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ENHANCED TEACHING AND LEARNING IN SPATIAL SCIENCE COURSES

Mark Shortis[1] and William Cartwright[2]

[1]Department of Geomatics, University of Melbourne, AUSTRALIA, m.shortis@unimelb.edu.au
[2]Department of Geospatial Science, RMIT University, Melbourne, AUSTRALIA, w.cartwright@rmit.edu.au

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ABSTRACT:

Educators at all levels, but particularly tertiary, are embracing techniques such as curriculum transformation, the provision of online information and the introduction of multimedia delivery to improve learning by students and gain greater efficiencies in teaching. Curriculum transformation, online information and multimedia delivery can be intimately intertwined to provide a resource-rich environment for learning for a single tutorial, a subject or an entire course at undergraduate or postgraduate level. Many such multimedia "products" are developed as a reference for course-wide application, professional development or even lifelong learning as an additional aim. This paper will identify the primary issues, techniques and implementations of the new technologies and new techniques for enhanced teaching and learning with particular emphasis on disciplines drawn from the spatial sciences.

1. INTRODUCTION

During the last several years a number of factors have combined to encourage, and indeed force, the adoption of new teaching and learning methods in tertiary education. Not least of these has been the developing awareness that the volume and complexity of the available information in any discipline has been increasing rapidly, along with demands by employers for graduates with high levels of design and communication skills. A total catalogue of information and other skills cannot be embraced within a four year, single degree course, nor combined degree courses of longer duration.

In many universities an added problem has been that courses in the scientific disciplines have been considered to be "over-teaching", particularly in comparison to courses in commerce, law and arts, which are often the other component of a combined degree program. As a consequence, some courses have been totally re-designed with substantially fewer contact hours. For example, at the University of Melbourne all courses in engineering have been restructured from an average of around 25 contact hours per week in the early 1990s to the current level of 16 contact hours per week. A further rationale for these changes is uniformity of subject units across the university (the majority of faculties have adopted a common scheme of 8 subjects, each of 12.5 points, per year), allowing greater scope for students to enjoy a broad tertiary level education through elective units or other mechanisms

The third significant factor has been a climbing student to staff ratio, as universities and departments attempt to maximise the diminishing incomes from government sources and simultaneously accept more fee paying students. For example, the Faculty of Engineering at the University of Melbourne has increased the number of students in engineering and geomatics courses from 1600 in 1990 to 3300 in 2000 accompanied by little if any increase in the number of teaching staff. The Faculty had a staff to student ratio of 1:18 in 2002, however this ratio is expected to remain stable as the Faculty intends to increase the proportion of fee paying students from 30% to 40% over the next five years without any overall increase in student numbers. The additional income generated from the growth in student numbers and increasing numbers of fee paying students has more often been directed to deal with the physical limits of the infrastructure available for teaching, such as computer laboratory space. The natural response is to make efficiency gains wherever possible in teaching, in order to sustain consistent levels of teaching resources whilst teaching ever larger classes.

The reactions of tertiary educators to address these issues have been mixed, with many opting for streamed or specialised courses to reduce the amount of information delivered to large student cohorts. Particular universities with a reputation for a particular bias in a course have stressed the bias, for reasons of both specialisation and marketing. However this response has typically been used in concert with computer based learning remedies which take full advantage of recent developments in computer technology and the rapid spread of the Internet. University academics are embracing techniques such as curriculum transformation to improve the learning of generic skills, the provision of online information resources to compensate for fewer contact hours and the introduction of multimedia delivery to improve the efficiency of teaching.

2. DELIVERY MECHANISMS

Cartwright *et al*. (1998) proposed the term 'hypereducation' as a generic term for the delivery of virtual educational programmes employing flexible media as the primary agent for learning. The new, flexible delivery media for education programmes can be generally classified into three distinct multimedia tool types:

- Tactile multimedia;
- Discrete multimedia; and
- Distributed multimedia (Cartwright, 1999b).

Tactile multimedia are those media elements that can be touched, held, folded, annotated by hand and generally used for personal information researching. It includes things like paper maps and atlases, books, photograph albums, sketches, audio tapes, video cassettes, plan presses full of maps and supportive documentation, and reams of original data collection forms and print-outs. If flexible delivery is assumed to still require the use of the post (for some areas of the world), then this form of multimedia must be included in any flexible delivery 'toolbox'. Many distance education courses still rely on discrete

multimedia to deliver content, especially lectures on videotape. Also, a number of courses rely on audio cassettes to provide students with access to adjunct materials, especially in language classes. The Open University has traditionally used tactile multimedia in its distance education course. In 1995 it printed over 30 tons of paper materials per week, shipped over 34,000 special equipment kits, around one million audio cassettes, over 100,000 video cassettes and over 350,000 computer disks (Cartwright *et al*., 1995).

