THE CHALLENGE OF PROVIDING PHOTOGRAMMETRIC EDUCATION FOR THE 21st CENTURY

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ABSTRACT:

In recent years society has been undergoing fundamental restructuring brought on by extensive technological change. Almost all professional communities, including the photogrammetric community, have been affected. While the wider community is embracing digital techniques at a staggering pace, photogrammetric organisations, with a few exceptions, are generally using analytical or analogue instruments and methods. In addition the Surveying and Mapping profession has embraced and absorbed the domains of GIS/LIS and remote sensing. The challenge to the education institutions is to provide the necessary education now which will equip students with the knowledge, interest and training which will support them throughout their professional lives. This paper reviews current photogrammetric syllabi in two Australian Universities and suggests an approach to ensure photogrammetric education will be relevant and important as the world moves into the 21st century.

KEY WORDS: Photogrammetry, Remote Sensing, Education, Training.

1. INTRODUCTION

Technological change is fundamentally altering the nature and workings of many aspects of society. Photogrammetry along with many other disciplines has been swept along by this change. Techniques and equipment used for many years are suddenly obsolete. Computer technology is providing new solutions and redefining the nature of photogrammetry itself.

The key to acknowledging, understanding and accommodating this change is the educational process. This paper will consider the future of photogrammetry from the perspective of the educationalist. In doing this a case study involving two Australian Universities will be used.

2. INSTITUTE BACKGROUND

2.1 *Royal Melbourne Institute of Technology (RMIT)*

Surveying has been taught at the RMIT since the early 1930's A formal professional course (the Associateship Diploma in Land Surveying) commenced in 1954 and was soon followed by the Associateship Diploma in Cartography. Fellowship diploma programs were introduced in 1962 and in 1964 the Department of Land Surveying was formally established. In 1971 the three year course leading to the Bachelor of Applied Science (Surveying) commenced and in 1975 the Diploma of Applied Science (Cartography) replaced the Associateship Diploma in Cartography, this later became the Bachelor of Applied Science (Cartography).

In 1989 the Department (whose name was changed (1987) to Land Information rather than Surveying) introduced a new four year degree program entitled Bachelor of Land Information with streams in Surveying and Cartography. The Department also conducts a Graduate Diploma in Land Data Management, a Master of Applied Science (by coursework), a Master of Applied Science (by research) and Doctoral programs.

The Department is, together with the School of Surveying at UNSW, the largest of its kind in Australian tertiary institutions.

2.2 *Queensland University of Technology (QUT)*

The Bachelor of Applied Science (Surveying) course within the Department of Surveying, Faculty of Engineering of the then Queensland Institute of Technology commenced in 1974 as a six year sandwich course. The course was extremely popular with the Surveying Profession and continued in this form until 1986. It was then changed to a 3 year full time Bachelor of Applied Science with strands in Surveying and Cartography as part of an agreement with the University of Queensland to rationalise surveying education in Queensland. Undergraduate education became the responsibility of the QIT and post graduate education the responsibility of the University of Queensland. (This arrangement has been discontinued in 1992).

In 1989 the Queensland Institute of Technology (QIT) became the Queensland University of Technology (QUT). In 1990 the Department of Surveying became the School of Surveying within the Faculty of Built Environment and Engineering on the restructuring of the University following a merger with two Colleges of Advanced Education in Brisbane. The School is a Founding Member of the Australian Key Centre in Land Information Studies.

In addition to the undergraduate program the School offers a Graduate Diploma in Surveying Practice and a Double Degree in Surveying/Business. The School does not currently have a formal Masters Program but has offered Doctoral Programs since the Institute became a University.

3. THE STUDENTS

Graduates of the RMIT Department of Land Information and QUT School of Surveying enter into a diverse range of employment. It is no longer the case that all graduates take up positions in Surveying or Cartography.

However, the bulk of graduates (some 60% to 80%) still find employment in the traditional private practice areas of cadastral and engineering surveying. Placements are mainly with private surveying firms but also with government departments and large industrial organisations. The other graduates are absorbed into fields such as GIS, photogrammetry, remote sensing, computing and mine surveying.

