Interactive Multimedia in Australian University Science Teaching:
A New Toy or a Useful Tool?

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Declaration

I certify that this sub-thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

S. L. Errington
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Abstract

Tertiary education in Australia has altered significantly in the last twenty five years due to changes in funding as well as in the diversity of students entering the system. Added to this is the rapid development of computer technology which has had a marked effect on all aspects of our lives, including education.

Interactive multimedia (IMM) programs have been developed mostly in the area of entertainment, although development of programs for use in primary, secondary and tertiary education has recently increased. Universities have developed and used programs with the objective to enhance and replace conventional modes of delivery. Laboratory simulations in science-based courses, assessment programs and problem solving tasks have been some of the major areas in which IMM programs have been developed.

IMM programs lend themselves well to the constructivist theory of learning and student-centred learning. Access to IMM via the World Wide Web (WWW) means that universities can offer a wide range of material in distance mode and, in some cases, deliver to students in their home a very similar product to that experienced in the laboratory.

But how effective has the use of IMM been in improving student learning? This is largely unknown. The evaluation of programs from conception to completion is often neglected and little evidence exists to indicate that the use of IMM has improved student learning. In many cases during the design phase educational objectives may not be addressed and appropriate follow up of the programs’ effectiveness is not done.

The use of IMM in tertiary education, especially in science-based courses, has the potential to revolutionise and enhance the current system. Some developers and users have done this well. However, there is always the risk of using IMM gratuitously with no serious consideration given to design principles and educational outcomes. These must be addressed if the use of IMM in science tertiary teaching is to be seen as useful tool and not merely a new toy.
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Chapter 1

Introduction and Overview

In a recent report issued by the Department of Industry, Science and Tourism, it was stated that Australians are well educated in science and technology and adapt to new developments in everyday life very rapidly (Department of Industry, Science and Tourism, 1996). One example given of this is the high usage of computers and microwave ovens in Australian homes. As neither of these devices require a high skill level to use satisfactorily, one can only question how their usage relates to the level of science education of the users.

Between 1989 and 1993 there was a 70% increase in the number of science degrees awarded in Australia (Department of Industry, Science and Tourism, 1996). From this it might be assumed that potential university students are more interested in science and that the resultant graduates are filtering into the workforce and improving the overall scientific literacy of the population. Yet, judging by the amount of science promotion that occurs, there still appears to be a perception that the number of students enrolling in science and continuing with science as a career is low. One problem is the apparent lack of career options and opportunities in science and the public image of science and scientists. As Peter Jeffrey (1997) points out, scientists have images ranging from total nerd to complete madman which are perpetuated in the media and there appears to be little progress in changing the situation.

The nature of tertiary education in Australia has changed significantly since the Labor government dismantled the binary system. Universities are no longer the exclusive domain of the academic elite. Australian universities offer awards ranging from diplomas in hairdressing to doctoral degrees and the changes in structure have automatically brought about changes in the client base. University students are much more diverse in age, culture, ethnicity and academic backgrounds and thus much more representative of the general public than they have been in the past.
With the proposed acceptance of full fee paying domestic students by at least some Australian universities, it is likely that some of these places will be filled by those at the bottom end of the academic echelon rather than the top end. Most Higher Education Contribution Scheme (HECS) funded places, having been filled on the basis of academic merit rather than ability to pay, will certainly account for the top students irrespective of their financial situation. This will create an even bigger burden on a system which is basically designed to educate the intellectually privileged, rather than run remedial courses for students entering tertiary education at a level which ten years ago would not have been acceptable.

The reorganisation of the tertiary sector has meant that universities are competing with each other for students, with many reducing entrance requirements to secure adequate numbers. The result of this is large first year classes with students of varied backgrounds and abilities. Many students entering science-based courses may not always have a solid grounding in science. Some institutions have been able to accommodate this in the past by offering introductory courses in science subjects to bring students up to a minimum standard. This may be enhanced by the adoption of new educational technologies such as computed-aided instruction.

Although the doors of universities are much more open than previously, not much has changed behind the doors. In many cases the style of teaching and instruction remains the way it has been for decades. Delivery of material is usually didactic and often reflects the preferred learning style of the lecturer rather than the needs of the student. This is also a reflection of the nature of undergraduate courses in which students are exploring a known field where there is usually a pre-defined standard solution to any problem raised (Laurillard, 1994a).

This style of teaching does very little to encourage students to think critically and analyse data, something that might be considered essential in the education of science students. Sometimes students are required to passively regurgitate knowledge without any serious critique or analysis. Courses based on the accumulation of facts do not enable students to develop confidence in their own powers of investigation, which is what science should be about (Dearn, 1995). The mere presentation of facts does not automatically result in students developing thinking and communication skills. Science knowledge needs to relate to personal, social and historical contexts for meaningful learning to occur (Dearn, 1995).
Traditionally, the tertiary education system does not accommodate different learning styles and individual lecturers often take a 'sink or swim' attitude towards students. Given the diverse nature of students this attitude translates into high attrition and failure rates, especially in first year classes. There are, of course, exceptions to this with many examples of innovative teaching techniques developed in tertiary institutions.

Small group tutorials can be effective in helping students deal with conceptually difficult ideas. However, university funding cuts over the years have meant a reduction in staffing levels which makes this type of instruction much less feasible than it was in the past. For example, in 1997, Murdoch University reduced the number of tutorials offered in first year chemistry so that the number of students per staff member is as high as 30 in any given class (Mark Ellison, personal communication). In science-based subjects funding cuts have also meant a 're-think' of areas of high cost such as practical classes that require expensive equipment and consumables, especially where the benefit to the student is totally dependent on the success of the experiment which cannot be guaranteed.

One way of dealing with the changing nature of students and the role of universities is to embrace new technologies. There are many of us (both students and teachers) who are still technophobes. This makes adoption and implementation of effective computer programs difficult in many cases, with lecturers being reluctant to change and students reluctant to use new technologies.

One initiative that encouraged innovation and quality in tertiary teaching was the establishment of the Committee for the Advancement of University Teaching (CAUT) in 1992. The mission of the committee was to improve the status of university teaching and to contribute to the improvement of teaching and learning in Australian universities. Most applications for funding received by CAUT involved incorporation or development of new technologies such as computer-aided learning, multimedia or other applications of information technology (Anderson, 1994). In the first two years of CAUT Teaching Development Grants there were 1500 applications, approximately 755 of which involved the development of computer-based programs (Anderson, 1994). This represents a significant amount of available funds going towards the development of new
teaching technologies. But has it worked towards improving teaching and learning? Computers have been used in teaching and learning for many years now, although how effectively is difficult to say; this has yet to be evaluated on the larger scale.

Despite the lack of knowledge of the effectiveness of computers in education many universities and other educational institutions have embraced their use and the access to information they allow. For example, the Australian National Genomic Information Service (ANGIS) has a 24 hour on-line dry lab for molecular biology, genetics and genomics. Although the primary role of the service is as a research tool, some Australian universities are using it as a teaching tool allowing students access to the same material as researchers (Littlejohn, 1996).

The University of Western Sydney has incorporated the use of the World Wide Web (WWW) into a third year immunology course. This has allowed a problem solving approach to be taken with the subject, reflecting the real world of the scientist, and helping in developing students’ conceptualisation and evaluation of the topic and laboratory procedures (Deane, 1996).

Computers are also useful for teaching report writing in science and engineering courses (Allen and Mackenzie, 1995; Taylor and Drury, 1996). The University of Sydney has incorporated the teaching of writing skills into their first year biology course. The use of computers for assessment and feedback as well as the development of a self-help package are seen as invaluable in the delivery of the course (Taylor and Drury, 1996).

Similar use of computers has been adopted in other disciplines for the replacement of traditional methods of teaching. These include computer simulations of laboratory experiments and clinical encounters with patients in areas of psychology, medicine and social work (Anderson, 1994). In areas that traditionally use animals to demonstrate physiological phenomena, the use of computer simulations has been most advantageous in relation to the high costs of technical assistants, drugs and the animals themselves, especially when the success of the experiment or demonstration cannot be guaranteed (Tarttelin and Fyfe, 1996). The use of new technologies also overcomes the ethical problems and objections with using animals in experiments.
In another application of technology, Bork, Britton and Gunnarsdottir (1994) propose that computers can be utilised to relieve the angst of students during examinations. Their argument is that assessment should be geared towards finding out where students are and where they should be directed next in the learning process, rather than just used as a ranking tool. Computers can be used for assessment of modules on a regular basis which would overcome the problem of exams and examiners who may be judgemental and weary during the examination period (Bork et al., 1994).

In the last few years the development of interactive multimedia (IMM) has increased significantly. Much of this development has been in the area of computer games (Merakovsky, 1994) but the situation is now changing with considerable development occurring in educational institutions. One aspect of IMM is that the learning experience is student-centred and often individually paced. The medium also has the ability to accommodate different learning styles (Phillips and DiGiorgio, 1995) and thus may be suitable as an aid in bringing students with diverse backgrounds up to a minimum acceptable standard in the early stages of their tertiary education, giving them a better chance of success.

In Australia, many tertiary institutions are developing and implementing IMM programs. They are being used to replace costly practical classes or as instructional aids. Some institutions are also offering online courses through the WWW. IMM is being used to enhance traditional lectures, with the proposed purpose of making tertiary teaching more innovative. However, there is some debate over the effectiveness and appropriate use of IMM and other forms of educational media. Based on studies in the United Kingdom Laurillard (1994a, p.8) makes this observation:

"Research and development projects on educational media pay quantities of hard cash for development, lip-service to evaluation, and no attention to implementation."

This is in contrast to the analysis of IMM development in Europe where Gardiol-Gutierrez and Boder (1992, p. 127) comment that:

"...efforts are directed towards the implementation phase, whilst the decision and planning phases receive only secondary attention."
It is not clear whether these differences of opinion are due to different work practices between the United Kingdom and Europe or a different slant by the authors.

