EDUCATING SURVEYORS FOR THE NEXT CENTURY
ISSUES AND STRATEGIES

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ABSTRACT

In designing a degree course for surveyors which will serve their needs in the next century, there are many issues to be addressed. Firstly, the changing requirements of the community regarding professional skills required from the surveyor need to be determined and then translated into appropriate academic courses. Secondly, the ongoing dilemma in surveying education concerning the dichotomy between emphasizing land management and land-related issues, and the science and technology of surveying, must be addressed. Thirdly, the subject streams must be designed so that they reflect current developments in technology and the underlying sciences.

This paper reviews the vision of the surveying degree programs at The University of Melbourne and discusses some of the strategies in addressing the above issues. In particular, the paper reviews the market for surveying skills in the next century, considers the land measurement and measurement science dichotomy, summarizes major considerations in designing a land surveying program for the next century and examines how subject or discipline streams should be designed. In this regard it examines the integration of fundamental theory and applications as a logical sequence throughout the course.

Finally, the paper indicates how an undergraduate program can be designed to interface with a range of graduate programs from graduate diplomas through to doctoral studies.

INTRODUCTION

There is no simple model for educating land surveyors for the next century. Nobody can be certain that any educational model chosen is correct and appropriate. The world is changing and so are the professional disciplines, with surveying changing more than most. The information society is becoming a reality with many professions including surveying being caught up in this tide of change. As a consequence surveying is becoming increasingly dependent on expensive technology. Yet this is occurring in an economic environment where funding for education is being continually squeezed. Countries like Australia have large foreign debts and balance of payments
problems. The Government's attention is turned to export and increasing the
wealth of the country while reducing the national debt. At the same time
environmental issues are becoming a dominant focus which are reflected very
much in policies for natural resource management. Cities are expanding with
a corresponding reduction in rural populations, however the planning,
management and operation of cities is changing considerably from a decade
ago.

What then is the role of the surveyor in society in the future? This is the
dilemma educators face for the 1990's without even considering the next
century.

The reality is that it can take a decade from the time of a decision to
undertake a major review of a course to the time that the change fully
impacts on the community. Therefore the programs which educators design
today will have to satisfy the needs of the 21st Century.

These uncertainties for and demands of the future, highlight and exacerbate
the dichotomy in educating surveyors through achieving a balance between an
emphasis on science and land matters, the major strength and tradition of
the land surveyor. This dichotomy has been evident for most of this century
but has become particularly important over the last couple of decades and
will most certainly be a major issue in the future.

THE LAND MANAGEMENT AND MEASUREMENT SCIENCE DICHOTOMY

Surveying as a profession has always been closely tied to the land. In most
countries the cadastral surveyor has been the dominant professional
surveyor, certainly in numbers. Cadastral surveyors have been involved in
the full range of activities in the development and administration of land.
They have been traditionally involved in natural resource and environmental
management, generally at a practical and pragmatic level. In many countries
they are closely involved with urban and rural planning and land
consolidation. A primary activity of all land surveyors is the support of
land registration systems by undertaking and supporting necessary cadastral
survey and mapping functions.

At the same time surveyors have been equally involved in the science of
measurement in the broadest sense. This expertise has had application in
the measurement and mapping of the earth's surface (geodesy, photogrammetry
and mapping) and supporting the construction of engineering structures
(engineering surveys), to name a few of the surveyors' major activities.

It is this bridging between the sciences, measurement science and a full
understanding of spatial data, and land management and an appreciation for
the environment, that makes the surveying discipline special and unique;
this is the surveyors' competitive edge in the market place. It is this
ability which will maintain the strength of the surveyor and the use of the
surveyor to the broad community, in the decades ahead.

