TRENDS IN CARTOGRAPHIC EDUCATION IN AUSTRALIA

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Abstract

The cartography profession in Australia has been subject to substantial change during the past two decades, which has been brought about by several factors. This includes significant developments in the technology, a national concern for environmental issues, emphasis on geoinformation management rather than data presentation, encroachment of other disciplines into *traditional* cartography, the ageing of the profession, and economic constraints leading to downsizing of many large government mapping agencies.

For young people entering the cartography profession, as well as those already in the workplace, it is now becoming more important that they acquire and maintain the background and qualities necessary to ensure rewarding lifelong careers. Educational organisations in Australia have adopted a leadership role by taking an expanded view of the profession, where some traditional tasks are discarded in favour of new geoinformation management activities. Courses at all levels are being revised, postgraduate programs implemented and research activities being undertaken in a range of multidisciplinary areas.

This paper examines recent and potential developments in cartography and cartographic education in Australia in the light of world-wide trends in education, training and the workplace. It looks at the range of cartography programs Australia-wide as well as the level of education offered by diverse organisations. It also draws upon the authors' experience in North America and, more recently, at Curtin University in Western Australia, where a traditional degree program has recently undergone comprehensive revision in order to meet the demands of the marketplace.

1 Introduction

Australia has been in the process of continuous *development* since the First Fleet landed at Sydney Cove in 1788. For the first 150 years there was a great need for mapping and charting the vast continent. Surveyors General, who controlled access to and distribution of the land, held powerful positions in Federal and State governments. Over this period the outback was opened up and rural settlement encouraged. Cartographers, such as Matthew Flinders, were imbued with the spirit of exploration and mapping the frontiers of this *developing* Australia.

Since the second world war, urbanisation has replaced the dream of a rural Australia. The decline of the agriculture and pastoral sectors over the past half century has meant that most of Australia's population is now located in cities, which are large, sprawling and infrastructure dependent. These host a range of problems including substandard housing, crime, unemployment and lack of adequate public transportation. Successive Australian governments have now begun to emphasise quality of life, and are endeavouring to address the so-called problem of *cities*.

These issues in Australia are symptomatic of a much larger problem worldwide. We have entered an era characterised by the problems of global change that stem from the *interdependence between human* development and the environment [1]. No longer is the focus on development *per se*, but on

development that leads to a sustainable society, i.e. *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* [2].

Moving people and nations towards sustainability requires changes in values and institutions, on a scale similar to those encountered during the agricultural revolution and the industrial revolution. Global issues involve changes to the atmosphere climate, threats to the world's water, a growing human population, agriculture, and energy use.

Cartographers have always had an important role to play in the development of natural resources. As pressures mount world-wide to develop a sustainable society, it therefore becomes important that they move their emphasis towards the management and monitoring of the world's resources, rather than remain concerned simply with mapping them.

Within this challenge, there may well be some significant rearrangement in roles between the government and private sectors, which may, in turn, offer new opportunities. In Australia, these revolve around the commercialisation and privatisation of many government functions, and the rationalisation of many government activities.

As regards commercialisation in the geoinformation area, much more emphasis on the selling and marketing of land-related information can be expected. Cost recovery, which already exists for such items as maps, satellite data, street directories and land title certificates, where sales are on a piece-by-piece basis, is likely to extend to the sale of substantial or complete data sets.

There are also likely to be calls for privatisation of many of the roles of government. Here, Australia is following the lead of the USA, Canada and the UK, where more of the routine or commercial aspects of government are contracted out to the private sector. In surveying and mapping, this should lead to a much closer relationship between the government and private sectors, particularly in the area of offshore marketing initiatives and the development of export consortia for large-scale international projects.

2 Technological Change

One of the major challenges and opportunities for the cartography profession is the application of new technology. Mapping has traditionally been a service industry and labour intensive. However, technology is now providing the means to gather land information more quickly and process it more rapidly, thus reducing staff and operating costs. Therefore cartography, in the traditional sense, is likely to become much more technology oriented, and will need to develop new horizons in order to remain a viable, if not expanding, profession [3].

In three-dimensional positioning at the continental level, GPS technology is making a tremendous impact. Accuracy over distances of hundreds of kilometres can now be obtained almost instantaneously down to centimetres, depending on the techniques used. Large tracts of previously unsurveyed land can now be mapped quickly and efficiently, compared to earlier methods.

The development of soft photogrammetry techniques and the use of digital data are also enabling an order-of-magnitude increase in the ability to carry out photogrammetric mapping. This will allow the more rapid completion of existing mapping programs, the undertaking of larger scale mapping on a routine basis, and also the efficient carrying out of specialised mapping tasks. It will also be possible to utilise effectively the enormous amounts of digital data collected from airborne and space platforms, at much lower cost.