One graduate every few years goes specifically into photogrammetry, but these graduates are usually from the top 10% of their class. However, it is almost inevitable that all graduates entering the traditional areas will be associated with photogrammetry via mapping at some time through their professional career. In most cases this is through the provision of ground control.

At RMIT photogrammetry is also offered as an elective to other courses. Landscape architects, photography students and engineers are amongst the groups studying photogrammetry. Photogrammety is also part of the service teaching at QUT, the engineering group is by far the biggest with class sizes typically over 100. The engineering students are potentially the most important user group that receive service teaching. Along with traditional surveying they are exposed to photogrammetry as an efficient method of calculating volumes (Queensland has a large open cut mining industry), providing infrastructure mapping and so on.

4. EDUCATION AND TRAINING WITHIN A UNIVERSITY.

It is occasionally difficult to distinguish between education and training because in many ways the two aspects are complementary. However, an education implies a knowledge base and the ability to think and solve problems and is useful throughout one's professional life time.

Training on the other hand suggests practical skills and ability with a relatively short life, particularly in a rapidly changing world.

Education is generally seen as the domain of academic institutions while training is considered to be the responsibility of individual organisations who know what is best for their particular circumstances.

From a teaching point of view a certain amount of training helps to emphasise, reinforce and consolidate theoretical aspects. Training builds students' confidence and makes them more desirable (in the short term at least) to the profession who will employ them.

Both the RMIT and the QUT have achieved a balance between education and training which makes graduates from these institutions highly marketable. The challenge is to maintain a correct balance for photogrammetry in the years to come.

5. AVAILABLE RESOURCES.

Restricted financial resources due to the economic conditions currently prevailing in Australia have resulted in large class sizes and an inability to afford sufficient and up-to-date equipment. This of course has the affect of diminishing the effectiveness of the educational process. The future is not likely to see this circumstance changing in any significant way. Thus if students are to be properly taught, appropriate policies need to be developed which will overcome these problems. Ideas such as changing the means by which students are taught and seeking financial resources from non-standard sources are examples of the approaches that need to be considered.

6. CURRENT PHOTOGRAMMETRIC SYLLABI

6.1 *RMIT*

LD219 Photogrammetry and Remote Sensing 1 (for 2 semesters)

Contact Hrs/Week:	3hrs
Lecture - Photogrammetry	1hr
Lecture - Remote Sensing	1hr
Pracs - RS & P	1hr

Involves 26 hrs. of practical work which is implemented by students undertaking 2 hours practical sessions in small groups. 6 x 2hr. projects are undertaken in photogrammetry.

Practical content includes introductory work related to stereoscopic viewing and measurement and calculation on assumed vertical photographs, image interpretation exercises and problem solving related to the material presented in lectures.

LD319 Photogrammetry and Remote Sensing 2 (for 2 semesters)

Contact hrs/Week:	4hrs
Lecture - Photogrammetry	1hr
Lecture - Remote Sensing	1hr
Pracs - RS & P	2hrs

Involves 52 hrs. of practical work. Of this 26 hrs. are related to photogrammetry.

Practical work currently includes some analogue photogrammetry (setting up of models and plotting), some analytical photogrammetry (mainly problem solving) and practical utilisation of terrestrial photogrammetry.

6.2 *OUT*

SVB343 Photogrammetry 1 (for 1 semester)

Contact Hrs/Week:	3hrs
Lecture	2hrs
Pracs/tuts	1hr

Introduction to Photogrammetry; photogrammetric optics; aerial photography; geometry and use of single photographs; geometry and use of stereogram.

The subject is structured and uses computer based education CBE packages for both photogrammetry and remote sensing. Practicals include 1: instrument use and 2: object reconstruction by manual digitising of student acquired photography and use of existing photogrammetric software.

SVB443 Photogrammetry 2 (for 1 semester)

Contact Hrs/Week:	6hrs
Lecture	2hrs
Pracs/tuts	4hrs

Principles of construction; operation of analogue and analytical stereoplotters; aerial triangulation; terrestrial photogrammetry; analytical photogrammetry.

Practical work involves carrying out a complete mapping exercise from ground control through aerial triangulation to producing a digital map.