Educational institutions and professions around the world have taken
different approaches in designing education programs for surveyors which
address these needs. In general the European model makes surveyors
specialize in either the land or measurement science area. North America
(USA and Canada) has adopted a range of models ranging from specialist
programs in geodesy to generalized programs. It appears the most acceptable
and the most common model is to educate surveyors as "survey engineers". In
this case however the professional must satisfy professional engineering
standards which places some restriction on the flexibility of these
surveying programs. Within this model surveying usually has a heavy
measurement science bias however there are significant exceptions.
Australia however, has developed broad surveying programs which are usually administratively located in either engineering or science faculties. These programs have endeavoured to maintain a balance between measurement science and land however some programs have concentrated heavily on measurement science. The concentration on measurement science was influenced to a large degree by the growth of surveying programs in the 1950's and 1960's at a time when geodesy and national mapping programs were at their peak. The last decade has seen a swing back towards a land focus with particular emphasis on the management of spatial data in the broadest sense and land information management. However the greatest emphasis in all programs is still and will most probably remain, measurement science and the management of spatial data. This is the underlying foundation on which the land related studies build.

The dichotomy between measurement science and land related studies becomes increasingly evident when attempting to design education programs for the next century. With the expansion of knowledge, individual courses in programs are continually under pressure as to their relevance and necessity, particularly from the science and computing areas. Land related studies are easy to reduce, while at the same time the environment, natural resource management and land management (especially in urban areas) are becoming increasingly important.

The difficulty arises in not knowing what are the requirements of the surveying profession or the broad needs of the community for surveying expertise in the year 2000. What is certain however is that the courses we teach now and during the next decade will influence to a large extent the role and skills of the profession in the future. If the educators don't "get it right", they will be responsible for undermining the future role of the surveying profession while at the same time not serving the communities needs.

**CONSIDERATIONS IN DESIGNING A LAND SURVEYING DEGREE PROGRAM**

Considering the changing world and the obvious uncertainties facing the surveying profession, it is important to maintain flexibility as well as a good foundation of basic principles in any surveying program. Surveying programs should provide a range of career opportunities in measurement science (obviously including the range of surveying areas such as engineering surveying, hydrographic surveying, geodetic surveying etc), computing, land and geographic information systems, land management and administration, cadastral surveying and mapping, land development, environmental management and natural resource management. Surveyors should not necessarily be the experts in all these areas but it is highly desirable that they have sufficient background, confidence and skills to move into these areas, in many cases with the addition of further studies.

In designing surveying programs for the future there are a few important considerations:

(a) Measurement science as a discipline for surveyors is becoming more cohesive. Programs in the future will not be dominated by the three measurement science streams of geodesy, photogrammetry and plane surveying as separate entities to the same extent as in the past. Measurement science will however continue to be the major focus for surveyors but in a more cohesive form.
(b) A balance must be struck between the sciences, measurement science and the management of spatial data, and land management and an understanding of the environment. This is essential in order to maintain the surveyors' competitive edge.

(c) Technology has imposed necessary changes on surveying programs. For example the impact of the Global Positioning System (GPS) has necessitated fundamental changes to surveying practices, the least not being a reduction and in some cases a disappearance of disciplines such as classical astronomy and some of the more classical surveying techniques. Analytical photogrammetric instruments have had a similar impact on photogrammetry as has electronic distance measurement (EDM) on measurement practices. Arguably the biggest technological impact has been to computing with the development of "field to office" systems becoming the norm. Overall one of the significant impacts of these technologies on surveying education is a reduction in the expertise required for traditional field surveying techniques. It is a concern to many in the profession to see non-surveyors using EDM and GPS.

(d) The above changes and the need for flexibility has placed an increasing emphasis on basic principles and in particular the basic sciences. In particular there is an ever increasing requirement for a greater amount of computer science in surveying programs.

(e) While it is essential to design programs for the future, it is just as important that the present demands of the profession, industry and society are served. The requirements of Boards of Surveyors in Australia for example still need to be fully addressed although educators should be trying to influence the requirements of such boards to reflect future practices and to discard outdated requirements.

(f) The surveyors of the future will have to be skilled in the management of spatial data in the broadest sense. They should be the professionals with the technical expertise to understand the operation and data requirements of land and geographic information systems.

