# Apple University Consortium
# Academic and Developers Conference

## e-Xplore 2001:
## a face-to-face odyssey

**Proceedings of the Apple University Consortium Conference**
**September 23 – 26, 2001**
**at**
**James Cook University**
**Townsville, Queensland**
**Australia**

**Edited by**
**Neville Smythe**
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# Editor's note

These Proceedings contain the 25 papers selected for presentation at the Apple University Consortium (AUC) Academic and Developers Conference held at James Cook University, Townsville Australia in September 2001. The selection procedure involved a rigorous review by a panel of academics in which each paper was refereed by at least two reviewers and assessed by each against normal academic publishing standards, and recommended solely on the academic merit of the content — the review process was "blind", that is, the paper's author and affiliation were not revealed to the referee.

My thanks go to the panel of referees for their help in the onerous but rewarding task of selection of these papers, and to Andrew Jeffrey for organising the blind review and the arrangement of publication in printed and electronic form.

*Neville Smythe*
*Proceedings Editor*

## Panel of referees

| | |
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| Ms Lynn Alford | James Cook University, Australia |
| Dr Darl Kolb | The University of Auckland, New Zealand |
| Ms Roisin O'Reilly | James Cook University, Australia |
| Dr Neville Smythe | The Australian National University |
| Professor Roly Sussex | The University of Queensland, Australia |

## AUC Conference Organising Committee

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|---|---|
| Mr Stephen Young (Chair) | AUC Chairman – The University of Melbourne |
| Ms Jeannette Armstrong | Apple Computer Australia |
| Ms Leanne Craddock | The Events Centre |
| Mr Andrew Jeffrey | Apple University Consortium |
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| Ms Julie Land | James Cook University, Australia |
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# Foreword

We are delighted to welcome delegates to the 2001 AUC Academic and Developers Conference to James Cook University and to the Conference itself. The conference is an opportunity to learn, share experience and understand emerging opportunities in the Universities, with a particular focus on Apple's exciting new operating system, MacOS X.

We have a busy program of academic papers, presentations from Apple, workshops, special-interest lunches and show-and-tell, all about using and developing Apple technology in Universities, and from which we can all benefit. We also look forward to the informal aspects of the conference: lunches, coffee breaks and the Conference Dinner: all opportunities for new and renewed discussion and learning.

The AUC has been working hard to engage students. Building on the success of the Student WWDC Scholarships and the AUDF Seeding Grants, we're especially pleased for the first time to welcome students, and student developers, as conference participants. We're pleased also to welcome delegates from New Zealand and from India.

We thank all who are giving papers: that's why we're here. We're especially grateful to our keynote and plenary speakers from Australia and the United States, for giving us their valuable time and insights.

The Conference would not be possible without the unique relationship between Apple and the Apple University Consortium. Thirty-one Australian Universities are AUC members. We thank all members, and delegates, for their support of the AUC and of the Conference. The mission of the Consortium is to enhance and increase computing technology on campus, provide low-cost computing to the University community and, in conjunction with Apple, further develop Apple products and share experiences amongst other tertiary education institutions. The Conference is a crucial part of our mission.

Thanks are due to the organising team of Jeannette Armstrong, Julie Land, Leanne Craddock, Andrew Jeffrey, Darl Kolb, and Neville Smythe, of Apple Australia, James Cook University, The Events Centre, the AUC, the University of Auckland, and the Australian National University. Darl Kolb and Neville Smythe served also in the blind review of papers, with Roly Sussex of the University of Queensland and Roisin O'Reilly and Lynn Alford of James Cook University.

Welcome.

**Stephen Young**
*Chair,*
*Australian Apple University Consortium*

**Warren Bruce**
*National Education Manager*
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# Contents

# eDucation: some of the economics of eCommerce and the future of Higher Education

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**Abstract**   Reactions in higher education to the opportunities and challenges of the Internet have ranged from naked fear and loathing to pure hype and hope. A balanced assessment of the prospects for Higher Education requires a clear understanding of just what eCommerce is, its likely impact across the whole economy and the nature of the "goods" produced in Higher Education. Using standard economic concepts (easily explained to the non-specialist) it can be seen that eCommerce is a highly significant new way of conducting business but hardly the herald of a New Economy. The principal effects of eCommerce will arise from reductions in both the transaction costs of using the market and the organisational costs of bureaucracy. To realise these gains and the associated opportunities for innovation requires a new fundamental Internet competency and a high degree of cross-competency between business and information technology practitioners. Producers of information intensive products, like Higher Education institutions, face a whole raft a challenges in the form of instilling these new competencies, new modes of delivery, new providers and shifting market areas. Notwithstanding any of these, traditional face-to-face Higher Education is a normal good. That is, as incomes rise (due in part to the rise in eCommerce itself) people will demand more face-to-face Higher Education, not less.

## 1. Introduction

The rise of the Internet, its attendant information technologies and their application to business has engendered a great deal of hype. Commentators have, among other things, heralded the arrival of a new economy and foretold the total transformation of higher education, including: the rise of the virtual university, global competition in education and the end of campus education. The purpose of this paper is to see what can be made of the future of higher education in light of the emerging economics of electronic commerce (eCommerce).[1] Like eCommerce itself, the economics of eCommerce is an emerging field and many of features of both are yet to stabilise. However, from the perspective of economics, some of the salient features of eCommerce seem quite clear, even at this early stage, and much of this is relevant to a measured understanding of the implications of the new information technologies for higher education.

In section 2 below consideration is given to just what constitutes eCommerce and why it matters. The forces at work in its uptake across the economy are examined. The key concepts of transaction and organisational costs are defined and discussed, as are some of possible economic and labour market effects of eCommerce. Scrutiny is then turned to the lessons of all this for higher education in section 3. Some concluding observations are offered in section 4. Finally note that this is a paper for non-specialists, an attempt has

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[1] The current state of the economics of eCommerce can be gauged in the *Journal of Economic Perspectives* symposium on the topic published earlier this year. See Lucking-Reiley (2001); Goolsbee (2001); Borenstein (2001); Barber (2001); Bakos (2001); and, Autor (2001).

been made to define terms as they are introduced and to concentrate on analytical results rather than the formal analysis itself. For those interested in the latter some aspects of the analysis are outlined in an appendix.

## 2. Some Economics of eCommerce

There is no single, well-established, and widely accepted definition of eCommerce. However, this is not a serious impediment. For present purposes it is sufficient to follow the OECD view of eCommerce as:

> business occurring over networks which use non-proprietary protocols that are established by an open standard setting process such as the Internet. (OECD, 1998).

Moreover, the term "business" is to be understood broadly to include both networked activity between, and within, economic units like firms, households, government agencies and institutions of all sorts (including, of course, institutions of higher education). This definition also nicely reflects the fact that eCommerce is a new way of doing business not just a new business sector.

Much of the discussion of eCommerce has focused on new information products and networks per se and has under-emphasised the significance of the Internet and its attendant technologies for the most fundamental costs of doing business, the costs of transacting and the costs of organisation. (These terms are discussed in more detail below.) The potential of eCommerce to reduce these costs is of the first importance because they don't just affect Internet service and content providers or even just those firms with computers. Transaction and organisational costs affect every business, every household, every government agency and every educational institution. This is why eCommerce is best seen as a whole new way of doing business, rather than just a matter of firms developing an Internet version of their product catalogues or something for consumers with a liking for gadgets.

Lest this point be overstated, note that eCommerce does not imply a new economy in the sense of a radically changed set of outputs or fundamentally different social institutional forms.[2] While some new markets, products and firms are emerging; it is the processes of business that are changing significantly not its content. Indeed, it is simply not a matter of choice for firms[3] in the advanced economies: they must pursue whatever transaction and organisational cost savings are offered by eCommerce. And, moreover, while these opportunities are being explored there is likely to be a great deal of trial and nearly as much error, as recent rash of dot com failures illustrates only too well.

A transaction cost is anything that interferes with or limits the ability of agents (firms, households or institutions) to pursue and make mutually beneficial exchanges in markets. These difficulties are often, at base, problems associated with acquiring the relevant information. Among a host of other things, these information problems can lead to costs in locating an exchange partner, specifying precisely what is to be exchanged, agreeing a price, and ensuring that which was to be exchanged, was actually exchanged.

Organisational costs, on the other hand, are anything that inhibits an agent's ability to consciously coordinate their activity to achieve some understood objective within a single economic entity; that is a particular firm, household or institution. Again these difficulties

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[2] Parham (1999) contends that there may be a new economy in the sense of a new productivity growth path, but that is another matter entirely.

[3] Unlike consumers, whose preferences can extend over the mode of transaction, as well as the various bundles of goods on offer.

are primarily informational in nature. In a firm this class of costs relate to the coordination of production, logistics, the operation of management information systems and internal communications in general. The organisational costs of a firm do not include marketing and input procurement costs as these arise from the use of the market and are better regarded as transaction costs in the sense employed here.

There seems to be, as yet, no systemic wide-ranging empirical study of the comparative transaction costs of conducting business via the various means now available: face to face, mail order catalogue, telephone, and now via the Internet. However, there have been a number of industry studies conducted. Thus, for example, it has been estimated for the US computer software industry that seller transaction costs are $15 per transaction for face-to-face transactions, $5 for telephone transactions, and between 20 and 50 cents for Internet transactions. (Bollier, 1996) A set of Australian estimates puts seller transaction costs for a sales representative visit at $300, a customer initiated face-to-face transaction at $25 to $30, a telephone transaction at $4 to $8, and an Internet transaction at less than 25 cents. (Callaghan, 1999) As an illustration of organisational cost savings, consider the case of Ford Motor Company's move to use an Internet system for processing the more than one million travel and expense accounts employees submit each year. Large corporations like Ford spend about $36 on processing each paper-based expense report. With the Internet and electronic downloading of credit-card receipts, it is estimated that the cost can drop to about $4 per expense report on average. (Warner, 1999)

If the relative organisational and transaction costs are of the order indicated above, it is little wonder that eCommerce has captured so much attention and expanded so rapidly. Indeed, given the competitive pressure faced by firms, it is to be expected that the uptake of eCommerce will be fastest in firms and for transactions between firms.[4] In competitive industries it is matter of survival, not taste, for firms to minimise costs, including organisational and transaction costs. Interacting firms will drag their business partners into eCommerce as both can gain from doing so. Similarly, firms in less competitive industries will be pressured to adopt best practice eCommerce to minimise transaction costs in the presence of the discipline of increasingly net-savvy capital markets. In short, for the firm there seems little escape from the clutches of eCommerce. The pressures of competition will see its adoption wherever there are cost savings to be made.

The competitive pressure on firms to adopt eCommerce does not, however, apply to household members acting as final consumers. Here tastes, or consumer preferences, drive behaviour rather than the requirements of cost minimisation. In standard economic theory, consumer choice is seen as a process in which agents do the best they can in light of their preferences over all possible bundles of goods, given market prices and their income. With the introduction of eCommerce the pattern of consumer preferences can be extended to cover the various means of transacting business. Otherwise identical goods can be distinguished on the basis of the means of acquiring them. For example, we can distinguish between buying a book in a face-to-face visit to a bricks and mortar bookstore and buying the same book over the Internet. Clearly, the two are quite different experiences, where the purchasing experience is part of what the consumer buys. In this setting it is a simple matter to generate two general theoretical results. First, the introduction of a new transaction experience like eCommerce yields an unambiguous welfare improvement for consumers and society, as will any subsequent reduction in the transaction costs of conducting eCommerce. Second, with the introduction of the new

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[4] A raft of estimates of business-to-business eCommerce puts it at between 61% and 90% of all eCommerce activity. (OECD, 1998)

means of doing business there will be an unambiguous fall in sales involving the pre-existing means of conducting business (controlling for other variables like population and income levels). However, after this first shock, the impact of further reductions in the costs of the new means of transacting are not as clear cut for the sales of both new and old products, as both income and pure price substitution effects are involved. This, in itself, is a very important result as, over time, with increasing incomes or reduced prices, it is perfectly possible for the sales by both means to rise. (Some aspects of the analysis underlying this statement are outlined in the appendix.)

The whole issue here turns on whether the product characterised by the pre-existing means of conducting business (say, face-to-face) is a normal or inferior good. A normal good is one for which consumption rises as income increases while controlling for all other influences on consumption. An inferior good is one for which consumption falls as income rises, again controlling for other influences on consumption. (In Australia, for example, in aggregate mutton is an inferior good while lamb is a normal good.)

The upshot of this distinction between normal and inferior goods is that so long as the product characterised by the pre-existing means of conducting business is not an inferior good it is quite possible its sales, along with those of the eCommerce product, as incomes rise or the cost of the latter falls. The effects of the introduction of the VCR on the movie industry provide an instructive illustration. At first the VCR was greeted with a great deal of concern about its implications for cinema ticket sales. In effect consumers now had a new means of purchasing and consuming the movie experience: renting a video and watching it home. This was a new means of acquiring the good and is quite different from the previously established modes: going to the cinema or going to the drive-in. Just as would be expected on the basis of the modelling outlined above, attendances at both cinemas and drive-ins both initially declined with introduction of the VCR. Over time, however, in the presence of both rising incomes and falling total cost for watching movies at home on a VCR, the sales of cinema tickets recovered to now exceed pre-VCR levels. Drive-in ticket sales, however, did not recover and continued to fall to the point where the drive-in has virtually disappeared. In the terminology introduced above, the cinema movie experience would seem, in aggregate, to be a normal good but the drive-in movie experience an inferior good. Total expenditure on cinema tickets and movie rentals could, and did, both rise as incomes rose and the price of watching a video at home fell, while the same two phenomena combined to kill off the drive-in.

While household agents acting as final consumers are free of the competitive pressure firms face to adopt eCommerce, it is quite a different matter when household agents act as sellers of productive inputs, like labour services. Over time the pressure of competition between agents seeking to sell labour services will see those agents acquire the skills demanded by buyers of these services. As firms adopt eCommerce under the requirements of cost minimisation there will be increases in the demand for the staff required to support, and be proficient in, the new means of conducting business. The sellers of labour services can be expected to respond to this shift in demand, the result being a general increase in eCommerce skills. This, in turn, will have a derived demand effect in the education and training sector. This is a topic for further consideration in the next section.

For government the case may seem more like that of final consumers, where the tastes of decision makers may be a critical determinant of the extent to which the practices of eCommerce are applied. However, two factors would seem to work towards a rapid uptake of eCommerce by government agencies. First, demand by agency clients for the provision of eCommerce interfaces, for instance where firms are users of government

information; and second, the pressure on governments to minimise costs in the provision of services to allow either the provision of additional services without increases taxes or offer the same services with lower taxes. Indeed, there is probably just as much scope for the use of eCommerce in the re-organisation of government agencies and their relationship with their constituencies as there is for the restructuring of firms and the markets within which they operate.

The significance of eCommerce for inter-action between agents via markets and their intra-actions within firms and other organisations means, as already observed, that eCommerce is better treated as a new means of doing business rather than a new, somehow separate, sector of economic activity. For the economy as a whole, the significant potential transaction and organisational cost savings implicit in eCommerce imply significant potential improvements in economic efficiency and an increase in the long term growth in aggregate output. Savings on transaction costs will release resources that would otherwise have been absorbed in transacting or organisation alone. These resources will be available for the production of more and new goods and services. In the first instance, these costs savings will be associated with better managed inventories, cheaper sales execution, more effective procurement, and cheaper intangibles like banking and distribution. All this should allow an improved coordination of productive activity, leading to the better allocation of resources and significant productivity improvements. And it would seem that evidence of this is already appearing for the economies rapidly taking up eCommerce. (Coppel, 2000)

## 3. Some Lessons for Higher Education

Four broad lessons for higher education can be drawn from the preceding review of the emerging economics of eCommerce. First, and most importantly, the future of campus education turns, in part, on whether it is a normal or inferior good. This distinction makes it possible to address questions like, what will happen to the demand for the shared, face-to-face, educational experience offered on thousands of different campuses across the globe in light of the alternatives provided by on-line instruction? What initial impact will the new delivery mode have and what will be the longer term effects as incomes rise and the costs of on-line delivery fall?

Economic choice theory modelling suggests that the introduction of a new delivery mode will be associated with a short-run decline in the demand for campus education. This decline might only be in the form of a reduced rate of growth as other variables affecting demand for campus education are also continuously changing like population levels and age composition, income levels and the returns to higher education. As for the longer term, there are strong grounds to see campus education as a normal good, that is demand for campus education rises with income and might even rise as the cost of on-line education falls. Thus in the short term there might be relatively low, or negative, growth in the demand for campus education and rapid growth from a very low base for on-line delivery. In the medium to longer term this seems likely to reverse with relatively strong growth in the demand for campus education and relatively weak growth in on-line delivery.

The second lesson follows from the far-reaching potential of eCommerce as a new way of doing business that can reach into all aspects of our lives. This suggests a correspondingly far-reaching integration into education and training. Information technology literacy might become as important as numeracy in education at all levels. Indeed, the requirements of change alone, and eCommerce in particular, have far reaching

implications for education, training and the labour market in general. Success in the new way of doing business means new skills, new outlooks and a new commitment to life-long learning. Preparation for success in the new way of doing business is much more than teaching students HTML, or even web competencies. None of us can know how we will be working in five or ten year's time. To take on the new challenges and seize the new opportunities it is more important than ever that members of the workforce have critical and analytical skills, the desire to learn and understand, and the ability to think from different points of view. (In fact, just the sort of things valued in higher education.) This means that in our desire to prepare for a world in which the web and its technologies are as commonplace and ubiquitous as the telephone we must not forget the existing arts and sciences that provide the myriad other competencies required for a fast changing, vibrant modern economy. Little, if any, of what of universities have traditionally done is less relevant and there is good reason to think that most of it will be more relevant.

The third lesson from the economics of eCommerce is that publicly funded institutions of higher education have to expect increased pressure from governments to exploit the new information technologies to reduce costs or do more with the same resources. Governments are under constant pressure to provide more services from a given tax income or the same services at from a smaller tax income. (Indeed, in Australia the Department of Education Training and Youth Affairs and the National Office of the Information Economy have launched a project to explore the opportunities for business-to-business eCommerce in higher education. (NOIE, 2000)) Combined with this pressure from governments will be demand for information technology competencies from employers and from students with an eye on their employability. Institutions of higher education will have to thoroughly embrace the new way of doing business: it will be demanded of them by their funders and there will be a demand for it by education consumers, both students and the employers of graduates.

The fourth and final lesson derives from the fact that new products are a relatively unimportant part of the wide raft of implications of the development of eCommerce. There is simply not a 'new economy', in any profound sense, or even the birth of an 'information economy' or a 'knowledge economy'. Information and knowledge have always been fundamental to economic activity. There will be some products and new organisational forms, with the changes perhaps being in the order of those associated with the arrival of the telephone or modern electricity generation and supply systems. The rise of eCommerce is not on a par with, say, the development of equality before the law or the invention of the limited liability joint stock company.

There will certainly be a place for on-line delivery of higher education and new partnerships with industry in research and life-long learning but the fundamental place of universities is not at threat from the arrival of new information technologies. (Bad policy decisions in particular political jurisdictions are, of course, quite another matter.) If anything, the increased role for information technology, innovation, economic globalisation, and the rapid rate of change all point to a more substantial place for, and more, university education and research, not less. To take that place universities will have to seize the nettle, embrace the technologies and the new ways of doing business. The campus educational experience must be enhanced and enriched by the new technologies and practices, not abandoned because of them. Moreover, this is not just a matter of meeting demand (giving students a campus education because they like it, which is a good thing in itself); it is a strategic matter: campus education can instil many of the traits required in an advanced rapidly changing economy: communication skills, critical thinking, a willingness to subject ideas to the data, the joy in learning, flexibility and the

ability to work in a team. Indeed, success in developing these very skills is critical to success in capturing the potential of the new ways of doing business.

## 4. Conclusion

In summary then, the four lessons for higher education from the economics of eCommerce are:

- remember that campus education is a normal good;
- the arrival of eCommerce alone does not provide grounds for significant changes to university offerings;
- new partnerships and delivery will emerge but not dominate; and
- expect pressure from a range of sources to enhance campus education in light of the new practices.

New virtual universities, or virtual incarnations of established institutions, will not sweep aside their rivals and dominate higher education across the globe. (If information technology alone could make this sort of difference, then surely the VCR and TV would have already done so.) Location and the campus educational experience matter and will continue to matter. Indeed, perhaps the most important educational opportunity provided by the new information technologies is in enhancing the on campus experience by allowing more resources to be committed to those elements of the campus experience that matter most to students.

The normal good characteristics of on-campus education and falling transaction and organisational costs lend a certain logic to the likely evolution of higher education. None of this is, however, immune from bad policy decisions. For instance, flying in the face of the normal good nature of campus eduction could be a national disaster, with too few acquiring the skills required for the full realisation of the potential inherent in the new information technologies. Governments can fail, just as markets do in certain circumstances. In light of the apparently dazzling array of new opportunities and the increasing economic importance of university education and research getting higher education policy right has become more important. As always, the only hope for getting it even approximately right is intense, critical and well informed debate.

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## Appendix

There are many ways to incorporate the means of purchase into formal economic consumer choice theory. Just two of these possibilities will be illustrated here. (Note, these are by no means complete treatments of the topic and are included only to outline the procedure in each case.) The first to be considered is the simple diagrammatic indifference curve analysis from intermediate microeconomics. The analysis is kept to just two goods so that a diagram may be used. Let us, then, consider a case where the two goods are $x_f$ and $x_e$, with $x_f$ being a good purchased face-to-face in a bricks mortar store, while $x_e$ is the same good only differentiated by the fact that it is purchased on-line. All possible bundles of these two goods can then be represented in two-dimensional diagram with $x_e$ and $x_f$ on the axes, as show in the figure above. It is now possible to tell the following sort of story. Prior to the introduction of $x_e$ this consumer purchased $x_{f0}$ units of $x_f$, and, of course, no $x_e$. On the introduction of $x_e$ the consumer is faced the new market opportunity frontier, $b_0$, which reflects the relative prices of the two
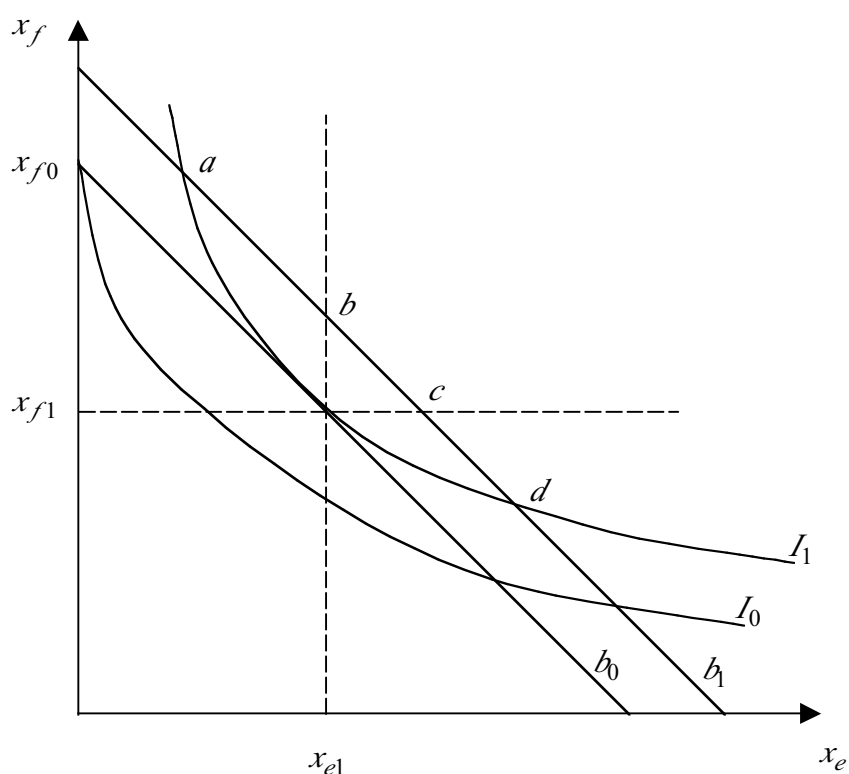


goods and the consumer's income level. The consumer's purchased bundle changes from $(0, x_{f0})$ to $(x_{e1}, x_{f1})$ as the latter is now the best the consumer can do in the circumstances faced. The consumer is able to move from indifference curve $I_0$ to $I_1$ representing an unambiguous welfare improvement. (Any bundle above and the right of a given indifference curve is preferred by the consumer to any bundle on an indifference curve. The consumer is indifferent between any two bundles on a given indifference curve, any bundle on an indifference curve is preferred to any bundle below and the to the left of that curve.)

The key question is what happens as the consumer's income increases? In the diagram an increase in income is represented as a change in the market opportunity frontier from $b_0$ to $b_1$. The consumer will be better off again as more preferred bundles of the two goods

are now within reach. Under standard assumptions about the consumers preference ordering, the bundle selected after this increase in income will lie on $b_1$ somewhere between points $a$ and $d$. There are five possibilities:

- the consumption of $x_e$ falls and $x_f$ rises, i.e. the new purchased bundle is between $a$ and $b$,

- the consumption of $x_e$ is unchanged and $x_f$ rises, i.e. the new purchased bundle is at $b$,

- the consumption of $x_e$ and $x_f$ both rise, i.e. the new purchased bundle is between $b$ and $c$,

- the consumption of $x_e$ rises and $x_f$ is unchanged, i.e. the new purchased bundle is at $c$, and

- the consumption of $x_e$ rises and $x_f$ falls, i.e. the new purchased bundle is between $c$ and $d$.

The only thing that cannot happen is that the consumption of both $x_e$ and $x_f$ falls. The outcome turns entirely on the consumer's preferences and whether the goods in question are considered normal on inferior. And recall that the goods are here only distinguished by their mode of purchase.

A second and more formal treatment is a generalised Lagrange-multiplier approach to the consumer's constrained optimisation problem. He we consider a consumer faced with all possible consumption bundles in some set $X$, usually assumed be the nonnegative orthant of the $k$ dimensional Euclidian space. Let the vector $\mathbf{x}$ in $X$ be an individual consumption bundle such that $\mathbf{x} = \left(x_{f1}, \cdots, x_{fn}, x_{e1}, \cdots, x_{em}\right)$ where the $x_{fi}$ for $i = 1, \cdots, n$ are the $n$ goods available for purchase in-store and $x_{ej}$ for $j = 1, \cdots, m$ are the $m$ goods for sale on-line. It follows that $n + m = k$ and we can probably say for the moment that $n > m$, or that the number of goods for sale on-line is less than the number for sale in-store, but this is not germane to the analysis. Let us also posit that when $i = j$ the goods $x_{fi}$ and $x_{ej}$ are only distinguished by their mode of purchase.

Let $\mathbf{p} = \left(p_{f1}, \cdots, p_{fn}, p_{e1}, \cdots, p_{em}\right)$ be the price vector of the $k$ goods, and $m$ the consumer's money income. The set of affordable bundles for this consumer is therefore

$$B = \left\{\mathbf{x} \text{ in } X : \mathbf{p}\mathbf{x} \leq m\right\}$$

If the consumer's preference ordering over all $\mathbf{x}$ in $X$ can be represented by a utility function $u(\mathbf{x})$ such that for any two distinct bundles in $X$, say $\bar{\mathbf{x}}$ and $\check{\mathbf{x}}$, $u(\bar{\mathbf{x}}) > u(\check{\mathbf{x}})$ if and only if $\bar{\mathbf{x}}$ is preferred $\check{\mathbf{x}}$, then the consumer's problem of seeking their most preferred affordable bundle can be written as:

$$\max u(\mathbf{x})$$

$$\text{such that } \mathbf{p}\mathbf{x} \leq m \quad \mathbf{x} \text{ is in } X$$

If the utility function is differentiable and the consumer always prefers more to less (meaning that the selected consumption bundle exhausts the consumer's income, i.e. $\mathbf{p}\mathbf{x} = m$), then the Lagrangian for this problem can be written as

$$\ell = u(\mathbf{x}) - \lambda(\mathbf{px} - m)$$

with the associated $k + 1$ first-order conditions

$$\frac{\partial u(\mathbf{x})}{\partial x_{fi}} - \lambda p_i = 0 \qquad \text{for } i = 1, \cdots, n$$

$$\frac{\partial u(\mathbf{x})}{\partial x_{ej}} - \lambda p_j = 0 \qquad \text{for } j = 1, \cdots, m$$

$$\mathbf{px} - m = 0$$

Where a solution to this system of equations exists it is possible to generate a vector of $k$ demand functions $\mathbf{x}(\mathbf{p}, m)$ which relate the quantity demanded of each good to the prices of all goods and the consumer's money income.

In this generalised solution, the influence of changes in income on the quantities of all the goods purchased is driven by the signs of the first-order partial derivatives of the $k$ demand functions $\mathbf{x}(\mathbf{p}, m)$ taken with respect to $m$. That is the signs of:

$$\frac{\partial x_{fi}}{\partial m} \qquad \text{for } i = 1, \cdots, n; \text{ and}$$

$$\frac{\partial x_{ej}}{\partial m} \qquad \text{for } j = 1, \cdots, m$$

These can take values greater than, less than and equal to zero, depending entirely on the preference ordering of the consumer. In other words the demand for any good (where the characterisation of a good is extended to cover the mode of purchase) can be positively, negatively, or uninfluenced by changes in income.

For a more detailed treatment of the indifference analysis see any intermediate microeconomic textbook. For a full coverage of the generalised analysis of consumer behaviour see Varian (1992).

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# The Wedge Virtual Reality theatre

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**Abstract**   We describe the history and construction of a stereoscopic projection theatre known as the Wedge. Originally built as a means to introduce supercomputer level visualization facilities into a cash-strapped Australian university, the Wedge has attracted some thousands of visits from the general public. Wedges can now be found in two Australian universities and two museums (visitor centres). Recently, the programming interface to the Wedge has been consolidated and the theatre has become an important part of a new computer science teaching program at the Australian National University (ANU).

## Genesis of the project

Even though the popular image of virtual reality is still one of participants with massive helmets pointing cable-tethered guns at each other, there has been over a decade of development of "immersive" virtual reality theatres where stereo images are projected onto screens surrounding an enclosed space. Many participants at once can view the images by wearing relatively light shutter glasses to filter the correct images to each eye. (This is also the technology used in stereo IMAX$^{TM}$ theatres.) A lead participant is usually given some means of controlling and interacting with the images. The correct (true) perspective of the images is usually displayed for the head position and orientation of this lead participant. Foremost amongst these immersive theatres is the CAVE [1] theatre that has been closely associated with supercomputing installations in the USA and elsewhere as a means of providing scientists and engineers with a sophisticated means of viewing complicated, multi-dimensional datasets. In the CAVE, images are back-projected onto three walls of a small room and down-projected onto the floor. The perspective is calculated using a "window-projection paradigm" illustrated in Figure 1. In late 1996, we were attending a plasma physics meeting at Argonne National Laboratory in Chicago, USA, and had been encouraged by our local computing experts to visit the CAVE facility there. We were "blown away" by the experience and resolved then and there to build one for ourselves. We were particularly impressed with a simulation of a fish tank where fish would swim from one wall to another in front of the seam between the two screens. This motivated us to build a two-walled theatre which had the junction at centre-stage and where much of the viewing would be in the direction of this vertex with the screens receding from the viewers. This is shown schematically in Figure 2.
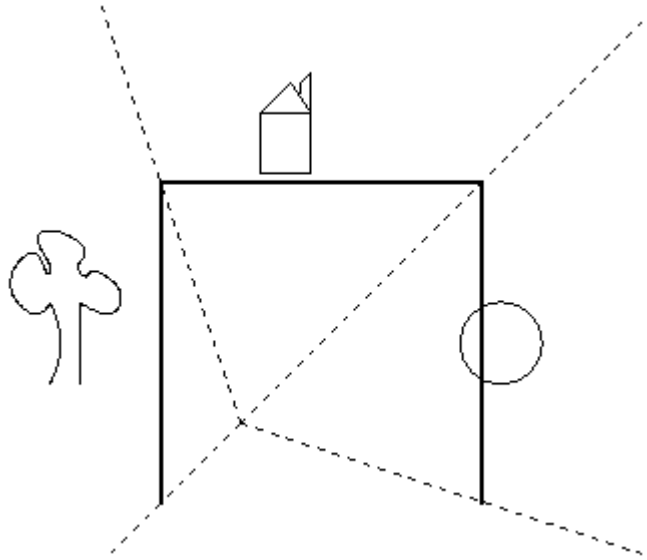
*Figure 1: Schematic representation of the window projection paradigm for three walls of a CAVE. A planar view of the three asymmetric frustums needed to calculate projections for one eye is shown*
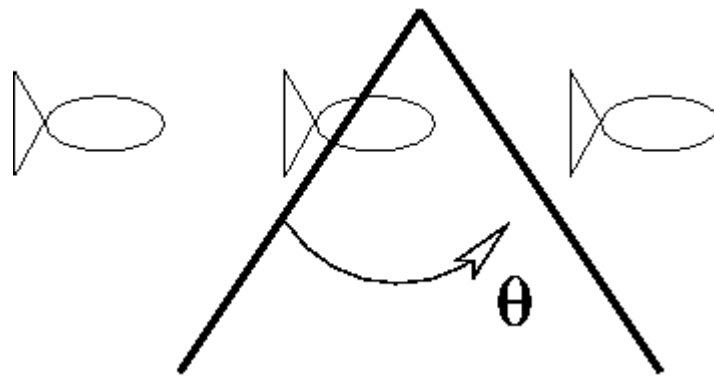


*Figure 2: Projection paradigm for the Wedge. Two frustums for each eye are drawn. The scene is presented about the vertex joining two screens.*

## First attempts

In 1997, early attempts were made to trial component technology. Our initial equipment grant was nil, and we relied on the enthusiasm and largesse of local computer and projector industry representatives to lend us trial equipment.