A further difficulty identified by Anderson (1994) is that the adoption of new technologies in tertiary teaching will not necessarily advance learning effectively or efficiently no matter how they are adopted. There has been an extensive increase in the amount of scientific knowledge available to students over the last few decades. This has been translated into ever increasing curricula for undergraduate courses. The question arises as to whether new computer-based teaching tools, used in conjunction with conventional teaching methods, will free students from the burden of overloaded curricula or merely add to it (Anderson, 1994). If the latter is true these new technologies will have further adverse effects on students for whom the programs have been designed to help.

Alexander and Hedberg (1994) claim that as much academic effort is applied to developing computer-based learning programs as that required for research projects, yet little recognition is given to such developments when it comes to tenure or promotion within universities. Lecturers, particularly in science, tend to be judged by their peers on the basis of their research endeavours rather than teaching expertise or innovations. Until such recognition is given there would appear to be little incentive to encourage development of computer-based learning programs which take time and effort.

In summary, there has been a significant increase in the use of computers in teaching, largely due to their increased power and the reduced cost of technology. However, the use of technology-based learning is seen differently by different people. Some see its use as a chance to improve teaching and learning, whilst others see it as a panacea (Alexander and Hedberg, 1994). In the wrong hands it certainly will not do the former, and it is not the latter in regard to overcoming educational shortfalls, whether they be financial or intellectual.

This review examines the current state of development, evaluation and implementation of IMM in science-based courses in Australian tertiary institutions. The benefits and pitfalls of the introduction of IMM into university courses will be assessed to determine whether it is in fact valuable to enhance the quality and communication of science in tertiary teaching.
Chapter 2

Learning Theory and Application of New Technologies

The Speaker, and the schoolmaster, and the third grown person present, all backed a little, and swept with their eyes the inclined plane of little vessels then and there arranged in order, ready to have imperial gallons of facts poured into them until they were full to the brim.

Charles Dickens

From the way university science classes are often conducted one could assume that one of the tenets of traditional tertiary education is that the minds of new students are a blank slate needing to be filled with a multitude of facts and figures accumulated over centuries of scientific endeavour. This is very much an 'objectivist's' approach where knowledge is thought to exist independently of any human experience (Phillips, 1995b) and assumes that the learner is an empty vessel that can be filled with knowledge.

Beatty, Dall’Alba and Marton (1990) proposed a number of ways of addressing the process of learning. These included increasing one’s knowledge base; memorising and reproducing; applying knowledge; understanding; seeing something in a different way; changing as a person.

The first three points make the assumption that learning is a passive experience which involves receiving and absorbing knowledge transmitted by the teacher (Åkerlind and Trevitt, 1995). Learning is the transmission of facts to the student where the learners play a minor role in the learning process (Laurillard, 1991). These views are consistent with objectivist theory.

The last three points imply a more active approach to learning (Åkerlind and Trevitt, 1995). Knowledge is seen more as an outcome of negotiation and discussion. Students are encouraged to construct their own understanding and perspective (Laurillard, 1991). These views form part of another learning theory or model that has been developed based on a different approach to students and the
learning process - constructivism. The basic principle of constructivism is that learners effectively create their own knowledge from their interactions with the learning environment (Yager, 1991; Hedberg, Harper, Brown, and Corderoy, 1994).

The constructivist learning model has been incorporated into the theory, if not the practice, of science education for a number of years (Yager, 1991) and IMM lends itself well to the incorporation of constructivist theory into the design of programs for educational purposes. It has been a requirement that all CAUT applicants must have the quality of students’ learning as the focus of the innovation and recognise that learning is an active and interactive process (Anderson, 1994). The funding bodies, if not the academics, recognise the need and desirability to incorporate more student-centred teaching techniques into universities.

This is not meant to imply, however, that students are not without responsibility in the learning process, especially where it requires active input on their part rather than passive absorbence. If it is the teacher’s responsibility to create conditions in which understanding is possible, it is the responsibility of the student to take full advantage of those conditions (Laurillard, 1994a).

For students to learn they need to be able to relate knowledge to their own experiences (Laurillard, 1994a; Dearn, 1995), an opportunity often lacking in university teaching. One of the problems faced by students is the lack of ability to transfer information and knowledge from one situation to another. What is learned in the classroom may not obviously be applicable to the everyday environment (Laurillard, 1994a). Brown, Collins and Duguid (1989) proposed the notion of ‘situated learning’ where meaningful learning will only take place if it is incorporated into the social and physical context within which it will be used. The knowledge to be learned cannot be separated from the situation in which it will be applied. Use of IMM in university curricula may be one way of incorporating advanced learning theory into more familiar settings. There is some concern, however, about the claim that computer-based learning environments can really be considered situated learning given that the setting only simulates the real life situation (Herrington and Oliver, 1995). Others have a broader definition of situated learning. For example, McLellan (1994) says that situated learning can be in the context of the actual working setting, a highly realistic simulation of the work environment or an anchoring context such as a video or a multimedia
program. The relevance of the learning environment to the real life situation may relate to how well the program has been designed. A well designed multimedia program may provide students with improved learning opportunities through interaction and feedback often lacking in conventional university-style lectures.

**What is interactive multimedia?**

Sterling (1996) reports finding 8,784 books written about multimedia, yet it is still difficult to find a single definition of IMM. Multimedia in its literal definition means 'more than one medium' (Darby, 1994). The term can include television which relays text, sound, pictures and animations into the living room, but this is generally not what is meant by multimedia (Phillips and Jenkins, 1995). In its current usage the term multimedia refers to the combination of text, pictures, video, animation and sound into computer programs (Latchem, Williamson and Henderson-Lancett, 1993; Merakovsky, 1994; Phillips and Jenkins, 1995; Maras, 1996). Tucker (1990) describes IMM as a knowledge-based learning environment in which the developer, instructor and student share a symbiotic relationship. Hartnett (1996, p. 5) describes IMM as the:

> ...simultaneous use of multiple forms of media to communicate information, ideas, thoughts, and knowledge to employees and customers of today's corporations in a way that is better, faster, more efficient and more effective than conventional methods.

Although Hartnett takes into account desired outcomes as well as the components of IMM, it remains to be seen whether IMM will ultimately live up to this definition.

IMM lends itself very readily to three dimensional concepts and can be very useful in linking together ideas in broad contexts (Phillips and Jenkins, 1995). Students often find microscopic or dynamic processes difficult to understand and providing the concepts visually through IMM programs can aid in the learning process. Beattie (1994), however, puts forward the idea that it is not necessarily justifiable to use IMM for representing material in this way as those who are teaching the subject 'developed an appreciation of those same systems without the help of computer technology' (pp. 246-247). On the other hand, many of us who are now
teaching did have conceptual difficulties as undergraduates and would welcome new technologies to help overcome the problems associated with conceptually difficult ideas. Although IMM should not be seen as a panacea for all learning difficulties, its lack of availability in the past does not mean its use cannot be justified now that the technology is available. IMM also offers the opportunity for individualised learning when there are various starting points in a program depending on the needs of the user (Nash and Alexander, 1995). The use of various forms of IMM also accommodates different learning styles and personality types not accounted for in conventional university teaching (Yardley, 1996).

What IMM programs offer, unlike television, is interactivity which enables the user to control the program and its learning outcomes (Looms, 1993; Phillips and Jenkins, 1995). But what is interactivity? It is more than just making a choice from a sub-menu or deciding when to start or stop a program. It is about the environment in which the student uses the information and allows for mistakes to be made and knowledge from those mistakes to be gained in a ‘friendly’ situation (Maras, 1996). Hepple (1996) describes participation in IMM as the user putting back into the program something of themselves. IMM allows for novel approaches to education at all levels as well as self-paced learning and individual control over the learning process. However, increased user activity per se does not necessarily improve the learning process (Looms, 1993). The interaction must be meaningful for any real advantage in learning.

In theory, IMM is a ready made medium for the constructivist learning model. The application of theory to practice, however, can be problematic.

**Application of learning theory to practice: Will it work with interactive multimedia?**

The use of IMM through the Internet has huge potential for increasing productivity levels of education, especially when used in conjunction with our understanding of the learning process (Yardley, 1996). Asynchronous communication via computer networks (as opposed to everyone sitting in the same room listening to the same lecture at the same time) allows for reflection and assimilation of information before students are required to air their ideas publicly (Yardley, 1996). This obviously has advantages for many students who may be shy or lacking confidence, but it may not be advantageous for those lacking motivation.
There are some problems associated with the adoption of constructivist theory in education. Many students are ill prepared for the freedom and choice of direction this learning process allows (Perkins, 1991). Generally, students’ educational experiences in the classroom, particularly at the lower tertiary levels, are more objectivist than constructivist. Students are largely unprepared for self-directed learning and circumstances have been documented where students have complained about attempts to enhance the quality of education through self-directed learning (Åkerlind and Trevitt, 1995). Jonassen (1991) proposes that the most effective application of the theory is at the stage of advanced knowledge acquisition.

As people learn at different speeds, the ability of students to regulate their own pace of learning does have its benefits. Some students, however, will adopt the attitude that being the first to finish is the objective of the program. Another potential problem is having too many choices in relation to the sequence of presentation of material. This can lead to confusion for some students resulting in the program’s objectives not being achieved (Bork et al., 1994).

Despite these problems, learner-controlled education has been shown to improve learning outcomes and student motivation even if it is necessary to give initial guidance to help students through the transition period from a teacher-controlled to a learner-controlled setting (Åkerlind and Trevitt, 1995).