(g) Surveyors of the future should loose their "backwoodsman" image. They should become good managers and entrepreneurs in applying and marketing their skills.

A CASE STUDY - THE UNIVERSITY OF MELBOURNE

In the early 1980's the Department moved its emphasis from the traditional geodesy, photogrammetry and plane surveying focus to a greater emphasis on land information studies and the management of spatial information in the broadest sense. At the graduate studies and research levels the Department wished to consolidate its activities in land information studies and in its existing area of excellence of high precision measurement, particularly in the photogrammetric area. It wanted to also expand its already considerable linkages with industry.
The Department developed a five year plan which it commenced in 1986 to move in this direction. A major component of this plan was the implementation of a new undergraduate program. In order to achieve this objective the Department did a review of professional and community needs, at that time and in the future, attempted to assess future job prospects for surveyors, attempted to determine the type of professional required to serve those needs and fill those jobs, determined the skills required to meet those needs and then attempted to design a surveying degree which would provide the necessary education.

Considering the new direction of the Department towards land information management it became evident that the profession, industry and community required two programs; a modified four year Bachelor of Surveying program and a five year program with a major emphasis on computer science leading to the award of two degrees, namely the Bachelor of Surveying and the Bachelor of Science (Computer Science). These two programs were introduced in 1989 with a combined intake of 45 students. One of the hardest tasks however in designing these two programs was to get the right balance between basic sciences, measurement science and land related studies.

In recognition of the new direction and activities in land information management, the Department included "Land Information" in its name in 1987, and was designated in 1988 as a Centre of Excellence by the international Institute of Land Information based in Washington DC. The primary focus of the Department however still is and will remain "surveying", as reflected in the name of the department and the degree.

STRUCTURING THE UNDERGRADUATE PROGRAMS

Prior to 1989, the structure of the undergraduate course in Surveying at the University of Melbourne broadly followed the European model for surveyors wishing to specialise in measurement science. Its emphasis was on geodesy, astronomy and photogrammetry with a significant physics and mathematics content to support these studies. The study of land management and cadastral surveying was included but with less emphasis. The course was also influenced by the existing model in the Engineering Faculty at Melbourne in that the first (and to some extent the second) year was basically a study of science subjects - physics, mathematics, statistics and engineering technology. The treatment of material particularly identified with the particular profession tended to be left to the later years.

The move to a greater emphasis on land management and the management of spatial was associated with a recognition of a need to increase the time given to computer science both as support to the measurement science stream and as an integral part of courses in the management of spatial data. Thus, on the surface at least, it appeared that the problem of course restructuring would reduce to the selection of material in the existing course which could be discarded in order to make room for an enlarged study of land and spatial data management and computer science.

It should be recognised however, that new technology in the form of equipment, computers and software eliminates the need for some of the more traditional "teaching intensive" components of courses including astronomy, analogue photogrammetry, geodetic surveying and manual computations at all levels. Further, developments in technology has tended to render artificial the boundaries adopted both within the traditional divisions of photogrammetry and surveying and between the divisions as a whole. When viewed from the highest level, the significant differences between surveys using GPS, total stations, laser levels or photogrammetry is only in the mode of data acquisition. Their planning, reduction, evaluation and
presentation are increasingly becoming very similar computer processes. At a lower level, the once distinct topics of mining, hydrographic or route surveying should now not seen as separate extensions to plane surveying but merely applications of measurement science to which a whole array of techniques should be considered before choosing an optimum. This approach also obviates (and, in fact, militates against) the practice of teaching these topics at length early in courses. These can be treated more broadly, concisely and efficiently in the final stages of the course when students have an appreciation of a range of techniques both simple and complex.

By adopting the philosophy that technology has allowed the processes associated with plane surveying, astronomy, geodesy and photogrammetry to be treated as part of the one broad discipline of measurement science, significant savings in teaching time can be made. This is helped by the adoption of a topic course plan which promotes firstly, the identification of that fundamental theoretical material which supports many of the applications to be studied and secondly, the teaching of that material with rigour and in common. This reduces the need for repeated teaching of similar material as has happened in the past. In the case under study, it is believed that this approach has allowed the reduction of the percentage of time given to measurement science without its significance being compromised.