Discrete multimedia is products made available through the use of isolated computers regardless of whether they are desktop, notebook or personal assistant. The packages made available are stored in digital form on floppy disk, hard disk drive, optical disk, videodisc or computer tape. Discrete multimedia forms the core for multimedia development and it is an essential component of producing any product. Discrete multimedia can also be sent by post, complementing tactile multimedia products. Computer laboratories often rely on discrete multimedia teaching packages, sometimes supplemented by distributed learning resources. Multimedia and hypermedia were adopted very early as tools for the development of discrete learning packages or producing learning packages linked to an existing or generic GIS. Some of the packages that have were developed very early for the geosciences were GISTutor II (Raper and Green, 1989), UGIX (Linsey and Raper, 1993), CoastMAP (Romão *et al.*, 1999) and Learning Station (Cornelius *et al*., 1994). Other examples are the Ordnance Survey of Northern Ireland (OSNI) and Northern Ireland Education Support Unit (NIESU) GIS teaching CD-ROM for secondary geography students (Galloway, 1996), the multimedia GIS developed to educate naturalists at the Faculty of Forestry, Warsaw Agricultural University (Olenderek *et al*., 1996) and the web-delivered GIS tutor in the Department of Geography at the University of Victoria, Canada (Keller *et al*., 1995).

A more recent discrete product is Geoskills, a CD-ROM package developed at the School of Human and Environmental Studies the University of New England (Jones, 2000). The CD-ROM provides an overview of mapping skills and more detailed information about types of maps and remote sensing.

Finally, distributed multimedia uses communication resources to link computers locally or internationally. Multimedia packages are delivered either using intranets, computers linked internally, say in agencies or corporations using the standard access methods of all distributed multimedia, or through the use of the Internet, whereby the World Wide Web with appropriate 'browsers' and 'plug-ins' is used to access hyperlinked multimedia resources.

Many courseware products are now available on-line and the sheer number available makes it impossible to provide a comprehensive list of even those that fall loosely into the category of geospatial science. However, some of these can be used as examples to illustrate the range of products. For instance, students of geography nowadays have access to a myriad of resources for studying this discipline. On-line resources are perhaps the most easily accessed:

- K-12 Internet Resources for Geography Education from the South Carolina Geographic Alliance. See www.members.carol.net/josh/geoindex.html. This site provides lesson plans and links to resources.
- Mapping the world by heart provides online resources, links, tools, maps, books. See www.mapping.com
- Quick Time virtual field trips. See www.uh.edu/~jbutler/anon/quick.html
- Geography – About the Human Internet – a general geography information resource that includes information about cartography. See geography.about.com/science/ geography/

There are also many products available online that are more specific to cartography:

- The history of cartography project. See feature.geography.wisc.edu/histcart/
- Mental Maps (MMap) is a program that allows students to test their knowledge about the location of cities. See geosim.cs.vt.edu/mmap.html
- The National Geographic Society's Geography Education Program. See www.nationalgeographic.com/resources/ngo /education/ideas.html
- Human Cognition of the Spatial World is part of the NCGIA Core Curriculum in Geographic Information Science. See www.ncgia.ucsb.edu/education/curricula /giscc/units/u006/u006.html
- The Open University on TV - Open2.NET, an OU/BBC enterprise. See www.open2.net
- Cartography and Geographic Information Systems Laboratory, Department of Geography / Geology, University of Nebraska at Omaha. See maps.unomaha.edu/demo/demo.html
- City University's Department of Information Science introduced their on-line Master of Geographic Information program in 2000. See www.city.ac.uk/pgrad/informatics /geographic.htm It also can be completed entirely on-line, although a face-to-face program is also offered. The fees are the same of both courses.

Recently a number of packages have been developed for the geospatial sciences in Australasia:

- The University of Southern Queensland's 'USQ Online', which provides web-facilitated education for students from 45 countries. 2,500 students were undertaking 200 on-line courses in 1999 (Hilsberg, 1999).
- Curtin University of Technology's School of Spatial Sciences Graduate Certificate in GIS. The course can be undertaken as 'standard' contact classes or Internet-delivered course programmes. See www.cage.curtin.edu.au/gis
- The Faculty of Engineering and Surveying, University of Southern Queensland's Graduate Certificate in Geomatic Studies (GIS) through the Faculty of Engineering and Surveying. The program components are delivered via the Internet and email (McDougall *et al*, 2001).
- Geoskills, a CD-ROM package developed at the School of Human and Environmental Studies the University of New England (Jones, 2000).
- RMIT University - A Web-Based Package for Student-Centred Discovery of Satellite Differential Positioning in Typical Australian Environments.
- RMIT University - a multimedia learning package for map projections. Understanding Map Projections (Cartwright, 1999).