The most common method of constructing immersive stereo theatres is to "time-multiplex" the left and right eye images (at a frequency of about, or greater than, 100Hz). Viewers wear LCD glasses with a cross-polarizing filter, which opens and closes in synchronization with an infrared signal transmitted by emitters, which are attached to the main computer. The images themselves are most commonly displayed using CRT projectors in which the electron trace starts at the top left corner of the screen and moves along a phosphor from left to right and from top to bottom. Each phosphor pixel has a finite decay time and care needs to be taken to ensure that there is little "bleed through" of an image from the bottom of one frame to the next frame. This is particularly a problem

with the green phosphor and we found it important to eventually purchase a CRT projector with a "fast green phosphor". (This phosphor is all that distinguishes the so-called virtual reality projectors, which are sold by some vendors.) Other factors that can detract from the "immersiveness" of a stereo image are the cross talk between the open and closed settings of the glasses and the colour scheme used in the images. Immersiveness is enhanced if the images move.

As a computational engine, we first considered using the cheapest Silicon Graphics workstations that we could find but it was not possible to synchronize (or "genlock") their images at the 100Hz needed for our system. Although it was possible to purchase a Silicon Graphics supercomputer to do the job, this was quite out of our ballpark so we were fortunate to happen across the Intergraph TDZ series of workstations which are used in stereo-photogrammetry and which can combine two stereo monitors to display one synchronized image. Using this system, it was possible to build an interface to program the first Wedge using the OpenGL and Glut graphics libraries (by splitting the screen into two borderless windows and calling the `glFrustum` and `gluLookAt` routines for each eye for each window). This was achieved by our visualization programmer, Drew Whitehouse, who then created the first Wedge visualization — a powerful animation of a "bucky-ball" carbon molecule, which hovers in space between the two screens [2].

The final system to be connected to the Wedge is a means of interacting with the images. We have had success with a LogiTech[TM] ultrasonic microphone and speaker system (together with a tethered "6D mouse"), which was designed for workstation use. The microphone is usually mounted on a baseball cap (worn backwards) to communicate the position and head orientation of the lead viewer. As the computer knows the full 3D geometry of a scene, this viewer is able to walk into virtual objects and to look around corners. For portable Wedge installations, such as the one demonstrated at this conference, we have commonly used a fixed viewer position and a joystick controller to move the images.

## Powerhouse Museum project

Although we developed the Wedge with scientific visualization projects in mind, a small amount of initial publicity led to an avalanche of requests for demonstrations and one concrete proposal to build one for an exhibit at the Powerhouse museum - a science and technology museum at Darling Harbour in Sydney. (Before we has been able to use the theatre properly for our own research it got put into a museum!) This was a fascinating exercise in the development of appropriate content for the public. In particular, the user interface needed to be robust enough to withstand boisterous school children and the "show" had to be short enough to encourage visitors to circulate. We mounted the joystick controller on a fixed pedestal for this installation. The show can be seen in the portable Wedge demonstration accompanying this paper.

Perhaps the most compelling industrial use of virtual reality is for design walkthroughs. We applied the theatre to the visualization of engineering drawings of a fusion energy experiment at ANU known at the H-1 Heliac (shown as an artist's impression in Figure 3). The extremely complicated geometry of magnetic field coils, hidden inside the vacuum vessel of this device makes it difficult to design and site new experimental diagnostic equipment. The Wedge visualization has provided some assistance in this. The project was assigned to a 4th year engineering student and resulted in some software layers to import and visualize various data types (and also led us to respect the difficulty of converting CAD data-types to graphics formats acceptable to our system).
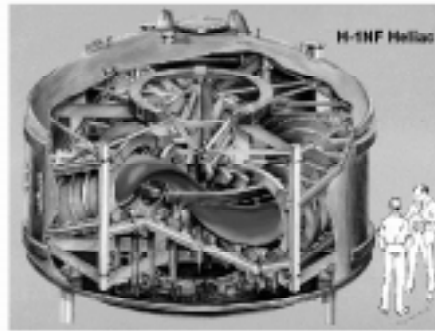
*Figure3: Artist's impression of the H-1NF Heliac showing a cut-away view of the vacuum vessel*

A more interactive, and abstract, scientific visualization project has been the development of a magnetic field line tracing code known as BLINE. In the Wedge theatre, a lead viewer is placed inside a magnetic configuration similar to the H1 Heliac and initiates a set of traces of magnetic field lines (by integrating along the stream-lines of the field). Field line geometry is very difficult to comprehend and this program gives the operator options to plot the cross-sections of the magnetic flux tubes (the Poincare surfaces) and to manipulate the position and orientation of the entire image. It is possible to zoom in and study the topology of regions of the field that are locally chaotic.

Other student projects have included an interface to teach mechanical assembly as well as an interactive "ping pong" game that can be played over a network.

## Design modifications to the Wedge

We have built several Wedge prototypes of which 5 full theatres are still being used. Figure 4 shows the largest prototype (dubbed "Wedgeorama") that had two screens measuring 4m by 2.2m each. Although the original Wedge had square screens, we have found that a more panoramic aspect ratio is more effective for viewing by small groups of people. We have built one Wedge with a very tall aspect ratio, which was necessitated by space constraints, but this is not our preferred configuration. We find that elevating the theatre, even a few cm, from the floor stops people saying, "Why don't you build another screen on the floor?"

We performed a series of experiments on a flexible version of the Wedge in which we varied the angle between the walls (θ in Figure 2) to be less than 90 degrees. This started off as a formal human factors study with the objective of proving that the "corner effect" was really important in making the Wedge an effective immersive experience. As the angle is reduced, participants walk into a space that becomes more funnel-like. One hypothesis was that the fact that the projection surfaces were physically receding would make the 3D experience more compelling. Our attempts to quantify this, unfortunately, failed because of the difficulty of isolating independently measurable effects. One problem was that as the Wedge becomes narrower, it is more critical for an observer to be at the correct viewing position (because straight lines will kink strongly when they are drawn across the vertex).

A Wedge type configuration with a vertex angle larger than 90 degrees could be useful for a walkthrough involving large groups. As the angle approaches 180 degrees, peripheral vision is lost which, it is well known, is a key factor in the enjoyment of walking into a

virtual space. Strangely, after considering these issues the convenient angle of 90 degrees appears to be optimal for a Wedge.



*Figure 4: The Wedgeorama*

A small (front or rear projection) version of the Wedge is presently being built using polarizing filters and 4 digital light projectors. It is hoped that this will result in a near-tabletop system that can be viewed by participants using cheap polarizing glasses rather than shutter glasses. Successful experiments have been carried out using this system to display stereo video images broadcast over the Internet.

## Human factors and visual stress

There is a tension in immersive virtual reality theatres between the planes of image focus (the screens) and the plane of *vergence* of the eyes (which is the position of a virtual object — either in front of or behind the screens). This makes the sustained use of a virtual environment stressful. The Wedge is most pleasant to use when the room is dimmed, but not completely dark, and when the image contrast is not too great. The speed of movement of images also needs to be kept reasonably slow and smooth.

Stereo images are most powerful when there are plenty of edged to distinguish the left and right eye views. For this reason, scaffolding (line) drawings of architectural designs are very spectacularly realized in the Wedge.

One of our present projects is to conduct a physiological study of brain waves in response to stereo imagery. It is thought that this may result in a non-linear model of the system response function of the visual cortex.

## The eScience graduate teaching program

The Wedge is the centrepiece of a new graduate teaching program at ANU known as *eScience*. Targeted at graduates from science and engineering, this program aims to produce IT professionals with a training in important aspects of program development and software engineering by providing experience in the design and construction of software for networked virtual environments. The first student projects are being run this semester and deal with topics from tele-medicine, 3D sound synthesis, video-conferencing and online education. In particular, the Java programming language is being used to encourage cross-platform, networked application development. A Java3D interface to the Wedge has been completed and can be released to interested parties. More information on this teaching program can be obtained from `http://eScience.anu.edu.au/`.

## Future technology

Ever since we began this project, we have been told that a desktop commodity PC will very soon be available to run virtual reality systems such as the Wedge. Even though the power of commodity graphics chips has exploded over the past few years, it remains a specialist requirement to have two screens with frame accurate stereo synchronization at 100Hz. Similarly, we have stuck with the CRT projectors because of their ability to be aligned very accurately at the vertex.

It turns out that the equipment needed to build a Wedge can still be obtained for about the same cost as our original 1997 theatre (AUD$100K) although the graphics performance is considerably enhanced. A companion paper by A. Lambert in this conference will describe a project to construct an external module to drive a Wedge from Apple computers.

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# QuickTime streaming: a gateway to multi-modal social analyses

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## Introduction

Apple's new *iMovie* and *QuickTime 4.0* programs place the tools of film-making and editing in the hands of academics and teachers. In an online, multimedia world, this opens exciting potentials for substantially enriching social and historical education. The challenge for social educators is to develop epistemological frameworks and pedagogic processes that will deploy the attractiveness of film media in ways that add real educational value to analyses and understandings. This paper reports on work-in-progress on an Arts Faculty Teaching Initiative Project at the National Centre for Australian Studies at Monash University. It outlines the epistemology informing the project development, describes the site design for the pilot stage, and reports on some student feedback.

In a print-based information world, words and conceptualisation provide the dominant modes of thinking, knowing, learning and communicating (Olson, 1996). In an electronic, multimedia information world words, concepts and written texts have to compete with other modes of information (Way, 1991). It follows that images, and the processes of framing, symbolising and perceiving that inform them, become much more significant, prominent and powerful — though not necessarily dominant (Morgan & Welton, 1986). Students, teachers and communicators need to attend to these processes more consciously — not simply as decorations, illustrations, or "packaging" (Carey, 1989). Furthermore, inter-actions between media and between "texts" can become powerful keys to knowing, communicating, thinking and educating. Inter-textuality — listening, reading, looking, comparing, relating, and contextualising — can open powerful gateways to engaging processes of conceiving *and* perceiving (Kress, 1997).

Interactive multimedia provides the informational capacities to capitalise on the power of perceiving and relate it more directly and inter-actively with the power of words and ideas (Langhorne, 1989). In an online world, inter-relating conceiving and perceiving can open powerful ways of enhancing analyses and understandings. Hence it is important to develop a range of framings, postures, imagery and models to interact with ideas, paradigms and conceptual frameworks if interactive multimedia is to be effectively harnessed to enrich analyses and understandings of persons times and places. *QuickTime 4.0* provides a powerful array of tools to deliver such enhanced teaching and learning capacities.

A current National Centre for Australian Studies aims to make more effective use of interactive multimedia capacities in social, political and historical education by incorporating *QuickTime* film clips into a range of teaching/learning tasks. Inter-textual and interactive capacities have been integrated into distance education assessment activities. Selected comparisons are being used to sharpen students' perceptions and conceptions; to foster more multi-dimensional analyses; and to use multi-media

representations and evidence to enhance multi-modal conceptual and perceptual understandings. The site can be viewed at:
http://www.arts.monash.edu.au/ncas/teach/unit/aus/aus1010/OOEmain.htm

## Informing Epistemology

Contemporary epistemology and pedagogy faces a radically changing social context. New information technology built on the silicon chip and its subsequent information explosion; radical changes in the means of production accompanying this technological change; the extent and accessibility of visual information through electronic media; and the shrinking — in communicative and interactive terms — of an emerging global world; constitute an interstice that has rendered unsatisfactory the traditional epistemology that has informed so much educational practice for much of the twentieth century (Way, 1991).

It is not surprising, therefore, that the past decades have seen profound shifts in epistemology and cognitive psychology (Gardner, 1985; 1999; Bruner, 1986, 1990, 1996). That shift may be usefully characterised as a movement away from an "assembly-line epistemology" of behaviourist psychology and associative learning. Under the older paradigms, knowledge was approached as a kind of assembly-line to which each specialist-expert added his/her own little packet of information before sending it on to the Executive Director: Objective Truth Esq. The accompanying pedagogy treated students essentially as empty vessels proceeding along the conveyor belt of classrooms and lecture halls. Each subject injected its dose of knowledge, and the students moved, year by year, along the assembly-line until deposited at various points off the line, having been appropriately — i.e. according to the amount of knowledge consumed — labelled and certified. Such a structure and process was in keeping, not only with the industrial society and culture which it was designed to serve, but also with older behaviourist paradigms, which dismissed as "unobservable" (and therefore not real) the internal processes of perceiving and conceiving; learning and knowing. The "post-assemblyline" epistemologies of contemporary cognitive psychology, building on models of information processing, take these internal processes very seriously indeed (Arbib & Hesse, 1987).

Why is that so significant? Fundamentally, because it means that the learner is no longer being approached primarily as a passive recipient of external stimuli. The new epistemological paradigms underline the inadequacies of treating students as products of some kind of "assembly-line" (Bruner, 1986; 1990). To treat students merely as parts of a process, or bytes in a program, may be superficially cheaper and administratively easier, but it ignores the reality of the active, constructive, meaning-making person who *is* the student (Bruner, 1990). Bits can be processed, but the "information that a person gets from a specified point of the outer world depends on the context or total situation, and on his [or her] past experience" (Abercrombie, 1969, p. 20. And see Bruner, 1990).

Such a perspective changes fundamentally the educational requirements of the students and of the society and culture learning to handle it (Bruner, 1990). The challenge for both is now less that of *accumulation* of knowledge (appropriate in an assembly-line, industrial world), than of *processing* — i.e., selecting, analysing, synthesizing, interpreting and evaluating — the vast amounts of information now accessible in words, texts, images and databases (Jorgensen, 1999). The challenges of the new information systems are challenges of analyses, evaluation and meaning-making. Increasingly, the more empirical 'what'-type questions can be answered from stored and retrievable data. Not surprisingly, therefore, the post-industrial cognitive paradigms have moved away from the older emphasis on memory and storage as measures of learning, and turned attention to higher

order cognitive skills, processes and structures required by effective information-processing (Gardner, 1985; 1999).

Contemporary epistemology points to the crucial significance of several powerful conceptual frameworks for understanding and enhancing learning and knowing (Arbib & Hesse, 1987). One is the concept of cognitive webs, or networks of shared ideas and perceptions, informed by the specifics of a particular culture (Bruner, 1996). Persons as active meaning-makers utilise and deploy cognitive webs, the "tool-kits" of their culture, to perceive, make sense of their situations and act accordingly. Experiences are processed via assimilation-accommodations through the minds of active social participants (Gruber & Voneche, 1977). These are the dynamics of persons, times and places that breathe living personhood into social circumstances, experiences and analyses.

Contemporary research into visual perception and its inter-relationships with learning and cognition also points to a profound and dynamic inter-relationship between perceiving and knowing (Bruce & Green, 1989). It suggests a cognitive richness for understanding people, their perceptions, and their uses of visual representations to which the older empiricist-representational paradigms had closed their collective eyes (Sless, 1981). It also highlights the multi-dimensionality of the processes of visual perception (Uttal, 1981).

Human knowing is too integrally dependent on the specifics of persons, time and place to be readily separable therefrom (Geertz, 1973). Full understanding of visual- and multi-media as tools of analyses, as symbolic modes, and as media of education, therefore, calls for thorough social, historical and cultural contextualisations as an essential component and foundation (Fyfe & Law, 1988). The information technology revolution underlines the crucial importance of relating learning and knowing to its socio-cultural and temporal surrounds and settings (Gifford, 1990). Learning, like any other human process, is profoundly affected by time, place and social context, and social and historical disciplines can shed much light on changing information media (Lowe, 1982).

In applying contemporary cognitive epistemology to enhancing analyses and understandings of social, political and historical events and themes, the framework of social situation — social, economic, political, technological and environmental settings and circumstances – constructed by, and in relation to, the phenomenological experiences of persons acting with intentions, as classically defined by Berkhofer (Berkhofer, 1969), offers a most useful framework through which to address multimedia analyses of persons, times and places. Examining a topic, event, or theme in its social, economic, political, cultural, spatial and temporal aspects enables analyses of inter-relations between the different dimensions of social experiences. It highlights the relationships between these aspects, and it facilitates the study of evidence in context.
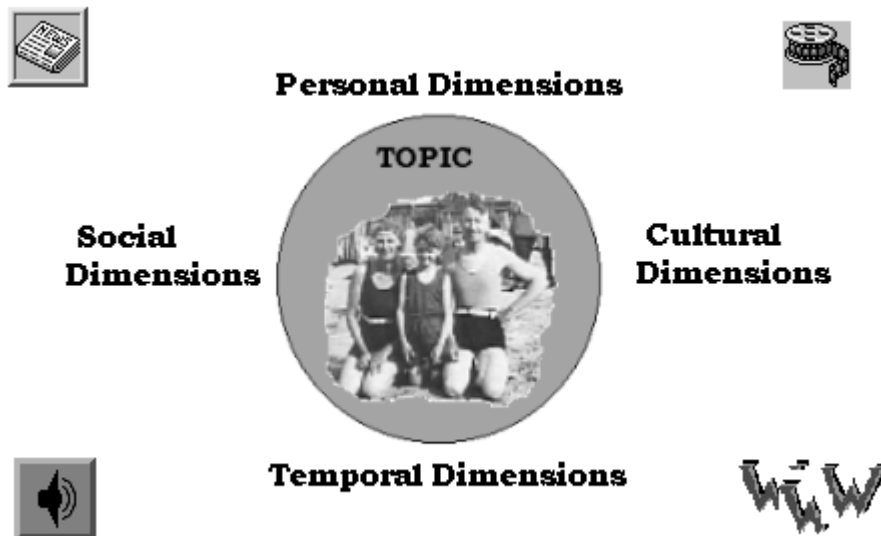
*Fig. 1. Situation Model as an Productive Framework for Multimedia Analyses*

Three key concepts constitute the core of contemporary social epistemology. The idea of *society* directs attention to examining people as participants in wider social groups, networks, relationships, structures and processes. The metaphor of system offers one very useful way of conceptualising society. The concept of *culture* is another of the most useful tools of modern social science. Culture can be most fruitfully understood as a way of naming networks of shared ideas and perceptions, metaphors, framings and symbols — webs of shared meanings — actively used by groups of persons to make sense of themselves, their situations, experiences, and worlds, and through which to construct appropriate actions. As communication and interactions between different cultural groups across the world have become more common in the twentieth century, the concept has become more and more central in the social sciences and in history, and its value increasingly evident. In the traditional industrial, behaviourist epistemology, persons were framed primarily as products of their circumstances. Research over recent decades suggests that perceiving and picturing are much more accurately and usefully framed as active constructions and processes (Bruce & Green, 1989). This is because each component — eye, brain, actions, and surrounds — is multi-dimensional, inter-related, and interactive. *Persons* are more adequately studied as active perceivers and meaning-makers, constructors of their social worlds and experiences through networks of shared ideas and perceptions, than as mere responders to external stimuli.

## Design of the Site

The pilot project is being built to support two Year 12 Australian History/Politics Enhancement Units run by the National Centre. The first Semester Unit: *Out of Empire* offers an overview of Australian political history across the twentieth century, and is supported by an outstanding series of 13 half-hour video programs produced in conjunction with the A.B.C. The second Semester Unit: *Democracy and Nation* focuses in much more depth on Federation and its developments in the early decades of the century. It is supported by a set of audio tapes produced in conjunction with A.B.C. Radio National. The direct involvement of the National Centre in the development of the television and radio materials forestalls many of the copyright problems in using these materials. Students are provided with a printed Study Guide of essays and primary source documents discussing the themes and issues raised week by week. Access to the videos

and tapes is provided either through Study Centres or by individual copies for distance students. A substantial set of printed documents is provided for each student in second Semester. Both Units are also supported by a website which provides electronic access to the printed resources and a direct avenue of communication to academic staff (http://www.arts.monash.edu.au/ncas/teach/). The current project is enhancing that online support through the use of *QuickTime* streaming. Because of submission dates, this paper concentrates primarily on the Semester 1 Unit.

The design of the project site draws on recent work by Shore on culture in mind (Shore, 1996), and Bruner on culture and cognition (Bruner, 1990). Shore substantiates and extends the classical insights of Geertz that culture is fundamental and enabling, central to processes of meaning-making, and crucial for understanding people, time, place and society (Geertz, 1972, 1983, 1995). Bruner, draws on the information processing revolution in cognitive science, and on schema theories, to show the centrality of meaning-making through shared cultural scripts for perceiving, thinking, knowing and acting. The project draws on Bruner's ideas as a basis for articulating the networks of shared ideas and perceptions, and the clusters of significant symbols, illustrated and used by the creators of the video series.

Historical photographs, films, and aural archives can be fruitfully addressed as evidential traces of past actions, behaviours, shared ideas, perceptions and meanings operating within particular systems of social institutions, structures, processes, relations and ecological surrounds (Tagg, 1988; Goldberg, 1991). Rich in actualities, their meanings, singularly and collectively, must be reconstructed through careful, precise, and faithful readings of the images within the socio-cultural context that engendered them (Crispin Miller, 1990). Such a process is also a reflexive one, for it facilitates recognition of contemporary parameters informing our own shared imagery and perceptions (Berger, 1972). Thus students can learn that perceptions have a history and that alternative perceptions are possible.

The design of the site is built around the assignment tasks as key focal learning activities in each Unit.


*Out of Empire* **Task 1**.

The initial task is essentially introductory, both in terms of the themes of the Unit, and in asking students to think about what different types of media can contribute to social and historical analyses. It requires students to summarise and review the content, and examine the use made by the film-makers of images and archival films, narrative voice-overs, music and interviews with experts, in the construction of the arguments presented in one of the first two video episodes. The site uses *QuickTime* capacities to help students "unpack" the use of different media in each episode by using short clips to highlight pertinent examples and thereby foster multimedia literacy.
http://www.arts.monash.edu.au/ncas/teach/unit/aus/aus1010/OOEtask1.htm .

An interview clip is used to prompt questions about the effects of background and the identification and presentation of the academic expert. A key segment in which the narrative voiceover changes, prompts questions about the choice and significance of voice for narration.

The videos make extensive use of a range of archival music from the periods depicted. Consideration of the role of music is addressed through clips from the introduction to

each episode, and by using *QuickTime* to separate the music itself from the on-screen visuals.

The use of still images in the programs is addressed by using *QuickTime's* capacity to extract stills from a movie to raise questions about the choice of pictorial stills. Why select that particular photograph? What does it reveal about the point of view of the historian and the film-makers?

The significance of visual perspectives is neatly raised through the capacity to embed two clips on the same screen. Short clips of turn-of-the-century Brisbane and Sydney — one shot from a tripod at street level; the other from the top of a moving tram — offer an intriguing comparison of the effects of camera angles.

The role of the written word is addressed through the addition of examples of poetry — Federation Odes — to prompt questions about the importance of ideas and the forms of their presentation for understanding the themes of the Unit.

Linked to the Task page are files introducing in words, diagrams and application questions, the key concepts of society, culture and persons. These are designed to help students scaffold the frameworks they will be using for analysing and understanding the people, actions, events and themes studied in the Unit.

*Out of Empire.* **Task 2.**

This learning task is a conventional essay task. Students have a choice of topics. One asks them to examine three or more aspects of Britain's influence on Australian political and cultural life in the C20th. The other asks them to explore the influence of Britain and Empire through the life of an Australian public figure of their own choice who grew up in the first half of the century.
http://www.arts.monash.edu.au/ncas/teach/unit/aus/aus1010/OOEtask2.htm .

To support the first essay, the site takes the core social concepts and applies them to providing a socio-cultural overview of Australian living in the 1930s using words, diagrams, and a wide range of archival images, photographs and graphics. This is designed to model a framework for using still images and photographs to survey and signpost the social territory, establishing a context within which to locate, scaffold and relate the personal and particular through which different aspects of living are so richly illustrated in the videos through film and sound.

The second essay topic is biographically based. Films provide a distinctive media for addressing not only movement and social dynamics, but especially for addressing the personal and person-to-person inter-actions in socio-cultural contexts. The site uses a short clip from a speech by Robert Menzies to help students read and locate an individual within his/her wider socio-cultural context.

Links to some of Australia's rich online, searchable, archival image databases are provided to assist students with their own investigations.

*Out of Empire.* **Task 3.**

The third assessment task is a 2-hour examination covering the whole Unit. In preparing for the exam, students focus on synthesising their studies across the Unit. The site provides some support for reviewing the learning frameworks developed in two ways. One reminds students of the core concepts of society, culture and persons and their

usefulness for developing analyses and interpretations for the various topics in the Unit exam. The other offers an example of a situational model applied to a specific topic — Federation — with cues to encourage students consider the various dimensions of the event.

http://www.arts.monash.edu.au/ncas/teach/unit/aus/aus1010/OOEtask3.htm .

Visitors to the site will see that it includes an online discussion space so students can share observations and interact with one another electronically. The Main page also provides direct access to a "Media Applications" page which is designed to prompt students to use and extend the skills of reading media and reading evidence fostered by the first task. Access to updated resources — such as new interviews — are made available via the "Updates" link on the Main page.

## On Streaming

Nothing has been written so far about the RTSP Streaming capacities of *QuickTime*. This is partly because of unavoidable delays in setting up a Faculty Streaming server. But, in any case, the initial stages of the project required clarification of the epistemological base as well as time for the developers to learn to use the extensive capabilities of *iMovie*. Standard HTTP *QuickTime 4.0* has been adequate for the initial needs of delivering key segments of video clips within fair dealing copyright parameters. *iMovie* produces high quality clips, has proved easy to use, and works first time, without hitches — a tribute to Apple's software engineering skills.

The next stage of the project has been to start filming some re-interviews of academic experts used in the series. This requires longer movie segments and takes advantage of RTSP streaming capacities. A pilot interview with Professor John Rickard from the National Centre for Australian Studies has been completed. We used a Canon MV300i digital camcorder, and were able to borrow a Sony camera to provide an alternative angle. Stands were used to secure the steadiness of the cameras. The interview was recorded in Professor Rickard's office under normal lighting conditions. Doing our own filming secures copyright control. The footage was processed and edited on a Mac G4 using *iMovie* and QuickTime Pro software. QuickTime 4.0 was used to create the point-movies for progressive streaming. Three interview segments of 4-6 minutes each have been assembled from the footage. The outcomes demonstrate that amateur filmmakers can obtain very satisfactory results using *iMovie* tools — especially if a little care is taken with lighting and camera stands. The pilot has also enabled us to learn how to post rtsp streamed movies on a streaming server — and finding one's way around the world of a unix server can be rather tricky. The end result has been some excellent resources for updating the unit.

It is envisaged that more use will be made of these streaming capacities in the second Semester Unit. The capacities for poster, chapter and tagging facilities in *QuickTime* will also be used to relate the personal and particular to socio-economic and cultural contexts more immediately and provocatively. An online seminar is planned for September and will incorporate the use of streaming technology.

## Project Feedback and Evaluation

To obtain some more specific feedback from the students in the pilot study, a questionnaire has been sent to them. Not all have been returned at the time of writing, but feedback so far has been very positive, indicating that the site is effective in opening

multiple perspectives, clarifying learning tasks, stimulating inquiries and enhancing interest in the content. Asked how the online materials might be improved, one student took the trouble to write:

> "I found them fine the way they were — they outlined the tasks clearly, and provided useful background information; the information on society, culture and so forth was particularly good as it helped me clarify my ideas."

Certainly, the feedback encourages the further pursuit of the lines of development guiding this pilot project.

**Conclusion**

The initial stage of the project has been primarily about clarifying the epistemological foundation for future experimentation, trialling and development. *iMovie* and *QuickTime 4.0* offer powerful tools not only for delivering, but for unpacking multimedia texts. Sorting out what to do with these capacities in terms of social education is quite a challenge. By extending control over the full range of information media increasingly available online, they substantially enhance the evidential bases available for social, political, and historical studies. The personal and particular of films and sounds can be embedded and inter-related with the social, cultural and temporal contexts through which they were constructed. By enabling the separation of media components, these programs can also facilitate media literacy through examinations of what different elements contribute to texts, evidence, analyses and social understandings. Studying the constructions of films, texts and multimedia can be used to challenge students to re-think their own perceptions, ideas and interpretations.

Working on this project has convinced the author of the exciting capacities of *QuickTime* streaming in relation to social, cultural and historical education. Streamng can be much more than just a vehicle for the delivery and consumption of film and audio resources. It can, indeed, be used to build "post-modern" gateways into digital epistemologies. Gateways that are post-modern in facilitating the "unpacking", the deconstruction, the reading of texts-in-context; gateways that can engage both conceptual and perceptual cognitive frameworks, processes and schemas; gateways for mapping socio-cultural contexts; gateways that can stimulate and enrich social analyses and understandings. This pilot project will now form a foundation from which to deploy the event stream authoring capacities of *QuickTime* to develop even more dynamic multimedia interfaces — integrated, inter-related, multi-modal cognitive interstices.

An overview of the Project can be examined online at the National Centre for Australian Studies at: http://www.arts.monash.edu.au/ncas/teach/unit/aus/aus1010/OOEmain.htm .

Questions and comments may be directed to Dr. Crean at
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# High Tech, High Touch — education at a distance.

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**Abstract**   At the 2000 AUC Conference in Wollongong, Mike Fardon, from the Faculty of Arts Multimedia Centre at the University of Western Australia, showed developments in the automated recording of lectures and the use of these as the basis of on-line delivery of courses. UWA decided to open a regional Centre in Albany, some 400km SE of Perth on the south coast of Western Australia. Initially, conventional video conferencing was intended to be the main form of delivery, but this quickly gave way to internet based delivery of course material lectures, accompanied by tutorial and lab sessions where appropriate, given by locally based tutors. Hence "High Tech, High Touch". This hybrid has proved to be a very effective way of delivering courses. This paper will tell the story of how the Centre was set up, the ongoing development of the delivery mechanism and how the students and the community have taken to this way of learning. We are now beginning our third year of teaching, and thus far, student marks have been higher that the averages for the same subjects on the main campus.

## Contents

## In the beginning.

One of the problems faced by many rural and remote areas in Australia is how to attract tertiary institutions and persuade them to provide access to their courses. Distance education has been around for many years, where a package of materials is provided to remote students augmented by short intensive periods at the institution itself.

The advent of on-line distribution of materials had provided easier access to those materials and easier contact with the teaching staff, but the principle has remained much the same.

In 1997, the City of Albany approached The University of Western Australia and asked that it consider setting up a remote facility in Albany. An Academic, Prof Dennis Haskell, was appointed to oversee the project, and I became involved, as IT Manager for the Faculty of Arts, in the technical considerations. The University looked long and hard at the idea and after protracted discussions with the City Council decided to set up the UWA Albany Centre and provide at least first year units as an entry to degree courses. This was welcomed by the Council. School leavers often have problems coping with both entry into tertiary level education and leaving home to travel to Perth and live on their own. Many potential students are put off by this hurdle and the City of Albany and the local community were particularly interested to address this issue.

In 1999 the University offered four, undergraduate first year units in Albany: Computer Science, Biology, Anthropology and English, as well as extending support for a Masters in Education program that was already running in the area. In this first year of teaching methodologies were established and refined and 31 mature age students successfully completed units. These were all continuing education students (non HECS) at the beginning of the year, but several students were successful in their application for HECS places in the second semester.

In 2000 the offering was expanded to 32 semester units[1] including one second year Anthropology unit. These units form the basis for a first year in five general degree courses; Bachelor of Arts, Science, Agriculture, Economics and Maths and Engineering.

## The Albany Centre

### The Centre

Our first home in Albany has been the Old Headmasters House, a heritage building in the centre of Albany, which is part of the original school complex. It is constructed of stone with high pressed tin ceilings and a great view of Princess Royal harbour.

*Overview*

The Centre currently has a Director (0.8), an IT Manager (0.3), an Administration Manager (f/t), and administrative assistant (0.5), a research assistant (0.4) and there are also 14 part time tutors.

Dr Billie Giles-Corti was appointed as Director and her tireless energy has enabled the Centre to get off to such a positive start. Barbara Black is currently acting director while Bill takes long service and study leave.

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[1] These units covered Classics & Ancient History, Anthropology, Biology & Human Biology, Chemistry, English, Economics, Computer Science, Geography, Italian, Mathematics, Political Science and Psychology.

The University Foundation in Albany, a group consisting of local business and other interested has been formed, principally to promote the Centre and raise money for scholarships and other purposes. They have been successful in raising enough to employ a full time Development manager at the Centre. The Friends of the UWA Albany Centre are another group who deal with more day to day activities in the community and give support directly to the Centre and the student body.

*Servers & Labs*

The Centre is Apple based. File and web services are provided by a B & W G3 server running Apple Share IP (ASIP) 6. There is another G3 running Mac OS X and the QuickTime™ streaming server. An iMac is used as a utility server, which runs a proxy cache, a network calendar and a software license manager[2]. All the staff and student computers are iMacs (except for one lone PC just to keep us honest and to test ASIP's PC connectivity). The network has a 100Mb UTP backbone.

These servers will be augmented by a dual processor G4 running MacOS X server for the QuickTime Streaming server and netbooting for the iMacs.