New technology is also having a significant impact on cartography through the continuing development of computer hardware and software. A whole range of mapping products can now be developed efficiently, ranging from traditional maps to photographic products and even animated films.

This is enabling various mapping activities to be carried out by a single operator, much more so than in the past.

Remote sensing technology continues to make a significant impact as more and diverse satellites circle the globe, at a range of acquisition frequencies, resolutions and repetitive periods. More interpretation software has become available for working with remote sensing data, and less expensive and more powerful PC and workstation computing is also at hand.

Similarly, there have been extensive developments in GIS/LIS systems. Today, useful GIS systems can be purchased for a few hundred dollars and run effectively on a $2,000 personal computer. This technology is now available to small groups, such as mapping companies, town planners and real estate agencies. GIS/LIS has become a powerful tool for decision support in regional planning and analysis for a broad range of applications.

Thus, traditional cartography, which had become a mature discipline by the 1970's, is now being revitalised by technological developments. This can either be viewed as an imposition forcing changes on the mapping industry, or can be embraced as providing the opportunity for the profession to expand its horizons into new areas.

In his keynote address to the 13th North American Surveying Teachers' Conference, Mueller commented that *surveyors and mappers will be in the information business (or in no business at all) and todays tedious tasks such as positioning, will become routine, even perfunctory* [4]. He also pointed out that surveyors and mappers of the future will have to be skilled in the management of spatial data in the broadest sense, whereby a balance must be struck between the basic sciences, measurement sciences, the management of spatial data, land management, and an understanding of the environment.

3 Response of the Profession

Cartography as a profession is often compared with surveying. In most countries the cartographer has worked closely with the cadastral surveyor, whose role has been protected by licensing, which has excluded competition in certain defined areas.

However, Groot suggests that the age of protected professional monopolies is fast disappearing and new combinations of surveying and mapping and applied geography will lead to new *professions in the information-driven economy*, which he refers to as *geomatics specialists* [5]. Geomatics is defined as the field of scientific and technical activities which, using a systematic approach, integrates all the means used to acquire and manage spatially referenced data as part of a process of producing and managing spatially based information [6].

In Canada, in the 1980s, the surveying and mapping profession looked at expanding its role into new areas, such as land management [7]. Surveyors recognised that their exclusive role in legal surveys was becoming limited and, in order to retain viability in the profession, an expansion of the traditional role of land measurement into the management of land information was becoming imperative.

In recognition of this need, the Surveying Industry Association of Canada changed its name in the late 1980s to the Geomatics Industry Association of Canada and established a full-time president with the responsibility to promote the surveying and mapping industry within Canada and overseas. His role is to undertake promotional initiatives on behalf of the profession, act as a lobbyist with the Canadian government, undertake a range of surveys on behalf of members, and develop strategic plans, which serve as a focus for the organisation in an on-going way.

In Australia, the profession has moved in similar, but in some respects different, directions. Surveyors, for example, have examined the feasibility of amalgamation of the Institution of Surveyors

Australia (ISA) and the Institute of Engineering and Mining Surveyors (IEMS) into a single national body. Cartographers, on the other hand, have always supported a single professional body, the Australian Institute of Cartographers (AIC). However, with a less exclusive and less clearly delineated profession, cartographers are promoting their profession in a broader context. To this end, the AIC membership has approved a name change to the Institute of Mapping Sciences Australia.

The new name recognises the broad and expanding nature of cartography within the context of the development of the geoinformation management industry. The change to the Institute of Mapping Sciences Australia is not only to redefine cartography as a broad-based geoinformation management profession, but also to appeal to non-cartographers (in a traditional sense), who today find themselves performing cartography-related functions.

An emerging trend has been the realisation that cartographic education is no longer provided solely by a degree or diploma in cartography or geography with a cartography major. It may, in fact, be the result of a qualification in geomatics or LIS/GIS. Consequently, cartographers are much less defined by their educational qualification than by their function within an organisation.

In terms of viability, however, the future prosperity of the industry will require a greater emphasis on geoinformation management rather than data presentation. As a consequence, government mapping agencies and individual mapping companies will need to diversify their activities, such as looking at spatial data management in a more holistic way as part of the land information process. This will mean integrating traditional activities into areas such as environmental management, land inventory and analysis, infrastructure development etc, and developing the perception that cartographers are an integral part of the development team and not merely performing a data presentation function.