- RMIT University – on-line modules in Geography via the Distributed Learning System (DLS).
- The University of Melbourne, Department of Geomatics Engineering - Plane Surveying project (Shortis *et al*., 2000).
- The University of Melbourne, Department of Geomatics Engineering - GIStutor project (Zerger *et al*., 2000).
- The University of Melbourne, Department of Geomatics Engineering - Survey Network Simulations project (Shortis and Woodhouse, 2001).
- The University of Melbourne, Department of Geomatics Engineering – Navigation and Positioning and Integrated Systems projects (Shortis *et al*, 2002).
- Massey University, New Zealand provides extramural study for New Zealand citizens and permanent residents. International students are not currently eligible. See extramural.massey.ac.nz

There exist a number of overseas universities who see the English-speaking world as their marketplace for web-delivered programs. The Open University (See www.open.ac.uk) has been a provider of courses to many disciplines, including geography. In 1999 it began a Pacific Studies course provided on CD-ROM, with the possibly of newer technology being taken on board as the course progressed. Whilst not yet critical, there are some universities, like Birkbeck College at the University of London that provides a web-delivered course for the spatial sciences globally. It offers a Master of Science program in Geographical Information Science by Distance Learning (see See www.bbk.ac.uk/study/pg2002/geography). The course is Internet-delivered and there is no attendance at Birkbeck required at any stage during the course. It is offered one year full-time or two years part-time and consists of coursework plus a dissertation.

Looking specifically at programs offered in the USA, a recent announcement from the Massachusetts Institute of Technology (MIT) shows how this university's initiative will promote further use of the web for program delivery. In an official announcement on April 4, 2001 the MIT President, Charles M. Vest stated that the University would make its materials for nearly all of its on-line courses freely available on the Internet over the next ten years (See web.mit.edu/ocw/). In a statement from the University it was noted that: "The idea behind MIT OpenCourseWare (MIT OCW) is to make MIT course materials that are used in the teaching of almost all undergraduate and graduate subjects available on the web, free of charge, to any user anywhere in the world".

A pilot program will begin in late 2001, and MIT has a goal of making over 500 courses available on the World Wide Web over the next 2-3 years. Access to the MIT OCW program will change forever how Universities globally, and especially universities in the English-speaking world, will approach the development of their unique on-line program offerings.

3. PRESENTATION STYLES

A number of different delivery 'package' strategies have been adopted. These can be generally categorised as:

- reference and resource material
- information portals
- computer mediated communications
- multimedia demonstrations
- realistic simulations
- Virtual Departments and
- Virtual Universities.

3.1 Reference and Resource Materials

Reference and resource materials once had to be sourced from paper materials. A visit to any university library (or resource centre) now will illustrate how important digital media is as a source of support materials for educational programmes. In 1996 the US Library of Congress enacted a five-year, US$60 million plan to establish a National Digital Library (Snider, 1996) to give Americans access to its collection in their homes or via public libraries. This illustrates the interest in providing access to repositories using non-traditional means. Both CD-ROM and web materials are used to facilitate the supply of materials. This has led to additional strategies that have been designed to support students in the quest for materials and their efficient exploitation.

3.2 Information Portals

Information portals provide student access to a plethora of information related to their particular area of study. Once equipped with an appropriate password for university-held information, or a web account with an Internet provider, students can gain an entrée to course or industry-specific information.

Whilst not specifically an educational site, but nevertheless an excellent resource for students studying in the geospatial sciences, The Alexandria Digital Library (Andresen *et al*., 1997) prototype provides access to spatially indexed information via the web. Hosted by the University of California at Santa Barbara, it provides a resource to explore the use of a digitally referenced geographical subject matter and to access a digital library.

3.3 Computer Mediated Communications

Computer mediated communications are used by many universities to communicate online, either via the Intranet or through intranets. Discussion forums, threaded discussions, mediated discussions and less formal chat rooms are some of the methods employed. Both mass communication (broadcasting) and focussed communication (narrowcast) are used. Most universities have developed strategies to cope with the many options offered, so as to properly implement available devices. An excellent example is the User Centred Information System (UCIS) from Griffith University. UCIS (Gilbert, 1999) is a web-based application that allows students to undertake independent work, to collaborate in small groups and large groups, to determine their personal interface preferences and to access a personal calendar.

In the geospatial science area, The University of Southern Queensland University offers a Graduate Certificate in Geomatic Studies (GIS) through the Faculty of Engineering and Surveying (Hilsberg, 1999) as part of its distance education courses. All course materials and instructional interaction are delivered via the Internet and email. The Certificate requires the completion of credit points of approved study. Students who have completed the programme are able to articulate into the Graduate Diploma of Geomatic Studies, which is delivered conventionally. Entrants into the course require a three-year undergraduate degree in an approved discipline.

As well as having the academic requirements to enter the course, aspiring students must also have access to the Internet, provide a personal e-mail address and demonstrate that they have the skills required to access and manipulate materials delivered electronically.