There are two laboratories for student use each with 10 workstations. One of these labs has Connextix VirtualPC™ for those units which require PC only software.

*Other Labs*

Some units (particularly the physical sciences) have a requirement for specialised laboratory facilities which were not able to be provided at the Centre. The University approached AGWest and one of the local senior high schools, and provided some funding to upgrade their labs to the required standards and UWA students now use those facilities.

*Software*

The Centre is very internet focused. Netscape™ or Internet Explorer™ give access to all lectures and lecture materials via managed learning environments; the Forum at the Faculty of Arts Multimedia Centre, the Faculty of Science WebCT™ server, and web pages for other units. Of the 16 units run during the first semester of 2001 14 were run via the Forum and 2 via WebCT. All units used the lecture recordings. Only one lecturer chose not to record the lectures but two weeks into the semester, pressure from the students changed his mind.

The Centre also has a range of productivity software[3].

## The Arts Multimedia Centre

### Beginnings

The Faculty of Arts involvement in multi-media began with the Theseus Project in 1994, which was funded by the AUDF and the UWA initiative fund. A presentation on this project was given at the AUC conference in Perth. In 1996 we set up the Multimedia Centre (MMC) "to facilitate the use of the new technologies in teaching within the Faculty of Arts". The preferred model from the beginning was to focus on enabling academics and students to produce their own digital materials, rather than forming a

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[2] Rapidcache ™ proxy server, Keyserver ™ from Sassafras software and Meeting Maker™.

[3] Appleworks™, Filemaker Pro, BBEdit ™ Lite, Microsoft Office 98,Abobe Photoshop™, Eudora ™ for email

technical production unit. This approach has allowed the academics to really own the process of producing their teaching materials.

These materials are accessed by students through the iMac lab in the MMC. There was an initial emphasis on the languages, and extensive use was made of the Chinese and Japanese language kits from Apple.

Mike Fardon was employed as the multimedia programmer and is now the co-ordinator of the MMC. He has been responsible for the majority of the software development, particularly StoryTime[4] and iLectures. During the second year of operation he was joined by programmer Shaun Procter. From the start the MMC was unusual at UWA in that it is jointly run by two directors, an Academic Director, initially A/Prof John Kinder and currently Dr Alexandra Ludewig, with myself as Technical Director until I moved to Albany and Michael Neville took over. I feel strongly that it was this partnership between academic and professional technical skill sets that has led to the success of the MMC.

From the start the MMC was entirely Apple based and I feel that development has been enabled by the extensive use of Apple technologies.

### The Forum

For several years some of the lecturers in Arts had been recording their lectures on to cassette tapes as a service for their students. These tapes were available on request and a room had been equipped with several cassette players for listening to these lectures. In 1998 the MMC undertook a major restructure to enable it to expand it's services. Basically, we needed the room. In order to keep the service we set up a stack of four LC475's each with a cassette player attached and using these, we digitised the lectures and offered them as Real Audio™ streams from the MMC website. So came the genesis of the Forum.

## The Albany Centre and MMC

### The initial plan

It was initially envisaged that the lectures would be delivered to Albany via video conferencing. A PictureTel ™ Concord 3500 unit was purchased along with the initial lab of iMacs. The idea was that lecturers for the four units offered in the first year would give an extra lecture via video conferencing. This very quickly met with resistance along the lines of "why should I spend an extra hour plus preparation for the small number of students in Albany".

### What actually happened

We all very quickly realised that the recorded lectures were the answer to this problem, and the MMC arranged to have three of the four units recorded on cassette and made available through their web site. That fourth unit (in English) remains the only unit to have been delivered using video conferencing.

And so the first year settled down. Mike Fardon continued to make improvements to the Forum adding discussion boards and chat rooms and evolving a modular approach. If a

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[4] StoryTime is a multimedia editing environment which allows the non technical to construct interactive multimedia materials. It can be used as is, or output to html format for use on a web environment. It is Macintosh based.

lecturer wanted to use the Forum to access the unit web site, they could do that or not as they pleased. Again, this allowed maximum flexibility for the lecturer.

From a student perspective this also meant that they could log into the Forum from home and listen to the lectures. This focused us on the idea that anything we did must be deliverable on a 28k modem across the internet. This was to influence what followed in a major way.

### Joint development

Albany became an important catalyst for development of on-line coursework within the University as a whole. The other Arts units which were already being recorded benefitted from the developments in the Forum and students accesses from the Perth campus itself began to increase.

Two barriers remained to overcome.

The first was a simple human problem. How to make sure that the lecturers remember to press the record button or remember to deliver the tape or remember to take the tape out of their shirt pocket before they put the shirt into the wash and other such problems.

These things were critical since students at the Albany Centre were now dependant on these lecture recording and any that failed were sorely missed and had to be given using video conferencing or some other method.

The second barrier was that units such as Maths need to unfold the material during the lectures, and this is very difficult to do using audio only. We had always rejected making video's of the lectures as being to time consuming (requiring a person to operate the camera) and requiring too much bandwidth for delivery.

## Automated Lecture Recordings

### The Visualiser and "the talking hand"

The MMC came up with the answer and the availability of the QuickTime™ streaming server gave the delivery mechanism and from these developments the automated iLecture was born.

The University approved funding to upgrade six of the major lecture theatres that were used for the lectures which had an Albany component.

An Apple G4 was installed into each of the upgraded lecture theatres to capture the audio stream for the lecture. A standard top lit "visualiser", as used for video conferencing, was installed where an overhead projector was required. The video from the visualiser was also projected within the lecture theatre for the students and this video stream was captured by the G4.

Dr Doug Pitney had been asked to deliver a first year maths unit to Albany in 2000 and so became the guinea pig for the project. Luckily he was very sceptical and insisted on the highest quality. Shaun Procter was given the task of working out the compression parameters and in the end he managed to satisfy Doug, which was no mean feat.

And then there was "the talking hand".

**Delivered to a modem near you**

Having adapted the visualiser, the task became how to deliver these stream at an acceptable standard to a 28k modem. This modem speed is a fact of life for many rural students and is unlikely to change in the near future. This has been successfully accomplished and a 28k stream is now available as well as the 56k stream which is used in the labs at the Albany Centre.

**Streaming Servers**

In the first semester of 2000, the number of units delivered in this way to Albany jumped from 4 to 16 and the demand for the lecture recordings increased accordingly.

Once the QuickTime™ streaming server came on line in the MMC, the first real test came in the first weeks of semester. It very quickly became apparent that the lectures were breaking up as soon as the link between Albany and the MMC was loaded. If 10 or 12 simultaneous stream were being accessed in the Albany Labs the link literally ground to a halt.

The first remedy was to increase the link from a single 64k ISDN channel to 128k but improvement was marginal. It was then decided to put another streaming server into the Albany Centre itself and access the streams locally. This resulted in a dramatic improvement in quality for the students. There was an additional overhead involved in downloading the lectures from the MMC server, but this solved the immediate problem for 2000.

**The Automated Recordings**

At the end of this effort the MMC had developed a fully fledged automated recording system, iLecture[5]. The raw lectures are uploaded to the compressors (a bank of G4's) over the network. These compress the raw audio and video recordings into QuickTime streams which are then uploaded to the streaming servers in the MMC and in Albany. A RealAudio™ stream is also produced. The Filemaker Pro™ databases which support the "Forum" are then updated with the links and the iLecture is then available to the student. PowerPoint™ presentations used in the lecture can be put into a network "drop box" and these are then included within the iLecture format on the Forum.

This process can take anything from 1 hour to overnight, depending on the loading on the system and the number of lectures to be processed. The lecture schedule is pre-set for those lectures which are to be recorded.

The whole system is scaleable and could be rolled out to the whole campus.

**Into 2001**

The effect of this lecture recording system and its associated managed learning environment, the Forum, has been quite startling. What began as the "Albany experiment" has had a profound effect on flexible delivery of coursework on the Crawley campus.

During the first semester of 2001, lectures from 115 units were recorded by the iLecture system, making UWA one of the largest providers of streamed materials in Australia. Of

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[5] A commercial version of the iLecture system is currently in beta testing. This has been made possible with the kind assistance of funding from Apple Computer and the University of Western Australia. For more details contact the Multimedia Centre in the Faculty of Arts.

the more than 49,000 hits on the recorded lectures during semester 1, 60% were from non-arts subjects and only 6% were from Albany.

| Forum Statistics | Total | Arts | Arts % | Non-Arts | Non-Arts % | FFS[6] | FFS % | Albany | Albany % |
|---|---|---|---|---|---|---|---|---|---|
| Units | 115 | 88 | 76.5% | 15 | 13.0% | 12 | 10.4% | 16 | 13.9% |
| Students | 5127 | 2083 | 40.6% | 3044 | 59.4% | | | 39 | 0.8% |
| Student Units | 10475 | 4867 | 46.5% | 3830 | 36.6% | 1778 | 17.0% | 79 | 0.8% |
| User Logins | 85008 | 54350 | 63.9% | 22381 | 26.3% | 8277 | 9.7% | 3203 | 3.8% |
| Discussion Posts | 16820 | 14492 | 86.2% | 2299 | 13.7% | 33 | 0.2% | 228 | 1.4% |
| Lectures | 1843 | 1080 | 58.6% | 483 | 26.2% | 280 | 15.2% | 521 | 28.3% |
| Lecture Hits | 49110 | 19505 | 39.7% | 20110 | 40.9% | 9495 | 19.3% | 3000 | 6.1% |

*Forum statistics for semester 1, 2001, by kind permission of Michael Fardon, Arts MMC*

## The Academic Staff

The academic lecturing staff were at first fairly ambivalent about providing a service to Albany, and many saw it in terms of extra work and so extra time. Once the recording of lectures was established and the extra lectures required to use video conferencing went away, this attitude started to change. The lecturers were persuaded to convert their lecture materials to a digital format in order to make them available via the Forum or their own web site. Many of those not using the visualiser, chose PowerPoint™ for their presentation and these are easily incorporated into the iLecture format. This is now seen as a major contribution to staff development.

## Web CT

Two of the units delivered to Albany use WebCT as their managed learning environment. In this case the lecture recording are downloaded in raw form from an FTP server and incorporated into WebCT.

# The Students

## Student reactions

Students in Albany have reacted to the system very positively. For them it is immediately "normal" and they don't really question it. One of the disadvantages has turned out to be quite an advantage for them. The fact that their only access to the lectures is through iLectures, has meant a very steep learning curve for some. This does mean, however, that their IT skills are very quickly honed and this gives them a distinct advantage in this area.

As for the recordings themselves, they get to know the lecturers really well and know all their bad jokes and little eccentricities. Some of the lectures will mention the Albany students every now and then and the Albany students really like it. Some of the lecturers are also really thoughtful and give good audio cues for changes of PowerPoint™ slides and the like.

And the "talking hand"? If you sit down and listen to a lecture which has a talking hand, the fact that the hands are "jerky" is very quickly forgotten and one becomes quite absorbed in the lecture itself. In a way it is so "obvious" that one very quickly takes it for granted.

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[6] FFS — Fee for service. These are all non Arts subjects. The distinction is made between Arts and non-Arts subjects because the bulk of funding for the MMC is from the Faculty of Arts.

And of course … one of the big advantages that the Albany student has, is that they get to chose the lecture time, and what's more, they can pause the lecture at any time and listen to more tomorrow if they want to. Particularly for those students with part time work, alas all too common these days, this is a real boon. The iLectures are also available for the duration of the unit for revision purposes.

Student results have on average been at least at the same level or better than those in Perth.

The first cohort of nine Albany students moved to Perth in 2001 to undertake second year units in their chosen degree courses.

**Scholarships**

The extent to which the local community has supported this undertaking, is clearly shown by the level of scholarships that are now offered. In 2001 a total of eleven scholarships were awarded to students ranging from school leavers to mature continuing education students.

## The Future

**Second Year and full degrees?**

At this time only one second year unit is offered in Albany and it is unlikely in the near future that other second and third year subjects will be offered. However, UWA is planning to teach a full three year economics degree in Singapore using iLectures and so it is possible that this degree may also be offered in Albany. Time will tell.

**Where to now?**

The UWA Albany Centre, which started as a three year trial, is now firmly established. UWA has recently taken a long lease on the Old Post Office and Customs house, a grand heritage building on Marine Terrace in the heart of the oldest part of Albany. With the assistance of a substantial grant from DETYA, the building is currently being refurbished, and the UWA Albany Centre will move its operations to the building at the end of this year, and will commence teaching there in semester 1 of 2002.

A Centre of Excellence for Natural Resource Management is also being established in Albany. This will establish a postgraduate research focus for the Great Southern Region.

And so it appears that "the Albany experiment" has proved to be a major catalyst for the University of Western Australia in the move to provide tertiary course material on-line. That this on line material is being sought out enthusiastically by the students themselves, must surely be a sign of success.

# JoePM: implementing a collaborative environment for learning multimedia project management.

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**Abstract**   Using the Web in tertiary learning environments can offer great adaptability and flexibility as it enables the planning and design of learning tasks that promote learning processes and monitor learning outcomes. This paper considers the design and development of a Web based learning environment (JoePM), from an application programmer's perspective.

JoePM supports a task oriented, time dependant model of interaction in which students are given weekly tasks and provided with the necessary resources required to complete them. With the exception of some paper-based readings, all resources are online including videos, links, hints and tips, training materials and past assignments. Individual and team-based student submissions, tutor feedback, peer feedback, communication and team tracking are all managed online.

JoePM has been designed in template form, which enables it to be used for other units of study by simply changing the database content. The system makes extensive use of FileMaker Pro (2000) as a database backend, Macromedia Director (2000) as shockwave, and QuickTime Streaming (1999) for delivery of extensive video content.

Whilst the pedagogic details of the system are dealt with in a separate paper, this paper describes the database structure and technical implementation of the system, as well as detailing issues and pitfalls involved in developing a large cross-platform online system.

## Introduction

The JoePM system is an online collaborative learning environment designed for students learning how to manage the development of projects in the School of Communications and Multimedia at Edith Cowan University (IMM 3228/4228 Project Management Methodology) The unit covers all aspects of project management, from the needs analysis and project proposal, to production and launch, and finally the post mortem and the development of project metrics.

It was decided to develop a Web-based application to deliver this unit to help support a constructivist learning environment by creating authentic context, clear communication channels, group work, learner control and the creation of tasks and experiences that foster higher-order cognition and self-directed learning (McLoughlin, & Luca, 2000). Learning outcomes sought in this unit were related to developing personal transferable skills of time management, teamwork, decision-making, conflict resolution and problem solving. Tasks were designed to maintain a focus on the learning processes and professional skill development rather than content-based outcomes.

This paper discusses the development tools used, the use of relational databases with FileMaker Pro, and the implementation of the system. The development of JoePM is based on a constructivist pedagogical framework (discussed in another paper). The application needed to reflect this framework in three functional components:

- student-centred learning activities;
- self-regulated learning activities;
- and learner support tools.

The learning environment is based on student centred learning activities where students were required to solve ill-defined "problems" on weekly team basis. This was supported with on-line content and information, such as streaming video, readings, links to external media, and tips/hints from industry. The students use these resources to develop solutions to ten tasks over the period of a semester. These solutions are then posted to an on-line forum area and assessed by peers in an anonymous fashion.

Self-regulated learning activities were promoted by students being required to commit to personal responsibilities and tasks within a team of four or five students. This involved initially filling out a "Student Contract" in which time commitments were made relative to a team role. This commitment is monitored by tracking actual time usage through a time-clock system and comparing the estimated times from the "Student Contract". A journal system also allows students to assess themselves as well as their peers through a confidential on-line system which is posted to the tutor weekly.

Students are provided with a range of learner support tools to help implementing their team structure. Individual team members can manage their own records and view the records of others. Project Managers can manage their team members, including options such as deleting members. The system also incorporates a range of general-purpose tools, such as on-line forms (inc bulletin boards), messages of the day, and links to team prototypes.
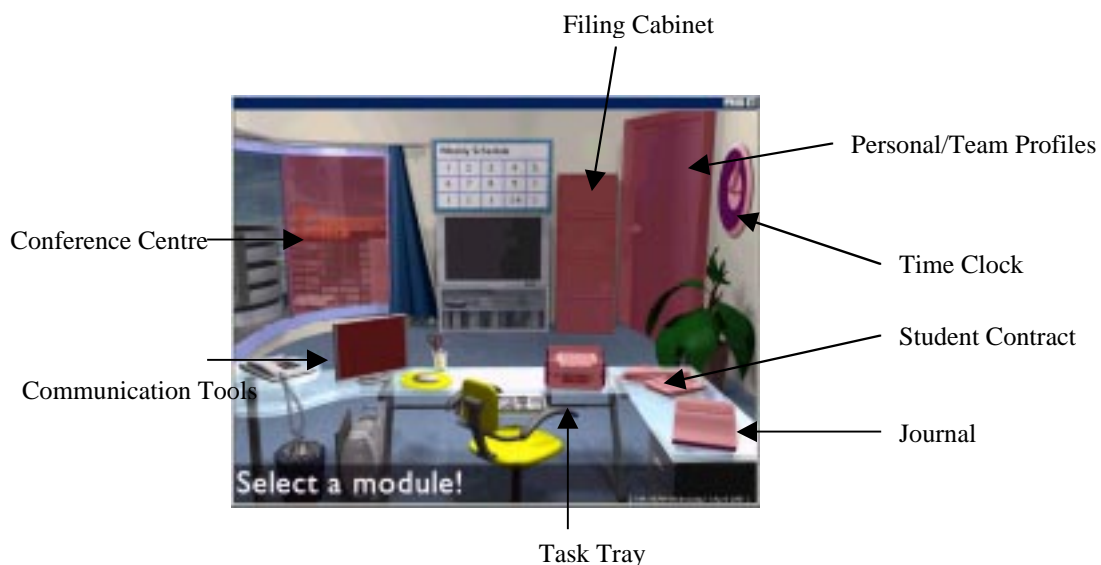


*Figure 1: JoePM main interface.*

The main interface metaphor for JoePM is an office. This metaphor provides ready access to the three main areas described above through the use of FileMaker Pro databases. The established metaphors (as shown in figure 1) are:

- student centred learning activities — these include the In tray, filing cabinet and conference centre;

- self-regulated learning activities — includes the student contract, time clock/sheet and the journal; and
- learner support tools — are located within the monitor icon and are available to all users of the system.

## Design and Development

The JoePM system is designed to run in both Macintosh and Windows environments. Developed for both platforms, the system has been optimised for Microsoft Internet Explorer 5 or higher, due to the inability of Netscape Communicator 4+ to adequately display Cascading Style Sheets (CSS).

FileMaker Pro 5 was chosen as the database backend for a variety of reasons. Prior experience with the database software within the School of Communications and Multimedia had shown the application to be reliable and relatively inexpensive to install and configure. The application can also be run on either a Macintosh or Windows server with no special hardware or configuration.

When transferring the imm3228/4228 unit into an online environment, FileMaker Pro allowed the automatic integration of many of the elements being taught within the original course. An example of the automatic integration can be seen in figure 2.
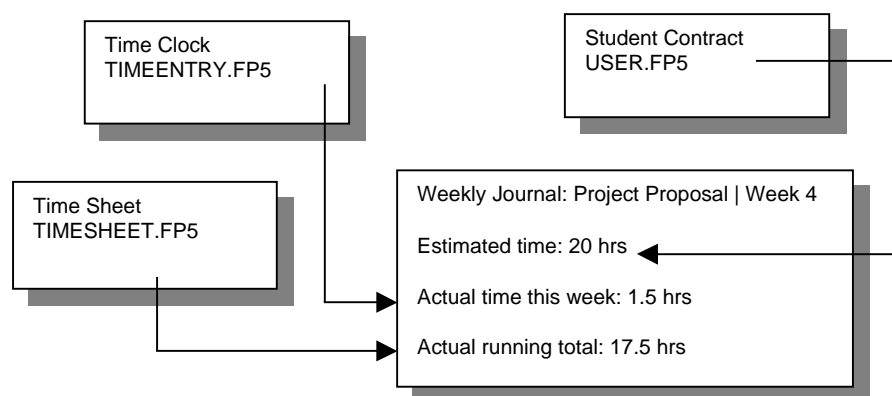


*Figure 2: Automatic integration.*

Previously, students had to submit a paper-based contract at assessment time, then use a separate spreadsheet application to compile their time expenditure. The FileMaker databases allow the JoePM system to calculate these figures for the students at any given time over the course. This information is then used by the students to complete their self and peer assessments each week. The FileMaker Pro system also gives tutors unprecedented insight into their students' progress by allowing them to monitor the same information, and review the self and peer assessments.

The interface was developed in Macromedia Director 8 and deployed as a shockwave movie. The shockwave compressor generated comparable file sizes to a sliced 800 * 600 image with JavaScript roll-over effects. The shockwave shell was designed to be modular in its use. The desire to create an interactive product, which could be used as a shell for delivering any task orientated course, is rooted in its construction. The ability to perform active scripting on the client side enabled the creation of a shockwave application that inputs data via parameters passed to it within the html embed process, as well as reading in a text file containing module descriptions and database actions.

By utilising a text file, the application can manipulate which sections become accessible within the movie and what action is to be performed upon its activation. This functionality could be extended to allow a generic model to be created which would allow the facilitator of a course to activate only the options of the interface that were necessary.

QuickTime was used in the extensive delivery of video footage, taken from a variety of local multimedia industry representatives. The video was streamed for either 56kps or LAN (T3) connections. Using QuickTime streaming server 3 running on a MacOS X server.

## Database design/relationships

The JoePM system uses sixteen relational databases. Most of these databases have a many to many relationship with each other. The original design focus was to create many inter-connected databases holding specialist data, rather than larger ones encompassing a larger amount of information. This approach was taken for two reasons. The first was the amount and frequency of use for the system, while the second was the large amount of collation required to bring together individual user records into larger, more meaningful team records.

In a two hour tutorial there can be anywhere from 50 to 100 students accessing the JoePM system at once across several computer labs. This amount of use and the frequency at which the users access the system creates a lot of network traffic. By separating larger databases into smaller ones we can more easily manage the databases and effectively share the system load. Each database action, especially search requests, can be performed faster due to the smaller size of the database itself.

This strategy has proved particularly effective across the university Macintosh network. The effectiveness is also increased if the users access a variety of different databases. Occasionally this method of segregating the load across many databases results in the FileMaker application failing to return a particular action. Usually when this error occurs the FileMaker application will cause the host computer's operating system to halt, which requires a restart. This fault is more pronounced over slower Internet connections.

Team members continually make different varieties of database entries in the course of the unit. The need to correlate a number of user's individual records into a larger team record highlighted the need for a relational database structure. The design structure adopted for the JoePM system was to use a database that draws data from a number of smaller databases and then presents that information to the user. This structure is highlighted in figure 3. The master file draws summary data from the three related databases and presents in to the user. This facility allows for the real-time reporting highlighted in the tutor access materials, outlined below.

The system correlates relevant data and utilises the power of FileMaker to perform in-line database queries while processing the current query.

An example of this interaction is connecting the journal and time entry databases, shown in figure 4.

Although these two databases do not have any relationships defined within the databases themselves, they do have connections made when displaying the data in a meaningful manner. Summary times are extracted from the time entry database using self-joins. This data is combined with the initial student contract via an in-line query to the user database. This information is then combined with the user's self-assessment from the previous

week, again via an in-line query. All this information is presented in one page — from which users complete the self and peer assessment tasks for the current week.

This method essentially replicates the function performed by creating many to many relationships between databases. The difference is it only creates a link to the data when necessary, and only on the web front. This reduces the number of inter-related databases, which in turn reduces the load on the whole system.
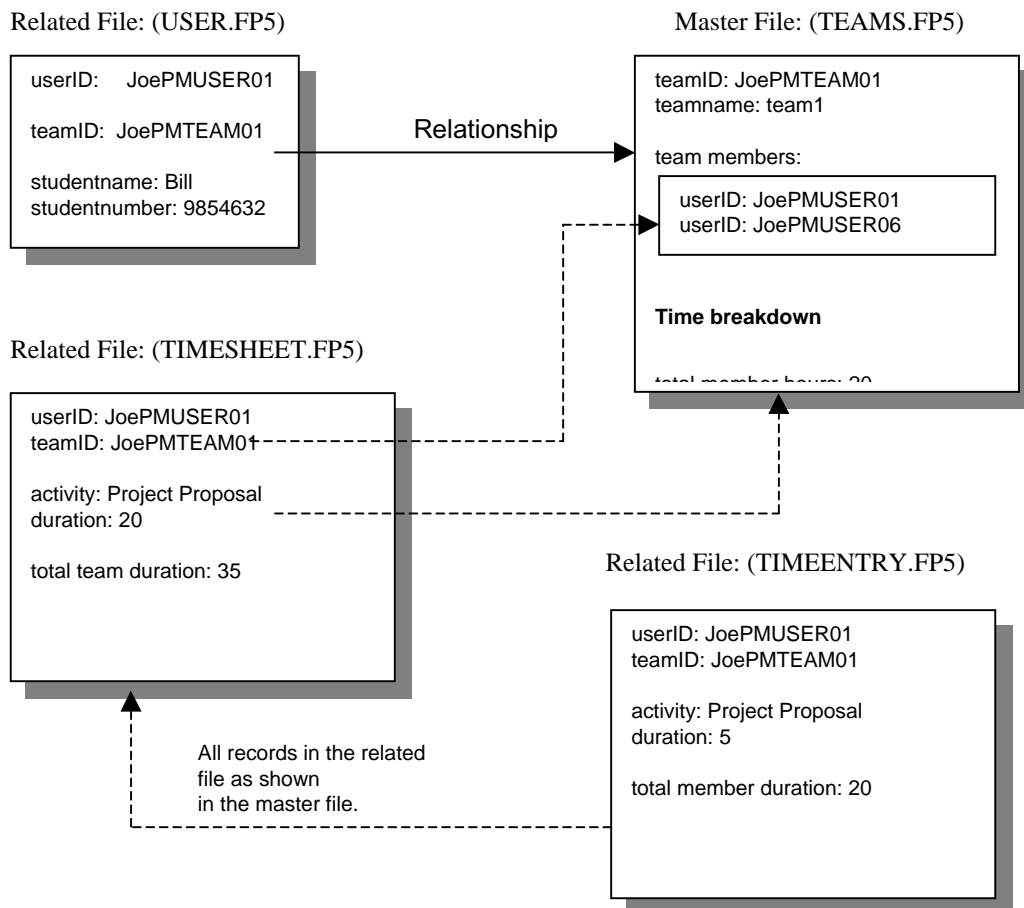


*Figure 3: Relational databases*

*Journal View:*



Related File: (USER.FP5)

```
userID:   JoePMUSER01

estimated times:

PP: 10 hrs
DS: 25 hrs
PD: 50 hrs


Total: 85 hrs
```

```
userID:   JoePMUSER01

self assessment:

comments: Over time on PP.
```

```
userID:   JoePMUSER01

PP total: 12 hrs
DS total: 14 hrs
PD total: 31 hrs
```

Related File: (JOURNAL.FP5)

Related File: (TIMENTRY.FP5)
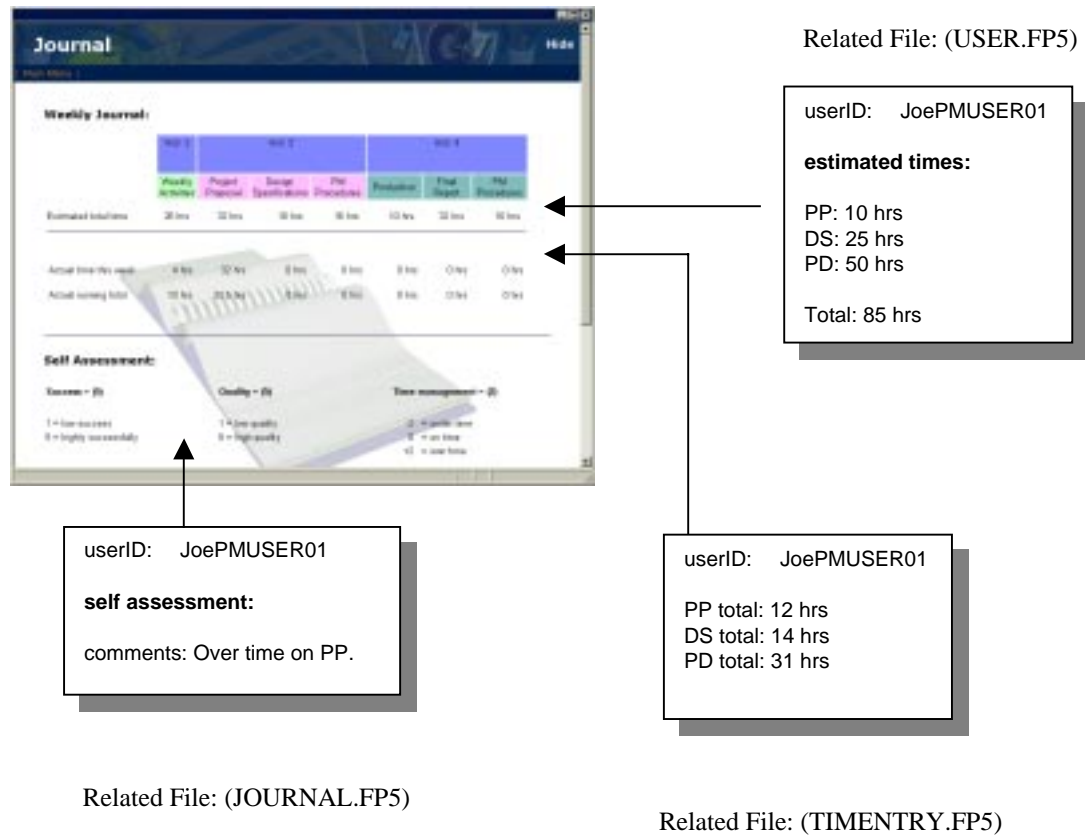
*Figure: 4: In-line actions within a webpage.*

This method essentially replicates the function performed by creating many to many relationships between databases. The difference is it only creates a link to the data when necessary, and only on the web front. This reduces the number of inter-related databases, which in turn reduces the load on the whole system.

## Implementation issues

The system was designed for relatively high-end computers, typically iMacs or Wintel 98 machines. This target specification adequately covers the majority of users within the expected scope of the application. The system itself is hosted on a Macintosh G4 with 256mb RAM, running MacOS 9.1, using FileMaker's own built in web server.

Although there have been no performance issues in relation to the operation of the JoePM system, averaging 4000 database hits a day within the first week of operation, a variety of technical problems have been encountered that are inherent in a large cross platform system.

The biggest problem encountered has been ensuring the correct version of the shockwave plug-in has been installed on the user's browser. A high proportion of remote users, using Windows, have reported what we have called the "Black screen of death", when attempting to connect to the JoePM system over a standard 56kbps Internet connection. This is the shockwave movie attempting to load but failing to finish downloading, thus

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leaving a black window. The problem has been linked to shockwave's inability to correctly overwrite its previous installation with a new version of the plug-in.

Another problem associated with Macromedia Shockwave is its inability to call a JavaScript within the page in which the shockwave movie is embedded. This ability is only compatible with the Netscape range of browsers on the Windows operating system.

This lead to the development of dual window system in which the interface window, containing the shockwave movie, is layered over the content window, which contains the database output.

## Access restrictions: User types

There are five levels of access restrictions in the JoePM system. These range from administrator access to guest accounts. The system options and configuration change depending on the user type and the mode of access in designed to be scalar for future expansions.

*Administrator*

This is the highest level of access for the JoePM system and allows the user to modify the contents of the courseware databases. It is envisioned that this access mode could be developed to allow the user to modify the operation of the system. This could include which parts of the JoePM system were active and what function they performed. Within this section the administrator has the ability to change the deadline for posting team solutions to the conference centre, as well as randomly allocating the teams for assessment and locking the assessment deadline. These three options give the administrator great flexibility in the operation of the conference centre.

*Tutor*

When a team or user registers themselves in the system they are required to select a tutor. Based on this choice, the tutor can login into the system and view any record that matches their name. This information can be user based — such as weekly self-assessments, time entries, personal information and student contracts. It can also be team based — such as peer assessments, weekly task submissions and total time expenditure per team. As a tutor they have the power to re-assign team members and delete users under their control.

This access provides a mechanism in which tutors can view a student or team's progress at any given time within the semester. In traditional courseware teaching this access to information is usually only available at assessment time. The JoePM system provides up to date information and comparisons between teams, allowing the tutor to proceed accordingly.

*Project Managers*

In an effort to make the system a reflection of real life practice, the project manager of each team is given extra privileges. As a project manager they can re-assign the roles of members within their team and delete members of their team. They can also manipulate their timesheets, as well as issues such as specifying a project URL address, a team email and selecting a supervising tutor.

*Users (team members)*

This access type caters for all users who are not part of any other classification. This user type gives access to all sections of JoePM, excluding administration.

*Guest*

Guest users are the most basic type of user and allow access the courseware databases and the weekly task tray. This user type was developed to allow the JoePM system to be used for any on-line courseware application.

## Summary

The JoePM system has been conceived as a shell that can be used to implement any on-line course. The use of relational databases integrated many of the courseware components of the imm3228/4228 Project Management Methodology unit, facilitating real-time reporting of information for tutors and students. This automatic integration, combined with the easy to use development tools allowed the creation of a sophisticated user experience.