New technologies, such as IMM, are well suited to learner-controlled settings which make the assumption that learners will be more motivated if allowed to self-regulate their progression. Multimedia programs give learners many options and more control over the subject matter and the learning process (McLoughlin and Oliver, 1995). Studies have shown that students are more positive about learning, enjoy the process more and are more motivated to learn when given control (Keller, 1979; Laurillard, 1984; Carrier and Williams, 1988; Becker and Dwyer, 1994; McLoughlin and Oliver, 1995; James, Clark, Hillis and Peterson, 1995). Control by the students also allows them to pace and sequence their learning to suit their own needs and abilities (Laurillard, 1994a).
Although there is much scope within the education system for innovation, especially through the use of IMM and other information technologies, translation of good theory into good practice can be a problem. Good intentions may lead nowhere if the correct approach is not made in the first instance. There are inherent problems with self-directed learning, as well as considerations of suitable design, implementation and evaluation of programs. The increased development in learner-controlled settings in the education system, especially involving IMM, needs to address the concept of education versus entertainment. Use of the term ‘edutainment’ tends to imply material that has little education value (Goldfayl, 1995). On the other hand, just because a program is fun does not mean that it has no educational worth. A successful IMM program requires a balance between the entertainment appeal and the educational value (Goldfayl, 1995). If Bloom’s (1956) taxonomy of learning is applied to the design of programs, a balance must exist between the affective domain, relating to attitudes and values, and the cognitive domain, which is thinking and knowing (Beattie, 1994; Goldfayl, 1995). The third level of taxonomy, psychomotor, which is the practical domain, cannot be ignored and should also be considered in the learning objectives of the program (Beattie, 1994).

In a study done by Nicholson (1994) at Deakin University, fourth year science education students were asked to design a multimedia program around one aspect of physics. The essential criterion was that a constructivist approach be incorporated into the design of the program. Although the students were well versed with the theory, application of it to their designs caused some difficulties.

Most of the students’ designs were linear in nature, reflecting a conceptual sequence perspective indicative of the way in which they had been taught the subject (Nicholson, 1994). It was also noted by the students that many of the IMM programs they had used themselves adopted the same linear design. Nicholson (1994) points out that the absence of constructivism in many IMM programs could suggest that the application of theory to practice is either too difficult generally or that little attention is given to good educational design in the first place. To ignore this really means that IMM programs become nothing more than electronic books contributing little to innovative teaching and learning (Nicholson, 1994; Phillips and Jenkins, 1995).
There are some who feel that there is no real advantage in IMM over other forms of computer-based learning. One consideration in this is the perceived high cost of development of IMM programs. Some developers do not see IMM as being cost effective by giving an inadequate return on investment (Ellis, 1994). However, a study in the United Kingdom indicated that multimedia is not necessarily more costly to develop than other computer-based programs (Darby, 1994). The reasons for this are not clear, but Darby (1994) suggests that developers of this medium are more efficient with their time or are able to incorporate existing material more readily into new IMM programs.

Computer-based learning, especially incorporating multimedia, can be very useful in overcoming some teaching and learning problems. Some studies have shown that learning curves can be up to 60% faster with content retention being 25-50% higher using IMM programs (Hartnett, 1996). The style of learning IMM allows has been shown to be effective in both learning outcomes and student motivation (Keller, 1979; Laurillard, 1984; Carrier and Williams, 1988; Becker and Dwyer, 1994; McLoughlin and Oliver, 1995; James et al., 1995). However, is it more effective than other forms of computer-based learning? Some think not. Dan Ellis (1994), former Director of the Queensland University of Technology’s Computer-Based Education Department, does not believe that IMM is any more effective in producing better learning outcomes than other forms of computer-based learning that are solely text-based. In relation to the style of teaching resources, Ellis claims that ‘...the fact that it’s dull and boring doesn’t mean it isn’t effective...’ (p. 153).

This may be true, but if material can be made more interesting, without the loss of educational quality, surely the students would benefit in relation to the generation of interest and motivation?

In contrast to Ellis’s view, Leung and Pilgrim (1995) found the multimedia component of a course in data communications at the Swinburne University of Technology, to be extremely useful for students to learn physical processes and abstract concepts. The use of simulated animations helped students grasp these difficult ideas over and above what would have been possible using a computer-managed learning system alone.
There are obviously areas in which multimedia has worked well and others where there is no real advantage. Careful consideration must be given to the development of IMM not merely to its use just because it is there. There are many positive aspects to IMM, but if a new program does nothing more to improve student learning than existing methods (whether or not they are computer-based), then it is a waste of time, effort and money (Phillips and Jenkins, 1995).

Despite some reservations about the value of IMM, there has been much development of the medium specifically for the education system. Before developing new IMM programs a number of issues must be considered before ultimately releasing programs to the end user. These include design and development, implementation and evaluation.

Much thought needs to be put into the design of IMM to be used beneficially. Designers and developers need to address the learning process and be aware of the end user's needs (Laurillard, 1994). There are many areas where the adoption of IMM as a medium for teaching or disseminating information is inappropriate. This relates to the amount of information and accessibility to the medium (Hunt and Abrahamson, 1994). Before the actual design process begins, one must have identified what an IMM program should be developed and to whom there is an audience for the end product. This will avoid the production of inappropriate or unnecessary software (Beale, 1994). The target audience must also be deemed to have the necessary basic computer skills to be able to use the end product. Finally, but probably most importantly the development of educational software, the learning objectives of the program must be derived from the beginning of the project. These then serve as a guide throughout the development, implementation and evaluation of the software (Beale, 1994). Once these initial parameters have been addressed, a well designed and managed IMM program has the potential to support the learning process very well (Laurillard, 1994).
Chapter 3

Design, Development, Implementation and Evaluation of Interactive Multimedia

Multimedia has been around long enough for many of the technical problems to have been overcome. Now is the time to focus on design issues (Gavora and Hannafin, 1995). The true potential and niche of IMM in the world of communication and education is yet to be realised. It should not be thought of as a replacement for existing media, but rather an addition. Nash and Alexander (1995) compare the emergence of IMM with that of radio earlier this century. It took about 40 years from the early days of radio to the development of unique formats which are now exclusive to the medium. Based on this time frame, IMM has a long way to go until we see it emerge to fill as unique a niche as other forms of electronic media.

Much thought needs to be put into the design of IMM if it is to be used beneficially. Designers and developers need to address the learning process and be aware of the end user’s needs (Laurillard, 1994a). There are many areas where the adoption of IMM as a medium for storing or distributing information is inappropriate. This relates to the amount of information and accessibility to the audience (Nash and Alexander, 1995). Before the actual design process begins, one must have identified why an IMM program should be developed and whether there is an audience for the end product. This will avoid the production of inappropriate or unnecessary software (Beattie, 1994). The target audience must also be deemed to have the necessary basic computer skills to be able to use the end product. Finally, but probably most importantly for development of educational software, the learning objectives of the program must be stated from the beginning of the project. These then serve as a guide throughout the development, implementation and evaluation of the software (Beattie, 1994). Once these initial parameters have been addressed, a well designed and managed IMM program has the potential to support the learning process very well (Laurillard, 1994a).
Design and development considerations for IMM

Lancaster (1996, p. 76) describes the importance of good design in IMM and the responsibility of the designer:

Interactivity involves the request for and agreement to collusion. The player or learner agrees implicitly to go along with the experience offered, opening themselves to possible change in areas that are very personal, including acquisition of new skills and attitudes, or being led through a make-believe world which may frighten or challenge them. This willingness to participate carries with it heavy responsibilities for the design team.

Too often IMM programs are little more than electronic books using old concepts, terminologies and metaphors in their design. Pre-existing material is often ‘re-invented’ in a new medium, with no real advantage over the old form.

Recent advances in computing and telecommunications have meant a massive increase in the amount of material available in the form of IMM, but with no real improvements in the overall design concepts (Yardley, 1996). Developers need to take into consideration the needs of the end user as well as general design principles such as screen graphics and ease of navigation. Most important, before development begins, one needs to be sure that IMM is the appropriate medium for the instructional task. Consideration of cost, suitability of content and the appropriateness of the medium must be considered before development begins (Schwier and Misanchuk, 1994). The content must be suitable for the medium in relation to its level of complexity, ability to be carved up into chunks and its stability. Material which is constantly changing as new developments emerge may not be suitable for some forms of IMM (Schwier and Misanchuk, 1994).

IMM is an excellent medium for self-paced learning allowing different paths to be explored through programs thus catering for the needs of diverse users (Schwier and Misanchuk, 1994; Laurillard, 1994a; Yardley, 1996). The initial design of IMM must include objectives and analyses of student learning needs (Laurillard, 1994a) and it is imperative that it is not merely systems based but is centred around how people think and learn. User-centred design has to involve a continual cycle of analysis, specification, implementation and evaluation (Quinn, 1994).
Preece (1993) has described four components of human-computer interaction:

- **The learner** has needs which involve a diverse range of physiological, social and psychological elements. Consideration of these are important in design. For example, the length of the program will determine how long the user is expected to sit in one place. The design may require group sessions rather than individual learning. Previous experience with computers and the users knowledge of the subject should also be considered.

- **The learning task** can be variable depending on the aims and objectives of the program. The learning process in IMM may be information seeking, knowledge acquisition or problem solving. The learners may also have their own goals associated with the program. These could be to find the answer to a specific question or just to browse the available information. Exploring a concept or organising information are other goals in which the user may engage.

- **The learning environment** is important. Learners need to feel comfortable with the technology and this may mean providing support aimed at new computer users within the design of the program.

- There are also **technical constraints** which may limit design concepts. These include slow response time of computers and small screen displays.

Whether the program being designed is a game or an educational tool, the designer will want the program to captivate the target audience long enough for the desired outcomes of the program to be achieved (Lancaster, 1996). In the situation of self-paced learning, where often the lecturer or teacher is not present to provide encouragement to the student, motivation must be built into the design of the program to keep the user occupied and interested (Lancaster, 1996).

Three elements are described by Lancaster (1996) as being essential to designing IMM programs with motivation:

- **Content message**: The information must be accurate and complete with a logical flow throughout the program.