3.4 Multimedia Demonstrations

Multimedia demonstrations are generally delivered on discrete multimedia like CD-ROM. In some professions multimedia demonstrations can be substituted for expensive laboratory classes, and this alternative to conducting face-to-face classes has been pursued with gusto in the engineering, science and medical disciplines. An example is a multimedia-learning package for map projections entitled Understanding Map Projections (Cartwright, 1999a). The underlying goal in developing this product was to enable the study of the mathematical nature of projections and in particular, geodesy, and displaying portions of the surface of the Earth as a map. The development of an appreciation of the properties of map projections is an important component of the study program of surveying and mapping tertiary students. Simulations were included in the package to simulate how, by altering various parameters in equations, the properties of a map projection can be shown to change. Understanding Map Projections is a computer based simulation teaching package that approaches the teaching of the concepts of map projections using visual methods to depict properties usually specified using mathematical formulae.

3.5 Realistic Simulations

Realistic simulations enable complex theory to be understood through the provision of computer-generated simulations, supported by associated learning materials, both digital and conventional.

A CD-ROM product that includes simulation that is directly related to the geospatial sciences has recently-been developed at RMIT University. This is A Web-Based Package for Student-Centred Discovery of Satellite Differential Positioning in Typical Australian Environments. The aim of the package is to enable students to explore and learn about the ways in which differential GPS observations are affected by error sources. A variety of site scenarios are presented that are indicative of Australian field environments. The package is structured around a predict-observe-explain paradigm that asks students to use their existing knowledge to predict position errors in different environments. Students visit virtual sites, view and analyse data in a real-time fashion and draw conclusions based on their observations.

3.6 Virtual Departments

As well as single product offerings from Universities and societies, there have been concentrated efforts to provide access to courses nationally. United States geography academics (with some international partners) have established an exceptional example - the 'Virtual Geography Department'. It provides unlimited (free) courses via the web. A consortium of university academics have provided individual programs that students can undertake to supplement programs offered by their home departments. A sample of the programs offered are extensive and they are listed in Table 1. For more information see www.utexas.edu/depts/grg/virtdept/resources/education/courses/cartogra/cartogra.htm It should be noted that these courses do not, when combined, provide a program leading to a formal academic qualification. They provide needed adjunct materials that ensure that students in geography have access to a wide range of courses that could not be provided by home universities due to the wide scope of the courses on offer.

Program	**Developer**	**University**
Advanced Cartographic Methods	Michael Peterson	University of Nebraska at Omaha
Advanced Digital Cartography	Jeremy Crampton	George Mason University
Analytical Cartography	Nicholas Chrisman	University of Washington
Cartographic Design	Barbara P. Buttenfield	University of Colorado at Boulder
Cartography	Daniel Karnes	Dartmouth College
Cartography and Visualization	John Krygier	Ohio Wesleyan University
Computer Assisted Cartography	Gerd R. Dowideit	University of Queensland
Computer Mapping and Analytical Tools	P.C. Lai	University of Hong Kong
Computer Mapping and Geographic Information Systems	Chad J. Shuey	University of Maryland
Digital Terrain Analysis	Daniel Brown	Michigan State University
Environmental Measurement and Mapping	Aileen Buckley and Pat McDowell	University of Oregon
Program	**Developer**	**University**
Geographic Visualization	Sara Fabrikant	State University of New York at Buffalo
Geographical Analysis	Jon Comer	Oklahoma State University

The History of Cartography Project	David Woodward	University of Wisconsin-Madison
Introduction to Cartographic Sciences	Arlete A. C. Meneguette	Sao Paulo State University at Presidente Prudente, Brazil
Introductory Cartography	Brian Klinkenberg	University of British Columbia, Vancouver
The Language of Maps	Gail S. Ludwig	University of Missouri, Columbia
Map Animation and Visualization	Jeremy Crampton	George Mason University
Map Projections	Keith Clarke	University of California, Santa Barbara Hunter College, City University of New York
Map Reading and Interpretation	James T. Hathaway	Slippery Rock University of Pennsylvania
Mapping Our Changing World	David DiBiase	Pennsylvania State University
Maps in History, Art, and Literature	Chuck Ehlschlager, Adele Haft	Hunter College, City of New York
The Power of Maps	John Krygier	Ohio Wesleyan University

Table 1. A sample of courses provided by the Virtual Geography Department project.

3.7 Virtual Universities

An excellent example of a Virtual University is 'The U' (See www.ccon.org/theu). It was developed from discussions at a workshop at the Fortezza da Basso, Florence. The concept of virtual university was developed and created as prototype in Alpha World (a web site dedicated to developing the concept of different, virtual worlds) during the operation of the workshop. The U is described as:

"... an exciting concept project for a new type of learning facility, initiated by the Contact Consortium. It is positioned to straddle between traditional campus based universities and the growing number of distance-learning projects. Distance learning using current methodology offers many advantages to students in remote areas and students attending part-time courses. However it lacks the sense of community and social interaction which can be achieved by sharing the same environmental spaces and experiences. In the long term we foresee Virtual Worlds technology becoming a tool for enabling completely new and innovative teaching methods".