Although the JoePM system was originally designed to teach students project management skills for the multimedia industry, the application boundaries of the system could be extended to other teaching domains. This system will be refined in the future to allow features to be controlled by educators when developing customised teaching environments based on constructivist learning pedagogy.

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# Sound in educational presentations

# the tantalising, terrifying, too-often-forgotten tool.

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**Abstract**   The capabilities of computers to educate are limitless — in the hands of good lecturers. But the amount of work needed to fully utilise the potential of this mode of lecture delivery is still considerable and often abandoned by even keen academics. The first thing to go is the use of sound — because it is fraught with problems — incompatibility of systems, non-uniformity in hearing ability and comfort of the audience, breakdown of sound signals because of streaming problems etc. In computer labs the administrators are quite often driven to turning off the sound capabilities of the machines because of the disruption of 20 or more computers all playing different sounds at different rhythms or different volumes.

This paper discusses some of the exciting possibilities of using sound to enliven a lecture, to enhance flexible tutorial material and to undertake simulated sound laboratory material The author believes that education will be the great winner if this extra dimension is added to the communication platform at the tertiary level — but much needs to change in the environment to make this possible.

## Background

In the early 90's computer equipment available to researchers and those teaching students in laboratory classes was reasonably well developed, however the use of computers in lecture presentations was limited to the few classes which could manage to win the coveted specially equipped lecture theatre at the time scheduled for the class. Apart from special invited one-off lectures, therefore, the lecturer had to prepare material to be able to present their material in two forms — one using their computer projection, one with OHP slides or possibly just "chalk and talk".

Because of hardy lecturers persisting with the technology, in spite of the frustrations and the increased workload, the situation today is considerably improved. The possibility of acquiring a well-equipped lecture theatre on a regular basis for a physics class now is quite good — at first year level, at least. Some smaller rooms are gradually being similarly equipped, for smaller late-stage classes. While some of those who attempted this mode of delivery when it was first introduced have been "sworn off", there is an increased acceptance of computer projection being at least sufficiently reliable as to not necessitate carrying a set of backup overhead transparencies "in case".

On the other hand, confidence in being able to use sound output from computers is still at a low level — and requests for sound connections have the technical support staff requesting more set-up time and in many cases requiring a particular person with knowledge of sound requests to be available. To reduce hassles one of our technical support staff volunteered to make me a special cable so that I could be guaranteed easy connection to sound I/O. Six months later the consoles had been changed and that cable itself ran into difficulties.

I am a sound enthusiast. In addition to being a physicist, I am a pianist, conductor and am very actively involved with the production of sound in the world of music. I like to regard my PowerBook as a partner in these endeavours — and part of the needs of partnership involves the actual production of sound — music, noise, resonance sounds, sound effects, etc. I delivered a paper on this topic to the Australian Institute of Physics [1], encouraging the use of sound to "enliven" the lectures. Having survived the uncertainties of early visual projection resources I am hoping that it will not be long before I can incorporate sound with as much certainty as visuals.

One reason for this is that our "audience" population — the learning students — are continually expecting more professionalism in the lecture material presented from the podium. They will accept an inspiring academic lecture even of "chalk and talk" if the quality of the chalk and the talk is good. For this to be replaced by "project and reflect" the projection and reflection also has to be of good quality — not just an amateurish revamp of chalk and talk. TV, the theatre, the cinema — all use sound to great effect — and so might we, if provided with adequate tools.

But there are special problems associated with the use of sound.

## How and Why to Use It

There are many ways in which sound can be incorporated

### mood music — setting the atmosphere

Music is not everyone's style — but there is a great variety of styles of music (or non-music) from which to choose. With the compactness of MIDI files it is possible to bring along a great supply of alternatives — to suit the audience. It can be an enhanced learning environment if the mood is set appropriately, e.g. in a special optics lecture on the Hubble Space Telescope some outer space music in the dim background would really add to the effect.

### real-life sounds

e.g. breaking glass due to a resonant vibration being picked up. When the vibrations increase in amplitude until the glass shatters — the appreciation of the effect is greatly enhanced by the inclusion of sound. A real-life demonstration is the best demonstration of all — but to do this requires far more time and materials than an efficient computer simulation — or possibly a videoed demonstration set up for QuickTime viewing. The reduced impact because the audience knows that it is sure to work is offset by the ability of the lecturer to choose critical points in the experiment by moving the slider to a particular point in the experiment.

### sense of reality

The Tacoma Narrows bridge is always exciting to watch. If there is no supplied sound track the lecturer comments appropriately on the key features. Alternatively there may be a pre-recorded voice describing the key features. Best of all is, say, the original footage — complete with the sounds of wind and crackling radio — obviously taken from the same era as the bridge collapse occurred. The students believe that they have had an experience of history — rather than of storytelling.

*Figure 1: the Tacoma Narrows bridge hitting resonance, from Physics:The Core (Saunders) {2} much more exciting — and understandable if the sound of wind is included.*

### alertness encouragement.

Just because lecture rooms are well equipped, with large screens and good colour definition, does not mean that it is any easier for the students to maintain concentration. Indeed the smoothness of a power point presentation, together with the compulsory wait for students to take down the notes — can provide the perfect scenario for the students to doze off during the lecture. With multiple blackboards to be scribbled on, pulling them up and down in between there was no need to wait for all students to finish the current board before starting on a new one and more chance of keeping the fast writers awake.

What better way to "wake up" the mechanics class struggling with orbital equations than to suddenly introduce a track from "Star Wars". It works — but is it worth the effort?

Realistic utilisation of space and time in the university scenario requires us to occupy lecture theatres for periods from one to four hours. And yet such periods of time are known to be far beyond the normal absorbing time for even keen listeners. Our entertainment industry colleagues work in ten to twenty minute "bursts". Can we really expect our audience to be attentive and enthralled for one or more periods of sixty minutes?

### live across the net

The rapidly expanding connectivity of the internet makes it possible for us to uplift the large lecture situation by bringing in "guest spots" — live into the studio or lecture room.

•interviews

•video-conference with distant physicists

In Sydney, for instance, we have a past student working at the Satellite tracking station and, as a special feature in one of the lectures could bring up a link with the real workers at the station while they were making some orbital changes to the geosynchronous orbit, for example. Not all of the students would be impressed — but many would. Our business faculty colleagues impress their students by linking up with marketing executives and financial entrepreneurs. We have the technical connectivity to similarly enthuse our students — but rarely do so.

### sounds from the deep

Teaching waves to first — year engineers or first — year biologists can be a little harrowing as one tries to verbally defend the teaching of such material as being of value in many fields. Why not hook up to the sounds from a whale in the deep Atlantic — and possibly perform a Fourier analysis on the signal to make some interesting observations on the special qualities of sound produced by such an appealing animal. Exploring the net

one can find an incredible range of unusual events — and real-audio plug-ins are making it increasingly possible to share this material with our students.

## When to Use ... i.e. Use vs Abuse

It is clear that overuse of sound could be the source of annoyance rather than of enhancement. So when should it be used?

•depending on the class it could be used routinely as atmospheric music as the students arrive. One would need quite a variety of tracks at hand to be able to make this a worthwhile practise over the extent of a semester

•primarily, however, it should be used to illustrate something for which the sound is important — such as wind effects in high velocity motion or resonance effects in glass or metal

•occasionally as an element of surprise — or it will not surprise and will definitely annoy

•for special events — such as hooking up to a special lecture on, say, nanotechnology, using the net to show how current the material is — much more exciting than just playing a video, though the quality will probably not as good.

## Where ... to find the sound files?

Sounds are captured in many formats e.g.,

- AIFF

- WAV

- SND

- CSND

- MUSIC

- MIDI

and of course the sound tracks in movie formats. The internet has a large supply of audio tracks of music, of sound-effects, of wild-life — and an amazing collection of voiced comments which may happen to be appropriate for a certain occasion. It is easy to spend many hours sorting through the possibilities — just as in finding graphics via the freeware on the internet.

Plug-ins such as LiveAudio and applications such as RealPlayer now make it possible to interpret many formats without the user being even conscious that conversion is needed. The audio equivalent to GraphicConverter will identify what format the files are in and then offer suggested possible output formats.

MIDI files are the most compact way of producing musical sounds and with computer utilities such as QuickTime Musical Instruments it means that you can easily transport full 30-minute music tracks with only a small storage requirement.

Just as the sounds are easily available on a net search, utilities for playing the sounds — or converting them to other forms are increasingly available and increasingly expansive in what formats are readable.

Copyright is of course an issue here — but if all else fails it is easy to take a microphone and record a track yourself.

# Why ... not?

*There are difficulties with consistent sound production on the computers*

Currently it proves very difficult to obtain reliable sound from computer systems and from lecture amplification systems. On the computers themselves a small change in system set-up — e.g. from QuickTime 3.0 to 4.0 can suddenly have products which produce sound no longer producing sound. Early applications running on newer machines cannot cope with the new hardware. This can prove extremely difficult if the sound has been incorporated into an animation — so designed to take a reasonable viewing time to appreciate. If the sound does not work, one can have the situation where the animation now runs at a greatly increased speed and the animation becomes unrealistic.

Sound compressions have greatly improved — but real-time recorded sound files are still large and need to be buffered to be played in apparent synchronisation with the video track. In video conferencing and internet interview situations the synchronisation is not satisfactory and a very much less than perfect experience results for the viewer.

*There are major difficulties in enabling confident sound output to externally provided speaker systems.*

I travel to lectures armed with many adaptors to try to be able to connect to any centrally supplied audio unit. The University aims for standardisation across its facilities — but there are occasions when I have found that the connection I used previously in a particular lecture room is no longer appropriate for that room. This means I need to have

- mono/stereo adapters
- mini stereo to 3.5 jacks, to 6.5 jacks, to n-pin DIN, to XLR

*There are major difficulties in adjusting the sound levels appropriately for the entire lecture hall — or even for two students sitting in adjacent seats but with different levels of sound sensitivity.*

Breaking glass should sound like a disturbing sound, not a gentle tinkle — but should not cause pain to the listener. The lecturer at the front of the lecture hall may perceive an entirely different sound level to be correct than a student sitting in the back row. In the theatres an elaborate system of mixers located within the audience enable on-the-spot adjustment. Such luxury is not available to the lecturer in normal lecture situations.

*Feedback can be a problem.*

Experienced lecturers know that they should not use a microphone in front of the speaker but even they are caught out when, say, moving over to a demonstration away from the lecture stand. Feedback is a sound which provides considerable annoyance to many people, with the audience often wishing that the speaker had not chosen to use miked sound anyway.

*Sound in Computer Labs*

Sound is a very important part of our world and needs to be investigated just as other more visual properties. Sound can be a very valuable addition in the form of "talking heads" accompanying instructive material on computers. However the nearby presence of other computers simultaneously talking about different topics as would happen in a computer lab dedicated to sound measurements makes working with those sounds an almost impossibility. Indeed in many cases computer administrators choose to disable the sound feature — to save annoyance to other users.

Sound can also be analysed — but the reference level is difficult to set. A "threshold" test of hearing requires one to adjust the sound level until the user is just able to hear the onset of sound. With computer hum and the nature of the sound produced it is very difficult to replicate the soundmeter version of this experiment. To try to overcome this problem I have written comparison tests, asking the subject to adjust volumes until the final result is the same as a test level. This works reasonably well.

*Educational vs entertainment — where is the line drawn?*

The primary role of the lecturer is to convey knowledge and understanding to the student. A difficulty can arise where the lecturer goes "overboard" in special effects, particularly sound effects. At the end of a lecture there are no bonus points for having the students enthused, relaxed, inspired ... if they have not learnt anything. Just as items for news broadcasts on TV seem to be partly governed by what footage is available of some items over others, so it is very easy for a lecturers choice of material to be guided by what sound effects (and visual effects) are at hand. This is poor lecturing. The content should be the main interest, with sound added where it is most appropriate — not just for the sake of entertaining the audience.

It is also possibly a good practice not to have the inclusion of sound so predictable that the students are expecting this to be included as part of the lecture. Surprise can be a valuable property of the inclusion of such material.

## Conclusion

Sound is a valuable tool of the modern lecturer and it should be possible to be included by the lecturer as most appropriate to the topic area being lectured. However, much more uniformity is needed in connection jacks for computers likely to be used in this situation. All AV technical support staff should be equally well trained in the art of providing audio as visual support and preferably a similar plug — in capability to the sound system should be provided as part of every console at the lecturing podium, so that the lecturer can simply arrive with the PowerBook, connect the video, connect the audio — and have confidence in the whole connectivity process so that he/she can concentrate on the lecture, rather than worrying about whether or not the sound is going to work.

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# Collaborative learning:
# on-campus in a technology based environment

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**Abstract**  We developed an on-campus collaborative learning environment (CLE) as a student-centred approach to learning. Computer-facilitated tutorials were combined with investigative group projects, designed to enhance students' communication and reasoning skills, peer-learning and peer-teaching. Cost-efficient web-delivered tasks were designed based on re-usable interactive web components that store student responses in a novel server database ("OCCA" : On-line Courseware Component Architecture) developed at this Institution. The data can then be re-presented in multiple forms to provide for group discussion, self-assessment and peer review. Student submissions were accumulated in a portfolio to enable them to reflect on their learning. Students worked in groups of 3 per iMac computer, during weekly 2-hour scheduled sessions during semester. 'Facilitutors' contributed to timely feedback using efficient templates for reviewing and annotating student work. Within these sessions, up to 30 minutes was allocated to collaboration on the group project. We have now been able to show significant positive influences of effective participation in collaborative learning on students' examination performance (over 4 semesters of physiology in 1999–2000).

Production of a successful integrated learning environment requires continual cycles of both formative and summative evaluation. In our study, in-depth course and tutorial-specific questionnaires and program specific audit trails have been used over 4 years. Our experiences show that any improvement in learning only comes from continuous carefully targeted in-house evaluation procedures. Evaluation of examination outcomes has also been undertaken and a novel approach is reported where student groups of "improvers" and "disappointers" were established for study. These subgroups were established from the total student group based on changes in examination outcomes compared with previously established levels of examination achievement. Comparison of these groups was used to establish clear differences which were then used as criteria for studying the total class population.

## Introduction

Tertiary institutions are increasingly moving towards the delivery of courses using computers to provide students with the opportunities to learn at their own pace, together with a reduction in traditional lectures. There is also a trend to provide asynchronous access to courses via the Internet. There is broad recognition that traditional forms of

university course delivery are inappropriate in preparing students for a dynamic workforce in a post-industrialist, knowledge society (Drucker 1995, Lohrey 1995). Where it has been successfully implemented, collaborative learning is recognised as a potent transition factor in supporting the development of higher order cognitive abilities (Johnson & Johnson 1992). Despite this recognition, evidence of direct positive effects on student learning remains largely anecdotal (Meloth 1999). Face-to-face collaborative learning, with academics as facilitators, is an area where campus-based universities have a major advantage in tertiary education. We contend that to provide such collaborative learning opportunities has advantages over relying only on electronic communication in virtual study groups. However, amidst contracting resources and increasingly crowded curricula, there is an understandable reluctance to establish the substantially different and potentially risky conditions of learning necessary for successful collaborative learning (Cooper & Sweet 1999).

We have now evolved a collaborative learning environment (CLE) in which we develop and present computer-facilitated learning as a means of effectively broadening the learning opportunities of science students studying physiology. Since 1993, our efforts in computer-assisted learning have aimed to extend, enhance and replace some of the students' lecture experiences with multimedia-based tutorials in an environment that encourages peer-learning and peer-teaching. A global aim in our science teaching in physiology is to use the curriculum to develop in our graduates some appreciation of the abilities required of them as practising scientists. Emphasis is given to understanding the experimental, research, theoretical, communication and critical reasoning base of the discipline.

Our concept of a collaborative learning environment consists of: a friendly and informal physical workspace that is conducive for group interactions, with an optimum group size of three students per iMac computer; an economical production model that provides a coherent set of weekly web-based problems; supplementary standalone highly-interactive multimedia tutorials dealing with essential concepts; a tutor to guide and assist (not teach); and extension after hours into the virtual classroom of the internet using electronic communications.

This article will discuss the broad range of innovative approaches we have adopted in both our curriculum and our evaluation practices. These evaluation strategies have been essential to the development of the many multimedia projects and their impact on course development.

Results so far suggest that the introduction of our collaboratively based approaches to course delivery has had a significant positive effect on student learning outcomes. These outcomes include not only traditional examination results, but also more 'authentic' (Wiggins 1992) methods of assessment such as observation of group role fulfilment and student audit trails of problem solving processes.

## Electronic Teaching Approaches

Scheduled computer-aided learning (CAL) sessions were introduced into Introductory Physiology (2nd year of the 3-year B.Sc. course) in 1997, as part of an ongoing strategy of decreasing lectures (from 4 to 3 per week) and increasing self-paced learning (Kemm et al, 2000b). The successful implementation of these initiatives has depended on continuous formative evaluation during development and summative evaluation at various stages, to determine if we could change students' approaches to learning and detect any changes in student learning outcomes.

## 2<sup>nd</sup> Year Science Course & Structure

Introductory Physiology is taken by students in the second year of their 3-year undergraduate degree at The University of Melbourne, following a general life sciences course in their first year. The Physiology subject is comprised of 36 one hour lectures and 12 two-hour collaborative computer aided learning sessions.

Students are assessed primarily by traditional examination procedures (90% of their semester mark), with the remaining 10% based on their group interactions (collaboration) and skills activities.

The CLE laboratory is a modern room with carpet and pleasant colours in which students work in groups of 3 at tables or benches, with comfortable seating. There are 15 iMacs, one for the tutor and the other 14 to house a maximum of 42 students. Students are encouraged to talk with their group, to bring food if they cannot survive 2 hours without, and may have coffee elsewhere in the room. A whiteboard and video projector are also available if staff wish to discuss issues with the whole class. Importantly, this room is located next door to the where the multimedia teaching co-ordinator and the multimedia developers are located, so students can and do readily bring any problems they have to the staff.

## Weekly Collaborative Learning

Students arriving for their weekly 2-hour sessions log on to the computer to access the weekly objectives (Fig 1).
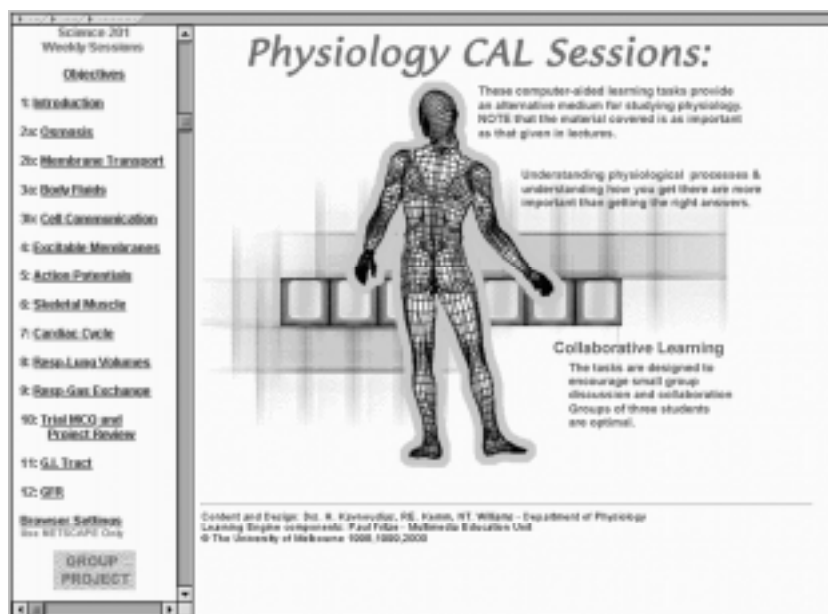


*Figure 1: Front page seen by students logging in for CAL sessions*

The material undertaken in computer aided learning exercises is linked to and follows lectures. Each computer aided learning session is comprised of:

- Introductory questions based on lecture material, to focus on the current topic
- Tasks based around an interactive computer aided tutorial
- A final extension question
- A collaborative investigative group project (in selected weeks), and

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- Revision of course material using interactive "learning" MCQs with feedback.

All sessions have questions to integrate these electronic sessions with lectures. On-line revision of the topic is also provided using series of interactive "learning" multiple choice questions. These questions differ from the usual format in that they are designed to reinforce knowledge rather than test it. Accordingly, four of five statements are correct and all statements have feedback that either supports the statement or tell the student why it is incorrect.

## CAL Sessions / Physiology tutorials

These tutorials may be on-line or standalone programs, and some have been developed in-house to meet specific needs, while others have been purchased commercially. Often, a paper-based Task sheet is also completed, to provide direction, extension and application of the major concepts covered.

The programs have been selected as ones which concentrate most on the underlying concepts of physiological mechanisms, rather than encouraging rote-learning of facts and numbers. Particularly in the locally-developed tutorials, highly interactive model-building exercises are used to encourage students to construct their knowledge in a step-by-step fashion, with specific feedback (both animated and textual) on the consequences of their decisions. Students can then apply different drugs or scenarios to their models to try out "what if" situations. At all times, attempts are made to ground this theory in practical situations, both to integrate physiology of other topics, and to maintain a high level of interest.

Figure 2 shows a screen of a case study included in one of the locally developed programs (Weaver et al, 2000a), and Figure 3 shows an example of the complexity of model-building exercises incorporated into a number of these programs (Weaver et al. 2000b). These have been covered in detail elsewhere (Weaver et al, 1996, 1999).
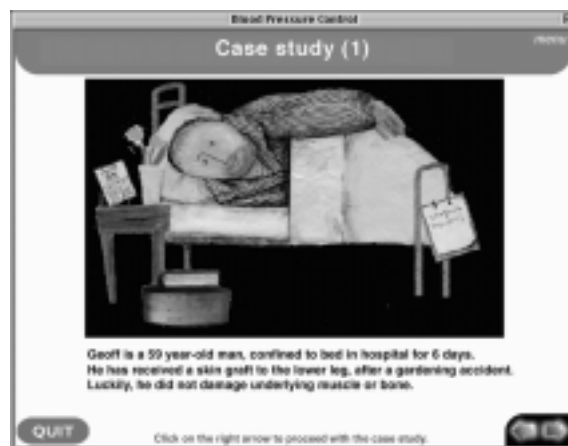


Figure 2: Case Study included in Blood Control tutorial
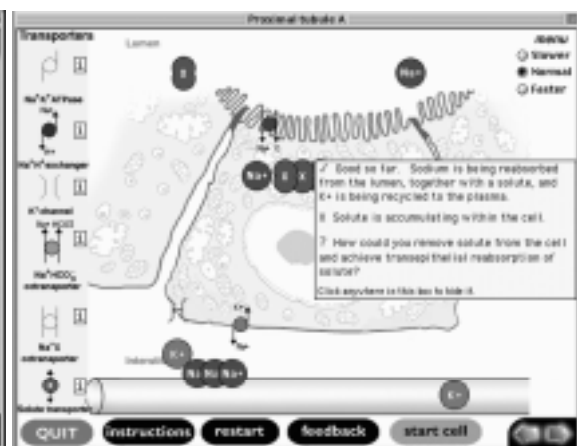


Figure 3: Partly completed cell transport Pressure model, demonstrating feedback to students

## Collaborative Learning: Analytical Reading & Writing (Group project)

**The need:** Physiology is taught as separate, semester-long subjects, in the 2nd and 3rd years of the 3-year Bachelor of Science course at the University of Melbourne, with some of these students choosing to continue their studies into the research-based Honours year of the degree. It has been identified that our graduate science students are good at reading, understanding and collating information, but are notably weak in identifying,

documenting and articulating key issues. Recently, employers have reported that our university's graduates need better communications skills (Harding, 2000).

We have attempted to improve these skills at different levels of student achievement. Initial attempts introduced a program at Honours level, as students actually need to use these skills in their reading for this course. Students were required to identify information in their literature survey that was seminal, novel, controversial or not confirmed. They were then requested to justify their selection with a short reasoned and critical synopsis of the material. Students were generally unable to complete this task effectively.

In an attempt to prepare students for these tasks, a critical reading exercise was then introduced into 3rd year Physiology, replacing 10 lectures. Students identified this task as useful but challenging. Staff found it overwhelming in terms of work commitment. These trials demonstrated that incorporating this initiative into the program could only be achieved if it was delivered electronically. Since critical reading was a considered a basic professional skill, we chose not to introduce it as a separate exercise, but to embed it within the overall teaching framework. Such an innovation sat well with the overall course, since electronic and online strategies already underpin all our teaching formats (lectures, practical classes and computer-aided learning).

**Implementation:** The overall task has been broken into several component pieces. A small collaborative group project has been introduced. aiming at encouraging students to be more perceptive about approaches to reading. The objective is to have students consider analytically what is presented, so as to eventually reflect and make judgements about content and conclusions. Computers are used for presenting a topic for study, with each step of the process having interactive feedback following submission into a portfolio in the framework specially designed for these higher order skills.

Small groups exposed students to different views and interpretations from which they could resolve their differences and develop a "consensus" point of view.

**The planned outcomes and benefits were for students (as a group) to:**

- appreciate the words used to describe a scientific phenomenon

- appreciate the accuracy of the descriptions

- identify key concepts underlying the explanations of physiological processes

- write with clarity and with the precision required for scientific disciplines

- develop the individual and team skills (and confidence) required for analysing scientific information from published sources and from peers

- develop a portfolio of their learning activities permitting them to reflect and revise

then *individually* to transfer these skills to new unseen piece of physiology.

### Description of the Initiative

*Overview of the student activities:*

Small groups of students were guided using electronic help through a relevant reading task to identify and rank key concepts in a fundamental area of physiology in a manner previously described (Hooper 1992). Web-based interactive-help was used to progressively reveal issues for consideration and to assist in the groups' identification and ranking of the key concepts underlying the problem. They were given a collaborative

writing task to draft a concise treatment of the area of study (500 words max.). Peer review assisted them in generating good writing structures, essential for effective scientific communication.

Students worked on their group projects in the last 30 minutes of the 2 hours of scheduled weekly collaborative computer assisted learning sessions, (Kemm et al, 2000a). It was not an optional activity and counted towards student's final assessment.

*Delivery of the Project — The Development of Specialised Courseware Architecture:*

Classes of 40 are repeated several times each week, in a collaborative learning laboratory with 15 computers. Although the project is cross-platform, we chose iMacs because of their reliability and ease of use in delivering computer assisted learning classes. Facilitation of interactive collaborative learning with feedback was not successful in our trials with commercial packages, and an online architecture has been specially designed with us that focussed on submission, feedback and portfolio generation. "OCCA" — On-line Courseware Component Architecture (Kavnoudias et al, 2000; Fritze et al, 2000) incorporates re-usable interactive web components which store student responses in a server database. These components provide opportunities for group discussion, self-assessment, reflection on learning and peer review. Personable staff help is required to contribute timely feedback using efficient templates for reviewing and annotating student work.

*Appearance to the students:*

Each week, activities presented to students on the different Web pages posted corresponding records to the OCCA database for that group. Web pages could contain interactive objects and references to stored records that were dynamically updated on delivery. Each student group was provided with one of four real-world problems to work on (an example of a more advanced topic is "What are the physiological effects of human growth hormone and why would Olympic organisers consider its administration to be performance enhancing?).

Students' activities involve preparation of material in their written workbook, combined with progressively submitting their work on Web pages.

*Initial task:*

This was performed individually by students reading around the topic to identify what they perceived as the crucial issues. They submitted this by email to their 'facilitutor' and also had it available to share with the other members of the group in the following week.

*All the following activities aimed to promote high levels of group discussion.*

- Brainstorm around the issues
- Identify what they considered were key phrases (new web page)
- Prioritise these key phrases by dragging them up and down their list
- Report on the level of consensus in their group decisions
- Indicate how confident they were that their efforts addressed the problem.

*The essence of the subsequent weeks' activities was for students to:*

- Learn to appreciate and interpret physiological information and to communicate effectively within a collaborative peer learning environment

- Use web-based interactive help that progressively revealed issues for consideration

- Reflect and review their own work using guidelines provided

- Review the work of peers using several suggested criteria and justifying each of their ratings

- Respond to their peer reviewers' comments of their own work, professionally and without emotion, and change their final submission if it was warranted.

The students' work was progressively stored in their groups' learning portfolio. Additionally, electronic communication was used to exchange information amongst student group members, 'facilitutors' and academics responsible for the project's development.

*Appearance to Staff*

Various Web page templates were used to generate customised screens for assessors that:

- Summarise each group's activities in a particular week

- Show on a single page a group's final submissions, the peer review, and their responses to the review

- Provided views that compared different groups' approaches to specific tasks

'Facilitutors' could use entry boxes on these templates to provide simplified and timely feedback to students on their progression through the problem. Such feedback was saved as records in the database and made visible on appropriate pages accessed by the group. Thus, relative assessment of group activities was continual and seamless within the scaffolding, being made easier by being able to scan all class responses for an issue on one template page.

The summary templates were also crucial in the final assessment by supervising staff, who were able to bring together the students efforts, together with the 'facilitutors' reports and ranking of each group.

## Course Improvement: The Importance of Evaluation

**General Approach:**

A number of evaluation strategies have been used to collect data in 1998, 1999 and 2000. These are part of our overall action research strategy for dealing with global learning outcomes from collaborative computer-assisted learning and focussed evaluation of additional standalone learning modules.

We required human ethics approval for our surveys and logging of student activities in the computer tutorials, since we wanted to be able to correlate individual student's responses to several questionnaires, their exam results, as well as their 'facilitutors' comments and assessments. Such approval required a student's enrolment number to be replaced by a randomised 'research number', with original records identifying students stored in a secure location and only available under strict guidelines to researchers who were not examiners.

## Evaluation of the CLE

*Student Questionnaires*

Questionnaires specific to the CLE were used to survey students' attitudes to various aspects of the CAL tutorials and the CLE sessions, in consultation with our educational advisors. The student questionnaires had approximately 80 questions designed to reveal students' attitudes and use of the CLE, covering aspects such their pattern of work within the CLE, development of independent learning skills, the perceived relevance of the CLE to their learning compared with lectures, and their attitudes to group work. Approximately half the questions focussed on issues pertinent to the Group Project. Most questions required students to rank their responses on a 5-point scale, supplemented by several open-ended questions. In addition we investigated students' self-assessment of their approaches to learning. We used a modified study process questionnaire to extend the investigation of deep, achieving and surface learning-approaches (Biggs, 1987), so it included additional learner characteristics. Its use is discussed in application to one of our standalone interactive tutorials (Kemm et al, 1997). We found that students co-operate well with questionnaires and interviews if they are fully informed about their purpose and that the results have been acted upon each year.

*'Facilitutors'* play a key role in the implementation of the program so their impressions of the course are most relevant to understanding student reactions. They made observations and kept records of students' work and participation in the CLE sessions. Formative evaluation continued throughout, with regular formal meetings between the main developer and tutors, as well as many informal interactions amongst the students, tutors and the academic developers whose nearby location enabled and encouraged this latter process. In the recent semester, we provided additional training for tutors to be able to better facilitate group learning processes and make better judgements about students' contributions.

The highlights of the questionnaire responses in Semester 2, 2000, with numerical data being on a scale of 5 (with 3 as a neutral response), are as follows: students rated ease of use and feedback on the OCCA-based web pages highly (>3.9). They were neutral/disagreed that the project was a waste or time (2.8). They rated group work as useful, enjoyable and an important part of their development (>3.5). They did not think that the group project increased their knowledge much, but this single exercise was not designed for that purpose. In open-ended questions, most important comments emphasised working with people and discussing problems, researching and clarifying issues. Many students (45%) thought that they should be left alone as they already had the required scientific reading and concise reporting skills, although analysis of written answers (both assignment and exam) show that they are misled in their perceptions of their own abilities.

As a formative assessment assignment, a short, written one hour test was individually undertaken by students as an open book assignment that required them to transfer these skills to a separate task. It required students to follow exactly the same format as they had undertaken collectively in their group. Only those students who went through the same process they learned in the group project were able to write concise answers. Many students wrote their answers directly and submitted answers that were either too long or made the tight word limit by writing generalities with little scientific content.

### Evaluation of specific programs

Computer-based tutorials designed in-house are extensively evaluated through out all stages of development. For any particular tutorial, any or all of the following methods are used:

- Analysis of previous written exam responses, to identify major misconception
- Student questionnaires, with many open-ended questions
- Observations of student use of program (by developers and tutors)
- Focus group interviews
- Analysis of electronic audit trails (collected anonymously)
- Pre- and Post-CAL multiple choice tests
- Subsequent exam response analysis.

We have found that by themselves, these methods give interesting but incomplete information on the effectiveness of any development. Only when results from multiple methods are collated can a more complete picture of student use of the programs and student learning of the topic be gained. Additionally, this integrated evaluation technique must be repeated through 2 or more cycles before it can be ascertained if modifications introduced as a result of previous evaluations have indeed been effective, as hoped.

*Example of integrated evaluation:*

"Reflex Control of Blood Pressure" is a standalone CD-ROM tutorial, developed in-house to assist student understanding of a difficult physiological concept. (Weaver et al, 2000a). Students are required to construct a model of a simple neuronal reflex circuit, and then to experiment with disruptions to this. Figure 4 gives an indication of the complexity of the model.