SVB643 Photogrammetry 3 (elective) (for 1 semester)

Contact Hrs/Week:	3hrs
Lecture	1hr
Pracs/tuts	2hrs

Numerical relative and absolute orientation; independent model and bundle methods of block adjustment for triangulation; close range photogrammetry including non conventional techniques; analytical plotters including generation, manipulation and storage of digital data; use of micro and mini computers in analytical photogrammetry.

The subject is project based with emphasis on independent student learning.

7. EVOLUTION OF PHOTOGRAMMETRY

The advent of photography in the mid 1800's was the necessary precursor to the development of photogrammetry. The potential for the use of photography as a measurement tool was apparent from the earliest days of photography but it was some time before the many technical problems were overcome and reliable solutions were possible.

Early applications of photogrammetry were largely terrestrial. The first stereocomparator was constructed by Pulfrich in 1901 and the first stereoplotter was developed by Von Orel in 1909. For the next 60 years, these analogue instruments, which sought to mechanically reconstruct the photogrammetric model, were the mainstay of photogrammetry. During this time, the use of aircraft as camera platforms moved from being feasible into the realm of accepted practice, and mapping from aerial photography using analogue instruments became the dominant form of photogrammetric activity.

As the mathematics of photogrammetry became better understood, more analytical solutions were sought to the photogrammetric problem. The formulation of the collinearity equations was the birth of analytical photogrammetry but is was not until high speed electronic computers became available that analytical solutions became viable.

Analytical stereoplotters, which were free from the constraints of their analogue counterparts, have been readily available for less than twenty years. In addition to freedom from mechanical constraints, analytical instruments have significant advantages in performance and accuracy over analogue solutions.

The relentless advance of computer technology has lead in recent times to the development of digital photogrammetry. The availability of high resolution scanning systems and high performance graphics workstations has enabled full digital or softcopy photogrammetric workstations to become a reality. The first commercially available/viable systems have only been on the market in relatively recent times.

8. FUTURE TRENDS IN PHOTOGRAMMETRY

Predicting the future, particularly in an era of rapid change, is always difficult because one tries to visualise quantum leaps in systems and technology and this is always dangerous. In his paper *Teaching in Photogrammetry* (Harley, 1977) Harley discusses many things, most of which are just as relevant today as they were then. For example he foresaw great change and associated pressures and difficult times for educational institutions; foresaw the need for real cooperation for small professions or disciplines to survive and the paper even contains the phrase "the world is going digital".

More recent writers such as Gugan (Gugan, 1989) identified or predicted a trend towards the increasing sophistication of systems and the need for modular components with simple interfacing in order to manage such systems efficiently and effectively. He also thought that data storage and manipulation and interfacing between peripherals would perhaps become more important from an operational point of view than the technical aspects of the analytical plotter itself. And of course he predicted an increasing use of digital systems. Leberl (Leberl,1992) has suggested that with the coming of digital or softcopy photogrammetry the academic home for photogrammetry may be better in computer science. This is a problem which also has to be addressed.

Over the past few years close range measurement has been attracting a lot of interest and activity particularly for industrial measurement. The trend here is towards automation and turnkey systems (Shortis and Fraser, 1991) and does not necessarily mean an increase in activity for photogrammetrists.

However, there are some predictions or trends which the authors believe to be fairly reliable. We live in a digital age and can expect to continue to do so for quite some time. As reported in Ghosh(Ghosh, 1988) "Recent United Nations' Studies 1983 on the status of mapping in the world ..... indicate that photogrammetry has reached an effective level of efficiency and would remain for years to come the most efficient base technique for producing topographical and other maps with the use of aircraft and satellite base imageries". We can conclude that digital photogrammetry (in one form or another) will be the way of the 21st century.

Rapid technological change and the consequences of that change have had profound affects on academic institutions.

Some of these trends and their consequences have been:

* Equipment becomes obsolete after a short period of time and replacement costs are often prohibitive.

* Much modern hardware and software involves the necessity of maintenance contracts. These are often expensive and recurrent rather than a once only cost.

* As course content becomes obsolete and new knowledge and methods emerge, there are significant pressures and stress on staff to be able to relinquish the teaching of the obsolete, recognise the emerging trends and become competent and able educators in the constant flow of new (and old) knowledge.

* The problem of teaching now to students who will graduate in 3 or 4 years time. The rapid rate of technological change could very well make current knowledge of limited value to the prospective graduate.