4 Educational Issues

In order to support the cartography profession during this time of rapid change, it is important that educational institutions adopt a leadership role. This can be done through offering courses that provide appropriately trained and broadly-based professionals who will join the workforce in government and industry, ready to meet the challenges of the years ahead. It also means providing professional development courses that will broaden the horizons of existing practitioners into areas of new opportunity.

The identification of appropriate educational objectives must be undertaken through broad-based consultation with industry, academia and cartography graduates. A recent investigation reported by Pupedis [8] highlighted the following important educational issues:

- Technology in all aspects of land information is continuing to change rapidly. Consequently, education programs must be balanced, allowing for continual change.
- The nature and type of employment is changing. Employment is often determined by employee performance and job description, defined by the ability to carry out particular tasks (rather than formal cartography or surveying qualifications).
- Graduates in the field of land information are expected to have qualities that were not demanded in the past, such as more effective written and verbal communication skills, the ability to operate in multidisciplinary teams, and the approach and competence to be able to accept change and solve problems.
- The traditional definition of a cartographer or other professional in the field of spatial information appears to be becoming less relevant. The merging of professional boundaries emphasises the importance of flexible course structures, allowing students greater control over the directions of their future careers.

- Teaching methodology needs to focus more specifically on the process involved in learning, such that the student is encouraged and supported, so as to become a self-motivated lifetime learner.

- The design of undergraduate programs should also take into consideration the fact that increasing numbers of students are continuing into higher degree programs.

In the past, educational institutions and professions around the world have taken different approaches in designing education programs for cartographers. Some are located in surveying departments, others in geography departments. Still others are located with other disciplines in the land science area. In Australia, however, many cartography programs are offered in conjunction with broad surveying programs, which are usually administratively located in either engineering or science faculties. These programs have endeavoured to maintain a balance between both land and geographic studies, and measurement science.

Several such Schools in Australia have already recognised the need to broaden into land information management. For example, the University of Melbourne has introduced a Graduate Diploma in GIS for students wishing to gain a working knowledge of the theory, technology and applications of GIS, as a subset of the broader discipline of the management of spatial data. This course draws from graduates presently active in the disciplines associated with land administration, natural resource management, facility information management, environmental management, and urban planning and conservation [9].

Gracie [10] reported similar trends concerning the changing emphasis towards GIS in surveying and mapping education in Canada. He indicated that several universities and colleges have established, or are in the process of establishing, comprehensive programs in GIS while others include GIS courses in their regular surveying and mapping programs.

Young [11] summed up this approach by arguing in favour of a broadly-based geomatics education, which would reflect the integrated nature of previously discrete discipline areas in developing a graduate whose professional activities are in producing spatial information for a variety of users. Such an education would encompass the traditional discipline areas of surveying, cartography, remote sensing and spatial information systems.

Combined with formal programs, there will be a requirement for retraining practitioners and staff who are already in the workplace. Continuing education programs are currently offered by universities and TAFE. In addition, the Australian Institute of Spatial Information Sciences and Technology (AISIST) is developing an integrated set of spatial information systems training packages, designed for presentation throughout Australia to groups of practitioners who are interested in updating their knowledge base. At the international level, the US National Centre for Geographic Information and Analysis (NCGIA) has developed an extensive curriculum for both theoretical and practical training for university level education in GIS/LIS.

5 Cartography Education in Australia

5.1 Cartography Courses

An excellent summary of the history of cartographic education in Australia appeared in the Australian National Report to the International Cartographic Association, presented at the Mexico conference [12]. In that paper, Williams explained how cartographic education courses available in Australia have gradually increased in their academic content, so that by 1987 it was possible to study cartography at all levels, from certificates and diplomas, to undergraduate and masters degrees, right up to PhD level.

More recently, the status of cartography education in Australia was reviewed by Worth [13]. He found that because of the rapid technological changes over the previous decade courses had to be rewritten,

new units introduced and outdated ones replaced, new staff found to teach the new courses, expensive computer equipment and software purchased, and the key concepts of cartography rethought and taught in different ways. Some courses were able to remain contemporary, others became outdated and lost the support of new students, and still others were forced to close down altogether.

In 1992, there were nine cartography courses available to students in Australia. Two of these are degree level courses, five are Associate Diploma courses, and two are Advanced Certificate level courses. Details of the programs are summarised in Table 1.