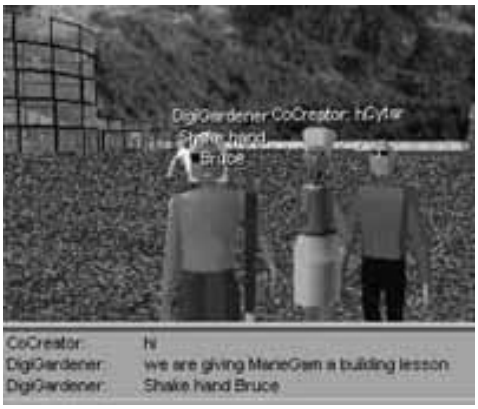

Figure 1. 'Students' (avatars) meeting on the virtual campus.

The U was further developed as one of the initiatives of Contact Consortium, which has projects that "involve live interaction in several types of on-line virtual worlds, working closely with their inhabitants". The Consortium is developing these virtual worlds as a new medium for "collaboration, play and learning." The U has a virtual campus (see figure 1), and virtual lecture theatres (see figure 2). It was developed to have the look and feel of a real university from 3D renderings of the campus, plus students and lecturers represented as digital avatars that are able to interact using global communications. In the 'early days' of multimedia course content development the educator/developer/presenter really had to produce product without any real assistance.

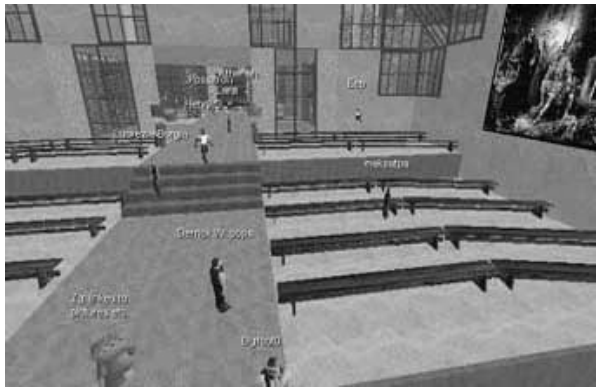

Figure 2. Virtual lecture theatre on the virtual campus.

Now, most universities have development support services and media support. Also, many universities provide online support services via the Internet, delivered in-house or, more recently, as collaborative learning facilitation tools support resources. Typical of these resources is the Multimedia Authoring Guidelines published by the University of Queensland (see www.tedi.uq.edu.au/mas/). The introduction to the resource indicates how it can be used:

If you are thinking about developing or using multimedia in teaching and learning, then these guidelines will help you to decide whether you

- *need a multimedia solution*
- *should develop the product yourself*
- *should outsource the production*
- *should buy an existing package*

and outline how to proceed if you make the choice to develop or outsource the production of multimedia.

Making available many resources to aid student learning is only a part of flexible learning. Both academics and students alike need new skills. The need for the skills is well stated by Wilson and Parker (1999):

The effectiveness of their use computers in education, however, is dependent upon the skill levels of the students. Adopting a flexible approach to the delivery of a Unit brings with it the need to develop learning resources and strategies that enhance each student's accessibility to the learning process. The time, energy and funding required to achieve these outcomes, however, is wasted if the skill level of students is not factored into the process of unit development.

4. TEACHING AND LEARNING IMPERATIVES

4.1 Consistency of Presentation

Clearly, changes to teaching and learning practices must be designed and implemented to facilitate learning by students that have a variety of information technology skill levels. A consistent structure and interface style is important to allow students to navigate within and make efficient use of multimedia material. Consistent structures and interfaces are more difficult to maintain if online material and teaching resources are based on different presentation styles. Further, the use of a variety of delivery platforms and learning frameworks can exacerbate inconsistencies in style and navigation. It is often only at faculty or departmental level that the local use of a single learning framework, such as commercial systems like TopClass (see www.wbtsystems.com) or a locally developed system such as WebRAFT (see webraft.its.unimelb.edu.au), enables and encourages a uniform design. However, the primary intent of the multimedia material may necessitate a very different approach to the style of the material and the interface design. For example, a design for a web delivered tutorial is unlikely to be similar in style to a stand-alone multimedia demonstration used within a computer laboratory.

4.2 Engagement and Interactivity

Whereas there is an acceptable need for different approaches to style and design that are in context with the teaching and learning aims, there is one operational imperative that all presentation styles universally attempt to achieve. Engagement of the student or user by the multimedia product is absolutely essential for the material to be effective and have the potential to realise the teaching and learning aims.

Computer based teaching and learning material universally incorporates text, images and graphics, as these are the staples of multimedia products that are sometimes known as an "electronic text". Computer based teaching and learning that is not primarily based on information content, for example relying on computer mediated communications systems, rarely stands in isolation and includes background or contextual information that includes at least some of the three staples. However, use of text, static images and graphics alone is a change in medium only. Whilst perhaps taking advantage of the convenience of distribution via CD-ROM, an intranet or the Internet, a change in medium only does not constitute the transformation of a curriculum and could be considered to be no better than a paper text book.