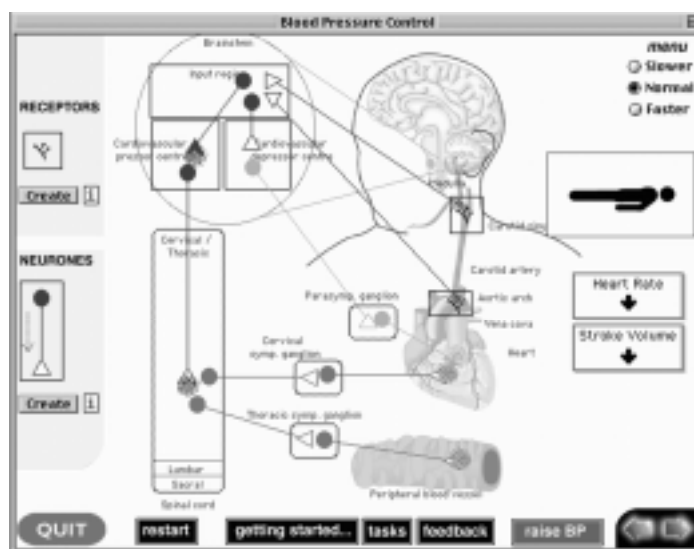
*Figure 4: Completed reflex circuit from "Blood Pressure Control" tutorial*

Evaluation of student survey responses, combined with observations of a class in progress, indicated that students were experiencing a great deal of difficulty in constructing their model, but did not reveal specific stages which caused this difficulty. Student comments were varied as to where trouble was encountered.

During the same class sessions, electronic audit trails were collected from all computers, which logged specific feedback panels seen by students, and how many times each of these panels was viewed. Deciding that viewing of a particular feedback panel 3 or more times indicated difficulty in moving past that stage of model construction, we were able to collate class data on which stages posed the greatest challenge (Fig. 5). By matching the questionnaire responses for each student with their respective audit trail data, we were able to identify exactly which element or process was causing difficulty at each stage of the model construction.
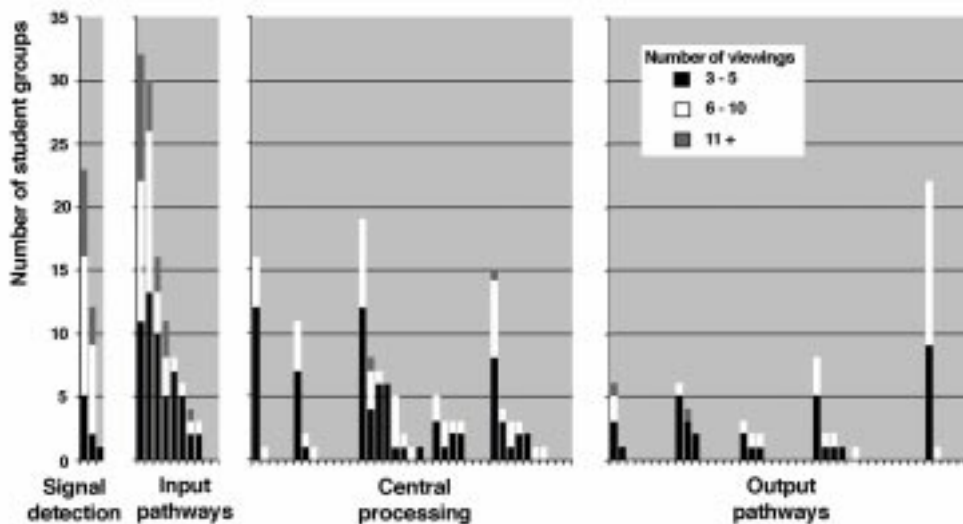


*Figure 5: Frequency plot of number of student groups returning for repeated (>2) viewings of feedback panels at various phases of model construction.*

*(Total number of student groups = 93; Total number of feedback panels = 88)*
*(from Weaver et al., 1999)*

In the example shown, we found the greatest peaks in repeated viewings corresponded to getting started (a cognitive overload in learning how to use the tools provided at the same time as trying to understand the tasks involved), stages involving central brain processing (due to complex and ambiguous anatomical terms being used), and few peaks in the output stages of the model, (once students had gained familiarity with the tools & processes), corresponding with ambiguous feedback panels.

Appropriate modifications were made to the program to address these crucial sites of confusion, and a further round of evaluation conducted in 2000 to ensure these measures addressed the initial concerns. Also during 2000, summative evaluation was commenced to determine whether student use of this program was improving the desired learning outcomes. Pre- and Post-tutorial multiple-choice questions were matched to determine whether student understanding of key concepts had improved. Further analysis and evaluation is ongoing (Weaver & Gilding, in preparation).

It is concluded that multiple approaches to evaluation is beneficial, that multiple cycles of evaluation is necessary, and the involvement of the instructional designer in the evaluation process is highly desirable.

## Evaluation of Learning Outcomes

This aspect of the evaluation was to determine whether the collaborative computer-aided learning program we had established actually had an impact on examination outcomes assessed under traditional methods (written answers and multiple choice questions). As an initial summative evaluation approach, we compared the examination outcomes for second year Science Physiology across 4 semesters (Table 1). The exam result excludes all collaborative computer aided learning assessments, and is proportioned as 60% toward written answers and 40% toward multiple choice questions. The student cohort was divided, based on their overall first year performance, into subgroups of high-achieving students (1st year Faculty score ≥ 75), low-achieving students (1st year Faculty score ≤60), and those in between (61-74). Each group was further sub-divided into whether students made an effort or not at their collaborative learning (≥ 7.0/10) and their exam and CLE results compared.(Table 1). A score of >7.0 was chosen, as it excludes students who attended and were poor- or non-participants.

The components of the assessment of the computer aided learning were based on attendance and participation (student interaction was graded) of 5 and group project of 5. The marking of the group project was heavily weighted toward quality of submission, quality of review and ability to transfer the skill to a new topic.

Within each grouping of students, we found no difference between the subgroups of students who performed well at CLE and those who performed poorly. This implied that students who performed well at CLE are represented across the entire student cohort, and not just the higher-achieving students.

These results indicate that collaborative learning may assist students achieve higher examination outcomes. Students (in the high achievers and middle groups) who performed well in the collaborative learning component, also performed markedly better than their peers in the writing component of the examination, enhancing their overall result.

| Grouping (based on 1st year Faculty Score) | CLE participation sub-group | 1st year Faculty score | Physiology Exam result | Writing component of exam | MCQ component of exam | Collaborative Learning mark |
|---|---|---|---|---|---|---|
| | | % | % | (out of 60) | (out of 40) | (out of 10) |
| ≥ 75 | Good | 79.5 ± 0.2 | 70.2 ± 1.9 | 42.5 ± 1.4 | 27.8 ± 1.9 | 8.6 ± 0.3 |
| | Poor / None | 78.5 ± 0.5 | 62.5 ± 1.3 | 36.3 ± 1.4 | 26.3 ± 2.3 | 4.8 ± 0.5 |
| 61 - 74 | Good | 68.0 ± 0.4 | 62.1 ± 1.8 | 37.8 ± 1.3 | 24.3 ± 1.7 | 8.3 ± 0.5 |
| | Poor / None | 67.3 ± 0.3 | 56.5 ± 1.1 | 33.8 ± 1.5 | 22.7 ± 1.2 | 4.0 ± 0.5 |
| ≤60 | Good | 56.8 ± 0.2 | 52.0 ± 2.1 | 31.3 ± 2.1 | 21.0 ± 0.9 | 8.1 ± 0.2 |
| | Poor / None | 56.8 ± 0.5 | 49.0 ± 2.0 | 28.8 ± 2.4 | 19.8 ± 1.1 | 4.2 ± 0.6 |

*Table 1: Comparison of learning outcomes with performance in CLE*
*(Results are averaged Means ± SEM from 4 semesters of teaching, 1999-2000).*

This correlation was further investigated by comparing the examination assessments with components of the computer aided learning assessment Table 2. We decided to evaluate the data of those students who markedly improved their Physiology score relative to their

1st year score (termed "*improvers*") and contrast it with the data from those students who did markedly poorer than their 1st year score (termed "*disappointers*"). The criteria for determining the groups was based on whether a student improved their score by more than 1 standard deviation (8%) calculated from all first year scores.

While all the *improvers* group had high attendance and participation scores, the scores of the *disappointers* groups was varied, and a significant proportion of *disappointers* also had good scores. When the scores of the group project was compared with the written component of the exam, a marked difference is observed. The very large majority of the *improvers* group had group project scores of ≥7/10 while the majority of students in the disappointers groups had scores of < 7/10. Similar 1st-year Faculty scores indicate that both *improvers* and *disappointers* appear to be representative of the total student population.

A significant observation was the marked discrepancy in the outcome for the written component of the examination between the *improvers* and the *disappointers*. The high score for the *improvers* in writing assessment correlated well with the high score in the Group Project. This contrasted with the *disappointers* group, who did poorly overall, and this performance appears correlated with a poor group project assessment. It is suggested that the skills learned and transferred in the group project might help contribute to the improved written examination outcome of the select *improver* group of students, Statistical analysis of this data is currently being undertaken.

| Student Group | Second Year Physiology assessment | | | | First year Faculty Score |
|---|---|---|---|---|---|
| | Written component | MCQ component | CLE Tutorials | CLE Group Project | |
| | (out of 60) | (out of 40) | (out of 10) | (out of 10) | % |
| All Students (n = 163) | 37.6 ± 8.6 | 25.4 ± 4.7 | 7.8 ± 2.4 | 5.4 ± 2.2 | 67.5 ± 8.2 |
| Improvers (n = 15) | 48.7 ± 5.2 | 28.3 ± 3.9 | 9.2 ± 0.8 | 7.8 ± 2.2 | 66.0 ± 5.1 |
| Disappointers (n = 40) | 31.0 ± 7.0 | 22.0 ± 4.8 | 7.6 ± 2.6 | 4.0 ± 2.4 | 69.4 ± 7.6 |
| Remainder (n = 108) | 38.6 ± 7.6 | 26.3 ± 4.7 | 8.0 ± 2.4 | 5.4 ± 2.2 | 67.0 ± 8.5 |

**Table 2**: *Analysis of components of the computer-aided learning with traditional examination assessments.*

## Conclusions

We describe an initiative which integrates traditional teaching and assessment procedures with more novel technologically driven approaches to learning. These approaches embed higher-order learning aimed at enabling students to learn using professionally-orientated skills and practices.

The requirement for a flexible interactive database with a portfolio feature has led to the development and use of a customisable learning environment based on OCCA. This framework has given us significant advantages in producing some of our desired learning outcomes, compared with our previous efforts using a commercial package (Kavnoudias, 2000). Generating structured collaborative exercises adds value to any high level framework, such as WebCT, while allowing academics to produce effective student-centred learning environments without specialist programmers.

Our experience during this implementation process has led us to decide on a strategy of "evaluate or perish", similar to the "publish or perish" philosophy of research scientists.

This is essential to not only maintain what has been developed, but to identify which modifications are successful and to continue with innovations. Many multimedia innovations are funded short term with little opportunity for long term evaluation, but data collection and analysis is essential to obtain further funding for innovation, to justify the curriculum change by convincing colleagues and the institution that the changes are effective and worthwhile.

The process of reasoning that has been introduced in this group project work is a first step in developing the training of critical thinking science graduates (with skills in analysis, criticism, aware of different views and with skills to manage those differences — both personally and as a consensus document).

## Future Directions

Once our collaborative learning environment is fully implemented, with strengthening of students' ability to extract and understand physiological concepts, it is envisaged that more factual material would be taught in a structured student-centred collaborative self-paced learning environment with less emphasis on lecture material.

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# Programming the Velocity Engine

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**Abstract**  Vector processing has been used in supercomputers to crunch large Single Instruction Multiple Data (SIMD) problems since the 1980s. While Intel's MMX technology was the first to bring vector processing to the desktop, the lack of a separate vector processing unit and an extremely short vector size meant that MMX only provided small speed gains of around 1.5x to 2x, and only rudimentary vector processing.

In contrast, the introduction of Apple G4 computers brings more complete and faster vector processing to the desktop. Unlike the 1980s supercomputer, which supported vectors of several hundred elements, the vector processing unit in the G4 processors, called the Velocity Engine by Apple, uses vectors of at most 16 elements. This shorter vector size is targeted at applications like multimedia and communications where several hundred elements are overkill.

This paper seeks to provide a tutorial introduction to programming the Velocity Engine.

## 1  Introduction

Vector processing has traditionally been the domain of the supercomputer, where the main task of the computer was to crunch huge amounts of numbers, instead of waiting for the user to click the mouse. Times change however, and with the introduction of AltiVec technology to PowerPC processors, vector processing is now available on your desktop in the form of the new PowerPC G4 computers from Apple.

AltiVec adds a separate vector processing unit, called the Velocity Engine by Apple, to the processor. This vector processing unit is capable of sustaining 1.3 Gigaflops at 400 MHz. In fact, the vector processing unit is so fast that the main bottleneck in programs is the main memory [9]. However, vector processing is not applicable to all kinds of programs — it is only applicable to Singe Instruction Multiple Data (SIMD) applications like video imaging.

While MMX also provides vector processing, its capabilities, compared to AltiVec, are severely limited. A maximum vector length of 1 to 4 elements, as opposed to 4 to 16 elements for AltiVec, limits the speed increase available from using MMX. In addition, the lack of a true vector processing unit means MMX cannot handle vector floating-point operations at all. Vector fixed-point operations can be done with MMX by using integer operations and shifting the point manually.

This paper seeks to provide a brief introduction to the G4 processor, with comparisons between AltiVec and MMX, followed by a tutorial introduction to programming AltiVec.

## 2  The G4 Processor

The G4 processors are the newest processors available from Motorola. There are several different versions of the G4 — the 7400, 7410, 7440 and 7450, with the 7450 being the newest. The 7450 has an upgraded architecture and is therefore also known as G4e or

G4+. G4 processors consist of 4 major units — the Floating-Point Unit, Integer Unit, Load Store Unit and the Vector Processing Unit. It is the addition of this Vector Processing Unit that allows the G4 to support a wide variety of vector instructions, including the ability to work with floating-point vectors (single-precision only).

Unlike the supercomputers popular in the 1980s, which had vector sizes of hundreds of elements, AltiVec's vectors are 4, 8, or 16 elements long depending on data size. While the long vector approach of the 1980s supercomputer is useful in the scientific calculations that they were used to crunch, it is overkill for applications like multimedia and communications, for which AltiVec is targeted.

AltiVec's vectors are all 128-bits long. Possible elements for the vectors are 8-bit signed and unsigned characters and integers, 16-bit signed and unsigned integers, and 32-bit signed or unsigned integers and floating-point numbers. While double-precision numbers are not supported by AltiVec, double-precision operations take the same time as their single precision counterparts in the Floating Point Unit. The lack of double-precision limits the use of AltiVec in traditional scientific applications.

While Intel's MMX$^{TM}$ technology [4] also supports vector processing, it supports only a small subset of AltiVec's features — only integer (and fixed point) operations. With MMX, there is no separate vector processing unit as in AltiVec. MMX simply uses the existing floating-point processor, and maps the vector registers to existing floating-point registers. The meaning of these 64-bit registers are then changed to mean a series of elements that Intel calls "packed data" — a vector.

## 3  Programming for AltiVec

AltiVec programs can currently only be written in assembler or C. Implementations in either language are similar because there is a 1:1 correspondence between almost all the functions.

Five new type specifier keywords are introduced to C by AltiVec: `vector`, `__vector`, `pixel`, `__pixel` and `bool`. `vector` and `__vector` are type modifiers used to define vectors. `pixel` refers to a 16 bit unsigned short (1/5/5/5 pixel), and `bool` refers to boolean types (usually mapped to int in C).

AltiVec functions are prefixed with `vec_` and perform duties like arithmetic operations, testing predicates, and moving data between memory and registers. A complete list of all the AltiVec functions available in C can be found in [5].

Only 16-byte aligned memory addresses can be used with AltiVec (vector types are automatically aligned by the compiler). Asking AltiVec to use unaligned memory causes AltiVec to use the largest 16-byte aligned location equal or smaller than the unaligned location without any errors or warnings. While loading correctly from unaligned locations is possible, it has a much higher overhead, and could therefore reduce the overall speed of the program.
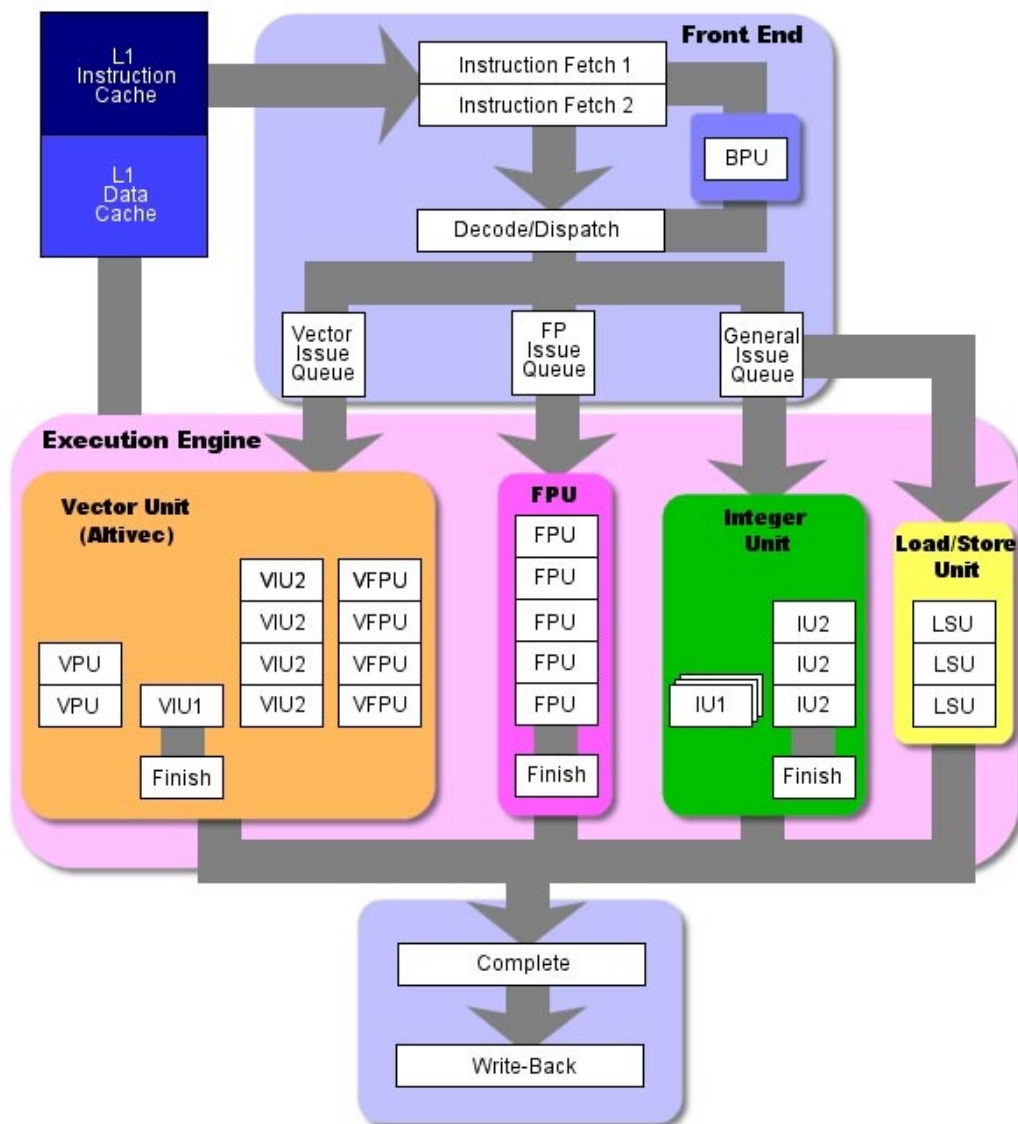
*Figure 1: G4e Processor Architecture from [11]*

A severe gap exists between the speed of memory and the vector processing unit. Due to this gap, the main bottleneck in programs is usually memory [9]. In order to reduce this bottleneck, special care is required to do even simple things like loading vectors with constants — it is best to generate the constants using AltiVec instructions, instead of loading from memory. In addition, alignment of data becomes important as well, as it reduces the amount of time spent sending data to the processor.

Compilers that support AltiVec currently include the GCC compiler (from Apple) and the Metroworks Compiler. The GCC implementation however lacks printf extensions to support vectors. The GCC compilier require two switches (*-faltivec* and *-force_cpusubtype_ALL*) to turn on AltiVec language extensions, while the Metroworks Compiler uses *-vec on*.

Examples: The following show how to compile *hello.c* using the two compilers.

**GCC:** `cc -faltivec -force_cpusubtype_ALL hello.c`

**MrC:** `MrC -vec on hello.c`

Apart from compilers, there are also tools around for profiling AltiVec programs, the most prevalent being Sim_G4 with pitsTT6Lib. These tools and their usage are discussed in [9].

## 4 Example Programs

This section will discuss the creation of an image addition operation using AltiVec. Two images will be added together and their elements printed out. One of the images will be 16-byte aligned while the other will be unaligned. In order to create this program, several smaller examples, illustrating different important aspects of programming AltiVec, will be tackled first. The full source is available in Appendix A.

Example 1 demonstrates how to get access to each element of a vector, and provides a mechanism for cleaner code using unions. Example 2 focuses on another important aspect of AltiVec programs — alignment. Since the processor can only load quickly from aligned memory locations, memory alignment becomes of critical importance in AltiVec programs. Example 2 shows how to align data, and provides a mechanism for isolating alignment issues to a small section of the code. Example 3 shows how to load unaligned data.

Please note that the AltiVec vector variables start with the keyword "vector" or "__vector".

### 4.1 Example 1: Printing Vectors by accessing each Element of a Vector individually

This example illustrates how to individually access each data value in the vector. It also shows how to print out results of vectors without using the %v extensions to printf that are unfortunately missing from the GCC compiler libraries.

```
1 // Example1.cpp
2 #include <iostream>
3
4 int main()
5 {
6     __vector unsigned char v1;
7
8     // Assign 16 8-bit elements to vector v1
9     v1 = (__vector unsigned char)(
10         '0', '1', '2', '3',
11         '4', '5', '6', '7',
12         '8', '9', 'A', 'B',
13         'C', 'D', 'E', 'F');
14
15     // Print out the contents of v1 char by char
16     // &v1 is casted to (unsigned char *)
17     for(int i = 0; i < 16; i++)
18         std::cout << ((unsigned char *)(&v1))[i];
19     std::cout << std::endl;
20
21     return 0;
22 }
```

Following is a second version that uses unions. Unions make access to the individual elements in the vector easier and cleaner.

```cpp
1 // Example1_union.cpp
2 #include <iostream>
3
4 typedef union
5 {
6     __vector unsigned char AsVector;
7     unsigned char AsUChar[ 16];
8 } vec_uchar;
9
10 int main()
11 {
12     vec_uchar v1;
13
14     // Assign 16 8-bit elements to vector v1
15     v1.AsVector = (__vector unsigned char)(
16             '0', '1', '2', '3',
17             '4', '5', '6', '7',
18             '8', '9', 'A', 'B',
19             'C', 'D', 'E', 'F');
20
21     // Print out v1 using AsUChar
22     for(int i = 0; i < 16; i++)
23         std::cout << v1.AsUChar[ i];
24     std::cout << std::endl;
25
26     return 0;
27 }
```

Running either of these two example programs produces

```
0123456789ABCDEF
```

### 4.2 Example 2: Aligning Pointers without fuss

As discussed previously, AltiVec requires all its vectors to be aligned against a 16-byte boundary. Failing to do so can result in incorrect programs without any warning from the processor — the processor ignores errors, and just approximates the instruction to one that it likes. While programs can read unaligned data using vec_ld and vec_perm together [9] (see 4.3), it can incur huge performance hits. Therefore aligning your pointers is paramount.

Memory allocation routines provided by the compiler do not necessarily guarantee 16-byte aligned blocks (the GCC compiler from Apple assumes everything is 16-byte aligned [2] though). To obtain a pointer to a 16-byte aligned memory block, more memory than required is allocated, and the pointer is shifted to the first 16-byte address in the unaligned allocated block. Once this aligned pointer has been located, data can be loaded into the block; since the data is now 16-byte aligned, it can be used with minimum penalties.

A pointer can be aligned using the following function, modified from [10]

```cpp
1 // Returns an aligned version of ptr
2 void *align16(void *ptr)
3 {
4     void **aligned_ptr = &ptr;
5     (*(long *)aligned_ptr) &= 0xFFFFFFF0;    // Strip lower 4 bits
```

```
6      (*(long *)aligned_ptr) += 16;          // Move pointer up by 16
bytes
7      return *aligned_ptr;
8 }
```

While this alignment function provides an aligned version a pointer easily enough, using it is a bit horrid because the programmer needs to keep both the unaligned pointer (for freeing the block), and the aligned pointer (for use with AltiVec). Code using this function becomes some like:

```
 1 // Allocate COUNT + 16 bytes for our data
 2 // 16 extra bytes need to be allocated because align16
 3 // will waste 1 to 16 bytes
 4 unsigned char *p_buffer = new unsigned char[ COUNT + 16];
 5
 6 // Align p_buffer using align16
 7 unsigned char *p_aligned = static_cast<unsigned char
*>(align16(p_buffer));
 8
 9 // Now that it is aligned, we can load into a vector
10 __vector unsigned char v = vec_ld(p_aligned, 0);
11
12 // Use v for calculations
13 // ....
14
15 // Free Buffer
16 delete[] p_buffer;
```

There is a cleaner alternative. Extra data can be stored in unused memory locations to allow the unaligned pointer to be calculated from the aligned version. The align16 function will waste at least 1 byte, and at most 16 bytes. Using this knowledge, we can leave an offset in the byte preceding the aligned pointer (since we waste at least 1 byte). This offset will always fit in 1 byte, because the offset is at most 16 bytes, so we only need to store 16 different numbers. This leaves 4 bits free, which can be used to store "magic numbers" for debugging.
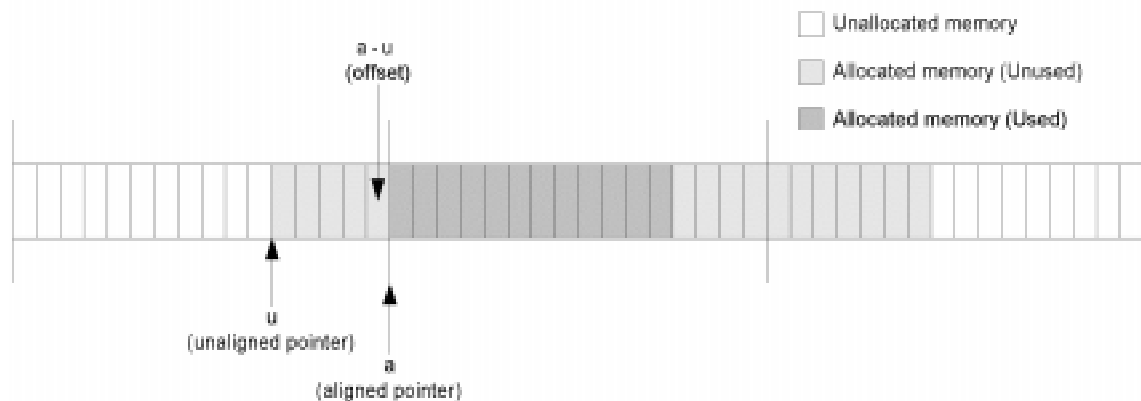


*Figure 2: Allocating an aligned memory block*

Thus we can write a new allocate function to allocate aligned memory blocks as follows:

```
1 template <class Element>
2 Element *allocate(unsigned int n)
3 {
4     // Allocate n * sizeof(Element) + 16 bytes
5     Element *p_unaligned = (Element *)::operator
6               new(n*sizeof(Element) + 16);
```

```
 7
 8      // Align the pointer
 9      Element *p_aligned = static_cast<Element
*>align16(p_unaligned);
10
11      // Store difference between aligned and unaligned in
12      // byte at location (p_aligned - 1)
13      unsigned char *p_offset = p_aligned - 1;
14      *p_offset = p_aligned - p_unaligned;
15
16 #ifdef DEBUG
17      printf("allocate: %x->%x (%x)\n",
18              p_unaligned,
19              p_aligned,
20              p_offset);
21 #endif
22
23      return p_aligned;
24 }
```

And the corresponding deallocate function is:

```
 1 template <class Element>
 2 void deallocate(Element *p_aligned)
 3 {
 4      // Fetch difference between aligned and unaligned from
 5      // byte at location (p_aligned - 1)
 6      // and calculate p_unaligned
 7      unsigned char *p_offset = p_aligned - 1;
 8      Element *p_unaligned = static_cast<Element *>(p_aligned -
*p_offset);
 9
10 #ifdef DEBUG
11      printf("deallocate: %x->%x (%x)\n",
12              p_aligned,
13              p_unaligned,
14              p_offset);
15 #endif
16
17      ::operator delete(p_unaligned);
18 }
```

These two functions use 5-bits in the offset location to store 1 to 16, and do not use a magic number. Using these two functions, the programmer is relieved of the responsibility of keeping the unaligned pointer addresses, and the original code sample becomes

```
 1 // Allocate aligned COUNT unsigned char
 2 unsigned char *p_aligned = allocate<unsigned char>(COUNT);
 3
 4 // Now that it is aligned, we can load into a vector
 5 __vector unsigned char v = vec_ld(p_aligned, 0);
 6
 7 // Use v for calculations
 8 // ....
 9
10 // Free Buffer
11 deallocate<unsigned char>(p_aligned);
```

### 4.3 Example 3: Loading unaligned data

While programs using AltiVec should always strive to use only aligned data, since using unaligned data incurs huge performance hits, this might not always be possible. Data loaded by other non-AltiVec aware programs is a prime example. Unaligned data loads are carried out by loading data around the unaligned data using two separate loads. Then using a permutation function, the appropriate values are picked up from the two different vectors.

The unaligned load, slightly modified from [9] becomes

```
1 // Load a vector from an unaligned location in memory
2 __vector unsigned LoadUnaligned(__vector unsigned char *p_v)
3 {
4     __vector unsigned char permuteVector = vec_lvsl(0,
static_cast<int *>(p_v));
5     __vector unsigned char low = vec_ld(0, p_v);
6     __vector unsigned char high = vec_ld(16, 0);
7     return vec_perm(low, high, permuteVector);
8 }
```

And the unaligned store, also slightly modified from [9] becomes

```
1 // Store a vector to an unaligned location in memory
2 void StoreUnaligned(__vector unsigned char v, __vector unsigned
char *p_where)
3 {
4     // Load the surrounding areas
5     __vector unsigned char low = vec_ld(0, p_where);
6     __vector unsigned char high = vec_ld(16, p_where);
7
8     // Prepare the constants that we need
9     __vector unsigned char permuteVector = vec_lvsl(0,
static_cast<int *>(p_where));
10    __vector unsigned char oxFF = vec_splat_u8(0xff);
11    __vector unsigned char ox00 = vec_splat_u8(0);
12
13    // Make a mask for which parts of vector to swap out
14    __vector unsigned char mask = vec_perm(ox00, oxFF,
permuteVector);
15
16    // Right rotate out input data
17    v = vec_perm(v, v, permuteVector);
18
19    // Insert our data into the low and high vectors
20    low = vec_sel(v, low, mask);
21    high = vec_sel(high, v, mask);
22
23    // Store the two aligned result vectors
24    vec_st(low, 0, p_where);
25    vec_st(high, 16, p_where);
26 }
```

Both these functions use unsigned char vectors. Changing this vector type to elements with 2 or more bytes leads to problems. To load vector type with elements having 2 or more bytes, the vector needs to be cast to unsigned char vector.

### 4.4 Image addition program — tying it all together

The complete image addition program is listed in Appendix A. It uses examples presented in 4.1, 4.2, and 4.3 to display vectors during computation, produce aligned memory blocks and load/store data from unaligned memory blocks respectively. The program generates two random images, one aligned and one unaligned, using a seed provided by the user via the command-line and then adds these two images together, and stores the result in a third unaligned image.

## 5 Further Directions

There is plenty of information on AltiVec and on all the operations that it supports, all freely available on the Internet.

1. *AltiVec.org* [1] altivec.org is a website dedicated to AltiVec. In addition to links to other AltiVec resources, it has an email group forum where you can discuss AltiVec issues with people who are using the technology.

2. *Motorola AltiVec References* [7,5,6,8] Motorola has several AltiVec references which describe all the functions that AltiVec supports in detail and more. Of particular interest, is [5], which has a reference for all the C AltiVec functions. In addition, [6,8] contains information about the number of clock cycles needed for each AltiVec instruction.

3. *G4 with Velocity Engine* [3] Apple also has a website for developers of AltiVec. It has links to programs and tools for use with AltiVec and a programming tutorial among others. The programming tutorial uses the MrC compiler.

4. *AltiVec Tutorial* [9] Ian Ollmann, Ph.D., has written an AltiVec Tutorial that is 55 pages long. It covers almost everything this paper does and more. In particular, the paper discusses how multiplication, division, square root, reciprocal square roots, and other common operations are performed.

In addition, libraries optimised for AltiVec are currently being developed. Examples of AltiVec optimised libraries currently available from Apple Computer Inc. [3] include vectorOps — a set of Basic Linear Algebra Subprograms, and vDSP — a collection of digital signal processing functions like FFTs.

## 6 Summary

Motorola's AltiVec technology has been applied to the new G4 family of processors giving the processors a separate short vector processor. This vector processor uses 128-bit vectors with 4, 8 or 16 elements. While the number of elements does not seem much compared to the 1980s supercomputers which had hundreds of elements in their vectors, AltiVec is aimed at a different application area than the supercomputer. AltiVec is aimed at applications in multimedia and communications.