Table 1: Cartography Courses Available in Australia in 1992

Institution (School)	Course name	Student numbers (full/part-time)
* Curtin University (WA) (Surveying & Land Information)	B.Sc. (Cartography) plus Honours	52/13
* Central Metropolitan College of TAFE (WA) (Surveying & Cartography)	Assoc. Dip. (Cartography) Adv. Cert. (Cartography)	41/34 36/30
* RMIT (Vic) (Land Information)	B. Land Info (Cartography) incl Honours	85/8
RMIT (Vic) (Survey & Civil Technology)	Assoc. Dip. of Engineering (Surveying & Mapping)	13/30
Institute of TAFE (NT)	Assoc. Dip. of Science (Cartography)	0/15
ACT TAFE (Construction Studies)	Assoc. Dip. of Engineering (Cartography)	6/5
* University of SA (Surveying)	Assoc. Dip. (Cartography) Adv. Cert. (Cartography)	16/11 13/9

* run in conjunction with surveying courses

There are degree courses in cartography in Western Australia and Victoria, and Diploma courses in Western Australia, Victoria, South Australia, the ACT and the Northern Territory. There are no cartography courses in Queensland, New South Wales or Tasmania. In the 1980s, a degree and diploma course closed down in Queensland and a diploma and certificate course closed down in New South Wales. In 1992 a total of 276 students were enrolled in these courses. Many of these courses are run in conjunction with surveying courses.

Worth suggested that the reasons for course closures are many and varied, and several would have combined together to produce today's situation [13]. Of the cartography courses which are still operating, only those in Western Australia and Victoria have viable student numbers. These are successful because they have a long tradition of cartographic education, have institutional support for the study of cartography, have been able to invest in the necessary equipment upgrading that is

required, and because they have recognised the need to change with the times, (i.e. introduce new subjects and courses, new hardware/software, new staff, etc).

5.2 GIS/LIS Courses

As traditional cartography courses have gradually reduced, there has been a complementary increase in GIS/LIS Australia-wide. Worth lists 12 such courses [13]. The majority of these are at the Graduate Diploma and Masters level. This is because they are designed for professionals in allied fields who want to apply GIS to their own discipline, whether that be forestry, soil science, ecology, mining, planning, landscape architecture, or any other. In this respect, these courses do not overlap with the employment possibilities for graduate cartographers. In 1992, a total of 251 students were enrolled in these courses. Many of the programs are also run in conjunction with surveying, geography, planning or computing courses.

Within the field of GIS/LIS, the importance of cartography is well recognised. In a recent survey, map reading, database management, spatial analysis, computer cartography, technical writing and statistics were determined to comprise the six most important topics within GIS/LIS courses [14]. A course with these attributes may be considered a well-rounded GIS/LIS course or, alternatively, a modern and comprehensive cartography course.

5.3 Future Developments

In summary, therefore, many cartography courses taught in Australia over the last five years have either experienced a decrease in student numbers, or have closed down. Meanwhile, many GIS/LIS courses have been introduced, and have achieved wide support. Those cartography courses which are exceptions to the rule, and are expanding, are doing so because the Schools operating them have been prepared to review their courses and syllabuses, to introduce GIS/LIS, remote sensing, electronic publishing and multimedia so as to complement the traditional aspects of cartography, and to invest in equipment and software, to appoint new staff members, and to promote the changes effectively to prospective students and employers.

This process is expected to continue, at least for the next few years. While some existing cartography courses may close, more GIS/LIS courses will come on-stream, with existing GIS/LIS courses increasing their student numbers as the industry expands. Evolution of the profession is likely to see the development of educational programs which derive their basic philosophy from traditional cartography, yet embody the emerging areas of geoinformation management. In essence, there is scope for the development of a modern cartography course which will be viable, as well as meet industry requirements.

6 Cartography at Curtin

The School of Surveying and Land Information at Curtin University of Technology has been involved in the formal education of surveyors and cartographers since 1947, when a Diploma in Cartography was taught within the then Department of Engineering, Perth Technical College. The School currently offers a range of courses at both the undergraduate and graduate levels. These comprise:

- Bachelor of Surveying
- Bachelor of Surveying (Honours)
- Bachelor of Science (Cartography)
- Bachelor of Science (Cartography) (Honours)
- Graduate Diploma in Remote Sensing and Land Information
- Postgraduate Diploma in Surveying and Mapping
- Master of Science (Surveying and Mapping)
- Doctor of Philosophy

In addition, a Graduate Diploma in Geographic and Land Information Systems is offered in collaboration with the School of Computing.

Short courses and workshops covering a variety of specialist topics are also regularly offered by the School as part of a continuing education program. This reflects the commitment of the cartography profession to raising the general level of formal education for new practitioners, and the need to provide established professionals with refresher courses on aspects of changing technology. Members of industry may also attend postgraduate course units as *extension* students to further their education in specific subjects.