- The ‘**look and feel**’ of the program must be inviting to the user and create emotional responses (affective domain) through appropriate sound, graphics, animation and video.

- The human-computer interface needs to be intuitive, transparent and ‘**user friendly**’. Nothing alienates users more than a program that is difficult to use and appears to require a degree in computing to be able to operate.
Programs that are easy to move through will put users at ease and allow them to concentrate on the content rather than the logistics of navigation. Navigational design is also important in relation to the type of program. An instructional program that presents material in a sequential fashion would be expected to have a different navigational strategy than one which allows the user to explore a myriad of ideas and concepts within the program.

The simplest navigational design is linear (Figure 1) and is consistent with more conventional methods of presentation such as lectures and books. The advantage of this form of navigation is that it is the easiest to program and an argument can be built in a sequential fashion (Schwier and Misanchuk, 1994; Phillips and DiGiorgio, 1995). A disadvantage is there is little opportunity to access the middle of the program without starting at the beginning or going backwards through a number of screens (Phillips and DiGiorgio, 1995).

An hierarchical design of navigation (Figure 2) is more complex and enables the user access to various pieces of information and choices of direction through the program (Schwier and Misanchuk, 1994; Phillips and DiGiorgio, 1995). This is advantageous because it is also relatively easy to come back to previously viewed information in the middle of the program rather than having to return to the beginning (Phillips and DiGiorgio, 1995).

Probably the most common navigational design incorporates the simpler linear design with the hierarchical design (Figure 3) and is referred to as mixed hierarchical (Phillips and DiGiorgio, 1995). This design tends to have the advantages of both styles of navigation and the linear segments may be quite appropriate for parts of an otherwise complex program (Schwier and Misanchuk, 1994).
Figure 1: A model of linear navigational structure. (After Phillips and DiGiorgio, 1995)

Figure 2: A model of an hierarchical navigational structure. Links to the main menu (black square) exist from all levels but have been omitted from the diagram for simplicity. (After Phillips and DiGiorgio, 1995)
Figure 3: A model of mixed-hierarchical navigational structure. Links to the main menu (black square) exist from all levels but have been omitted from the diagram for simplicity.
(After Phillips and DiGiorgio, 1995)

Figure 4: A model of hypermedia navigational structure. Links to the main menu (black square) exist from all levels but have been omitted from the diagram for simplicity. In this model it is also theoretically possible to access any screen from any point in the program.
(After Phillips and DiGiorgio, 1995)
The three navigational designs discussed so far are relatively limited in user control and tend to follow an objectivist approach to educational issues (Phillips and DiGiorgio, 1995). In some instances this is highly desirable. For example, Curtin University has developed a program to help nursing students calculate drug dosages. It is a requirement that the students develop skills that enable them to get the correct answer every time. In this type of program a mixed hierarchical design with an objectivist approach is the most appropriate for the specific learning task involved (Phillips and DiGiorgio, 1995).

Probably one of the most complex organisational structures in multimedia is referred to as hypermedia. Unlike other designs discussed so far, hypermedia is not limited to two dimensions, allowing multi-directional movement within the program (Schwier and Misanchuk, 1994; Phillips and DiGiorgio, 1995). Figure 4 gives a simplistic depiction of the complex branching associated with hypermedia. The educational advantage of this design is that it strongly supports a constructivist approach to learning (Phillips and DiGiorgio, 1995). In theory, hypermedia branching allows access from any given screen to any other in the program, in reality however, the number of links is often more limited (Schwier and Misanchuk, 1994).

Shapiro (1994) conducted a study to determine the effect of hypermedia links on learning. Undergraduate students were tested on programs depicting an imaginary world with information about ecosystems and animal species. The four programs differed only in navigational design and complexity, but not in content. The designs ranged from typical linear to complex hypermedia. The data obtained from the study indicated that students exposed to hypermedia integrated information presented in the linked model better than those exposed only to the linear model.

However, other data obtained from the study indicate that there was no real advantage using hypermedia with respect to developing problem solving abilities (Shapiro, 1994). From this study the true advantage of hypermedia in educational settings remains to be proved especially when one considers the high level of complexity in programming and hence the increased cost of development of hypermedia programs.
One of the problems with highly branched designs, such as those in hypermedia, is the possibility of becoming sidetracked and eventually lost within the program (Phillips and DiGiorgio, 1995). This can be overcome to some extent by providing appropriate links via a control panel on each screen which allows users to either get back to the main menu or to be able to 'see' precisely where they are in the program (Schwier and Misanchuk, 1994).

The planning and design processes begin with the brief which is a description of the subject matter to be developed into an IMM program. Layout of the screens is important in relation to culturally influenced reading patterns, colours and other dominant elements. Drawings, diagrams and animations need to be relevant to the subject as well as the visual communication (Phillips and DiGiorgio, 1995). As with a printed page, a single screen should not be cluttered with too many ideas. For optimum communication it is better to present a single idea on each page or screen (Heinich, Molenda and Russell, 1982). More is not better, simplicity being the key to good design.

The appropriate use of colour can create the desired ambience and even influence moods (Heinich et al., 1982) while also providing some structure to the program by distinguishing between central and peripheral material, being used as a cuing device or indicating movement (Heinich et al., 1982; Romiszowski, 1988; Phillips and DiGiorgio, 1995). People prefer colour to black and white (Romiszowski, 1988), but that should not be seen as a cue to the overuse or abuse of colour (Heinich et al., 1982; Phillips and DiGiorgio, 1995).

The choice of colours may also be determined by the target audience for the program. Saturated or warm colours, such as red and orange, are appropriate for children, whereas cooler colours, such as violet, blue and greens, are more suitable for an adult audience (Heinich et al., 1982; Romiszowski, 1988). Even the names of colours can be important in the appropriate choice. Romiszowski (1988) reports that easily named colours aid memory more than colours that have complex names. Another consideration is the use of reds and greens in relation to colour blindness. However, if the correct tonal choice is made of these colours, afflicted individuals should still be able to differentiate between graphics or text on the screen (Simon Yates, personal communication).
The target audience is the major determinant of the level of writing for the text component of the program. The text must be written appropriately to maintain interest and prevent alienation to ensure maximum educational value. Short, concise sentences work best with a maximum of 7-10 words per line and no more than 20-30 words total per screen. Spacing between the lines of text (leading) is also important to ensure easy reading of the text (Phillips and DiGiorgio, 1995).

Many of the general principles of graphic design that apply to the print medium also apply to screen-based design. However, some special consideration needs to be given due to the fact that the resolution of a computer screen is much less than that of the printed page (Phillips and DiGiorgio, 1995). Screen resolution is only 72 dots per inch compared with 300 dots per inch produced by the average laser printer. This makes a considerable difference to the readability of the same material presented in print and influences the choice of font style and size for computer programs.

The same principles apply to other elements of the program. To work well, the program must make the target audience feel comfortable while still being in the appropriate genre for the content and purpose intended. Entertainment programs may have quite a different ambience than an educational program even if the target audience is the same. All of these design issues must be given extensive consideration before development gets underway.

Laurillard (1994a, p. 204) lists some problems which should be avoided in computer programs, most of which need to be addressed at the design stage. These include:

- looking for the ON button
- wondering why nothing is happening
- discovering you are unable to get back to the point you were just at
- being told you are wrong when you know you are right
- wondering how long this is going on for
- trying to guess the word the program is waiting for
- coming upon the same feeble joke for the fifteenth time
- trying to work out how to get to the point you want
These are just a few of the annoying little things that can turn users away from computer programs in droves. They should be easy to overcome if the user is considered at all stages of the design process.

Once the design principles have been determined a development team needs to be assembled. The size of the team can vary considerably but there are some crucial areas which must be included during the development of IMM programs. These include obvious skills such as programming and graphic design and a content expert. There are also other issues which must be addressed during development including copyright law, production problems and evaluation techniques (Laurillard, 1994a). The whole project needs to be managed by a team leader or manager who has some grasp of all aspects of the project as well as the appropriate interpersonal skills to keep the team together and on track.

Laurillard (1994a) suggests that the most productive path to development of new programs, including IMM, for use in tertiary teaching is for institutions to collaborate more. This has a number of benefits including the pooling of ideas to improve the quality of design, better use of resources and hence a reduction in costs, as well as the elimination of unnecessary duplication of coursework materials.

Peer review throughout the development stage, especially in relation to the subject matter, is important to ensure that those who will eventually be involved in the adoption and implementation of the program are happy with the program. It may not be possible to please everyone, but a general consensus on the suitability of the content and applicability to courses is important if the program is to be implemented (Laurillard, 1994a).

One thing that must be considered is a professional approach to the design and development of IMM in relation to having the right people involved at the right time. The content expert may well be the concept creator for the program, but that does not necessarily mean they are appropriate for the design and development of the program, even though extensive consultations may be necessary throughout the entire process. It is unusual for the concept creator to have adequate knowledge across the necessary areas to complete the design phase alone (Lancaster, 1996).
As stated by Yardley (1996, p. 84):

... simply using a video camera does not make one a Steven Speilberg, just as using a word processor does not transform us into a Hemingway!

Good teamwork is the basis of good IMM design.

**Implementation of IMM**

The effective use of IMM is not just a matter of sitting a student in front of a computer and waving the green flag. Thought must be given to how the program will be used and implemented to enhance the learning process to its optimum. Herrington and Oliver (1995) propose that there are three interacting elements that must be considered - the learner, the program and the implementation of the program. According to Herrington and Oliver (1995), these three elements, shown in Figure 5, are the constitutive elements of situated learning in IMM.

![Constitutive elements of situated learning in interactive multimedia.](Herrington and Oliver, 1995).
Some enthusiasts envisage that computer programs, especially elaborate ones such as IMM, will replace traditional teaching methods, and consequently teachers to a large extent. Others see lecturers and teachers as having a pivotal role in the implementation of IMM. The role of the teacher as mentor or coach is important in the implementation of most IMM programs and should be an integral part of the program design rather than the assumption being made by the designer that the program is entirely self-contained (Herrington and Oliver, 1995). The learning cycle described by Laurillard (1994a) of goal-action-feedback, requires the participation of a teacher/lecturer in the discussion of material and reflection of the learning experience.