AltiVec can be programmed currently with only two languages — assembler and C. The two implementations are very alike with a 1:1 correspondence between virtually all functions.

Two C/C++ compilers currently support AltiVec — Metroworks Compiler and GCC.

## References

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## Appendix: Example Program Full Source

The following program adds two grayscale images, one 16-byte aligned and one unaligned, together. The program will print the original two images and the final result. The entire program listing is shown below.

```
 1 // fullexample.cpp
 2 // Adds two random images together. One of the two images is
 3 // guaranteed to be 16-byte aligned while the other and
destination
 4 // images could be unaligned.
 5 // The program takes a seed value from the command-line. This seed
 6 // is used to generate the two images.
 7 #include <stdlib.h>
 8 #include <stdio.h>
 9
10 const int COUNT = 96;
11
12 //=============================================================
13 // Printing Elements from Example 1
14 //-------------------------------------------------------------
15 void output(__vector unsigned char v)
16 {
17     for(int i = 0; i < 16; ++i)
```

```
18          printf("%2x ", static_cast<int>(((unsigned char
*)(&v))[i]));
19 }
20
21 void output(unsigned char *p, int n)
22 {
23     for(int i = 0; i < n; ++i)
24     {
25          printf("%2x ", static_cast<int>(p[i]));
26          if((i + 1) % 16 == 0)
27              printf("\n");
28     }
29 }
30
31 //==================================================================
32 // Aligned Allocate and Deallocate from Example 2
33 //------------------------------------------------------------------
34 // Returns an aligned version of ptr
35 void *align16(void *ptr)
36 {
37     void **aligned_ptr = &ptr;
38     (*(long *)aligned_ptr) &= 0xFFFFFFF0;    // Strip lower 4 bits
39     (*(long *)aligned_ptr) += 16;        // Move pointer up by 16
bytes
40     return *aligned_ptr;
41 }
42
43 template <class Element>
44 Element *allocate(unsigned int n)
45 {
46          // Allocate n * sizeof(Element) + 16 bytes
47          Element *p_unaligned = (Element *)::operator
48                              new(n*sizeof(Element) + 16);
49
50          // Align the pointer
51          Element *p_aligned = static_cast<Element
*>(align16(p_unaligned));
52
53          // Store difference between aligned and unaligned in
54          // byte at location (p_aligned - 1)
55          unsigned char *p_offset = p_aligned - 1;
56          *p_offset = p_aligned - p_unaligned;
57
58 #ifdef DEBUG
59          printf("allocate: %x->%x (%x)\n",
60              p_unaligned,
61              p_aligned,
62              p_offset);
63 #endif
64
65     return p_aligned;
66 }
67
68 template <class Element>
69 void deallocate(Element *p_aligned)
70 {
71     // Fetch difference between aligned and unaligned from
72     // byte at location (p_aligned - 1)
73     // and calculate p_unaligned
74     unsigned char *p_offset = p_aligned - 1;
```

```
75    Element *p_unaligned = static_cast<Element *>(p_aligned -
*p_offset);
76
77 #ifdef DEBUG
78    printf("deallocate: %x->%x (%x)\n",
79           p_aligned,
80           p_unaligned,
81           p_offset);
82 #endif
83
84    ::operator delete(p_unaligned);
85 }
86
87 //===================================================================
88 // Load and Store unaligned pointers from Example 3
89 //-------------------------------------------------------------------
90 // Load a vector from an unaligned location in memory
91 __vector unsigned char LoadUnaligned(__vector unsigned char *p_v)
92 {
93    __vector unsigned char permuteVector = vec_lvsl(0, (int
*)(p_v));
94    __vector unsigned char low = vec_ld(0, p_v);
95    __vector unsigned char high = vec_ld(16, p_v);
96    return vec_perm(low, high, permuteVector);
97 }
98
99 // Store a vector to an unaligned location in memory
100 void StoreUnaligned(__vector unsigned char v, __vector unsigned
char *p_where)
101 {
102    // Load the surrounding areas
103    __vector unsigned char low = vec_ld(0, p_where);
104    __vector unsigned char high = vec_ld(16, p_where);
105
106    // Prepare the constants that we need
107    __vector unsigned char permuteVector = vec_lvsl(0, (int
*)(p_where));
108    __vector unsigned char oxFF = vec_splat_u8(0xff);
109    __vector unsigned char ox00 = vec_splat_u8(0);
110
111    // Make a mask for which parts of vector to swap out
112    __vector unsigned char mask = vec_perm(ox00, oxFF,
permuteVector);
113
114    // Right rotate out input data
115    v = vec_perm(v, v, permuteVector);
116
117    // Insert our data into the low and high vectors
118    low = vec_sel(v, low, mask);
119    high = vec_sel(high, v, mask);
120
121    // Store the two aligned result vectors
122    vec_st(low, 0, p_where);
123    vec_st(high, 16, p_where);
124 }
125
126 int main(int argc, char *argv[])
127 {
128    if(argc != 2)
129    {
130        printf("%s <seed>\n", argv[0]);
```

```
131          return 1;
132      }
133
134      // Initialise Random Number
135      char *p_end;
136      int seed = strtol(argv[ 1], &p_end, 10);
137      if(*p_end != '\0')
138      { // Failed to convert number
139          printf("%s is not a valid seed\n", argv[ 1]);
140          return 1;
141      }
142      srand(seed);
143
144      // Create a random image
145      unsigned char *p_image1 = allocate<unsigned char>(COUNT);
146      unsigned char *p_image2 = new unsigned char[ COUNT];
147      unsigned char *p_dest = new unsigned char[ COUNT];
148
149      // Fill images with random values
150      for(int i = 0; i < COUNT; ++i)
151      {
152          p_image1[ i] = rand() % 255;
153          p_image2[ i] = rand() % 255;
154      }
155
156      // Add the two images
157      __vector unsigned char a, b, c;
158      for(int i = 0; i < COUNT / 16; ++i)
159      {
160          a = vec_ld(0, &p_image1[ i * 16]);
161          b = LoadUnaligned((__vector unsigned char *)(&p_image2[ i
* 16]));
162          c = vec_add(a, b);
163          StoreUnaligned(c, (__vector unsigned char *)(&p_dest[ i *
16]));
164          printf("  a: "); output(a); printf("\n");
165          printf("  b: "); output(b); printf("\n");
166          printf("a+b: "); output(c); printf("\n");
167      }
168
169      printf("\n");
170
171      // Print Images
172      printf("image1 (aligned)   at %x:\n", p_image1);
173      output(p_image1, COUNT);
174      printf("\n");
175      printf("image2 (unaligned) at %x:\n", p_image2);
176      output(p_image2, COUNT);
177      printf("\n");
178      printf("dest    (unaligned) at %x:\n", p_dest);
179      output(p_dest, COUNT);
180      printf("\n");
181
182      // Free Images
183      deallocate<unsigned char>(p_image1);
184      delete[] p_image2;
185      delete[] p_dest;
186
187      return 0;
188 }
```

The programs output running with a seed of 34 is shown below. The program was compiled with Apple's GCC and the DEBUG macro defined. The DEBUG macros turns on debug messages from allocate and deallocate functions of the form `Unaligned->Aligned (Offset Address)`. Please note that because Apple's GCC automatically assumes 16-byte alignment [2], all the addresses are aligned.

```
allocate: 4d550->4d560 (4d55f)
  a: e0 10 ad 2d b7 f1 40 44 2d 39 8b f9 c9 5e 88 69
  b: aa 20 30 e9 8f ea 61 27 bc b6 d3 4c a5 92 f5 64
a+b: 8a 30 dd 16 46 db a1 6b e9 ef 5e 45 6e f0 7d cd
  a: 1e b9 26 91 bb 87 39 10 9a 5b db cd f2  2 3d 1a
  b: ef 36 a5 b8 55 fb 24 28 34 8f c5 2b 52 4b 47  a
a+b:  d ef cb 49 10 82 5d 38 ce ea a0 f8 44 4d 84 24
  a: 82 57 e0 b5 c5  8 4d ce 9f c6 2e eb ed ec e0 48
  b: ce 47 58 c1 41 13 d5 9a  d a7 32 eb e2 81 11 13
a+b: 50 9e 38 76  6 1b 22 68 ac 6d 60 d6 cf 6d f1 5b
  a: 95 12 74 9e f5 8b 9b e4 52 62  9 77 29 b5 40 36
  b: f1 6f  d 18 49 11 35 84 68 82 b3 67  3 3a a8 8a
a+b: 86 81 81 b6 3e 9c d0 68 ba e4 bc de 2c ef e8 c0
  a: 7c 8f 56  d 86 26 1f f1 65 91 cd cf ad 6e  5 61
  b: f0 98 34 d9 4f a1 2e 77 53 6e 10 81 4b 48 90  8
a+b: 6c 27 8a e6 d5 c7 4d 68 b8 ff dd 50 f8 b6 95 69
  a: 77 70 d5 7d 50 e7 2e 51 27 b3 3a 8e 21 a4 b3 83
  b: 4e 76 ea 31 22 3c 58 90 47 86 ba 2b be c8 f5 ae
a+b: c5 e6 bf ae 72 23 86 e1 6e 39 f4 b9 df 6c a8 31

image1 (aligned)  at 4d560:
e0 10 ad 2d b7 f1 40 44 2d 39 8b f9 c9 5e 88 69
1e b9 26 91 bb 87 39 10 9a 5b db cd f2  2 3d 1a
82 57 e0 b5 c5  8 4d ce 9f c6 2e eb ed ec e0 48
95 12 74 9e f5 8b 9b e4 52 62  9 77 29 b5 40 36
7c 8f 56  d 86 26 1f f1 65 91 cd cf ad 6e  5 61
77 70 d5 7d 50 e7 2e 51 27 b3 3a 8e 21 a4 b3 83

image2 (unaligned) at 4e5e0:
aa 20 30 e9 8f ea 61 27 bc b6 d3 4c a5 92 f5 64
ef 36 a5 b8 55 fb 24 28 34 8f c5 2b 52 4b 47  a
ce 47 58 c1 41 13 d5 9a  d a7 32 eb e2 81 11 13
f1 6f  d 18 49 11 35 84 68 82 b3 67  3 3a a8 8a
f0 98 34 d9 4f a1 2e 77 53 6e 10 81 4b 48 90  8
4e 76 ea 31 22 3c 58 90 47 86 ba 2b be c8 f5 ae

dest   (unaligned) at 4e650:
8a 30 dd 16 46 db a1 6b e9 ef 5e 45 6e f0 7d cd
 d ef cb 49 10 82 5d 38 ce ea a0 f8 44 4d 84 24
50 9e 38 76  6 1b 22 68 ac 6d 60 d6 cf 6d f1 5b
86 81 81 b6 3e 9c d0 68 ba e4 bc de 2c ef e8 c0
6c 27 8a e6 d5 c7 4d 68 b8 ff dd 50 f8 b6 95 69
c5 e6 bf ae 72 23 86 e1 6e 39 f4 b9 df 6c a8 31

deallocate: 4d560->4d550 (4d55f)
```

# Developing a Java API for digital video control using the Firewire SDK

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**Abstract**   FireWire is a standard on the Macintosh platform, with most Digital Video cameras supporting the FireWire interface. We believe that it would be of great benefit to the Macintosh community to have a simple programming interface between the Macintosh platform and Digital Video cameras. This paper illustrates how to build a simple Java application that controls a Digital Video camera though the FireWire bus. This is the first step in providing a Java API for Digital Video camera interaction.

## 1 Introduction

FireWire is a high-speed bus (up to 400 megabits per second) designed to connect video devices and computers. This high speed, along with easy of use, hot-swapping and simplified cabling makes Firewire ideally suited for multimedia applications. Defined as IEEE Standard 1394-1995, Firewire has become a standard interface to Digital Video cameras. Firewire has been included with most Apple products for some time.

Digital Video (DV) is only one kind of data that can be sent across the FireWire bus. DV is a digital tape format for video cameras.  Using compression similar to motion-JPEG, it stores video data at approximately a 5:1 rate. DV has a constant data rate of 36 megabits per second, making it easily transferred over FireWire. FireWire provides a mechanism that allows computers and DV devices to interact. On a DV camera, commands can be sent from the computer that allow for remote camera control. Video frames can also be delivered though the FireWire interface, allowing video from the camera to be sent to the computer screen, and video stored an a hard disk to be recorded to the camera.

We are building a Java Application Programming Interface (API) that will allow users to take control of a DV camera. This API will allow users to control a camera's functionality, including retrieving frames from and recording frames to a camera, and also including the ability to retrieve time code information from the camera.

This paper describes a simple application that allows viewing and control of a DV camera connected to a Macintosh computer though FireWire. It is the first step towards building a fully functional API.

## 2 Software Architecture

The software architecture of this project consists of a C library that interfaces with the Firewire SDK. A Java wrapper class using the Java Native Interface (JNI) calls the C library. This allows applications written in Java to access DV controlling routines though the Java wrapper class. The application is built using Apple's ProjectBuilder running

under Mac OSX. This application will only work using Mac OSX with a Firewire equipped Macintosh.

| | |
|---|---|
| Control and Capture Application (Section 3) | Java |
| Java DV Controller    (Section 4) | Java API |
| Java Wrapper Class    (Section 5) | JNI |
| DV controller Library    (Section 6) | C Library |
| DV Device control/ Isochronous data handler | IOFWCVComponents.kext |
| Firewire DV handler | IOFireWireDV.kext |
| Firewire SDK | IOFireWireFamily.kext |
| DV Camera | |

*Figure 1.  Software Architecture*

Figure 1 illustrates the layers of the system, from the highest level at the top, through to the lower level supplied by the FireWire SDK. The bottom row represents the physical layer, the Digital Video Camera. At the top, the Java Application makes an instance of the DV controller class. This class sets up an interface for sending commands to the camera. The controller class makes an instance of a controller in the JNI class. Calls to methods from the JNI class enact native C code, that is compiled as a shared library. This C library makes calls to a FireWire Digital Video Handler that is provided with the FireWire SDK 2.7 for Mac OSX.

## 3  Control and Capture Application

The Application developed enables users to remotely control a DV camera through an interface on the screen. The application also previews the video in a window on the screen. This application is written in Java, utilizing swing to provide the graphical user interface, and the Sequence Grabber in QuickTime for Java to provide the preview. The main Application makes an instance of the controller and the preview window as shown in the code below.
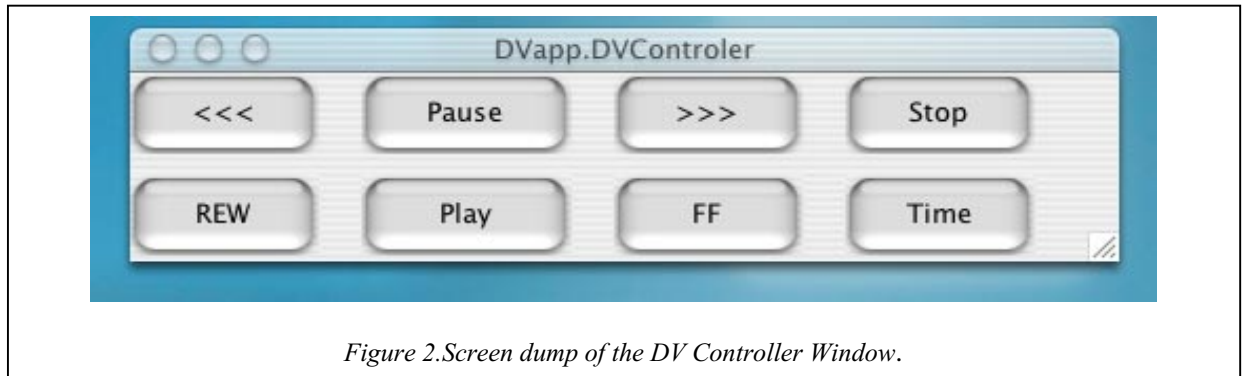
```java
public class DVapp {
    public DVapp() {
        try {
            // make a controller
            DVController frame = new DVController();
            frame.initComponents();
            frame.setVisible(true);
            try {
                // make a preview window
                SGwindow preview = new SGwindow("Preview");
                preview.show();
                preview.toFront();
            } catch (Exception e) {
                e.printStackTrace();
                QTSession.close();
            }
        } catch (Exception e) {
            e.printStackTrace();
        }
    }
    // Main entry point
    static public void main(String[] args) {
```

```
    new DVapp();
    }
}
```

The *DVController* class produces a window with all the buttons that allow remote controlling of a camera, as seen in Figure 2. The *SGWindow* class allows an on screen display of the camera's video.



*Figure 2.Screen dump of the DV Controller Window.*

## 4  Java DV Controller

The *DVController* Class extends a *javax.swing.JFrame*. Members of this class are the *javax.swing.JButtons'* and the *JNIDV* interface class.  When the *DVController* class is initialized the constructor makes an instance of the JNI native interface class *JNIDV*. The initialize functions from *JNIDV* are then called to allow control commands to be sent to the camera. The buttons in this window are members of the *DVController* class, they are initialized and an action listener is added to each button. When a button is clicked a *JNIDV* method is called. Below is the abridged code for the *DVController* class.

```
class DVController extends javax.swing.JFrame {
      javax.swing.JButton jButtonPlay = new javax.swing.JButton();
      JNIDV interface;
      public DVController() {
            interface = new JNIDV();
            interface.InitDV(); // call to native code
            interface.OpenDV();
            interface.OpenControlDV();
      }
      public void initComponents() throws Exception {
            jButtonPlay.setText("Play");
            jButtonPlay.setLocation(new java.awt.Point(110, 50));
            jButtonPlay.setVisible(true);
            jButtonPlay.setSize(new java.awt.Dimension(100, 40));
            setLocation(new java.awt.Point(5, 40));
            setTitle("DVapp.DVControler");
            getContentPane().setLayout(null);
            setSize(new java.awt.Dimension(470, 115));
            getContentPane().add(jButtonPlay);
            jButtonPlay.addActionListener
            (new java.awt.event.ActionListener() {
                  public void actionPerformed(java.awt.event.ActionEvent
e)
                  {
                        jButtonPlayActionPerformed(e);
```

```
                }
        });
        addWindowListener(new java.awt.event.WindowAdapter() {
                public void windowClosing(java.awt.event.WindowEvent
e) {
                        thisWindowClosing(e);
                }
        });
}
void thisWindowClosing(java.awt.event.WindowEvent e) {
        interface.CloseControlDV(); // call to native code
        interface.CloseDV();
        setVisible(false);
        dispose();
        System.exit(0);
}
public void jButtonPlayActionPerformed(java.awt.event.ActionEvent
e){
        interface.controlPlayDV(); // call to native code
}
}
```

The Preview window is instantiated from the main application. This Code is modified from the Sequence Grabber sample code on apple web site [1]. This Code is independent of the DV Control API that we are developing. A screen dump of both the DV controller and preview window can be seen in Figure 3.

## 5 Java Wrapper Class

As the application is written in java, and the Firewire API is a C library we have to develop an interface between them. Interfacing between the two languages is done using the Java Native Interface (JNI) to develop a wrapper class. This wrapper class allows a Java application to call functions from C code. Also it allows for passing objects between the two languages. The following code defines the Java side of the JNI interface.

```
public class JNIDV {
// The following Java methods call C functions
    public native void InitDV();
    public native void OpenDV();
    public native void OpenControlDV();
    public native void CloseControlDV();
    public native void CloseDV();
    public native void DVGetTime();
    public native void controlPlayDV();
// Load the JNIDV JNI library when this class is loaded.
    static {
        try {
            System.loadLibrary("JNIDV");
        } catch (Exception e) {
            e.printStackTrace();
        }
    }
}
```

When a program wants to use the DV control it must first make a call to *OpenDV()* to setup the device, then a call to *OpenControlDV()* to open the device for control transactions.
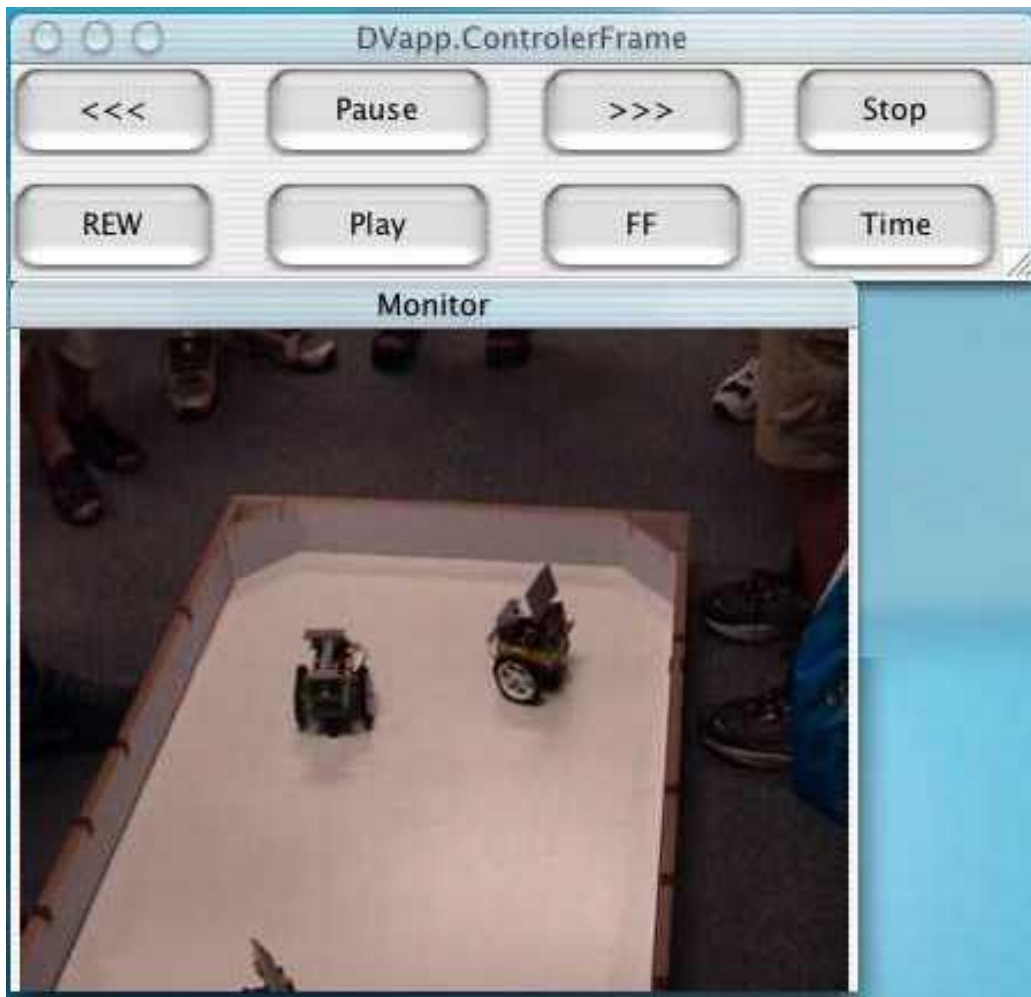
---

*Figure 3.Screen dump of the controller and preview window.*

The *InitDV()* prints a message to standard output indicating whether a camera device was found. Control functions such as *controlPlayDV(), controlStopDV(),* and *controlPauseDV()* can then be called to control the camera. Also, *DVGetTime()* can then be used to get the time code from the camera. The methods in this class call C code from *DV.c*, which interacts with the Firewire SDK.

## 6  C Library

The *DVComponentsGlue* framework is included with the FireWire SDK for MacOSX, the framework is for use with digital video devices and is documented in the SDK [2]. We wrote a C library to make the calls that interface with the *DVComponentsGlue* framework and the QuickTime framework. These functions calls are made by the C side using the JNI interface. The java wrapper class calls the public functions.

### 6.1  C Library Function Prototypes

Public Functions
```
JNIEXPORT void JNICALL Java_JNIDV_InitDV(JNIEnv * env, jobject obj);
JNIEXPORT void JNICALL Java_JNIDV_OpenDV(JNIEnv * env, jobject obj);
JNIEXPORT void JNICALL Java_JNIDV_OpenControlDV(JNIEnv * env, jobject
obj);
JNIEXPORT void JNICALL Java_JNIDV_CloseControlDV(JNIEnv * env, jobject
obj);
JNIEXPORT void JNICALL Java_JNIDV_CloseDV(JNIEnv * env, jobject obj);
```

```
JNIEXPORT void JNICALL Java_JNIDV_DVGetTime(JNIEnv * env, jobject obj);
JNIEXPORT void JNICALL Java_JNIDV_controlPlayDV(JNIEnv * env, jobject
obj);
JNIEXPORT void JNICALL Java_JNIDV_controlStopDV(JNIEnv * env, jobject
obj);
```

## Private Functions

```
static void doControl(ComponentInstance theInst, QTAtomSpec
                                *currentIsochConfig, UInt8  op1,  UInt8
op2);
static  OSStatus  notificationProc(IDHGenericEvent*  event,  void*
userData);
```

## 6.2  Description of Functions

*InitDV:*

This function finds the first component that is a camera using *FindNextComponent*. Then it prints the information about that component, which is obtained with a call to *GetComponentInfo*.

*OpenDV:*

This function first opens a *ComponentInstance* of the digital video camera device using *OpenDefaultComponent*. Calling *IDHGetDeviceList* and passing the *ComponentInstance* with a *QTAtomContainer* will return a list of devices. Making a call to *QTCountChildrenOfType* returns the number of DV devices connected to the computer. The code below illustrates these calls.

```
theInst = OpenDefaultComponent('ihlr', 'dv  ');
IDHGetDeviceList( theInst, &deviceList);
numberDVDevices = QTCountChildrenOfType
            ( deviceList, kParentAtomIsContainer,
        kIDHDeviceAtomType);
```

The function then makes use of QuickTime calls to find the device and its configurations.

```
// get the atom to this device
deviceAtom = QTFindChildByIndex( deviceList, kParentAtomIsContainer,
                                kIDHDeviceAtomType, i + 1, nil)
// find the isoch characteristics for this device
isochAtom = QTFindChildByIndex( deviceList, deviceAtom,
                                kIDHIsochServiceAtomType, 1, nil)
// how many configs exist for this device
nConfigs = QTCountChildrenOfType( deviceList, isochAtom,
                                kIDHIsochModeAtomType);


// get this configs atom
configAtom = QTFindChildByIndex( deviceList, isochAtom,
                                kIDHIsochModeAtomType, j + 1, nil);



// find the media type atom
mediaAtom = QTFindChildByIndex( deviceList, configAtom,
                                  kIDHIsochMediaType, 1, nil);

QTLockContainer( deviceList);
```

```
// get the value of the mediaType atom
QTCopyAtomDataToPtr( deviceList, mediaAtom, true, sizeof( mediaType),
                                              &mediaType, &size);

QTUnlockContainer( deviceList);

// is this config a video config?
if( mediaType == kIDHVideoMediaAtomType)   // found video device
{
      videoConfig.container = deviceList;// save this config
      videoConfig.atom = configAtom;
}
```

At the end of the *OpenDV* function, *IDHSetDeviceConfiguration* is called from the *DVComponentGlue* framework. *IDHSetDeviceConfiguration* sets a camera component instance to a specific configuration. This call is shown below.

```
IDHSetDeviceConfiguration( theInst, &videoConfig);
```

*OpenControlDV:*

The function *OpenControlDV* opens the device to enable it to handle action commands, such as play and stop. This function calls the *IDHOpenDevice* from the *DVComponentGlue* framework. *IDHOpenDevice* opens the currently configured camera. The currently configured camera is stored in the global *ComponentInstance* and passed to *IDHOpenDevice.*

```
JNIEXPORT void JNICALL Java_JNIDV_OpenControlDV(JNIEnv * env, jobject
obj) {
      OSErr err;

      err = IDHOpenDevice( theInst, kIDHOpenForReadTransactions);
      if( err != noErr)
            printf("error %d(0x%x)\n", err, err);
      printf("Opened device\n");
}
```

*CloseControlDV:*

*CloseControlDV* is called to close the device opened in the *OpenControlDV* call. It is similar to the *OpenControlDV* function. This function calls *IDCloseDevice* from the *DVComponentGlue* framework. *IDCloseDevice* takes an argument of the global *ComponentInstance* and closes the camera already opened.

```
JNIEXPORT void JNICALL Java_JNIDV_CloseControlDV
                                      (JNIEnv * env, jobject obj) {
      OSErr err;

      err = IDHCloseDevice( theInst);
      if( err != noErr)
            printf("error %d(0x%x)\n", err, err);

      printf("Closed device\n");
}
```

*CloseDV:*

This function makes a call to *CallComponentClose*. *CallComponentClose* takes the argument of a *ComponentInstance* and closes it.

```
JNIEXPORT void JNICALL Java_JNIDV_CloseDV(JNIEnv * env, jobject obj) {
    CallComponentClose(theInst, 0);
}
```

*controlPlayDV:*

There are a number of control functions, which can be called to send an action command to the camera. These functions call *doControl*, passing two *opcodes* to it. The *opcodes* passed by each function and a sample function call can be seen in the list below.

| Action | opcode1 | opcode2 |
|---|---|---|
| Play | 0xc3 | 0x75 |
| Rewind | 0xc4 | 0x65 |
| Rewind Play | 0xc3 | 0x4e |
| Fast Forward | 0xc4 | 0x75 |
| Fast Forward Play | 0xc3 | 0x3e |
| Stop | 0xc4 | 0x60 |
| Pause | 0xc3 | 0x7d |
| Next Frame | 0xc3 | 0x30 |
| Slow Forward | 0xc3 | 0x35 |
| Previous Frame | 0xc3 | 0x40 |
| Slow Rewind | 0xc3 | 0x45 |

```
JNIEXPORT void JNICALL Java_JNIDV_ControlDV(JNIEnv * env, jobject obj) {
     doControlTest(theInst, &videoConfig, op1, op2);
}
```

*doControl:*

This function is passed a *ComponentInstance* of the DV camera and a *QTAtomSpec* reference to the video configuration. The other two arguments are the control commands. The first command specifies the group, e.g. 0xc3 is the play group, and 0xc4 is the wind group. Then next command specifies what kind of control it to be preformed from that group. The complete list of these parameters can be found from the document "AV/C Digital Interface Command Set" from the IEEE trade association web site [3].

The function *doControl* calls *IDHGetDeviceControl*, which returns an instance of a device control component, which was set by calling *IDHSetDeviceConfiguration* from the *OpenDV* call. The *IDHGetDeviceStatus* is called to get the device status from the specified configuration. Then the *DVCTransactionParams* are built up consisting of a command buffer pointer and a response buffer pointer. The function *DeviceControlDoAVCTransaction* is then called to send an AV/C command to the device and return a response from the device.

```
static void doControl(ComponentInstance theInst,
                 QTAtomSpec *currentIsochConfig, UInt8 op1, UInt8 op2)
{
    ComponentInstance          controlInst;
    ComponentResult            result;
    IDHDeviceStatus            devStatus;
    DVCTransactionParams       pParams;
    char                       in[4], out[16];
    int                        i;
```

```
    IDHGetDeviceControl(theInst, &controlInst);
    IDHGetDeviceStatus(theInst, currentIsochConfig, &devStatus);

    // fill up the avc frame
    in[0]   = 0x00; //kAVCControlCommand;
    in[1]   = 0x20;
    in[2]   = op1;
    in[3]   = op2;

    // fill up the transaction parameter block
    pParams.commandBufferPtr = in;
    pParams.commandLength = sizeof(in);
    pParams.responseBufferPtr = out;
    pParams.responseBufferSize = sizeof(out);
    pParams.responseHandler = NULL;

    do {
        for(i=0; i<sizeof(out); i++)
            out[i] = 0;
        result = DeviceControlDoAVCTransaction( controlInst, &pParams);
        if(result == kIOReturnOffline) {
            printf("offline!!\n");
            sleep(1);
            continue;
        }
        if(result)
            break;
    } while(result != kIOReturnSuccess);
}
```

## 7  Conclusion

We hope this paper has helped make FireWire and Digital Video more accessible to the
Macintosh community. Providing a simplified access to these technologies can have many
applications such as in education, image processing, web-cams and the Internet, and
monitoring and security. We plan to repackage this work as a "FireWire for Java" API to
make it available to Java programmers.

## References

[1]http://developer.apple.com/samplecode/Sample_Code/QuickTime/QuickTime_for_Java/SGCapture.htm

[2] The FireWire SDK can be obtained from:
http://developer.apple.com/hardware/FireWire/Developer_Info.html#FireWireSDK The
documentation is located in Examples/IsocTest/IsochComponentsRef.txt.

[3] http://www.1394ta.org/Technology/Specifications/specifications.htm

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# Beyond "eye-candy": improving learning with animations

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**Abstract**   The use of animations is becoming increasingly widespread in electronic learning materials. Authoring animations is now relatively straightforward, even for university teachers without advanced computing skills. Many lecturers want to know how to convert the traditional static pictures and diagrams in textbooks into instructionally effective animated presentations. This presentation will show how this can be done by demonstrating animations that have been specifically designed to make learning easier by applying simple but powerful principles of visual learning. These principles are derived from human information processing research and are applicable to many different types of instructional content. When students are given static pictures that are meant to represent dynamic subject matter, they are faced with the cognitive burden of having to "mentally animate" the content. However, well-designed animations can eliminate this burden so that learner thinking processes are freed up and can be devoted to educationally worthwhile activity such as the development of understanding. The animations to be demonstrated were developed using a step-by-step design strategy that will be described in this presentation. Practical approaches for analysing the instructional content to facilitate the design of effective animations from static pictures will be explained and illustrated with a number of animated examples.