The quantum leap from an electronic text to an engaging multimedia delivery is of course enabled by audio, video, animations and virtual environments, all of which cannot be provided by a text alone. Further, engagement of the user is enhanced by interactive components such as animations, simulations and requirements for feedback. Other than more flexible access, a passive user clicking through the pages of an electronic text is unlikely to derive any more benefit beyond turning the pages of a paper text. An active user that must manipulate a simulation to demonstrate a particular concept is much more likely to be engaged and gain a clearer and more comprehensive understanding of the issues presented.

4.3 Online Assessment

Engagement of students by multimedia products is further enhanced by the inclusion of an assessment component. The strong compulsion of a linkage between computer based learning material and self-paced testing or feedback for the relevant subject can overcome the reluctance of students to become more active learners and encourage frequent and regular use of multimedia and computers in general.

There are many factors to be considered for the inclusion of online assessment, particularly the security of delivery systems, the authentication of users, the efficiency of the analysis process and the proportion of assessment to be derived. On the latter issue, retaining a component of independent, individual testing will always be advisable and there is increasing use of computer laboratories under examination conditions, primarily to achieve greater automation and therefore efficiencies for marking. Notwithstanding this, even a small percentage of online assessment is advantageous to encourage use of multimedia material. The assessment of self-paced testing and computer based examinations can be very efficient for large student cohorts if the analysis of the responses is automated (Norfolk *et al*., 1999).

4.4 Integration into the Curriculum

The last major imperative of the use of multimedia delivery is integration with the curriculum. Whilst this is not at issue with distance education courses, integration is very important if computer based delivery is used as an enhancement of learning by a university that values the student experience of learning within the campus environment. Online information must be relevant, current and a valuable enhancement to a subject or course. Students must be able to progress through the online information and multimedia material in concert with progress through the curriculum. Although not always an ideal solution, components of a web site, for example, may be released during a teaching semester to coincide with classes and control progress. Finally, the online information is most effective if it is integrated with all aspects of a subject or course, viz. lectures, tutorials, practical classes and, as noted above, assessment. An "immersive" environment of online information is the strongest encouragement for students to embrace a change in the culture of learning.

5. CURRICULUM TRANSFORMATION

As noted previously, computer based delivery does not necessarily imply a curriculum transformation. Many academics believe that the provision of online or CD-ROM based information, typically comprising course notes, tutorial sheets or other resources such as applications and data, combined with computer based presentations in lectures and tutorials, constitutes a fundamental shift in the teaching and

learning paradigm. Whilst this may be so, the straightforward provision of information in different media does not significantly enhance teaching and learning.

The perceived convenience of digital information and digital presentation can often be outweighed by other factors. Students are frequently frustrated by attempting to print information that was not designed to be read on the printed page, but rather was based on a computer screen format. Access to online information using modem connections can entail unacceptable response times, diminishing the advantage of unfettered access to online information. Inconsistencies between online information, lecture presentations and distributed paper course notes can lead to confusion and a high volume of student queries directed to teaching staff. Last but not least, the requirement for a change in learning culture by students, in order to be more pro-active in accessing online information, may not be well received.

Whilst none of these problems are insurmountable, the advantages of online information and computer based presentations are enhanced when used to support a revised approach to teaching and learning. Just as a change in the delivery medium can be independent of a curriculum transformation, the reverse is also true because a curriculum transformation can be implemented without the use of computer based delivery. However, the use of the new technology to provide a rich educational resource, and the opportunity to revise an approach to a teaching and learning problem can produce a result in which the sum of the parts is greater than the whole.

5.1 Multimedia Demonstrations

The most straightforward case of a curriculum transformation is the use of multimedia demonstrations of material that was previously impossible to provide to students. The provision of multiple perspectives of layered dissection of the human body that can be viewed for detailed analysis (Riddle *et al*., 1999) is theoretically possible using non-computer based media. However the power of this type of curriculum transformation is the ability of students to repeatedly review the dissection images and the associated contextual information at their own pace. There are numerous examples of multimedia presentations that fundamentally change teaching and learning practices.

5.2 Computer Mediated Communications

The second type of curriculum transformation, the development of which has been critically dependent on the development of the Internet and intranets, is the use of computer mediated communications (CMCs). Whilst CMCs are often used as an adjunct to online delivery of curriculum material to allow discussion between students and question-answer interchanges with academic staff (see www.webcrossing.com), this type of facility is very effective at transforming the learning of languages and the learning of procedural inter-relationships. There are numerous examples of the use of synchronous and asynchronous communications to link groups of students at different tertiary institutions, in order to develop language skills and promote the exchange of cultural information. Teaching and learning of company-client and peer to peer relationships have also taken advantage of CMCs using role playing, particularly in business studies, law and politics. A good example of the latter is a course in the politics of international negotiations (Naidu and Linser, 1999) in which students take on the personae of prominent world leaders.

In all cases academic staff guide and facilitate the communications through moderation of discussions and the provision of background or introductory information. The transformation is based on the immediacy of the communications and the realism of interchanges with peers within or at other universities, none of which was feasible prior to the Internet and CMCs.