* The breakdown of the concept of disciplines has meant that undergraduate programs are becoming more multidisciplinary and generalist. As such, photogrammetry may become the domain of a wider range of undergraduate courses with detailed study becoming the domain of postgraduate studies.

These, and other problems, mean that we must take stock of our current techniques and methodologies. To effectively educate in the modern era we must question assumptions that we have held for many years. The problems and difficulties arising out of the current process of rapid change do need to be faced. We do have to resolve the difficulties outlined above. We cannot turn our back on change, if we were to do this then other groups, accepting of change, would soon make us irrelevant and obsolete. By addressing the challenges and developing innovative solutions to difficult problems we will, hopefully, retain our relevance and purpose.

9. PHOTOGRAMMETRY, REMOTE SENSING AND GIS/LIS. IS A NEW NAME JUSTIFIED?

In 1980 the then International Society for Photogrammetry (ISP) changed its name to the International Society for Photogrammetry and Remote Sensing (ISPRS). This change reflected the evolution of interests and activities of the members and of the discipline area. The ISPRS journals of the 1980's are dominated by articles on remote sensing even though pure photogrammetry articles have always appeared regularly.

The formal ISPRS definition of photogrammetry and remote sensing

> "Photogrammetry and Remote Sensing is the art, science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting imagery and digital representation thereof derived from non-contact sensor systems"

is an appropriate one and reflects the natural integration between photogrammetry and remote sensing.

In recent years the number of articles on Geographical Information Systems has been on the increase with the same evolutionary trend as was the case for remote sensing of the late 1970's. The integration of the three areas of photogrammetry, remote sensing and geographic information systems is very neatly linked through digital or softcopy photogrammetric systems which are now commercially available.

Perhaps it is again time to change the society's name to the International Society for Photogrammetry, Remote Sensing and Geographical Information Systems. Such a long name would be a true description of the current situation but for most cases the name is just too cumbersome.

The recently formed Department of Geoinformatics at the Institute for Aerospace Survey and Earth Sciences (ITC) reflects the growing integration of technologies in the geoinformation process and the need for cooperation between the various components of the surveying and mapping discipline. The former departments of Photogrammetry, Aerial Survey and Remote Sensing have been reorganised into the division of Aerospace Data Acquisition and Photogrammetry and the division of Image Processing of Remotely Sensed Data. These two new groups together with the former department of Cartography and a newly created Applied Information and Computer Science group have become divisions of the newly formed department (ITC, 1991). The names of photogrammetry and remote sensing have been retained in the structure but not at the primary level.

Laval University in Canada uses the term Geomatics to describe the integration of disciplines. The name, while incorporating photogrammetry and remote sensing, gives the information aspect the emphasis with the following definition as reported by Groot (Groot, 1991):

> "Geomatics is the field of scientific and technical activities which, using a systemic approach, integrates all means used to acquire and manage spatially referenced data as part of the process of producing and managing spatially based information"

Leberl in his paper *Towards A New Photogrammetry* (Leberl, 1991) concentrates on contents of the photogrammetric discipline rather than favouring a particular name although he refers to a range of those being used or proposed. He presents the view that the technological and scientific basis of digital or softcopy photogrammetry can be defined by computer science and that it is the application only that provides for the survival of the discipline within Surveying and Mapping. Leberl also expresses the opinion that photogrammetry will continue to survive and possibly find broader acceptance, whatever the name and in whatever academic context.

In his paper *From Photogrammetry to Iconic Informatics* (Li, 1992) Li reviews the development of photogrammetry and remote sensing and the increasing combination and integration with geographic information systems. The conclusion he draws is that photogrammetry has now passed on from a classical geometric science to the domain of information science. Li reports that Professor Wang of China has suggested on numerous occasions the term Iconic Informatics, a branch of modern information science, as the new name. A definition of Iconic Informatics is as follows (Li, 1992):

> "A discipline concerned with the recording, storage, measurement, processing, interpretation, analysis, administration, presentation and display of the image data and information of physical objects and their environments acquired by non-contact sensor systems".

The components and flowchart of iconic informatics from Li's paper is reproduced here as it very neatly shows the comprehensive relationship between photogrammetry, remote sensing and geographical information systems in a graphical format.