In other areas, compromises had to be made. As stated above, the first year of the existing course was designed as a foundation year in science. It included material, particularly in mathematics, statistics and engineering technology, which while not particularly relevant to surveying and mapping, was traditionally regarded as the broad and fundamental basis that was appropriate for any student embarking on a rigorous technical course. In designing a new course (and in some of its subsequent fine-tuning) it was realised that to accommodate new material on land and spatial data management, a more selective approach to the choice of basic science was required. In consequence, some science material was reduced (optics, geophysics) while the mathematics courses were selected to cover topics of more immediate benefit to measurement science. The latter action also paid a dividend of time saving in the planning the subsequent measurement science stream.

The approach brings with it an increased demand for the proper "sequencing" of topics as its effectiveness relies on the thorough and common teaching of fundamentals before the knowledge is needed in a subject where applications are treated. Thus care must be taken to select a sequence of teaching so that prerequisite topics have been covered before being needed in other subjects. The approach is also aimed at discouraging lecturers from indulging in the inefficient practice of reinterpreting and reteaching common fundamental material for their particular application.

At times, following this philosophy causes uncomfortable constraints on when particular material can be taught. For instance, in this case study, as the theory of least squares estimating is of such significance to many areas of the course, it is believed that it should be taught once, thoroughly and as a fundamental topic within a formal course of mathematics. Due to time table constraints within the Department of Mathematics, this material cannot be given until the third year of the course. As a consequence, topics in measurement science that rely on a deep understanding of the theory (e.g. network optimisation, testing, kalman filters) cannot be treated until very late in the course. This is not to say use cannot be made of the technique before consideration of the deeper theory. Experience has shown that first year students are more than ready to adapt to the use of network adjustment software to compute simple 2-dimensional traverses in preference to manual calculation.
The structure of the course as it existed before 1989, could be seen as consisting of the 3 clearly identifiable "streams" of mathematics/science, plane surveying/geodesy, photogrammetry/cartography. These were programmes of study that flowed through all years of the course with the material increasing in complexity with time. This very visible structure of measurement science was supported with a mixture of engineering, management and land related subjects.

The model adopted for the revised course was one of 6 streams covering all subjects. These streams are headed Mathematics and Science, Computer Studies, Surveying Science, Land Information Technology, Land Management and Professional Studies. The detail of the material contained in each stream is given in Table 1.

As can be seen from Table 1, the enhancement of the land management and the management of spatial data material was achieved by the introduction of the two streams of Land Information Technology and Land Management. Much of the material listed in these particular streams is not new to the course but had been covered in less depth and dispersed amongst measurement science subjects. The most significant areas where material on land related matters has been added is in the subjects concerned with land law and management, spatial analysis, computer graphics, remote sensing and land and geographic information systems.

<table>
<thead>
<tr>
<th>STREAM</th>
<th>COMPRISING SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics and Science</td>
<td>mathematics, physics, statistics, electronics</td>
</tr>
<tr>
<td>Computer Studies</td>
<td>computer science, programming, computer systems, computer graphics</td>
</tr>
<tr>
<td>Surveying Science</td>
<td>plane surveying, engineering surveying, geodesy, photogrammetry, geodetic surveying</td>
</tr>
<tr>
<td>Land Information Technology</td>
<td>cartography, spatial analysis, remote sensing, land and geographic information systems</td>
</tr>
<tr>
<td>Land Management</td>
<td>land law, cadastral surveying, land development and administration, land economy, town planning, ecology, geology, environmental assessment</td>
</tr>
<tr>
<td>Professional Studies</td>
<td>written, verbal and graphic communication, economics, project planning, minor thesis</td>
</tr>
</tbody>
</table>

Table 1. Subject streams in revised (1989) B. Surv. course.
Table 2. indicates the percentage of time allocated to each of the streams over each of the four years of the revised course. Comparative figures for the course as it existed prior to 1989 are given in Table 3.

