an inventory to be accessed with little data processing needed - thus the prime requirement of the professional is to understand how to DESIGN as good an LIS as possible. For the rural and urban LIS an important task is data analysis and processing - thus the prime requirement of the good professional is to understand how to USE an LIS as well as possible.

3.2.3 ITC LIS Diploma Third Block. Block 3 is devoted to a final project lasting three months. The participants can elaborate the design and implementation of an LIS suitable for use in his home environment. Material from the participant's home country is collected and processed. The software will be documented and can be taken home for further use and elaboration. The block is concluded by the student making a presentation of his final project to staff and participants.

These final projects vary very much from course participant to course participant, but in the cadastral stream (with which the authors are most familiar) emphasis is placed on the participant achieving independence and self-sufficiency in his chosen area. It is most important that participants can go home and begin to implement a GIS if necessary - and because they may be the only professional in their organisation with computer skills, self-sufficiency is an essential. The results are that software must be either completely understood by the participant (e.g. his own) or the software components (e.g. dBASEIII, AutoCad) be completely reliable, and that the hardware components present no maintenance problems (e.g. repairs can be achieved with a screwdriver or mailed parts). Another characteristic of the final projects is that the GIS built by the course participants will use low-cost hardware, unless the participant knows he is going to return to an existing GIS.

3.2.4 ITC LIS Diploma - Other Aspects. Throughout the course visits are made to organisations in several European countries (e.g. Germany, Denmark, U.K., and of course the Netherlands) where LIS are already installed and in use. Also guest speakers from further afield (for example Harry Christie - Canada, Lynn Holstein - Australia, Rebecca Somers - USA) are invited to share their experiences with the participants.

A final aspect of the course which can be mentioned are our 'work-shops'. These are intensive three or four day exercises (additional to those already mentioned), spread throughout the second and third blocks, exposing participants to one particular system at a time. As we have a large and growing number of systems at ITC (Intergraph, IGOS, Sysscan, Arc-Info, ContextVision, Dipix, Gimms, Masmap, Saladin, Cries, dBASEIII, AutoCad, MAP2, SPSS, ILWIS, USEMAP, etc.) which particular systems are used varies from year to year. The cadastral course participants have two such work-shops, the rural four, and the urban eleven.

3.3 GIS Modules within Other Diploma Courses

Our LIS Diploma courses started in 1985, so before GIS was

taught in some other way. It was, and still is - as part of other Diploma courses. In the Cartography department, for example, students have a ten-hour introduction to GIS, and a 40 hour practical exercise in which they build and interrogate a municipal information system. This is of course in addition to about 120 hours in other related digital subjects, and about 70 hours of CAC practical exercises. In the ADAP department it has been an integral part of courses for ten years, similarly other departments.

3.4 Cartography Department in LIS/GIS Teaching at ITC

As map documents are still the most important data source for GIS, Cartographers play a dominant role in teaching all aspects of data capture from maps.

Another function of cartographers in mapping is display design. At the moment cartographers teach display (both hardcopy and softcopy) design to only the Cadastral stream in the ITC LIS Diploma. This anomalous situation arises because the Cadastral stream at ITC is the joint responsibility of the Photogrammetry (ADAP) department and the Cartography department. However Cartography Department research into expert systems guiding good map design is resulting in a map design module for the ITC's own GIS (called ILWIS), and this should open the way for cartographers to influence display design for all the LIS Diploma streams.

4.0 CHARACTERISTICS OF EDUCATION AT ITC

ITC is different from a University in many ways, and these differences affect the way GIS is taught.

The most important difference is our students, or course participants. They are highly motivated mid-career professionals from a very great variety of LDC's. They come to us for only a year, in that year work solidly - without vacations, and in the case of the LIS course participants, expect at the end of the year to have learnt enough to go home and to establish or run (or both) an LIS. Often they are keenly aware of their priviledged status and the high expectations of their colleagues at home. This means they may expect to be provided with ready-made GIS solutions or recipes for their problems; instead they are provided with some example solutions to example problems, the means to identify their problems, and some of the intellectual and practical tools with which to build a GIS to solve their problems. In some cases the participants are disappointed by this. Teaching staff are aware of the high expectations of their students and the danger of disappointment. The result is a strong commitment by the staff to ensure that participants do acquire and master the tools forming the bulk of their 'diploma packet' and a very intense involvement by the staff members in the Final Projects, which as already indicated are related to the participant's home situation.

Because of time pressures on our course participants, all learning is expected to be relevant. A standard introductory programming course is not appropriate, and even the earliest programming problems should be designed to strengthen geographic thinking as well as programming skills. Or, as another example, in georeferencing, participants insist that projections used in their own

countries are dealt with.

The result is that much teaching is student driven. The partnership between student and teacher at ITC may be one of ITC's most unique features, and is certainly not found at a University where there is a real age and experience gap between student and teacher.

Another important difference between ITC and a University is that its staff both come from all over the world, and through ITC's consulting arm, work all over the world. Staff have practical experience of the professional domains of our students. The cultural domains of our students are, to a great extent, also known to us so we are aware of which alternative solutions might (given the cultural constraints) help with a particular problem, and which might not. These particular characteristics may not be found in a University staffed by nationals from mainly one country.

We do have students from industrialised countries too. Some are professionals wishing to update among students of similar age and experience, some have chosen to do their thesis work at ITC because of the rather exceptional range of hardware available, while others wish the experience of an international environment.

5.0 THE FUTURE

As with a University, our future is never certain. Changes in the teaching of GIS will arise - especially as our intake becomes increasingly computer literate. At the moment financial pressures ensure the popularity of courses dealing with the cadastral applications of GIS, but as LDC's become aware of the importance of maintaining and improving their natural environment, we may find a re-awakening of interest in satellite remote sensing and the rural applications of GIS.

During the last decade ITC's main thrusts have been in problem-oriented teaching and consulting. Although there has been individual research, strong research groups have not been operating. However two years ago the institute decided to support a group of about 20 staff and students in the creation of a microbased GIS. This is called ILWIS (Integrated Land and Watershed Management Information System), and is particularly suited to rural applications of GIS [VALENZUELA,1988]. Its present status is that it has been established at about ten locations outside Europe, and can handle satellite image enhancement and analysis, map data capture, analysis, and processing, map display and report generation. In its second version it is hoped additional modules will include digital mono-plotting, map design via a cartographic expert system, data and model quality handled by fuzzy sub-set theory, automatic digitizing and vectorizing, etc. ILWIS is the main teaching system for rural GIS applications in ITC, but it will also be the framework for much research at ITC in the next year or two.

Finally, as with any discipline, periods of integration and specialisation alternate in the earth sciences. The emerging GIS technology is a force for integration, and at ITC it is generating integrated research. In the case of teaching, an integrated teaching group has emerged for the

teaching of the ITC LIS Diploma Courses, but the specialist courses will continue - although such students will be expected to fully understand their specialist role within the umbrella technology of GIS.

6.0 REFERENCES

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