5.3 Simulations and Visualisation

Perhaps the mostly widely known and appreciated form of curriculum transformation is that provided by simulations and visualisation. Projects such as Understanding Map Projections and ‘The U’ are excellent examples of the use of these techniques in order to illustrate concepts that previously were very difficult to demonstrate. The advantages of these techniques to transform the learning process is further enhanced by three dimensional simulations and visualisations, such as the Simulated Site Visits project (Newton, 1999), survey network design simulation (Shortis and Woodhouse, 2001) and virtual GPS instruments (Shortis *et al*., 2002). Not surprisingly, simulations and visualisations are regular features of multimedia developments associated with the disciplines in the spatial sciences.

SSV uses a standard web browser plug-in to allow the visualisation of the construction of buildings from any external or internal viewpoint, showing CAD overviews, details, selected real images at various scales, timelines and materials specifications. Students can interact with the simulations by selecting the various stages of construction and any relevant auxiliary information. This type of approach is vastly superior to teaching and learning using 2D plans of buildings, list of materials and bar charts of schedules.

The survey network simulator (figure 3) allows students to gain survey design and analysis experience within a realistic virtual environment that provides interactive guidance on the efficiency and effectiveness of the survey network design. Networks can be designed by identifying station locations and measurements within a 3D virtual landscape, and real-time feedback on design outcomes is generated by survey network analysis software. Guidance on the design effectiveness is provided using error ellipsoids that can be used to identify weak areas in the survey network, and reliability and precision data that can be compared to appropriate design specifications. The realism of this method of learning is a substantial improvement on traditional systems that use text or 2D graphics to present results of survey computations.

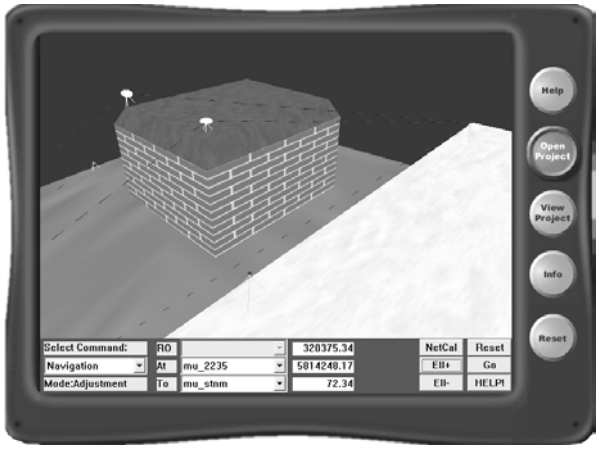

Figure 3. Survey network design simulator (Shortis and Woodhouse, 2001).

Figure 4. Simulated GPS receiver (Shortis *et al*., 2002).

The virtual GPS instrument (figure 4) is a component of a curriculum transformation project on integrated systems. Tertiary education institutions inevitably have restrictions on the resources that can be made available to teaching programs, and the provision of a broad range of current field survey equipment is often not feasible. It can be the case that a small number of geodetic class GPS receivers, for example, must be shared amongst a large number of students. Virtual access to equipment is not a replacement for actual experience, however virtual access is better than no access, and a simulated GPS receiver does allow students to have some preparation and familiarity with field equipment and therefore make efficient use of the equipment when it is available. Use of virtual equipment becomes an essential enhancement of the student learning process to facilitate very effective access to state of the art equipment.

5.4 Problem Based Learning

Problem based learning (PBL) is the fourth primary technique of curriculum transformation. PBL has been widely adopted in tertiary education, either as a complete approach to teaching and learning or as a presentation technique to overcome learning problems for particular aspects of a subject or course. Courses in medicine and the health sciences have been in the vanguard of adopting PBL using clinical cases (Finucane *et al*., 1998). From 2000 the entire course toward the Bachelor of Medicine at the University of Melbourne is being converted to problem based learning. Heavily reliant on computer based delivery and small groups of students working in concert, every week of the entire twelve semesters of the course is oriented around the "problem of the week". The benefits of the problem based approach are summarised in Shortis *et al*. (2000) regarding a project to remedy teaching and learning difficulties associated with plane surveying:

Rather than teach the basic skills of plane surveying (the bottom-up approach) which must be integrated to provide optimal learning outcomes, the teaching method can be changed to the challenge of problem solving (the top-down approach) with the emphasis on deep learning of design and analysis. This new approach has to be supported by a rich resource that provides the details of field procedures and theoretical concepts. A problem based approach concentrates on design and analysis in lectures, de-emphasising issues such as the fine detail of instrument handling and field procedures.

The emphasis in PBL is invariably to place learning in the context of realistic, real world problems and to channel the students toward feasible solutions through appropriate advice and channelled inquiry. Groups of students engaged in PBL can require high levels of guidance, support and resources. Online information, multimedia delivery and realistic simulations can currently provide a large component of this support. The concept of virtual tutors is being explored by many educational research programs to offer increased support in the future.