<table>
<thead>
<tr>
<th>Stream Year</th>
<th>Maths &amp; Science</th>
<th>Computer Studies</th>
<th>Surveying Science</th>
<th>Land Info Tech.</th>
<th>Land Manag'nt</th>
<th>Profess Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>14</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>25</td>
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<td>25</td>
<td>24</td>
<td>22</td>
<td>4</td>
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<td>20</td>
<td>17</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>9</td>
<td>36</td>
<td>13</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>16</td>
<td>24</td>
<td>9</td>
<td>17</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 2. Percentages of times given to subject streams for each year and total of the revised (1989) B. Surv. course.

<table>
<thead>
<tr>
<th>Stream Year</th>
<th>Maths &amp; Science</th>
<th>Computer Studies</th>
<th>Surveying Science</th>
<th>Land Info Tech.</th>
<th>Land Manag'nt</th>
<th>Profess Studies</th>
</tr>
</thead>
<tbody>
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<td>3</td>
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<td>0</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>4</td>
<td>31</td>
<td>0</td>
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<td>4</td>
<td>32</td>
<td>10</td>
<td>24</td>
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</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>4</td>
<td>29</td>
<td>5</td>
<td>13</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 3. Percentages of times given to subject streams for each year and total of the B. Surv. course prior to 1989.

The combined surveying/computer science degree runs over five years and includes, in the first 4 years, most of the material covered in the single degree but with a more extensive computer science stream. The fifth year contains advanced measurement science and computer studies. The latter is aimed at information technology and the management of spatial data.

It is recognized that both these programs are new and will need modification over the next few years. However the overall structure is now in place such that improvement is relatively easy. The Department believes the new programs 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 needs of the surveying, mapping and land information industry.

6. THE GRADUATE PROGRAM

The undergraduate programs are designed to support the graduate program particularly through the good grounding in the basic sciences and computer science within a broad land management environment. The graduate program at the Masters and Doctorate levels are directed mainly at the two areas of land information systems and high precision measurement although it includes applications of GPS technology, particularly in LIS/GIS.
A nine month graduate diploma in geographic information systems has been introduced in 1991 which is managed by a new Centre for Geographic Information Systems and Modelling, a joint initiative between the Department of Surveying and Land Information and the School of Environmental Planning. The graduate diploma will draw on the strengths of the above departments as well as other parts of the University in such areas as computer science, agriculture, forestry, geography and engineering.

An important objective of the graduate diploma is to bridge the gap between science and technology, and land related studies, as well as provide a relatively short coursework graduate program.

7. CONCLUSION

The surveying profession is undergoing major change due to the influence of the information society, technology, the environmental agenda, a difficult economic environment and the general pressure that many professions find themselves facing from government and society to justify their existence. Within this environment educators are finding it difficult to design appropriate programs such that the needs of the profession and society will be well served into the next century.

In designing programs, educators are finding it increasingly difficult to fit all the necessary subjects into a degree program. The traditional problem and dichotomy of maintaining an appropriate balance between measurement science and land studies becomes increasingly difficult. Since measurement science is the underlying foundation of the discipline it is usually the land studies which are under greatest pressure to be reduced. However to a large extent the strength and competitive edge of the surveying discipline comes from its ability to bridge between science and land matters.

Unfortunately there is no ideal model for a surveying degree however the experiences of the Department of Surveying and Land Information at The University of Melbourne suggest that it is important to maintain or increase emphasis on the basic sciences, increase emphasis on computer studies, move towards the management of spatial data in the broadest sense, maintain a strong program in the land related subjects, but most importantly maintain flexibility and a range of career options for the next generation of surveyors.

Note: This is an expanded and updated version of a paper presented to the XIX International Congress of the FIG in Helsinki in 1990.
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