## Introduction

Look at any web-page and you are likely to see some type of animated graphic jiggling around in the display. This reflects the realities that (a) animations have become very easy to produce and (b) today's hardware is eminently capable of the processing-intensive operations required to display even sophisticated dynamic presentations. University lecturers have been quick to take up the opportunity to include animations in their teaching materials with the expectation that these presentations will make the content easier for their students and enhance learning (but see Narayanan & Hegarty, 2000). They are eager to take advantage of the potential of animation to address many of the limitations of static graphics as instructional resources and current generation computers give them facilities to produce their own animations that have never before been available to individual lecturers. However, this adoption of animation is taking place in a context where there is little guidance available about how to maximise the educational effectiveness of these resources. An inevitable result of this lack of guidance is that authors of these animations have had to rely largely upon their intuitions about what design features they should include. Unfortunately this can be a rather hit-and-miss approach because authors are typically content experts who naturally tend to focus upon the content rather than the characteristics of animation that are critical in determining its educational effectiveness. Even if authors have access to instructional design consultants and skilled graphic designers, the problem remains of just what characteristics need to be included if animations are to be effective as tools for learning. This is because the traditional focus of instructional design has been on *static* text and graphics while the

training of graphic designers tends to be on *aesthetic* rather than educational aspects of presentation. This paper offers a systematic and research-based approach for designing the educational aspects of animations. Such an approach is necessary in a context where animations are becoming increasingly common in educational materials and expectations for their effectiveness in promoting learning are high. It would be unfortunate if a powerful technology capable of enhancing learning fell short of its potential because computer-based animation was found to be much less effective as a tool for learning than had been expected due to inadequacies in educational design.

## Animated versus static graphics

A variety of arguments for the educational potential of animations can be advanced in terms of their superiority over static graphics as a tool for learning. These arguments are related to both affective and cognitive characteristics of animation. The intrinsic attractiveness and entertainment value of animations hardly needs to be mentioned; the success of the animated movie industry bears witness to this. Animations are a highly motivating form of presentation with the capacity to attract and sustain our attention. Without both initial and continuing attention to the information being presented, learners are unlikely to reap much benefit from any type of educational resource. Therefore the affective characteristics of animation can certainly be very important in terms of learner engagement. However, thoughtful educators realise that for animation to fulfill its potential as a tool for learning, its function needs to go beyond that of being appealing "eye-candy". What is also needed is the more educationally "nutritious" cognitive contribution that can come from animations specifically designed to enhance aspects of learning such as understanding, remembering and problem solving. It is these cognitive issues that will be our main concern here. Cognitive characteristics of animations are typically given little consideration by animation developers and yet are those that are most critical to the achievement of high level learning outcomes. The following list gives some of the potential advantages of animated graphics over their static counterparts with respect to cognitive aspects of learning.

Compared with static graphics, animated graphics can be:

- More informative because they simply show us more about the subject matter than the corresponding static depiction,

- Closer to the characteristics of actual subject matter because their direct portrayal of dynamic aspects gives a better match between the referent situation (the actual subject matter) and the representation (the way the subject matter is depicted when presented to learners),

- More explicit because every dynamic aspect is "spelled-out" directly for the viewer rather than requiring inferences to be made about the dynamics from a non-dynamic depiction. This can mean that fewer mistakes and misunderstandings occur due to there being less reliance on the learner making the correct inferences,

- More explanatory because they offer the opportunity for providing multiple visual and conceptual perspectives on the subject matter. The depiction can hence advance from description to explanation,

- Clearer because unlike static graphics, they do not require various ancillary symbols (such as arrows, dotted lines, etc.) to convey the dynamic aspects of the content indirectly. This means the display can be less cluttered and learners are not

required to carry out the decoding processes necessary to interpret these symbols in order to understand the changes that the subject matter undergoes.

It should be noted that these are potential advantages; they do not automatically result just because we convert a static depiction into some type of animation. In other words, animated graphics are not intrinsically superior to static graphics. Without good educational design, it is perfectly possible to produce animations that are actually inferior to their static counterparts. In this paper, the task of designing an educationally effective animation will be conceptualized as one concerning how learners can be helped to build a satisfactory mental model (Johnson-Laird, 1983; Schnotz & Grzondziel, 1996) of the subject matter from its animated depiction. As with other forms of presentation, the success of this construction process is likely to be highly dependent on how well the animation's design takes into account the strengths and weakness of our human information processing capacities (see Sweller & Chandler, 1994). No amount of technical wizardry can make up for design flaws resulting in perceptual and cognitive demands that exceed the capacity of learners to process the presented information.
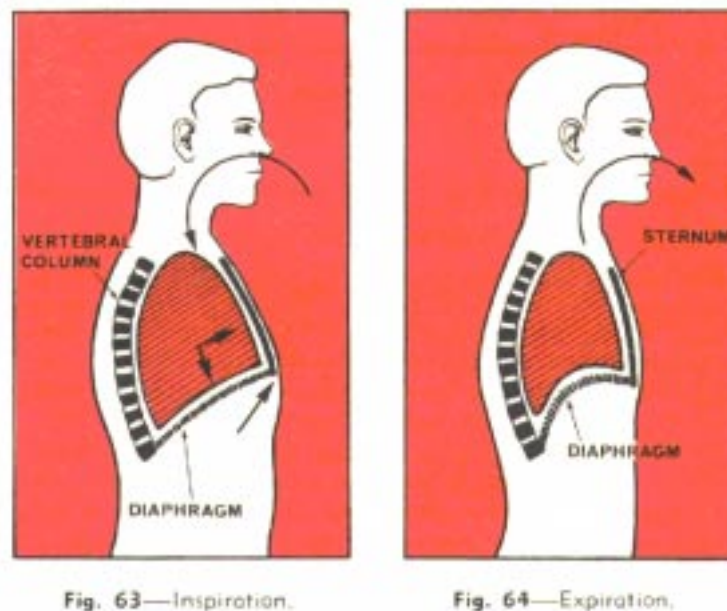


*Figure 1. Original static graphic for breathing mechanism*

## From static graphic to animated presentation

In practical terms, the most common starting point for lecturers wishing to develop animations is some type of static graphic (perhaps a figure from a textbook). This paper introduces a systematic approach for developing an animation from a static depiction that can help the developer produce a more educationally effective result. A relatively simple example is used to demonstrate this approach so that the focus can be on the design rather than the content. The original static material from which the animation was developed consists of two diagrams from a page of a textbook dealing with fundamental aspects of the way we breathe (Figure 1).

In order to depict the intrinsically dynamic nature of this subject, the static depiction must employ a number of techniques that add material to the diagram and manipulate the content in various ways. So, rather than looking at a single depiction, there are two diagrams to view simultaneously in order to make comparisons and contrasts. Further, arrows are used in the first diagram to indicate expansion of the lungs and outward

movement of the chest (in addition to those used for labeling and to indicate air flow). An important consequence of such techniques is that they require the viewer to carry out interpretative tasks that are not related to understanding the actual process of breathing itself. Rather, they are tasks which arise from limitations in the capacity of static depictions to represent dynamic information directly. These spurious tasks impose extra information processing burdens on learners that are additional to the processing involved in making sense of the core material they are trying to learn. These additional demands can have negative implications for the ease and effectiveness of learning because learners must devote a sizeable proportion of their limited cognitive capacity to decoding the depiction itself (as opposed to understanding the subject matter it represents). This is a consequence of the limitations of static media and their intrinsic inability to display dynamic information directly. Because there is a poor match between the characteristics of the dynamic subject matter and the characteristics of the static graphic, the learner must work harder to make sense of what is depicted.

Animation offers much better correspondence between the subject matter and its depiction because of its capacity to represent the dynamics explicitly. The animated version of the breathing mechanism (Figure 2) allows us to capture the situation in a way that facilitates the learner's task of mapping between the depiction and what is being depicted. However, the extent to which a developer succeeds in providing this facilitation largely depends on which dynamic aspects are selected for portrayal in the animation and the way these aspects are treated. It is therefore vital for the developer to carry out a carefully considered analysis of the subject matter before embarking on design of an animated version of the original. Naturally enough, this should be preceded by setting out some clear educational objectives (or desired learning outcomes) for the animation. Although these can normally be derived by considering the purpose of the original static material, it may be that the developer alters these somewhat in light of the different opportunities offered by static and animated depictions.



*Figure 2. A late frame from breathing animation sequence*

## Design Considerations

Designing educationally effective animations is a challenging task. On one hand, the type of information involved in animations is complex, being both graphic and dynamic, so designers need to consider the way humans process these two very different aspects of the display. On the other hand, relatively little research has been done on how people learn from animations so that there is not the same body of knowledge to guide designers that there is for more conventional resources such as textbooks. Indeed, it has been suggested that we may even have to start asking quite different types of questions when considering the design of the new generation of learning materials (Mayer, 1997). Research into the way people process static graphics can give us hints about some of the issues likely to be important in understanding how animations are processed (eg. Lowe, 1997; Winn, 1993). However, a whole new set of processing considerations arise when dynamic properties are conferred upon graphics. Because these temporal aspects of animation all have potential to impose additional interpretative processing demands on learners, each should be taken into account in designing animated materials. Their effect on learners may also be cumulative in the sense that their combination could exceed overall processing capacity. To manage the resulting information overload and maintain processing, learners would need to limit the amount of information they deal with.

Research findings (Lowe, in press b) suggest a management strategy by which learners limit their information load when viewing animations. This involves a form of "load-shedding" where the learner selectively attends to only certain aspects of the animation but neglects others. Such a response risks learners focussing on the wrong sorts of information by selectively attending to changes in the animated display that are perceptually compelling rather than those that are most relevant to the topic being explained (Lowe, 2000). This risk is particularly likely when learners are dealing with unfamiliar material and where key thematic information has relatively low perceptual salience. In these cases, there is a danger that learners will notice obvious changes such as those involving rapid movement of whole graphic entities whereas more subtle alterations in the properties of those entities will be missed. For this reason, it is important for designers of animated learning materials to consider both extrinsic changes (as when an entity moves from one position in the display to another) and intrinsic changes (as when an entity undergoes internal changes in properties such as size, shape, and structure).

What appears to matter here is the contrast between what could be considered the dynamic "field" and "ground" of the display. To appreciate how this dynamic contrast may operate, consider a temporal analogue of the traditional visuo-spatial field/ground distinction that designers take into account when dealing with static images. In effective educational graphics, the perceptual qualities of the different components of a static image are manipulated so that those constituting the field stand out prominently against the ground (which is often also manipulated to reduce its perceptual salience so that does not compete with the field for the viewer's attention). In animations, designers should also consider temporal field/ground effects, that is, those aspects which by virtue of their dynamic contrast with the context of the display as a whole tend to stand out from the overall set of visual information. Note that this can be either because such aspects change (extrinsically or intrinsically) to a much greater extent than their surroundings, or because they change relatively little compared with their surroundings.

## Steps in designing animations

The principles underlying the approach detailed below are partly derived from research into the way learners process educational animations (Lowe, 1999, 2001b, in press a). However, because of the small research base that currently exists in this area, more speculative, practice-based components are also included (see Lowe, 2001a, in press b). Let us assume that we expect the learning outcome of our animation to be that students will be able to explain the fundamental mechanism by which air is pumped in and out of the body. At its most basic level, this mechanism involves just a few body organs that work together via several simple processes. The following points suggest some of the more important steps involved in converting from static to animated depiction.

Analyse the dynamic situation and its events: All the essential entities ("things") that contribute to the mechanism must be identified as well as the key relationships existing between them and their properties. For this animation, the relevant entities were identified as the top half of the body (containing nose, airway and chest), the lungs, the diaphragm and air. There were also some basic relationships involved between these entities such as the spatial relationship amongst the body parts (how they are arranged). In addition, the entities are related in a temporal sense since the breathing process involves the way they change and interact over time (inhaling and exhaling, lungs filling and emptying, etc.). The properties of the various entities and relationships change over time (the diaphragm changes shape as it moves down and up, the lungs change size as they fill with air then empty, etc.). These various aspects of the situation need to be specified before beginning work on the animation itself so that there is a clearly defined basis for subsequent design decisions. It is a good discipline to begin this specification as a written document (rather than going straight to a graphic representation) because it facilitates distinction between (a) what needs to be shown and (b) how it is to be shown. This leaves our design options open rather than closing them off too early.

Select the graphic entities, relationships and properties: Once analysis of the referent dynamic situation has been completed, decisions need to be made about how you will depict the components that have been identified. Many of these decisions can involve simple adaptations of the material in the original static graphic but animation does give opportunities for new treatments that would not be particularly suited to static depiction. One of the consequences of going from static to animation graphics is that most of the ancillary symbols (arrows, dotted lines, etc.) can be dispensed with, so removing clutter from the depiction. Comparison of Figures 1 and 2 shows that a decision was also made to remove the vertebral column and sternum from the depiction since their function is simply to act as attachment points for the diaphragm. This considerably reduced the amount of visual clutter and a source of distraction from the main aspects of the mechanism. The facial features were also simplified considerably for the same reason. In general, the aim should be to use the minimum amount of graphic material for the maximum amount of explanatory effect; any graphic material in the original that will serve no clear educational purpose in the animated version should be omitted.

Establish and sequence main events: The extra dimension of time that distinguishes animation from static graphics gives the developer additional opportunities for supporting learners' exploration of the subject matter. Intuitively, it may seem that the best approach to sequencing the presentation of the content would be to mirror the natural order of events that takes place in the actual situation being depicted. This would certainly tend to give the most realistic representation of the subject matter. However, the desire for realism above all else is no more educationally justifiable in animation than it is in other

forms of representation (such as static explanatory pictures). Well-designed educational materials are both highly selective about what they present to learners and very structured in the way they present it. In such materials, the "raw" content is extensively manipulated before being served up to learners. In our breathing example, there is a causal chain from the flexing of the diaphragm through to the inhalation and exhalation of the air. The main events that lead from one to another during the breathing process certainly need to be clearly established, with their cause-effect dependency and sequence mapped out by the developer. However, as we will see, this "realistic" sequence may not be the best way to structure the animation.

Devise a presentation sequence: The natural sequence of events that takes place in the actual situation to be depicted will not necessarily be the sequence which is most valuable educationally. The design of animations should introduce information in a way that supports effective learning and this may mean that the presentation sequence needs to be different from the natural sequence. In a strict sense, the mechanism of breathing in our simple example can be considered to start with changes in the diaphragm. Nevertheless, this is not the most direct, physical sign that breathing is taking place. Rather, the external heaving of the chest is far more familiar to most people, particularly those who are likely to form the target learner audience for this educational animation. Because it is so familiar and directly observable, this chest movement was chosen as the starting point for presenting the explanation of how we breathe. This was followed by another very obvious effect of breathing — the movement of air in and out of the body. Only after these two external parts of the breathing process had been introduced did the explanation move to address the hidden internal causes for these changes. This rearrangement of the natural sequence of events followed the broad educational principle of working from the known to the unknown. It is important to note that despite this manipulation, the presentation sequence maintains the integrity of the cause-effect chain overall but is built in a way that makes the content more accessible to learners.

Construct a temporal structure: In the real world, time flows regularly and continuously. This is the reason why temporal events can be difficult to understand "as they happen" but become more comprehensible if we are given the opportunity to reflect on them and analyse their cause-effect structure. Often, we need someone to draw our attention to the salient aspects of the subject matter, particularly if these are not very conspicuous. It is also helpful if what we are seeing is linked to something we already know. In most cases our job of interpretation what we see is simplified if we have help in breaking the continuous flow of a process into a number of discrete steps. Another matter to consider with respect to temporal structure is the amount of information presented per unit time. Static depictions such as those used in textbooks have little alternative but to present all their information at once which can be overwhelming for learners. However, animations can stage the presentation so that information is built up gradually throughout the period of the animation so that cognitive load is always kept within reasonable bounds.

Cue the critical information: The use of visual cues to guide learners through the key features of a set of presented information is common practice with static graphics (Lowe, 1997). Similar techniques should be used (but sparingly) within animations as can be seen with the colour coding of different entities involved in the breathing example. However, animation also provides opportunities for making use of temporally-based cues to help guide learners. A simple example is the way the change in each entity is repeated during the gradual build-up of events that constitute the whole breathing process. There are repetitions of the chest moving in and out, the air being inhaled and exhaled, the lungs expanding and contracting, and the diaphragm rising and falling. By dwelling on each

change, the repetition signals to the learner that breathing is made up of a number of stages and identifies the boundaries of these stages. After each repetition cycle, the addition of a new changing entity temporarily disrupts the display so that it acts as cue drawing attention to a different aspect of the subject matter. If all the changing information was presented simultaneously instead of via this temporal cueing, learners would have to segment the display for themselves.

The six steps suggested in the above strategy do not claim to be comprehensive. Rather, they are intended to offer the beginnings of a systematic and principled approach to the design of educational animations. There are numerous other relevant considerations involved in designing educational materials generally that will be familiar to experienced developers of learning resources but which have not been addressed here. For example, this strategy does not address the critical issues of formative evaluation and revision that are essential parts of a systematic development process. This paper has also not dealt with a number of important issues regarding how animations are used in educational contexts such as the effects using animations may have on other aspects of instruction (eg. Wright, Milroy & Lickorish, 1999) or their use in cooperative rather than individual learning situations (Schnotz, Böckheler, & Grzondziel, 1999). However, the strategy presented does focus upon aspects of animation design that tend to be neglected or else are handled in an intuitive way rather than being subjected to a more analytical and informed approach. Although these steps are presented in a particular order, this is not to suggest a sequence that should be followed slavishly. Those who are experienced in designing educational materials know that any model intended to guide the design process should be treated simply as a tool for supporting their efforts, not as an inflexible prescription for action.

## Conclusion

Animation is not a magic solution to educational problems. If animation is poorly designed or applied, it may create more learning problems than it solves (with respect to both its affective and cognitive aspects). Already, some of us are disturbed by the inane animated graphics that seem to pepper almost every website we encounter. They can be both intensely annoying and a source of distraction from our central purpose. We are quickly learning to "shut-out" these distractions, ignoring them so that we can focus on the material we are seeking. A carefully considered approach to the development and use of educational animation is needed so that its status is raised (rather than lowered) in the eyes of learners. Inept and superficial use of animation in learning materials is likely to result in students adopting the same filtering approach that many of us already use with animated websites. In the longer term, this may result in animation becoming a "devalued currency" in educational terms. Considering the potential power of animation as a tool to foster learning this would be an educational tragedy.

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# Designing an on-line learning environment to support the development of generic skills: a case study

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**Abstract**  Higher education institutions are experiencing continual pressure from government, industry, funding authorities and students to place a greater emphasis on developing generic skills that are currently delivered through the "hidden curriculum". In most courses skills such as teamwork, time management, critical thinking and conflict resolution are developed incidentally and rarely made an integral part of the course. However, the demand for these has become a priority issue and can no longer be ignored.

This paper explores ways of designing learning environments that help develop these skills through the use of on-line technology. A theoretical model is developed which is based on contemporary teaching methods to enhance generic skills, and this is then used to help design an appropriate interface to promote the development of students' generic skills. The implementation of the model will be demonstrated with a class of eighty-five third year higher education students who studied project management methodology for multimedia development.

## Introduction

Over the past decade there has been a growing concern about the role of higher education institutions and how they are meeting the needs of employers. Increasingly, higher education institutions are being asked by industry, government and higher education funding bodies to produce graduates with versatile workplace skills, as well as subject-specific skills. This is causing a major reappraisal of higher education institutions purpose, learning outcomes and research activities (Australian National Training Authority, 1998; Bennett, Dunne, & Carre, 1999; Candy, Crebert, & O'Leary, 1994; Dearing, 1997; Mayer, 1992).

In Australia, the Department of Education, Training and Youth Affairs (DETYA) has funded the (Australian Council for Educational Research, 2000) to develop a Graduate Skills Survey instrument which is being piloted in the year 2000 and implemented in 2001 across all universities in Australia. All first year students will be required to take a skills test at entry level, and then again in their final year of study at exit level. This will enable universities to compare the variance in students' generic skills over the course of study, differences in student profiles between fields of study, and differences between universities. How, and if universities will be assessed on students' generic skills development is still unknown but the subject of hot political debate: "a policy on the use of the data is still being finalised" (Australian Council for Educational Research, 2000). This testing shows the seriousness by which the government views generic skill development.

A framework proposed for promoting the development of generic skills in an on-line environment is based on the work of Oliver (1999), and consists of learning activities, learning supports and learning resources (Figure 1). *Assessment* is instrumental to the whole design process and is considered in each element of the framework. *Learning*

*activities* are based on a synthesis of the research, and focused on learning activities that promote authentic context, self-regulation and reflection. *Learning supports* such as coaching, scaffolding, modelling and multiple perspectives are designed to assist learners and provide feedback on their progress. *Support materials*, which are often seen by many lecturers as the main focus when developing new courseware, are considered last in this model and presented to the students as support materials in both print and on-line format.
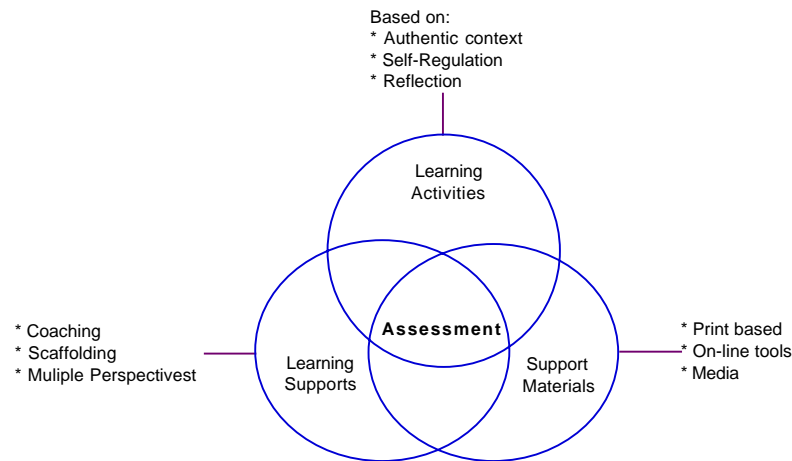


*Figure 1:A framework for developing effective learning environments (Modified from Oliver, 1999)*

## A Case Study

Final year students enrolled in the Interactive Multimedia course at Edith Cowan University are required to develop skills and expertise in project managing the development of multimedia products. These skills are taught through IMM3228/4228 "Project Management Methodology" unit where students practice creating web sites using project management models, performing needs analysis, developing design specifications, (storyboards, concept maps and rapid prototypes), conducting formative and summative evaluation. The unit consists of thirteen, three-hour class sessions and runs over a full semester, or thirteen weeks. Each session consists of a one-hour lecture followed by a two-hour team-based activity. Team skills and collaboration are continually promoted and reinforced throughout the unit with teams of four or five students working together to build the web site. Learning outcomes include:

- making a significant contribution to the development of a team-based web-based product

- developing suitable project management models

- documenting and reporting on QA procedures, communication strategies, timesheet estimates, overall costs, proposal, legal, design etc which are representative of industry expectations

- evaluating the quality and effectiveness of the product

- communicating and collaborating in a team-based environment to effectively problem solve, resolve conflict and make appropriate decisions.

The framework shown in Figure 1 is used as the basis to develop an instructional strategies needed for the required learning outcomes. As shown in Figure 2, learning activities are designed to promote self-regulation, authenticity as well as reflection and self/peer assessment. Using these learning principles, the design process focuses on developing learning activities to support the required outcomes, which in this unit is to

develop students' generic and project management skills. In creating a learning environment based on these principles, decisions were firstly made on the form of assessment and what proportion would be allocated to team and individual activities.
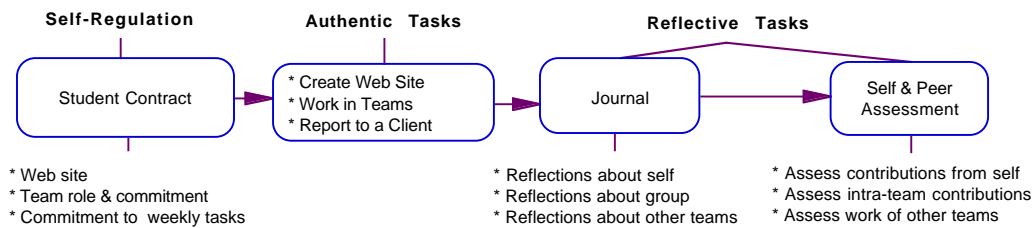


*Figure 2:Assessment and learning activities*

In the workplace, these graduates work in collaborative environments using specialised skills as part of a team to create multimedia products. Teamwork is an important part of their future-working environment, so it was decided to allocate 75% assessment to teamwork, with a strong focus on peer-assessment and reflection to adjust marks. Students are required to complete three assignments: a project proposal/design specification, web site with metrics and weekly tasks. Assessment is based on the quality of documentation, web product, weekly task solutions, and individual reflections. Also, reflective reports, are designed to encourage students to reflect others contributions. Peer assessment is encouraged and negotiated with the team and tutor at the end of each assignment.

As shown in Table 1, the generic skills being targeted in this unit include time management, collaboration, setting priorities, locating relevant information and giving/receiving feedback. These generic skills are aligned to each of the learning activities, which are based on the learning principles derived from the literature. However, by adjusting the assessment criteria and the nature of the learning activities, other generic skills could be targeted using the same framework.

The site is based on the framework outlined in Figure 1, and focused on learning activities that promote authentic context, reflection and self-regulation. On this basis, an office metaphor for the main interface is used as shown in Figure 3. It contains icons such as an in-tray for weekly tasks, a clock for students to enter timesheet entries, a journal for weekly self and peer assessment, a contract to gain commitment at the beginning of the semester, a pin-up board which shows weekly requirements, a video player with streaming video of industry representatives, a filing cabinet which contains support materials, a conference centre where students post weekly solutions to problems (and assess others), and a computer screen which allows forum discussions and views of other students work.

The following sections discuss how each section was designed and implemented.

| Learning Principles | Learning Activities | Generic Skills |
|---|---|---|
| **Authenticity** | Develop a web site<br>Create a portfolio of QA procedures | Forming teams<br>Problem solving and communicating in group situations<br>Completing tasks with the team<br>Using timesheets to track time & calculating metrics<br>Managing time to complete required tasks<br>Scheduling and planning |
| **Self-Regulation** | Create a "Student Contract"<br>Complete weekly team tasks | Negotiating project topic, team roles & responsibilities<br>Committing to team roles/responsibilities and deliverables<br>Locating relevant information for weekly activities<br>Setting priorities for task completion |
| **Reflection** | Complete weekly journals<br>Perform intra-team self & peer assessment<br>Perform inter-team self & seer assessment<br>Complete reflective reports | Performing intra-team peer assessment<br>Receiving feedback from peers, clients and tutors<br>Performing inter-team peer assessment<br>Discussing others perspective's |

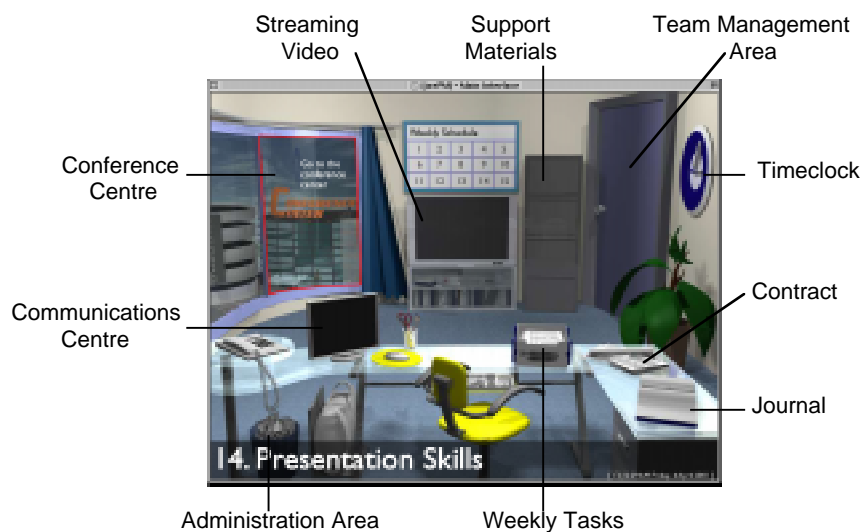*Table 1: Learning tasks and related generic skills*



*Figure 3: Main user interface*

## Designing Learning Activities & Assessment Strategies

To help gain commitment, students are required to complete a "student contract" at the beginning of the semester, signed by themselves, their team members', and the tutor. The contract outlines students' responsibilities needed for developing the teams' web site and weekly tasks. Students are required to commit to a project topic, team role/responsibilities, topics for their portfolio, amount of time they were prepared to commit to achieve these tasks (Figure 4), and contributions they would make to help the group achieve its goals. This is completed in week 3, with a meeting in which a "Team Contract" is signed, were all team members agree that the roles, tasks and times allocated for all team members' are acceptable. This helps the team commit to specific

responsibilities in order to create a collaborative environment in which they would complete the course objectives.



*Figure 4: Sample Student Contract*

To support the commitment given to their contracts, students are also required to track team members' contributions through on-line weekly journals completed at the end of each week. This gives an indication of team members' progress in completing allocated tasks to the required quality and within time against promised deliverables as agreed to in the contract. The weekly journal requires students to comment on:

- success on completing weekly tasks;
- tasks they need to complete for the following week;
- self and peer assessment (as shown in Figure 5); and
- comments on why they allocated high or low peer assessment marks.

| Assessment Categories | | Fred | Joe | Sam | Mark | Sue |
|---|---|---|---|---|---|---|
| 1. | Was he/she/you regularly at group meetings and punctual? | 4 | 3 | 4 | 4 | 4 |
| 2. | Did he/she/you collaborate well? (ie. try to assist, cooperate, make suggestions etc) | 4 | 4 | 2 | 4 | 3 |
| 3. | Did he/she/you complete the assigned tasks for the past week to the best of their ability? | 2 | 3 | 2 | 4 | 4 |
| 4. | To what quality did he/she/you carry out the tasks assigned for the last week? | 4 | 4 | 4 | 4 | 4 |

*Figure 5: Sample journal entry showing self & peer assessment*

Student comments made in weekly journals are confidential only to the tutor, which allows students to "safely" comment on other team members' performance. Tutors use this information at peer assessment meetings to clarify issues and difficulties identified about team members' contributions. At these meetings, tutors summarise confidential information gained through the journals and ask "targeted" students to defend criticisms made by their peers. If these students cannot defend their lack of input, as agreed to in their contracts, marks are negotiated and transferred to other students. So, the emphasis on

monitoring self and peer assessment becomes an important task for each team member, and can become a stressful exercise in some cases.

Another learning activity based on peer assessment uses the "Conference Centre" in which all student teams are required to complete weekly tasks based on key concepts. For example:

> *In order of priority, outline what you consider to be the essential procedures/commitments needed to effectively track the progress of a project (400 words or less).*

Students are given both print and on-line resources to help in developing a solution for these tasks. The solution must be submitted by 4pm each Friday, at which time the system is "locked" so no more postings could be made. Student teams are then anonymously allocated three other teams to mark by 4pm the following Monday. Tutors then marke these solutions and post their marks and feedback by 4pm Wednesday, at which time the system shows the overall marks, as well as the best three solutions for that week. As shown in Figure 6, participants can view the solution, peer/tutor feedback and overall marks. A scaled total out of three is given, as well as the overall running total for the complete semester.
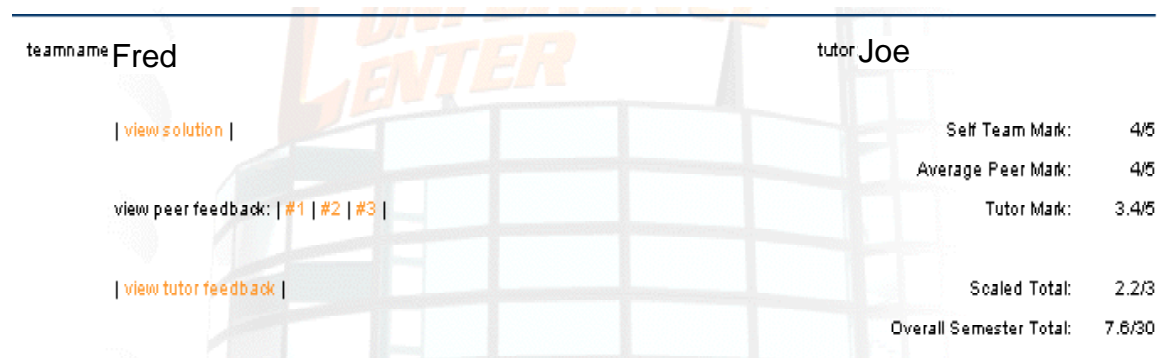


teamname Fred                                    tutor Joe

| view solution |

view peer feedback: | #1 | #2 | #3 |

| view tutor feedback |

Self Team Mark:    4/5
Average Peer Mark:    4/5
Tutor Mark:    3.4/5

Scaled Total:    2.2/3
Overall Semester Total:    7.6/30

*Figure 6: Conference centre results*

## Designing Learning Supports and Support Materials

Information and training resources are made available through the "Filing Cabinet" (Figure 3) from which students access resource materials and decide which training activities to perform to help complete weekly tasks. The following resources are available in the "Cabinet Drawers":

General course information - contained the unit outline, assessment details and help sheets

- "Brief" — provided information about the skills being targeted, items to be completed for the week, as well as focus questions to help promote reflective thinking

- "Resources" — as shown in Figure 7, provided text book/readers references, information and examples, useful links and multiple perspective's from industry representatives about the topic using streaming video (Figure 8)

- "Training" — included team based and individual activities that were scaffolded and modelled in the tutorial sessions

*Figure 7: Support Materials — "Drawer 3"*
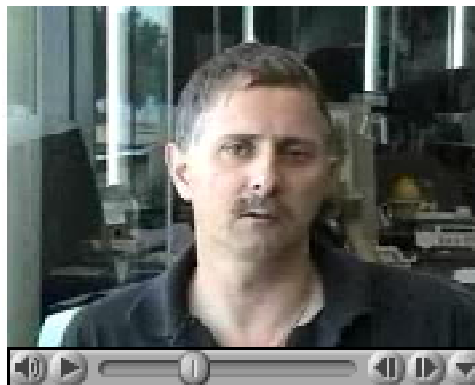


*Figure 8: Streaming video of Steve Pretzel – CEO of Pretzel Logic*

## Summary

In an attempt to create a course that promotes the development of generic skills and deep meaningful learning, a framework has been derived from the literature, which proposes that learning activities, learning supports and learning materials need to be carefully considered in order to obtain appropriate forms of assessment. Also, the emphasis in design and development should be placed on developing appropriate learning activities, rather than learning materials. The learning activities in this case were based on authentic, self-regulated and reflective activities. These attributes are evident in the design of the interface and related activities.