6. EVALUATION

Considerable effort and resources has been and is being injected into the design, development and implementation of computer based curriculum material. The outstanding question is whether these techniques demonstrably improve teaching and learning. Although all the indicators are positive and educational research typically shows that the new methods are valuable, there is little hard evidence of improved knowledge and skills. Evaluation is one tool that can provide some evidence.

Evaluation needs to be separated into the evaluation of the multimedia material and evaluation of the learning effectiveness. Evaluation of the multimedia material is generally conducted through the mechanisms of feedback from instructional designers, content experts and students to ensure that the curriculum material is well presented, comprehensive and accurate. Whilst the style of presentation may well be an individual preference, issues such as the ease and consistency of navigation, clarity of layout and the logic of the paths through the material are paramount to facilitate ease of use. Students who have already completed the component of the course for which the multimedia material will be used are often very useful evaluators. Their focus is frequently on the areas in which the multimedia material is potentially most effective from the student perspective, and this can be an excellent predictor of the most valuable material within a project.

Efforts to evaluate the effectiveness of transformed curricula are typically based on the use of survey instruments aimed at the users of the transformed curriculum material. Chief amongst the instruments are feedback responses, questionnaires, one to one interviews, focus group discussions, direct observation and audit trails of the use of the material. Evaluations may be formative (prior to implementation whilst the material is still under development), summative (after

implementation when the material is available) or integrative (monitoring of the integration of the multimedia delivery with the teaching and learning processes).

Although the aims of the evaluation many be manifold, the principal enquiries attempt to assess teaching and learning outcomes. Specifically, evaluation of effectiveness should determine whether the curriculum transformation, combined with multimedia delivery, has significantly improved the students' understanding of the curriculum material. Formative and summative assessment are necessary to assess the effectiveness of the material in the development and completion phases, but integrative evaluation is the key to determining the actual effectiveness of the curriculum transformation in terms of learning outcomes.

However, the greatest difficulty in assessing improved outcomes is reliable evaluation techniques. In the absence of some method of calibration, it is typically the case that curriculum transformation or online information alone cannot be isolated from the many other confounding factors (Kennedy, 1999), such as differences in student cohorts, changes in technology and the continual evolution of curricula. Once the techniques have fully matured, the ultimate test of changes to teaching and learning will be the quality of graduates from universities that use immersive multimedia environments and fully embrace the new pedagogy of curriculum transformation.

7. THE REALITIES OF EDUCATION PROVISION

Factors that have a strong influence on evaluation are a number of potential problems with the delivery of online services. NextEd (see www.nexted.com) has identified some of the major issues as follows:

- Distance delivery being banned or regulated (for example online education delivery is banned in Indonesia and regulated in China).
- The Internet does not work well in every country and in every region of many countries.
- There is international latency due to Government policies.
- Providers can have difficulties getting paid.
- There exists a need for physical distribution networks.
- Cheating is hard to control.

This has led to the development of many techniques that are well outside the general area of education content development. For example the development and use of a web cam set-top devices to monitor tests carried out online.

Some students do find online courses frustrating. Research conducted by Hara and Kling (1999) it revealed persistent frustrations in web-based distance education. This was based on a case study that examined students' difficulties in learning effectively in a web-based distance education course offered at a major U.S. university. The entire course was organized through a web site. The report concluded that these frustrations inhibited educational opportunities.

Noble (1998, p. 1) argued that:

"... the trend towards automation of higher education as implemented in North American universities today is a battle between students and professors on one side, and university administrations and companies with "educational products" to sell on the other. It is not a progressive trend towards a new era at all, but a regressive trend, towards the rather old era of mass-production, standardization and purely commercial interests".

Most recently, the trend toward mass-produced online learning is being generated by the need to service a growing sector of the tertiary education market that cannot be catered for by the physical limitations of campus based universities. e-Universities are being created to address this demand and one example is U21global (see www.u21global.com), a consortium of internationally recognised universities in partnership with a commercial publishing company. The challenge that faces e-Universities is to provide high quality tertiary courses that overcome the realities of providing online education.

8. CONCLUSIONS

This paper has presented an overview of online information, multimedia and curriculum transformation with the emphasis on teaching and learning in the spatial sciences. There is no doubt that this is a maturing technology and that it is having a substantial impact on the culture, process and outcomes of teaching and learning. Further, the number of projects and initiatives is evidence that there is a substantial development effort amongst the spatial sciences that is paralleling the developments in many other disciplines.

Whilst the delivery technologies and the educational innovation will continue to advance and mature, the issue of evaluation will certainly gain greater focus. Funding agencies and tertiary institutions will require evidence that curriculum transformation and multimedia development are value for money. Inevitably there will be some emphasis on the efficiency and effectiveness of teaching by academics, but in reality the litmus test of usefulness will be the demonstration of improved outcomes for learning by students.

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