New technologies need to be incorporated totally within the existing system. However, this should not be seen as a one way operation. The whole system needs to adjust. The use of technologies like IMM, does not occur in isolation from other forms of learning, such as lectures and practical classes, which may be part of the whole course. The use of computers and IMM needs to be a natural part of the whole process, not just an added on after thought (Laurillard, 1994a).

For this to occur smoothly the system has to be flexible and those implementing IMM programs must be well versed and comfortable with their use. This means training the staff who will be involved in the implementation. One immediately thinks only of academic staff, but there are many more players in this than just those at the coal face. There are support staff for both the maintenance and administration of the equipment and software who need to be involved with the implementation process and its evaluation (Laurillard, 1954a). Implementation must be monitored to make ‘running repairs’ when necessary, so that the operation is as smooth as possible from the users point of view.

One major problem with the implementation of any computer-based learning activity is alienation of the user. In a study conducted at the University of Western Australia which examined the responses of students to four types of instruction in a human physiology course, students who commented adversely about learning through the use of IMM found computers intimidating or difficult to use (Stocklmayer, Lockwood and Dickinson, 1995). Good implementation of programs can help students overcome some of their problems and give them confidence so that the programs can be used to their full potential rather than being dismissed as not being ‘user friendly’. 
Evaluation of IMM

The process of evaluation is essentially the process of determining to what extent the educational objectives are actually being realised... (Tyler, 1949, p. 69).

Having developed a program, it must be evaluated. Or should it? Evaluation is not a distinct, stand-alone phase in the production of computer-based programs. It should be incorporated in one form or another throughout the process from initial concept and design to implementation.

...Most grants for product development downplay the impact of evaluation in the development of a quality product. If the developers realised the importance of information gathering as part of the design and production of interactive packages, the quality of the packages in terms of learning outcomes would be enhanced (Alexander and Hedberg, 1994, p. 241).

Alexander and Hedberg (1994) propose four major activities involved in the completion of a computer-based program, each of which requires some form of evaluation (or information gathering). These are design, development, teaching (or implementation) and institutionalisation.

Before the design of the program begins, there must be a needs analysis i.e. what is the perceived problem and is IMM the appropriate solution to the problem? From here formative evaluation should be started and continue through the development process (Alexander and Hedberg, 1994). The information obtained from these evaluations should answer questions that may arise about educational strategies, user interaction and how students are learning. Summative evaluation should follow as the program is put to the test in the teaching environment. This will determine what changes in understanding the students have undergone as a result of using the program. It can also determine whether the initial rationale for developing the program has been justified in regard to satisfying the objectives of the program (Alexander and Hedberg, 1994). At the broader, institutional level, an impact evaluation allows assessment of the broader benefits of the program in relation to the transfer of changes in understanding as applied to a broader context of learning (Alexander and Hedberg, 1994).
By including evaluation steps early in the project it is possible to determine fundamental problems which can be corrected early rather than find that the program is unacceptable and then not used (Ingram, 1996). But who should be the evaluator? Designers, developers and content experts are not always the most appropriate people to conduct evaluations. Usually they are too close to the project or are lacking in the appropriate experience and skills to carry out the task satisfactorily. To assure objectivity, evaluation should be done by those experienced in the process and not involved in the design or development of the program (Ingram, 1996).

Evaluation must be carefully planned from the beginning. It is not sufficient to know if users 'like' the program. The learning outcomes (objectives) must be evaluated (Beattie, 1994; Ingram, 1996). Ingram (1996) recommends that before the actual evaluation a 'dry run' of the test be conducted to ensure that the program and equipment run smoothly and the environment is suitable for the task. The method of evaluation will be determined largely by the target audience and the type of program (Ingram, 1996). Methods used for adults may not necessarily be appropriate for assessing a program designed for children. The choice may also be determined by financial concerns in relation to the amount of money earmarked for evaluation in the initial proposal.

A variety of methods is available for evaluation. Triangulation is a method by which more than one type of datum is used to evaluate the program (Beattie, 1994). By using triangulation one can theoretically overcome any biases or inconsistencies that may be inherent in any one particular method.

Observations of user interaction with the test program can be useful. Recording or observing two or three students using the program together (co-discovery) allows the students to help each other and discuss naturally their feelings about the program (Laurillard, 1994b; Ingram, 1996). However, care must be taken not to take comments made too literally in relation to what is 'liked'; what the user expresses as liking may have little to do with the learning outcomes (Beattie, 1994; Ingram, 1996). Observation can be very helpful in discovering unintended outcomes that go beyond those planned (Laurillard, 1994b).
Ingram (1996) recommends videotaping as essential for the observer. However, Laurillard (1994b) recommends notetaking rather than video due to the problem of ambient noise and the time and money involved in transcription of the tapes. The choice would probably depend on availability of professional equipment and personnel to make the recording worthwhile.

Questionnaires are useful with adults, especially when large numbers are involved, and can often elicit more honest answers than direct discussion with the evaluator. The questionnaire should be short and the questions easy to answer (Laurillard, 1994b; Ingram, 1996). For young children with limited skills in reading and writing this form of evaluation has little value (Ingram, 1996).

One of the more useful forms of questionnaire testing, which is often used to assess what students have learned or how attitudes of users may have changed after using an IMM program, is pre- and post-testing. The two tests must be identical for each evaluation, although the form of question and the way in which the data are analysed will vary according to the program being assessed (Laurillard, 1994b). For example, students may be asked before they use an educational program to give a written explanation of 'phenomenon X'. They would be asked to perform the same task after using the program and an evaluation made as to what the student has learned from using the program. Other parameters that may be measured are changes in language, attitude or the structure of thought processes which would indicate a change in understanding associated directly with use of the program (Laurillard, 1994b).

Beattie (1994) describes pre- and post-tests as a 'quasi experiment' but points out that there may be some problems in the credibility of the data obtained. Questionnaires such as these can result in the pre-test actually affecting the outcome of the post-test if the same students are used. One way of overcoming this, if enough students are available, is to test one group of students before using the program and another matched group after using the program. The only problem with this can be matching groups of students to obtain good data (Beattie, 1994).
Some programs are assessed using audit trails which keep a record of what parts of the program are accessed the most and how long is spent on particular screens. From these data the pattern of use can be determined and some insight into the type of learning that occurs during use of the program can be obtained (Beattie, 1994). However, this form of monitoring can generate enormous amounts of data which are difficult to interpret and not directly comparable between users (Williams and Dodge, 1993; Fritze, 1994; Laurillard, 1994b). There is also the added complication when interpreting data of users just walking away from the computer for some length of time. This could be interpreted as the user spending a long time at that point in the program, which would not be the case.

Direct interviews can yield useful results, but is extremely labour intensive (Laurillard, 1994b) and hence unlikely to be financially viable given other costs associated with IMM development.

An example of a triangulation approach to evaluation was in the assessment of the program 'Investigating Lake Iluka' developed at the University of Wollongong. The three approaches used in evaluation were expert review, one-on-one testing of the prototype and interviews with users from which in-depth case studies were developed (Hedberg et al., 1994). From this, information was gained about general use of the program including interface conventions, many of which are taken for granted during development and can cause user problems when inadequately assessed.

Where IMM programs are incorporated into an existing curriculum it is important to assess the whole program and not just the new component. The Faculty of Veterinary Science at the University of Melbourne introduced a computer-based approach to the teaching of microbiology within the veterinary science course (McNaught, Whithear and Browning, 1994). Conventional methods of delivery, such as lectures and laboratory classes, were retained, but an added dimension was the inclusion of a multimedia component. Evaluation involved the whole package, not just the multimedia component, and the design included feedback on modules, reactions to the changed format and analysis of changes in students' problem-solving abilities (McNaught et al., 1994). Evaluation of the multimedia
component alone, no matter how well designed or conducted, is not adequate to assess the true impact on the educational and learning processes taking place. Use of IMM in an existing curriculum does not occur in isolation and must be assessed in relation to the other components within the course (Laurillard, 1994a).

Once a program is evaluated, the question arises as to what to do with the results? It would be nice to think that evaluations are actually used to improve the design of existing or new programs. The data obtained from the evaluation process can be used by a variety of groups and as such needs to be in a language easily understood (Fritze, 1994). The potential users of the data include the target audience, designers of various types, lecturers, teachers, facilitators and educational researchers (Fritze, 1994). The results should also be included in the marketing strategy (Beattie, 1994). This may not only help sell the product, but give an indication that there is at least some level of quality control and care taken to ensure that the described objectives may actually be achieved by the program.

A recent observation made at a workshop devoted to the use of computer-based technology to simulate laboratory classes was that the largest deficiency in Australian universities was in the evaluation of materials being produced (Johnston and Peat, 1996). The programs discussed were largely 'in house'; however, that does not negate the need for adequate evaluation. One institution did monitor student performance in routine examinations (Johnston and Peat, 1996), but it would appear that no evaluation of the actual program was conducted. The question arises as to why bother developing programs in which valuable time and money are invested if no-one even bothers to assess if any improvement in learning or understanding occurs? Part of the answer to this lies in the reasons for development - not all of which are for the enhancement of the learning process.

Formative evaluation is essential to the ongoing development of IMM as it enables designers and developers to increase their knowledge base of what the medium is capable of, as well as its limitations (Laurillard, 1994b). No matter what form the evaluation takes it must be incorporated into the project from the very beginning and not left to the end where it could be too late to make any worthwhile changes (Beattie, 1994).
Some Australian universities have established units incorporating designers, programmers, content experts and evaluators to produce IMM programs for teaching purposes. The reasons for development vary between institutions and departments, although most see IMM as a useful and productive addition to existing teaching tools. The principles of design and development outlined above, however, need to be in place for programs to have their optimal effect in enhancing the learning experience. In would appear that at least in the area of evaluation, this is not always the case.