The name "photogrammetry" is well established and well understood within the Surveying and Mapping community. This ISPRS Congress is testimony to that. Any name change will refer more to the combined disciplines of GIS/LIS, remote sensing and photogrammetry together with certain aspects of computer science rather than referring to photogrammetry specifically.

The undergraduate courses at both RMIT and QUT are about surveying and cartography. Photogrammetry forms part of these courses and is not a degree course in itself. Accordingly, the authors are of the opinion that, at least for the time being, "photogrammetry" or "photogrammety and remote sensing" should be retained to describe the discipline area.

How the subject should be taught and incorporated into the courses is a different matter and is discussed under Teaching Strategies.

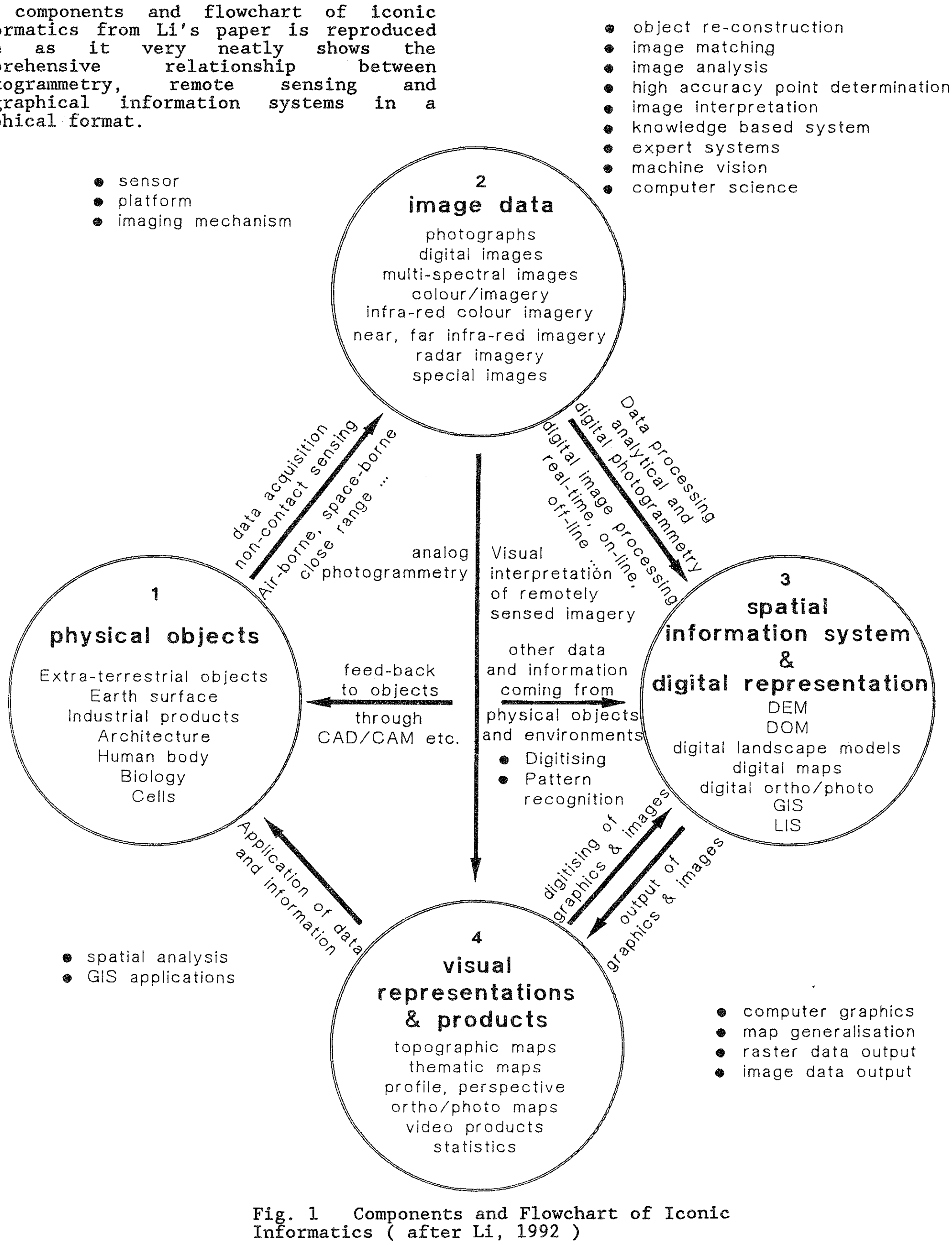

Fig. 1 Components and Flowchart of Iconic Informatics (after Li, 1992)