In 1991, the School undertook a thorough review of its teaching program. Substantial changes were made to all its courses in order to meet the new challenges. Apart from adapting its traditional material to the introduction of new technology, the School introduced new topics into its undergraduate program, such as computer assisted cartography, remote sensing, land information systems and environmental management. Subsequent revision of the cartography program has also resulted in the inclusion of multimedia, desktop mapping, spatial database management and studies of the Internet and UNIX operating system.

The revised undergraduate course structure recognises the commonality between surveying and cartography education. Both programs include elements of land studies and the measurement sciences. Altogether, two years of the three-year cartography program and the four-year surveying program are common.

The other two years of the surveying program emphasise spatial measurement, e.g. engineering surveying, measurement analysis, precise surveying, analytical photogrammetry, GPS, hydrographic surveying and applied field surveying. In contrast, the remaining year of the cartography program emphasises spatial information management, e.g. geography, map design, map reproduction and map evaluation.

Within the common areas of study are included introductory units in mathematics, physics, computing and communication. In addition, there is a range of specialist units common to both programs that cannot be defined as strictly related to either surveying or cartography. These units provide substantial foundation studies for subsequent units in both degrees or, in the case of environmental management, completely service a specialist area relevant to both disciplines [15].

Whereas other Surveying and Mapping Schools within Australia have introduced joint degrees or double degrees, Curtin has not yet embraced this concept. Other disciplines already contribute significantly to the program, because mathematics, physics, computer science, geography, english etc. already comprise part of the courses through service teaching. In fact, around one full year of subjects for both the surveying and cartography undergraduate degrees is contributed by other Schools. One important aspect of the teaching program is that the School undertakes responsibility for choosing the content for all of its undergraduate program. There is no common core requirement as is found in some other engineering studies.

This approach has also proved successful in that there is currently an excess demand for student places. In both 1994 and 1995 there were around 300 applicants each year who chose surveying and cartography as one of their four preferences for university entry in Western Australia. Of these, over 70 each year were first preference applications. This compares to a School quota for new undergraduate places of 45. In both years, the Tertiary Entrance Examination cut-off level for entry to the School was close to 70 percent compared to the 65 percent minimum entrance requirement of the University.

Another feature of the program is that cartography Honours students can also undertake a range of specialist streams in areas such as remote sensing, GIS/LIS, photogrammetric mapping, environmental management and computer cartography. This gives graduates the breadth of knowledge to be able to undertake employment in an expanding number of areas. Altogether, the School has

endeavoured to provide an integrated program of study that will equip students for a wide range of roles. A list of possible employment avenues is given in Table 2.

Table 2: Potential Employment Areas for Curtin Graduates

Bachelor of Science (Cartography)	**Bachelor of Surveying**
Administration	Administration
Advertising	Cadastral Surveying
Cartography	Defence Mapping
CAD/CAM	Digital Cadastre DBMS
Defence Mapping	Education/Training
Desktop Publishing	Engineering Surveying
Education/Training	Environmental Management
Environmental Management	Geodesy
Geological Mapping	Hydrographic Surveying
Graphic Arts	Land Planning
Hydrographic Charting	LIS/GIS
Land Planning	Marketing
LIS/GIS	Mine Planning
Map/Graphic Design	Mine Surveying
Map Reprographics	Photogrammetric Mapping
Marketing	Photogrammetry
Photogrammetric Mapping	Precise Surveying
Remote Sensing	Remote Sensing
Software Development	Software Development
Spatial Data Management	Spatial Data Management
Tourist Mapping	

7 Conclusions

Over the last two decades significant changes have overtaken the cartography profession. The most important of these stem from technological advances and from the economic revolution as Australia moves to an information society. To help adapt to these changes it is important that educational institutions take the lead in educating the next generation of mapping specialists with a renewed vision of the future. While it is true, as Groot has argued [5], that surveying and mapping education and training must be demand-driven activities, it is also important to recognise the integrated nature of professional training in cartography, so as to produce graduates with the flexibility and knowledge base to pursue a range of career options. This means balancing the data presentation and geoinformation management sides of the spectrum, and the incorporation of elements from other relevant disciplines.

Finally, it is very important that we in the mapping sciences area view the *big picture* and recognise that we are in the spatial information management business. This may mean developing and customising the various products to expand our horizons over a wider range of opportunities. It will also mean making use of suitably educated professionals who can adapt, learn, assimilate and embrace new developments relevant to the profession. As Toomey has indicated [16], *what are needed now are not mapping professionals with a mission of 'problem solving', but spatial information managers who are more capable of 'problem identification', an essential skill in today's rapidly changing employment arena.*

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