This chapter will take a look at some of the programs that have been developed in Australian universities, the reasons behind their development and, where possible, the outcomes of their use. This 'cross-sectional' view is not meant to be exhaustive. It represents the types of programs being used and reasons behind their development. The main focus is on the use of IMM within science-based courses.

Use of IMM to replace or enhance practical work.

There is much emphasis on the practical components of science-based university courses, yet little thought is given to the design or expected outcomes of practical classes. In many cases students dislike laboratory work, gain little from the experience and may even be turned off experimental science because of their experience (Peter, 1996). There are some science-based courses in which traditional laboratory classes serve no real purpose in the training of the students. Although students of mining and medicine need a good understanding of the life sciences, the practical skills obtained in a biochemical laboratory class are not relevant to their course or ultimate careers (Learmonth, 1996). In courses such as these, traditional laboratory classes could be replaced effectively with computer simulations without any loss of appropriate hands-on training.
Chapter 4

The Development and Use of IMM in Tertiary Science-Based Courses

Some Australian universities have units or departments dedicated to the design and development of computer-based programs for educational purposes. Some of these produce programs commercially, whilst others develop programs for internal use only. Many of the departments have grown out of the need to find alternative methods to deliver coursework, especially in science faculties, following continual cuts to the tertiary sector by the Federal Government. This is also the rationale behind some of the individual programs. Some, however, have been instigated by a desire to improve the learning process. Whether that has been achieved is difficult to determine.

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There is much emphasis on the practical components of science-based university courses, yet often little thought is given to the design or expected outcomes of practical classes. In many cases students dislike laboratory work, gain little from the experience and may even be turned off experimental science because of their experiences (Pearce, 1996). There are some science-based courses in which traditional laboratory classes serve no real purpose in the training of the students. Although students of nursing and medicine need a good understanding of the life sciences, the practical skills obtained in a biochemistry laboratory class are not relevant to their course or ultimate careers (Learmonth, 1996). In courses such as these, traditional 'wet' labs could be replaced effectively with computer simulations without any loss of appropriate 'hands-on' training.
In laboratory-based and field science courses one of the major costs is running practical classes. This is especially the case if the reagents are expensive, animals are used or the setting up procedure requires a lot of time. There are many experiments which cannot be done in the usual 3 - 4 hour block set aside for practical classes, but which may be beneficial for student learning and understanding. Field work usually involves a number of members of staff and many resources over days or weeks. There is no guarantee that experiments will always work or that field conditions will be suitable for the desired demonstrations/observations. In most instances, there is little for students to gain from a failed 'recipe book' style experiment except the idea that nothing is infallible. To continue to enable students meaningful access to experimental procedures and field work, whilst reducing overheads, some universities have developed programs to replace conventional practical classes.

At the Australian National University (ANU), the Department of Forestry has developed a computer-based program enabling the study of fire management within the forestry degree. This has developed out of problems in the past with field trips in which the time of the year or the conditions were unsuitable for adequate instruction in fire management (Trevitt and Sächse-Åkerlind, 1994). There are costs associated with this in relation to field trips and the resources they require. By using effective simulations the costs can be reduced and the students are guaranteed of success in the exercise.

The Department of Botany at the University of Western Australia has developed a computer simulation called Escuela Practica, (from the Spanish for school and practical) (Loneragan, 1996). The program grew out of exercises developed for students to do when the weather was too wet for field work. Unlike the 'real' equivalent, the computer-based exercise can be done relatively quickly and has none of the costs and logistical problems associated with field trips. The Department of Geography at the University of Melbourne has also adopted Escuela Practica for use in its first year program (Loneragan, 1996).

Use of computer exercises in place of field work has obvious advantages especially in first year classes where the numbers tend to be high, adding to the cost of a field trip. The data collecting and analytical skills of first year students are not usually advanced, adding further complications to the value of the exercise.
Through simulations students can concentrate on issues from which real learning and understanding can take place. As with laboratory techniques, however, the skills required to become good field scientists cannot be taught adequately through simple computer simulations. There is still a place for 'real' field work, although it may be better placed out of first year where the student numbers are lower and skills more advanced.

IMM programs have been developed which do not replace laboratory classes but rather prepare students for the practical class or help them analyse data and give them feedback in a way that is more meaningful than the methods used in the past. The Flinders University of South Australia (FUSA) formed the Computer Mediated Learning Unit in 1992. A variety of packages have been developed including laboratory simulations, marking programs and tutorial assessment programs (Pamula, Pamula, Wigmore and Wheldrake, 1996a; Pamula, Wigmore and Wheldrake, 1996b). In a second year biochemical exercise, observations that students had difficulty completing calculations lead to the development of a computer-aided learning program that guides students through the relevant calculations in a step by step manner, giving feedback and allowing the students to work at their own pace in a non-threatening environment (Pamula, Wigmore and Wheldrake, 1995; Pamula et al., 1996a, 1996b). The program does not replace the 'wet' lab which is undertaken over 4 x 3 hour sessions, but does allow appropriate processing and analysis of the data, reducing the amount of time previously required for tutors to pinpoint errors and give feedback. These types of programs are designed to enhance the understanding of the processes and data obtained allowing valid conclusions to be made from meaningful results (Learmonth, 1996; Pearce, 1996).

Another area in which computer-aided learning programs have been adopted to enhance the practical experience is in pre-lab preparation. Much time can be lost in the laboratory by students who are poorly prepared for the class or are unfamiliar with the equipment (Parslow, 1993; Pamula, 1994; Pamula et al., 1996a; Pearce, 1996; Wilson and Lewis, 1996). Another advantage, especially in large classes, is that all students get the same information at the beginning of the practical session, overcoming inconsistencies where a number of people of varying skills and abilities may be responsible for the delivery of pre-lab instruction (Pamula et al., 1996a; Wilson and Lewis, 1996).
In some instances 'wet' labs have been completely replaced by IMM programs. The MILL at the ANU has recently completed a program replacing a biochemical practical on oxidative phosphorylation (Day, Arundel and Bennett, 1996), one of the biochemical pathways involved in cell metabolism. The MILL co-ordinator, Mark Arundel, estimates that the program will save 60 rats per year and up to $150,000 in setting up costs to run a practical class demonstrating the same phenomenon. Clearly the motivation in developing this program lies in the reduction both in the use of animals and in the associated cost.

FUSA have developed a number of programs to replace some first year practicals. One of the most successful has been a computer-aided learning exercise in spectrophotometry (Pamula, 1994; Pamula et al., 1996a). The program is multi-faceted in that it includes a tutorial, a simulated practical component and it assesses the students ability to process the data obtained. There are some disadvantages to programs such as this in that students do not obtain the 'hands-on' experience of actually doing the practical in a laboratory setting (Pamula et al., 1996a). However, the ability to be able to receive rapid feedback on calculations, become familiar with equipment before using it in later years and being able to work at their own pace can outweigh any perceived disadvantages for the students.

The use of simulated experiments also allows students access to data and situations that would be impossible in the laboratory setting. Studies of population biology and evolution can not always be performed in traditional laboratory settings either through lack of facilities or constraints associated with generation times (Pamula et al., 1996a; Pearce, 1996). FUSA has developed a simulation to study resistance of agriculturally important fungal pathogens which enables students to vary several parameters of the fungal population and the properties of the resistant gene, an experiment not possible in the practical class (Pamula et al., 1996a). Simulations also allow students access to data generated by equipment generally not available to undergraduates (Pearce, 1996). In the School of Physics at the University of Melbourne, students use data generated directly by the researchers using a nuclear microprobe, an expensive piece of equipment not available for undergraduate use. The program not only allows simulated use of an otherwise inaccessible piece of equipment, but also allows students to use 'real' data generated from a research laboratory (Pearce, 1996).
The Computer Centre at Curtin University in Perth has been involved in computer-based education programs since 1980 (Phillips, 1995a). The Centre has produced a number of IMM programs including simulated experiments. One of these, 'Osmosis', was developed to reduce the handling of hazardous material and allow students to concentrate on the principles involved rather than trying to deal with unfamiliar and complex equipment (Phillips, 1995a; Fyfe and Fyfe, 1996).

In some cases, rather than replace an experiment completely with a simulation, computers have been used to enhance the normal laboratory experience. This can be through testing and on-line support (Pearce, 1996) during a practical class. Robert Learmonth (1996) at the University of Southern Queensland has integrated computer-aided learning programs with traditional laboratory exercises. Much of the third year biochemistry taught by Learmonth involves protein purification and analysis. Before beginning laboratory work students have a series of tutorials and computer simulations enabling them to familiarise themselves with the techniques and make mistakes before the actual practical class thus saving time and valuable resources in the laboratory.

In July, 1997 the University of Sydney opened the New Technologies in Teaching and Learning unit which is designed to co-ordinate and support technology-based developments within the University (Downie, 1997). One of the IMM programs currently under development is a simulation for medical students allowing them to learn and practise diagnostic skills. The students have the experience of interacting with each other and diagnosing illness in a situation as close as possible to the real thing.