10. TEACHING STRATEGIES

It is interesting to compare the points made above with those presented in *Teaching in Photogrammetry* (Harley, 1977). Many of the points raised by Harley have exact parallels with the situation today.

Harley talks of the difficulties presented by the rapid change in technology, inadequate funding, obsolete equipment and large class size. Perhaps all that has changed is the magnitude of the problems.

In such an environment, academic institutions cannot hope to provide courses structured around the latest technological advances. Nor is this necessary. In terms of an undergraduate course the main emphasis must be on education. Photogrammetry will continue to form a part of the broad education provided by Land Information/Surveying courses.

The issue of what to teach is more difficult. Many of the basic principles of photogrammetry will remain unchanged, despite advances in technology. It is important that students have a firm grasp of the mathematical formulations involved in model formation, collinearity and block adjustment. As technology and systems improve, some aspects of traditional photogrammetry will diminish in importance. Groot (1991) points to a decrease in the importance of the technical aspects ("hand skills") in photogrammetry and related disciplines. This suggests a change in emphasis for practical aspects of curricula from developing basic skills in photogrammetric measurement to developing skills in the interpretation and use of the results. As the digital age appears to be upon us, these skills will include some of the traditional aspects of photogrammetry, coupled with image processing, statistics and error theory. Groot (1991) also suggests that a change in skills should be accompanied by a shift in focus from a problem solving to a 'problem identification' approach.

The advances in digital and softcopy photogrammetry have paralleled and in part been driven by the broader areas of image processing, machine vision and robotics. Particularly in close range photogrammetry, the development of the three dimensional robotic vision has at times re-invented the concepts of close range photogrammetry.

Leberl (1992) argues that the future of photogrammetry therefore lies, from an academic view point, in the hands of computer science. In terms of pure research, this argument appears to have some validity but perhaps this is not of great concern. Our interest and strength should lie in the application of these technologies to our particular discipline.

In many ways, the advances in digital systems could be considered in the same light as advances in film resolutions and sensitivities, camera systems and lens. In many cases, the research for these advances was not the province of photogrammetry but was eagerly adopted as soon as it was available. These were enabling technologies that opened up new possibilities or shifted the boundaries of conventional practice. The advances in digital systems are likely to do the same.

The advances in digital systems also offer new possibilities for education. These systems will inevitably become cheaper and more accessible. Low cost, low accuracy systems are likely to be developed which could be employed in teaching environments.

The shift away from "skills based" learning and into "problem based" learning is also accommodated by the advances in computer technology. Many sophisticated data reduction and analysis programs are now available relatively cheaply and can be used to introduce students to the use of photogrammetry to solve real world problems.

11. CONCLUSION

In this paper the experiences and methods of teaching photogrammetry at two Australian Universities have been cited. Lack of resources, large student numbers and the rapid rate of technological change were common problems identified by both Universities.

History tells us that none of these problems are new, nor are they unique to photogrammetry. However, it does appear that the rapid advances in digital techniques are pushing photogrammetry towards a new threshold which may change its fundamental nature and practice.

The challenge for educational institutions is to provide students with a syllabus which is relevant to today's world and equips them adequately for the future.

The computer, as a catalyst to rapid change, also offers opportunities to develop new teaching methods and aids in the form of PC-based learning packages, cheap softcopy photogrammetric workstations and turnkey data processing systems.

The paper also advocates a move away from 'skill-based' learning and into areas of problem solving and problem identification. The linking of photogrammetry with the related disciplines of remote sensing and GIS/LIS in a problem solving environment is one method of developing these skills.

In the final analysis, an ability to think, to question, to enquire and to learn, coupled with a solid foundation in the basic subject matter is the best we can hope to give our students and should be all they need to cope with the changing world in which they find themselves.

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