The general consensus of delegates attending the 1996 UniServe*Science Dry Labs Workshop, was that new technologies, such as simulations and other forms of IMM, should be used to enhance the existing laboratory experience, rather than replace it (Johnston and Peat, 1996). There are some academics who are opposed to the replacement of practical classes with computer simulations. Johnston and Peat (1996) suggest this is the reason why a very small number of science departments within Australian universities are actually replacing 'wet' labs with 'dry' labs, despite the potential long-term financial benefits. Obviously it would be a mistake to consider replacement of all laboratory classes, even at the first year level. Practicals form the basis of experimental training and manual dexterity. Skills, such as aseptic technique, can only be acquired through practice and the
earlier the introduction to the technique the better skilled the students are likely to become. However, it would seem that where particular laboratory classes become too expensive to run or involve the use of dangerous chemicals, that a simulated alternative could be the answer rather than denying the students any experience other than that found in a static textbook. As an example from personal experience, both from the perspective of a student and a tutor, I fail to see the knowledge to be gained from the laborious task of counting and sexing fruit flies to demonstrate Mendelian genetics only to find that the results are not statistically significant (despite the pooling of data collected by hundreds of students) and that the class is totally overcome by ether fumes. Practicals such as this are well suited to computer programs, even with limited interactivity, with a guarantee that students may gain more from the experience than failing eyesight and an immense dislike of volatile organic chemicals.

Use of IMM to enhance the understanding of dynamic and 3-D processes

Another area where computer simulations and animations can be useful is in the teaching of dynamic processes which are often conceptually difficult and not easily portrayed in textbooks. Chemical and biological processes, especially at the molecular level, often cause much anxiety amongst students in their inability to grasp the concepts as delivered in conventional lectures. Students with little or no previous experience in biological sciences often perceive biology as a soft option when they enter university. They then find that they not only have difficulty with the jargon but also the concepts and dynamic processes with which they are unfamiliar.

The Department of Zoology at the University of New England began developing programs to address these conceptual problems under a CAUT grant (Whittington, 1995). One of the areas targeted for development as a computer tutorial was cell division, a dynamic process the concepts of which are very difficult to convey through a textbook. The material was supplementary, rather than a replacement of conventional materials and delivery. Concepts relating to structure (shape) and function are often difficult for students and the use of computer tutorials has been useful in overcoming these difficulties. Use by external students was also another consideration in the development of these tutorials (Whittington, 1995).
Curtin University has developed a number of programs which are designed to enhance lecture material as well as student tutorials to improve student understanding of dynamic, molecular processes with which students often have difficulty and which are difficult to teach effectively in traditional lecture-style delivery. Fyfe, Fyfe and Phillips (1995) first developed a computer animation for use in first year health science lectures to explain the molecular process of skeletal muscle contraction. This later developed into an IMM tutorial called ‘Sarcomotion’ which allows students to explore the subject in more depth and to access resources outside the scope of the tutorial via a link to a WWW page (Fyfe et al., 1995).

Chemistry is another discipline in which the processes are three dimensional and molecular and often deemed to be conceptually difficult. Rob Capon (1995; 1996) from the University of Melbourne, developed a self-paced IMM package to replace a laboratory exercise centred around the construction of chemical models. Although the class was scheduled in a laboratory, it was not a typical ‘wet’ lab and as such lent itself well to be removed from the chemistry laboratory and placed in a computer laboratory (Johnston and Peat, 1996). The program is focused around the shape of organic molecules and includes structural, geometric and conformational problems with which the students interact through animations depicting molecular processes at work (Capon, 1996). Students are able to work at their own pace and are supported by rapid assessment and feedback. The program was designed to complement rather than replace traditional teaching methods and tools, such as lectures or textbooks (Capon, 1996).

**Programs designed for problem-based and situated learning**

Although many of the programs already discussed do have a problem-solving element incorporated, they have generally been designed to replace or enhance existing methods of teaching such as ‘wet’ labs and tutorials. Other programs, although serving a similar purpose, have been designed specifically to develop problem-solving skills in the users.
Ralf Cord-Ruwisch (1996), from the School of Biological and Environmental Sciences at Murdoch University, has developed interactive computer modules to enhance the learning experience of students studying biotechnology. Traditional lecture material was transformed into highly interactive software modules designed to give immediate feedback, develop problem-solving skills and increase the motivation of the students whilst also improving retention of material (Cord-Ruwisch, 1996).

Other programs have been developed with a very specific task in mind, especially in relation to developing skills in applied science courses. After eight years experience of teaching science to nursing students in a university it has become obvious to me that there is a greater emphasis on academic rigour than there was when training was hospital-based. Although this has obvious advantages in relation to the academic credibility of the profession, in many cases it has taken relevant hands-on training out of the hospital and transformed it into what is often perceived as an irrelevant setting isolated from real life application.

The size of the science component of nursing courses varies considerably between universities. However many, if not all, teach disciplines such as microbiology in the same way to nursing students as they do to mainstream science students. The problem with this is that the long term application of the knowledge and skills is quite different for a nurse practitioner compared with a clinical microbiologist, although the same knowledge base is relevant to both professions. Curtin University have developed an IMM program for students of medical and health science to place the discipline in context and develop problem-solving skills relevant to what is experienced in the hospital setting (Edwards and Phillips, 1995). This is an example of where IMM programs can at least approximate situated learning.

Another program developed at Curtin University specifically for students of health science is designed to develop competency in drug dosage calculations (Glaister, Jenkins and Robert-Libia, 1995). Because of the absolute requirement to 'get it right' every time, this program is largely linear in its navigational design (Phillips and DiGiorgio, 1995) but permits student-centred and self-paced learning whilst facilitating transfer of knowledge to the hospital setting (Glaister et al., 1995) a most desirable outcome for this type of learning package.
Use of IMM for assessment

As well as programs to assist in the understanding and learning experience of students, programs have been developed to help lecturers and tutors produce and mark assessment material. Some forms of assessment are incorporated into programs previously discussed (Pamula, 1994; Pamula et al., 1996a; 1996b; Capon, 1995; 1996).

Uniserve*Science held a workshop on computer assessment in February, 1997 to discuss how computers are being used and could be used in the future for assessment (Johnston and Peat, 1997). Approximately 50% (24/50) of departments represented at the workshop used some form of computer-based assessment (CBA), although there were 170 science departments which were not represented. Most use of CBA tends to be in departments of biology and chemistry rather than other science disciplines (Johnston and Peat, 1997).

One reason for establishing CBA would be to relieve staff from the tedium of marking, especially numerical tutorials or multiple choice styled tests which lend themselves to this form of assessment. Whether CBA can actually save money for universities is still uncertain. There are issues of generating item banks, maintaining security within the system and replacement costs of hardware (Johnston and Peat, 1997). These issues may well determine whether CBA is a viable option in an already financially strangled system.

Does IMM enhance understanding and learning?

As previously discussed, a number of universities are using complete or partial computer simulations in laboratory exercises. The question arises as to the benefits of this to the student. The benefit to the university is obvious in terms of potentially saving money on expensive laboratory classes and there are many reasons given as to the benefits to the students, but have these been measured?

One of the weakest areas in relation to the development and use of IMM programs in Australian universities is the lack of adequate evaluation of the programs or the effects on the understanding and learning of the students using the programs (Johnston and Peat, 1996). Learmonth (1996) claims that integration of computer programs and laboratory sessions reduces the number of practical and conceptual
errors in the class, making the exercise more successful and rewarding for students. Wilson and Lewis (1996) evaluated IMM CD-ROM developed for use in chemistry classes. Various evaluation methods were used including an initial test trial, observation of students using the program and comparison of student performance. The student responses were positive on a number of parameters indicating ease of use of the program and an enhanced understanding of the subject matter.

In evaluations of student performance related to subjects contained within computer programs, Pamula et al. (1996a) obtained interesting results. Student grades were examined in 1993 when no computer simulations were used, and compared with student grades obtained in 1994, where several practicals were replaced with simulations. For one simulated exercise (Spectrophotometry), there was a clear improvement in grades after the introduction of the program. However, for another program (DNA melting point) there was a decrease in grades whilst others showed little change (Table 1).

<table>
<thead>
<tr>
<th>Program</th>
<th>1993</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrophotometry</td>
<td>74.6 (n=245)</td>
<td>98.1 (n=303)</td>
</tr>
<tr>
<td>DNA melting point</td>
<td>79.7 (n=254)</td>
<td>74.3 (n=304)</td>
</tr>
<tr>
<td>Genetics</td>
<td>77.8 (n=250)</td>
<td>84.4 (n=306)</td>
</tr>
<tr>
<td>Bacterial growth curve</td>
<td>68.7 (n=233)</td>
<td>68.6 (n=260)</td>
</tr>
</tbody>
</table>

**Table 1:** Mean final student marks for the four exercises in 1993 and 1994. (Pamula et al., 1996a).

These results may reflect the ease of use of the program or possibly just the way students perceive the subject material no matter how it is presented. Learmonth (1996, p. 12) sums up the situation nicely when he states:

The use of computer-based activity may not guarantee learning, although the question may be asked whether anything can provide such a guarantee.
In an earlier study done at the University of Sydney, first year biology students were given laboratory quizzes either by computer, which gave rapid feedback, or by a traditional paper-based question sheet, which required the students waiting a week for feedback on their performance (Peat, 1995). There were no significant differences in the scores obtained in the quizzes by the two groups. At the time the survey was done this was interpreted as indicating no disadvantage to those using the computer quiz and that much time and hence money was saved on the cost of tutors (Peat, 1995). But what the results also show is that there was no real advantage in using the computer quiz and obtaining immediate feedback on performance. Whether there is real saving in costs would depend on the institutional infrastructure. In some universities it may cost much more to establish a computer-based assessment program than would be saved by reducing marking time for tutors. If there is shown to be no real advantage to students then the real costs would have to be examined closely. The use of computers just because it is deemed to be the appropriate way to go may not always be justified.

Graeme Hart (1995) at the University of Melbourne did a study on preferred learning styles with one hundred final year undergraduate students. The survey was based around the use of hypertext on the WWW compared with conventional delivery through lectures and tutorials. The results of the survey showed no significant difference in attitudes of the students to different styles of learning (Hart, 1995). This is an interesting result given that one of the educationally-based justifications for using computer technology, in one form or another, is that it accommodates different learning styles of users. One might expect that some students would find computer-based technology preferable to other forms of delivery, whilst other would prefer methods such as lectures and tutorials.

In the School of Biochemistry at the University of Melbourne the use of computer simulations has been progressively increased. Student surveys have shown that biochemistry has gone from being considered in very low esteem by the students to being the most popular subject taught in second year medicine (Parslow, Livett and Stanley, 1996).
Evidence from the United States of America suggests that the use of computer-based instruction could actually be detrimental to learning and understanding. In a controlled experiment, Purdue University, in Indiana, introduced a computer-projected format into organic chemistry lectures (Bodner, 1997). The programs had many graphics and simulations which tended to generate much interest in the class as reflected by the number of questions and level of discussion generated by the students. However, the results of the examination based on material presented showed that students in the experimental group scored considerably less (44%) compared with those in the control group (63%) who had conventional lectures (Bodner, 1997). The conclusion by the instructor was that the:

...introduction (of the electronic blackboard) into the lecture has more profound consequences than would first appear, and a warning label should limit its use to those tasks it does best (Bodner, 1997, p. 11).

Although this is not an example of IMM, is an example of how use of new technologies may not always have the desired or expected results.

There is a general lack of data on the effects IMM and other forms of computer-based technologies have on student learning and understanding. One reason is the lack of evaluation being done, apart from finding out whether students like using the programs. Another is that there is no real common ground or standards. Differences in survey results probably reflect differences in individual program design, ease of use, even the subject matter. More thought needs to be put into evaluation from the very beginning of the design process if we are to assess the true value of IMM on learning in tertiary education.
Chapter 5

Future Prospects for IMM as a Teaching Tool

Where to from here? One of the incentives for developing IMM programs, particularly as laboratory simulations, is to reduce the costs of running 'real' laboratory classes. This perceived potential reduction in overheads seems to be based on a one off purchase or development of a suitable program to replace or supplement a laboratory class. But what is often not taken into account is the continual cost of replacing hardware every few years as it becomes redundant or simply wears out (Johnston and Peat, 1996; 1997). Although the relative cost of computers is decreasing, they are still a considerable outlay especially when you consider how many may need to be purchased to adequately provide for a large first year class. Hartnett (1996) is of the opinion that computers will need to come down in price before their use becomes more widespread. From personal experience in a small, new university, I am aware that it is very difficult to implement IMM programs, even in moderately sized classes, due to the lack of hardware as well as the lack of funds, space and sometimes commitment to develop new ways of teaching.

Distance education is rapidly becoming 'flavour of the month' as universities compete to increase their student base. Some universities have had distance education programs for many years and have been very successful. Changes to the way in which material is delivered to students has been the result of the computer age and the WWW. A number of universities (for example Central Queensland, Deakin and Murdoch) are using on-line material for distance education. The advantage of this is to overcome feelings of isolation for these students and provide a support network otherwise lacking in distance education (Yardley, 1996). Evidence from the United States of America supports the idea that interactivity via the WWW incorporated into distance education augments the learning process through continual motivation and support (Kozma and Schank, 1996). Lack of personal contact has always been a problem with distance education especially in very remote areas. Studies have shown that interaction with other students and staff on campus promotes persistence with courses through collaborative learning and interaction (Pascarella and Terenzini, 1980).
The use of on-line material is not restricted to students in distance education. The University of Melbourne has developed a number of science programs which are delivered to students via the WWW (Pearce and Riddle, 1996). The material is interactive, but includes lecture notes, handouts and copies of overhead projection transparencies as presented in lectures. The students can respond to the material and get feedback via the WWW in an asynchronised way that is non-threatening and can be done from their own home. This type of format allows for both communication and interactivity, giving freedom and control to the learner (Pearce and Riddle, 1996), elements often lacking in conventional lectures.

A program developed at the University of Adelaide allows post-graduate students of radiation biology to study from home via the WWW. The course co-ordinator, Professor John Patterson, says that it may be possible to complete most of the course via the WWW but admits that face to face contact is also important. Currently students are required to attend tutorials on campus (Johnston, 1997).

The next step from on-line lectures is of course the virtual university. This raises the question of whether university campuses will become redundant. Although sounding rather futuristic, virtual lectures and practical classes are being held at least in and through those universities which have adopted new technologies. All that is required is to modify teaching materials into a suitable format and display it on the WWW. Sounds simple, but what does it really mean for the quality of education and interaction as discussed above? There are already virtual universities offering whole courses through the WWW. It may not be long before Australian universities and other institutions offer alternative modes of study which allow students to complete their studies without ever having left their living room.

The head of the Learning Sciences Institute in Northwestern University, Illinois, Professor Roger Schank, claims that computer-based technologies will replace universities within 20 years (Maslen, 1996). But is this really feasible given the cost, both financial and social? Some might say yes, but not everyone. Technologies taken for granted in the western world, such as telephones, are not even available to more than half the world's population (Maslen, 1996). In these regions, where there are often many tertiary institutions, more conventional teaching methods will have to be retained. Closer to home, the cost of replacing
lectures, tutorials and laboratory classes completely is probably far beyond the boundaries of our current funding system. Add to this the reluctance of some academics, and institutions, to give up on existing methods of teaching, and it may be much longer before we see the reality of Schank's prediction, if ever.

One way of overcoming the problem of costs of development is to encourage the formation of consortia. Currently many tertiary institutions are operating in isolation. Lack of co-operation may be the result of other universities being seen as competitors rather than colleagues. There is pressure from the Higher Education Council (HEC) to systematically develop and manage new technologies to make programs more efficient and effective (Coorey, 1997). There is often very little financial support available, however, and even less credit given to academics who may wish to become involved.

The future of technology-based teaching in universities is largely unknown. There is good evidence to show that IMM can be used effectively to enhance learning, and in many cases is even cost effective. How far developments will go remains to be seen. Although virtual reality is largely a research tool at the moment, it may well become part of the teaching and learning environment (Pearce, 1996). If it does there may be no need for students ever to step foot into a laboratory. The experience could be such that the student cannot discriminate between virtual and real experiments, making the outcome effectively the same. If that happens, does it really matter? Only time will tell.
Chapter 6

Conclusions

The nature and client-base of Australian universities have changed considerably over the last 25 years. This dynamic process continues as methods of funding change and universities introduce full fee paying places for domestic students. The education process has also changed with the evolution of computers making accessibility to new technologies relatively easy. The move towards the use of technology-based learning in universities through IMM and the WWW requires significant changes in the thought processes of educators, students and administrators. Evidence exists to show that well designed and managed programs can have a positive effect on the learning process. IMM programs can be particularly useful in helping students with limited previous experience reach a minimal standard before entering mainstream tertiary studies.

Appropriate design and development, implementation and evaluation procedures must be followed to ensure a program is suited to its intended audience and meets the educational objectives originally proposed. Generally, each of these phases requires experts in areas such as content, programming, design and evaluation. At present, there appears to be a lack of serious evaluation of many programs being used or developed in Australian universities, particularly in relation to their effect on learning. It would seem that many university departments are incorporating IMM into existing courses without assessing the benefits (if any) to student learning and the education process generally. More emphasis must be placed on evaluation if the use of IMM is not to be seen as merely using technology because it is there and it is popular.

When implementing IMM programs, it is the responsibility of the lecturer to ensure that the program is relevant to the course and is incorporated appropriately into the overall structure. There needs to be adequate support for students using the program, especially for those who lack confidence in computer use. As many IMM programs rely on self-paced learning, students must take more responsibility for their own learning, something for which many are not prepared.
IMM programs have been introduced to tertiary teaching for a variety of reasons. Reduction in funds has forced many science departments to re-examine high cost areas, such as laboratory classes and field work, to find alternatives that reduce overheads yet do not devalue the education process. Some universities have incorporated simulated experiments into undergraduate courses and used computer programs to better prepare students for classes and give them rapid feedback in areas of assessment. In many cases, these have been seen as cost saving measures in reducing overheads associated with reagents, laboratory animals, technicians and tutors. For some institutions introduction of IMM programs may indeed have saved money but the costs of development and maintenance of both hardware and software are often not considered. Computer equipment becomes redundant very quickly, and the costs associated with replacement must always be taken into account.

New technologies, in all areas, are often seen as a panacea. Unfortunately they can often create more, or at least different, problems than those they were designed to solve. The key to the proper use of IMM in education is in the design and management of the programs. There are many areas for which it is not appropriate. That may change in the future, but the gratuitous use of IMM will serve no educational purpose and will be very expensive.

Because of changes to tertiary funding, Australian universities are becoming more competitive in the market place, especially in relation to attracting international students. New modes of delivery made available through new technologies such as IMM and WWW, will have an impact on how competitive Australian universities can be in the international arena. Alternative modes of education increase the attractiveness of institutions to both local and international students. Universities not offering courses which utilise new technology may find they are unable to compete successfully in either the international or local market. Virtual universities, although small in number, will no doubt provide significant competition to Australian universities, especially in attracting international students. Why would students bother travelling to Australia to study, when they can stay at home and study via the WWW? A number of universities and other organisations in the US offer courses online which will no doubt attract some students who might otherwise come to Australian universities.
The WWW offers great opportunities especially for distance education. Interaction with academics and other students is now possible for those in remote areas. This can help overcome feelings of isolation and probably improve motivation. The offering of whole courses through the WWW, however, may actually result in the isolation of urban students who would otherwise attend a university campus. Whether this will have significant social impact is unknown, but consideration should be given to the creation of a sub-culture of students whose only interaction with academics and fellow students is via a computer.

Is IMM all that it is cracked up to be for education? Probably not. In the right hands, however, it is more than merely a new toy. At the moment it is probably a useful toy. If designed, developed and implemented appropriately, IMM can be a valuable teaching tool. There is no value in gratuitous use of the medium for either educational or financial reasons.

Laurillard (1994b, p. 293) assessed the situation succinctly when she stated:

It is unlikely that IMM will prove to be a better medium in general. Like all learning methods it will be particularly useful at some aspects of the learning process.
References


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