A comprehensive evaluation study is currently being carried out to evaluate the success of the learning environment.

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# iMovie. A student project with many side-effects

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**Abstract**   Since the release of the Apple product iMovie, students in the Language Departments at The University of Western Australia (UWA) have been working with this software as part of their assessment. In this paper/presentation I would like to introduce the underlying concept behind using short film-making in language teaching by using the experiences within the Department of German at UWA as an example. Thereby I will elaborate on the underlying methodology, the rationale, the course objectives, the implementation as well as the evaluation process as a paradigm for a possible wider up-take. While the data and the research findings themselves are a powerful persuasion for a generic implementation of this teaching and learning tool, the iMovie project also has some indirect side-effects which are less tangible and measurable but not less important in the understanding of knowledge transformation. Among these are cultural literacy, technical literacy, and interpersonal communication skills thus ensuring for the students a very holistic learning e-Xperience. Overall, the iMovie project's success ultimately lies in its ease of use and versatility, and promises a valuable extension to many disciplines.

Making short films might not strike you as such an effective way of learning German on first sight. You might think it more appropriate for a media studies course or a communications degree. Yet an approach that marries technology with the target language actually has some major functions in the methodology of second language acquisition.

## Background

Learning German as a second language in Australia can be a very artificial exercise. Countries where German is spoken as the official language (such as Austria, Switzerland or Germany) are far away and migrants from these countries are among the best integrated and least noticeable in Australia. Rather than real-life interaction, German language learning is mainly based on textbooks and takes place in a "traditional" classroom. This environment and approach can be seen as highly constructed and also has a removed feel to it. We therefore wanted to provide students with a learning experience where they could prove and apply their language proficiency while playfully engaging deeply with an aspect of German culture and language in context.

As part of a first year course for intermediate speakers of German a ten percent component of the assignment was redesigned in such a way to accommodate an iMovie project. The generic skills more than the linguistic skills taught and fostered within this multimedia project were seen as a welcome learning outcome in view of a society where "changing work practices have increased demands for information technology [IT] skills within non-IT professions" (Lawson & de Matos 2000; 87). Since not all students take to technology in the same way, an alternative to the iMovie project had to be provided which was comparable with regard to the degree of difficulty and its assessment criteria. The curriculum was re-designed in order to accommodate for flexible assessment and student choices. This was achieved by offering a combination of assessment strategies: based on

participation, essay writing, class presentations, and a creative piece of work (short film or creative writing in the target language on the topic of "Cultural differences"). While the classroom interaction primarily tests oral and formal presentation skills; the essay tests research, cognitive as well as writing skills; and the class presentation assesses involvement, engagement and ability to work as a member of a team, the creative component was designed to stimulate a deeper involvement with and in the target language. No matter whether students chose short film making and had to actively script, film, edit and fine-tune their work, or whether they chose to draft a piece of creative writing, it was felt that students would gain "a greater appreciation of the subtlety and nuance of linguistic interaction, and learn some of the skills necessary to shape and motivate their own language learning process." (Riggenbach, 1988; 118).

The pedagogical underpinning for short film making was heavily grounded in the theory of language acquisition (Liddicoat; 2000) as well as in the theories of the cognitive,[1] psychomotor[2] and affective[3] domain. After all, in film-making, students practise all four macroskills — writing, reading, speaking and listening — as set out in language theory, as well as acquire intellectual, technical and interpersonal skills (Yelland, et al.; 1993). In addition to this, creative writing or short film making offer a means of story telling, which has a crucial place as a maker and marker of meaning. Good stories have levels of meaning and are carriers of insight that can help everyone involved towards a better understanding of each other's culture. Constructivists claim that we construct our own reality through interpreting our experiences in the world. "If learners actively build their own interpretation of the world, they can have more ownership of those thoughts" (Jonassen, 1996; 12). This was aided by the fact that the creative assessment item was project-based, collaborative and learner-constructed.

The primary outcome of the iMovie project is a physical product, that can be presented to the class, parents, at prospective student evenings, or elsewhere, thus "making learning public. Having a physical product during as well as after a learning activity keeps learners thinking, communicating" (Fisher et al, 1996; 122) and mentally involved for much longer. By enabling and empowering the learner "their interest, motivation, and commitment increase, and their natural sense of pride and ownership in the work are enhanced also." (Levy, 1997; 197). Moreover, as students involved in the iMovie project work in groups of three, their learning environment is socially challenging, demanding collaboration. In such "situations, students generally experience a shift in their intellectual development as they learn to articulate their own point of view and listen to the view of others." (Goodsell et al, 1992; 11). All of the above make the iMovie project (as well as the creative writing task) learner-centred and divert the control over the material from the teacher to the learner who must actively construct their learning around the given task.

## Assessment

With these considerations in mind, the assessment structure, weightings and criteria were planned for the course. Preference was given to formative rather than summative assessment, as it was felt necessary to provide students with incentives for continuous input and give them clear indications of their standing. The course therefore does not feature an end-of-semester exam or test but is based on the following assessments:

---

[1] The cognitive domain encompasses intellectual or thinking skills.
[2] The psychomotor domain encompasses physical skills or the performance of action.
[3] The affective domain encompasses attitudes and values.

| | |
|---|---|
| 1 Class Presentation (team work): | 10% |
| 1 Essay (700 words due in week 10): | 10% |
| 1 Short Film (prepared in small groups, due week 12) **OR** 1 Piece of Creative Writing (700 words, due week 12) | 10% |
| Participation during the semester: | 10% |
| **TOTAL** | **40%** |

To justify the allocation of marks for the creative components the following checklist was designed to cover creative writing as well as short-film making:

**CREATIVE ASSESSMENT CHECKLIST**

NAME _____

TOPIC _____

**LANGUAGE**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spelling / Pronunciation | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Grammar | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Sentence-Construction | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Vocabulary | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Style-Expression | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Language in Context (use of idioms, etc) | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Use of German at work (film only) | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |

**CONTENT**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Originality | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Addresses topic | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Interest / Variety | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Appropriate Length | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |

**PRESENTATION**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Technical Skill (film only) | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Artistic Design (film only) | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |

**DIARY**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency of Contribution | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |
| Critical Reflection: (actions / others) | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |

**CONDUCT**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Teamwork | $HD^+$ | $HD^-$ | $D^+$ | $D^-$ | $C^+$ | $C^-$ | $P^+$ | $P^-$ | $F^+$ | $F^-$ | N/A |

**FURTHER COMMENTS:**

## Objectives

While the checklist assesses all the direct learning areas and outcomes, the project itself had been designed with indirect or secondary learning objectives in mind, which proved invaluable for students to obtain. Among these are

- cultural literacy,
- technical literacy, and
- interpersonal communication skills.

Since these are difficult to assess quantitatively they only appear indirectly in the assessment checklist: Cultural literacy informs the marks for "Language in context" as well as the content marks. Technical literacy affects the "presentation" as well as "originality" of the work submitted, while interpersonal communication skills are practised in the work-in-progress stages on a day-to-day basis. The latter had been observed by the project coordinator as well as the support staff (technical staff and evaluation officer) and an expert group (consisting mainly of colleagues from related disciplines) whenever interacting with the students.

To explain the rationale behind these side-effects of the iMovie project, some further information will be given:

*Ad 1:*

Cultural literacy came into mainstream discussion in 1987 with the publication of E. D. Hirsch, Jr.'s book, *Cultural Literacy* (1987). Although Hirsch's definition has been heavily contested and subsequently rejected, he has to be given credit for initiating a debate which has led to a wider awareness in the boom area of inter- and cross-cultural communication. Today cultural literacy is understood as "an ongoing dynamic process of negotiating meaning and understanding differences of perspective. Furthermore, cultural literacy needs to be grounded in an understanding of embedded cultural concepts, beliefs, attitudes, and ways of interacting and looking at the world — in a word, what Raymonde Carroll (1987) calls the 'évidences invisibles' of a culture" (Furstenberg, 2001; 55).

Sensitivity towards cultural differences is part and parcel of literacy in acquiring a second language. Thus, this iMovie project was designed to explore difference in a creative and constructive fashion. Students were empowered "to construct a personal approach to the attitudes, values, and concepts which underpin the 'other' culture." (Furstenberg, 2001; 55). This exploration was grounded in developing a curiosity and sympathetic attitude toward the 'otherness' of the target culture making it "visible, accessible, and understandable" (Furstenberg, 2001; 55).

Thereby, this iMovie project provided a constructivist, interactive approach which allowed students to gradually build a knowledge and understanding of other's values, attitudes, and beliefs, in a very concrete and dynamic way. An indirect outcome proved to be the exploration and development of insights into "some key cultural concepts, such as work, leisure, nature, race, gender, family, identity, education, government, citizenship, authority, and individualism." (Furstenberg, 2001; 55). Students were equipped with invaluable insights into cross-cultural differences which pertain to their cultural literacy, i.e. their ability to evaluate what someone from another culture understands of a given situation in a different culture and how s/he therefore reacts to it (Furstenberg, 2001; 55). This form of cultural literacy is clearly a learning outcome that is difficult to measure or quantify. Yet it is invaluable in its real-life application in the students' interaction with their target language and the people who speak it as their native-tongue.

*Ad 2:*

Students who chose to participate in the iMovie project have been exposed to a variety of information adding to their technical literacy and their ability to communicate technical issues in their target language. In addition they have been directly and indirectly exposed

to the theory and practise of visual codes underlying messages, which could be described as 'media literacy'. "The word 'media' has added yet another layer to the idea of literacy to encompass not only knowledge of media itself, but also an understanding of how semantic perspectives differ according to the linguistic and cultural background of users." (Furstenberg, 2001; 55). The iMovie project allowed students to "gradually construct an understanding of the subject matter, at the intersection of language, communication, and culture." (Furstenberg, 2001; 55).

## Implementation

At the beginning of the semester students were provided with the choice of assessment and asked to consider within a week whether they wanted to be part of the Short Film teams or preferred individual work on creative writing pieces. Due to limitations of technical support and hard-drive space negotiations with the Multimedia Centre at UWA, which traditionally provides technical equipment and trouble-shooting services in the instance of such student projects, we had to carefully consider the infrastructure ramifications of this iMovie project prior to the implementation phase. In the planning stages, it became clear that we could only accept 15 students maximum, working in groups of 3 to produce a short film of maximum 5 minutes. Without letting these restrictions affect the students by complicating the issue from the onset, only after the students' initial decision to join the iMovie project was the framework explained in more detail. Rather than seeing the framework as restricting, the 15 students accepted it as part of the rules of the game.

All iMovie instructions that we deemed necessary for the students to know had been translated into German by a professional translator taking great care in appropriating the technical terms authentically, and thus students were issued with manuals and guidelines in English as well as their target language. Within the groups a mix of abilities was aimed for, by pairing a weaker language student with a high achiever and one free floater. This ensured a dynamic within the groups whereby students could look up to the high achiever for guidance with regard to language-matters whereas the "linguistically weaker" students could shine in the role of technical or artistic advisers.

With this pedagogical framework in mind, the implementation went according to plan. To enforce the timeline, a cultural evening was organised to which we invited lecturers, parents, fellow students, and the general public with an interest in German(y). In a revue-style ambience, students had the opportunity to show-case their achievements. Some read their "creative writing pieces", others performed music and the short films were shown on a big screen. To judge from the resonance of fellow teachers, parents and students themselves the project was a success. Feedback was sought throughout the planning, implementation and presentation phase of the project to substantiate any claims of failure or success. To this effect the expertise of a Project Evaluation Officer was sought to collect and analyse the evaluation data. An outline of the evaluation strategy that we employed and pursued is indicative of the importance that was accredited to this phase of the project.

## Evaluation

A necessary part of every new course component has to be a carefully designed evaluation process (Laurillard; 1993) which aims at ensuring high quality teaching and learning opportunities and ensuring courses are responsive to 'consumer' needs and demands. We therefore established and reviewed performance indicators for language

teaching and learning with technology. Within the iMovie component of the language course several areas needed to be evaluated and the design of an overall evaluation procedure tried to ensure a holistic strategy. A mixture of evaluation methodologies was therefore regarded as most promising, combining formative as well as summative approaches and covering all phases of the project's development, namely design, development, implementation and institutionalisation.

It was deemed necessary to obtain continuous reflection by means of interviews, observations, and written feedback from a number of varied sources. In addition, summative evaluation forms were prepared for all stakeholders in the project to reflect on

- knowledge gained with view to the learning outcomes,

- comprehension achieved,

- application of used material / skills,

- analysis of one anothers' work, and

- ability to synthesise the newly gained knowledge.

As a promising means of evaluating the iMovie project, the "360-degree assessment"-methodology was chosen, as it provided a holistic approach to feedback by way of tapping into many different perspectives, such as teachers, students, peers, support staff, and professional observers, who we referred to as an expert group. Feedback from peers, observers and the project coordinator was sought through interviews, questionnaires, and by way of analysing the marks/grades given. Students' feedback was obtained from interviews, questionnaires, diaries as well as by analysing their rationale for marks given to one anothers' work. As a corrective of this evaluation process, observations and judgements by a professional evaluation officer had been invited as well as from technical support staff who were able to provide feedback in form of technical evaluation (software, hardware ramifications, storage ramification, ease of use and service, etc.)

The following table is based on the Learning-centred Evaluation Framework[4] highlighting the different phases of the project analysis (c.f. Valdrighi/Fardon/Phillips, 2001). This framework has proven very useful in the formulation of recommendations with regard to the design, planning, implementation as well as institutionalisation phase of the iMovie project.

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[4] The Learning-centred Evaluation Framework described in Bain (1999) and also Phillips (2000) derived from earlier work by Alexander & Hedberg (1994) and has three main characteristics: 1. It assumes that evaluation will occur in each of the major phases of an educational project (design, development, implementation and institutionalisation); 2. It outlines the types of evidence and methods that may be appropriate for each phase; and 3. It demonstrates how close attention to the learning process and learning outcome should be treated through all phases of the evaluation. (Bains, 1999; 4).

*Explanation of terms in data collection section:*

| Assessment | Documentation | Interview | Diary | Observation | Expert Review |
|---|---|---|---|---|---|
| Justified and collected as outlined on pages 3 and 4 | Notes taken by project coordinator, evaluation officer, and support personnel will be written up for a final report presented to the Centre for Staff Development, and the Centre for Advancement of Teaching and Learning at UWA. | Group interviews with all three students of each team present were held at the end of the project implementation phase. Open ended questions aimed at gathering initial impressions and sharing actual experiences and served as a corrective for the analysis of student learning outcomes as evident from the marks given. | Students kept diaries on their observations and experiences. Participants were free to comment on any aspect of the project whether it was a negative or positive comment.<br><br>Ultimately, the diaries formed part of the student assessment (see page 4). | Observations by project coordinator as well as support staff and evaluation officer during the project implementation phase were noted down.<br><br>Particular emphasis was laid on the interaction between the students and teachers, experiences with the software, problems encountered and the teaching approach. | Certain aspects of the project were discussed with experts in the field. While these gatherings had an ad-hoc nature, there was a strong emphasis on sharing ideas. A final meeting of this group at the end of the project implementation phase focused upon identifying overall strengths and weaknesses of the project, and formulated recommendations. |

| Phase | focus | ()Purpose | Asses-ment | Doc-ment | Inter-view | Diary | Obser-vation | Expert Review |
|---|---|---|---|---|---|---|---|---|
| Analysis and Design | Curriculm analysis | Why choose the iMovie model? | | Yes | | | | |
| | | What are the potential problems with the model or with teaching the coursework? | | Yes | | | | Yes |
| | | What learning outcomes are appropriate? What do students need to be learning? | | Yes | | | | |
| | Teaching-for-learning analysis & Specific-ation of innovation | How will the learning outcomes be achieved? | | Yes | | | | |
| | | Why is the iMovie model likely to lead to the suggested learning outcomes? | | Yes | | | | |
| | | How does the technology facilitate this? | | Yes | | | | Yes |
| | | What is the appropriate assessment structure? Describe the desired assessment process, marking criteria? | | Yes | | | | Yes |
| Develop-ment | Formative monitoring of learning environ-ment | How easy is it for the students to use the technology? | | | Yes | Yes | Yes | Yes |
| | | How does student interaction throughout the process influence their work? | | | | Yes | Yes | |
| | Formative monitoring of learning process | Consider evidence from interactive stories projects (German, French, Italian, Chinese) to identify short-comings. | | Yes | | | | Yes |
| | | What changes have been made to improve on shortcomings, and why? | | Yes | | | | Yes |

| | | | Col1 | Col2 | Col3 | Col4 | Col5 | Col6 |
|---|---|---|---|---|---|---|---|---|
| Implementa-tion | Summative evaluation of learning process | How are short films structured? | | Yes | Yes | Yes | Yes | |
| | | How much teamwork and reflection occurs (and what sort)? | | | Yes | Yes | Yes | |
| | Summative evaluation of learning outcome Summative evaluation of innovation appropriate ness | How well do students meet the learning objectives? | Yes | Yes | | | | |
| | | Could the iMovie project be improved and how? | | | Yes | Yes | | |
| | | What are the educational benefits? | | | Yes | Yes | | |
| | | Do the educational benefits match the workload of the students, staff and support network as well as demand on technical resources? | | | Yes | Yes | | |
| Institutional-isation | Mainten-ance evaluation | Can this model be used equally well across a variety of language units? | | Yes | | | | |
| | | What factors determine the sustainability of the iMovie project? | | Yes | | | | |

**Major findings**

Analyses of the collected data has resulted in the following short-hand diagram displaying the major findings by highlighting crucial points in each phase of the project and giving the recommendation deemed necessary.

| Phase | Major Findings | Recommendations |
|---|---|---|
| Planning & Design | For the benefit of the students it is crucial to identify and clearly communicate the learning outcomes for a successful iMovie project. | Students need to be made aware of the intended learning outcomes from the beginning of their involvement in the project (explanations with examples). |
| Implementation | Ongoing technological problems have been a discouraging side-effect hampering the timeline of the projects. The target language was not used throughout the editing sessions. Effective teamwork has not taken place in all instances (for example with regard to listeneing to other points of view). | Students need to be better guided and trained from technical problems and require help from others. The iMovie application would have needed to be in the target language as students naturally fall back into using English when talking about the technology. Incentives for effective teamwork, i.e. marks for collaboration and communication in the target language need to be considered. |
| Institutionalisation | Students and staff have been dissatisfied with the extra workload without any time-in-lieu arrangements or other incentives. The transferability of the model from one language environment to another or to other disciplines might prove easy. Costs (technical infrastructure and human resources) are an issue for further research. | Staff and students have to be made aware that it is a time investment which is only justifiable when considering the positive "side-effect" (generic skills sought after by future employers rather than gained language skills, as well as a physical product suitable for publicity gains) Other languages could easily adopt the model without any problems. The model is also applicable to other disciplines. Extra resources would need to be provided for the wider institutional up-take of these types of student projects. |

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# Technological tools for visual thinking: What does the research tell us?

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**Abstract**  Educational systems tend to emphasise the verbal, symbolic and numerical modes of learning though recently, there has been a wave of change in education, with an increasing emphasis on visual literacy. In everyday life and in learning, visual information is used to interpret experience and build understanding. This can be illustrated in three ways. First, visual thinking is part of the way we reason, such as when we extract of information from a map, chart or table and represent and express it in language. Second, visual thinking can be integral to problem solving, as when we need to use a diagram to explain, document, calculate or show the steps involved in reaching a solution. Third, visual representation can play a role in communication, for instance using diagrammatic and visual forms to communicate information, represent data and show relationships. This paper aims to give an overview of current theories and research on visual thinking and how it relates to learning. Examples of how technologies can enhance the visual dimension of communication and learning are discussed.

## Defining visual thinking

Is a picture worth a thousand words? It seems so, as historical accounts of scientific discovery and invention have shown that visualisation is a powerful cognitive tool (Rieber, 1995). The term visualisation is familiar to us from common usage and fundamentally means 'to form and manipulate a mental image'. In everyday life, visualisation is essential to problem solving and spatial reasoning as it enables people to use concrete means to grapple with abstract images. The process of visualisation may simply entail the formation images, with paper and pencil or even mentally, to investigate, discover and understand concepts, facts and ideas.

The original meaning of the Greek word for "to prove" in Mathematics, (*deiknumi*) was *to make visible or show*, indicting the close link between demonstrating understanding and having the capacity to show or draw a proof. However, the world of mathematics teaching has oscillated between periods when visualisation was regarded as important in pedagogy and eras when it was viewed as hindrance. Practices in mathematics problem solving are often based on linguistic representations that make use of logical connectives in sequential reasoning. Recent research in mathematics teaching (Diezmann, 1997) however has advocated the use of diagrammatic explanation to assist comprehension. Pictorial and visual forms of representation can offer advantages over text-based resources by offering scope for:

- displaying spatial interrelationships;

- demonstrating proportional relationships within and between objects;

- facilitating perceptual inference (eg, relative size of objects)

In addition, visualisation has achieved huge successes in helping scientists and mathematicians to understand and present their research (eg Gleick, 1987; Cunningham 1994; Klotz, 1991).

In this paper, it is claimed that:

- visual forms of representation are important, not just as heuristic and pedagogical tools, but as legitimate aspects of reasoning and learning;

- the technologies can offer visual experiences which foster higher order cognition;

- students should be encouraged to use multiple modes of representation when learning with technologies.

In his review of literature on cognitive tools, Mike Graves (1993: 2) of *Learning Technology Group, Apple Computer* emphasises that "in order to accomplish complex cognitive tasks, we invent tools, which in turn influence and contribute to the design of ways in which we think, which enables us to invent further tools to accomplish more complex cognitive tasks on so on, in reciprocal, mutual design". The paper elaborates on this view and provides a case study as an illustration.

## Visual thinking and visual literacy

The ubiquity of visual messages surrounding our need to process visual information, has led to an emerging movement for development of visual literacy skills and spatial abilities (Mohler, 2000). The case is explained by Seels (1994, p. 99) as follows:

With visual literacy — the ability to both understand and make visual statements — we become sensitised to the world around us, the relationships and systems of which we are a part. Visual literacy integrates personal experience and imagination with social experience, technology and aesthetics.

There is an extensive literature on the application of visual literacy skills and knowledge in improving the teaching and learning process. Some examples are the use of mind mapping and concept mapping as learning strategies (Buzan, 1996), and the use of dynamic visual support through multimedia to assist language comprehension of short stories (Sharp, Bransford, Goldman et al. 1995).

Visual aspects of cognition are also recognised as important in instructional design. Research on textbook design by Mayer, Steinhoff et al. (1995) found that when illustrations were placed alongside texts and contained annotated captions of the information from texts, students' recall and comprehension improved. This result was interpreted in the light of a constructivist theory of learning which posits that learning involves constructing connections between visual and verbal representations of a system.

Similar and related research on the benefits of mixed sensory mode instruction suggests that in some cases visual instructional formats can enhance learning. Cognitive psychologists working with a theory of cognitive load theory now acknowledge that more effective working memory processing capacity is available if learners work in multiple modes, such as text and graphics. Working with in this framework, Jeung, Chandler & Sweller (1977) predict that audiovisual factors will enhance learning only if cognitive

resources are not required to relate audio and visual resources. In addition, students are more able to exercise thinking strategies as long as the computer and the user interface complement learning objectives, and do not distract the learner.

## Differences between visual and verbal thinking

What is the relationship between visualisation and reasoning? Some theorists say we need to envision information in order to reason about it, communicate, document and preserve it (Tufte, 1990). Although visual images are part of human cognition, they tend to be marginalised and undervalued in education. If we consider the differences between visual and verbal forms of representation for instance, we can begin to see the constraints of a purely language based approach to learning. Table 1 shows some of the differences between visual and verbal modes of representation and what can deduced from this comparison is the capacity of visual representation to support learning and understanding by presenting multiple perspectives and engaging the learner in dynamic, non-linear modes of thinking.

Both visual and verbal experiences support knowledge construction, and a great deal of sensory learning is visual (Sinatra, 1986). On these grounds, opportunities should be sought in learning environments to exploit the visual mode of expression and thinking.

| Verbal Representation | Visual Representation |
|---|---|
| May reflect temporal and logical relations among events and objects | Depicts spatial logical and typographical relations between objects or events |
| Arbitrary and sequential, ie based on semantic coherence | Non arbitrary: visual representation may resemble actual object and events |
| Linear, one dimensional exposition of ideas | Dynamic and continuous, can characterise multiple aspects of ideas and concepts |

*Table 1: Differences between visual and verbal representation*

Educational systems tend to emphasise the verbal, symbolic and numerical though recently, there has been a wave of change in education. The visual literacy movement is, according to Avgerinou & Ericson, (1997) gaining considerable momentum, and is all encompassing concept that deals with the multiple aspects of intentional *visual communication*, for example fostering visual imagery and perception and using visuals for communication, thinking, learning and creative expression. Trends are converging in education and research to emphasise visual approaches which support learning, which have implications for technology-supported environments where students are often learning at a distance, or in the open learning mode. The incorporation of visual resources is evident in current Internet applications, with multimedia and telecommunications which support flexible and dynamic knowledge representation. The next generation Internet will be very high bandwidth, with very affordable costs. We are already experiencing the integration of voice, video and data. In addition, very powerful servers providing huge amounts of storage will increase the multimedia capabilities of the network.

## Theoretical views of visualisation

One of the reasons why visual literacy has not yet achieved a sound theoretical basis is that it is not a construct with operational specificity, nor is it a discipline or profession (Seels, 1994). Adding to the complexity of the term, there several theoretical accounts of visual literacy.

Visualisation has been accounted for by a number of theorists who have indicated its centrality in reasoning and learning. Bruner (1984, p. 99) characterises two alternative approaches to solving problems, one being intuitive, the other analytic.

> In general intuition is less rigorous with respect to proof, more oriented to the whole problem than to particular parts, less verbalised with respect to justification and based on confidence to operate with insufficient data.

Some psychologists relate different modes of thinking to different hemisphere of the brain, the "metaphorical left and right brains" where the right is home to the visual, spatial, and analogical, and parallel processing capacities, while the right is verbal, linear, sequential and logical. The location of the different modes of thought is not as important as the distinction between intuitive thought processes and logical thought processes. For learning, integration of the two modes of processing would seem the best approach; appealing to the right brain to make global linkages and to the left brain to build logical relationships. Much current research has focused on the undue emphasis given to sequential logic, and current theories of higher order thinking have endorsed a definition of higher order thinking which includes both creative (intuitive) and logical reasoning components (eg., Paul, 1993; Sternberg, 1985).

In support of the notion of multiple forms of reasoning, several prominent theorists have rejected the notion that verbal communication is the most important means of representing and constructing experience. Gardner (1994) speaks of the theory of 'multiple intelligences', but argues for the special status of visual-spatial intelligence in contrast to verbal intelligence. Other theorists who adopt a social perspective on learning (eg., John-Steiner, 1995) propose the idea of *cognitive pluralism,* or varying sense modalities, to emphasise the multiple modes an practices that are available to generate, communicate, learn and display knowledge. This interpretation of visual thinking sees it as a form of action, a social activity through which learners can interpret and transform their own thinking.

Cognitive apprenticeship models of learning (eg, Collins, Brown & Newman, 1989) are related to the notion of cognitive pluralism, or the use and application of a variety of experiential modes in learning. The recognition that learning is a means of increasing participation in 'communities of practice' is based on the Vygotskyan notion of learning as activity (Rogoff, 1990, McLoughlin, 1999). Increasingly, there is a focus on integrating perspectives from the cognitive and social sciences to develop situated theories of learning where active participation in a social context or in authentic practice (Lave & Wenger, 1991) has redefined the nature of expertise and learning. A range of processes and experiential tasks envisaged by the cognitive apprenticeship model can be mediated by computers. For example, representation of expert knowledge and externalisation of thinking processes can be achieved by offering students multimedia learning tools. Conventional learning systems have relied heavily on verbal and symbolic modes of teaching, but recently there has been evidence that cognitive apprenticeship forms of learning, which emphasise participation, modelling and authentic activity are informing the design of multimedia learning tools (eg, McLoughlin & Oliver,1998). The multimedia

tools enable the learner to experience, observe and participate in activities which would otherwise be out of reach or not possible in formal learning contexts (eg Whalley, 1995).

## Visualisation and changing paradigms of learning

The visual representation of ideas is just as much a part of the learning process as using language and other symbolic representations, yet current theories of learning with technology do not always highlight this important dimension of the learning process. Theorists have emphasised that visual thinking is a fundamental and unique part of our perceptual processes and that visualisation is a partner to the verbal and symbolic ways we have of expressing ideas and thoughts.

To what extent does current educational practice utilise visual resources to enable individuals learn more effectively? The pedagogical function of visual resources has usually been associated with their motivational qualities, for the scope they has to substitute for direct experience by presenting objects and events that are beyond the daily experience of the learner. Today's graduates require both visual and verbal thinking skills and need explicit practice in representing, interpreting and manipulating the visual aspects of their knowledge in multiple forms.

Rieber (1995) gives an interpretivist overview of how visualisation and imagination lead to scientific and mathematical generalisation. He concludes that "we can turn to almost any object within our reach into a tool for visualisation". Multiple visual modes of thinking, varying in style and formality have characterised thinkers drawn from a variety of domains. Writers use generative notes to trigger imagery while sketches and jottings are a familiar way to note down thoughts a that are later expanded, showing that the condensed private thinking that individuals do must be expanded and elaborated for communicative purposes. Computers have the potential to support cognition, to be used to extend intelligence. Interesting examples of these uses have been found where computers are used for a variety of purposes, to enhance both visual and linguistic aspects of learning (Klotz, 1991; Hoyles, Sutherland & Healy, 1991).

Rieber (1995) argues that the instructional materials should enable visually oriented problem solving approaches and generate multiple representations, rather than confine the learner to abstract visual strategies. Salomon (1997) reinforces this view, suggesting that if education is concerned with merely transmitting actual knowledge, then a chalkboard is probably the right technology. Computer visuals and simulation tools provide objects and representation, to model and activate cognitive processes. Primarily, these representations are visual, ie symbols, pictures, graphics, simulations and animations. These visual and sensory modes of teaching and learning with computers can achieve what Salomon & Globertson (1991) have called a "cognitive residue" where there is improved cognitive ability, for example, in self-regulation and mindfulness.

In many disciplines, like mathematics and physical sciences, visual-spatial approaches have been dominant for some time (Zimmerman & Cunningham, 1991). In arguing a case for other forms of reasoning other than deductive inferences, Barwise & Echmedy, (1991) have emphasised the importance of visual non-linguistic inference. Some theorists are often sceptical about such reasoning as it is intuitive and does not have the sophistication of the semantic basis of linguistically based reasoning. Nevertheless applications of technology to support visual and spatial reasoning continue to grow.

## Information technology and visual learning

Telecommunications and technologies connect people in a range of different locations and enable them to share visual images, text and graphics and communicate by voice and text based messaging (Mason, 1994). In Western Australia, desktop videoconferencing and audiographic conferencing are used to connect learners in remote areas and to deliver curricula to students living in rural and isolated areas. Using Macintosh computers loaded with the software *Electronic Classroom,* students can create and share graphics while communicating with students at other remote sites in what has become an "extended classroom" model of education (Burge & Roberts, 1993; McLoughlin et al, 1997).

Observations of these classrooms show that telecommunications can expand the educational process and enhance the visual/sensory mode of communication among students who access the curriculum via telematics. One of the characteristics of telematics classrooms is that the computer can be used to share visuals and graphics. The screen can provide a number of interactive support for learning:

- immediate feedback to students when used as a blackboard;

- visual stimulation;

- a flexible, editable page;

- shared reading and writing;

- and record of written work that can be saved and printed.

In telematics classrooms, the technology can, when used appropriately, be used to promote higher order thinking outcomes, (Oliver & McLoughlin, 2001). However, the reliance on verbal communication can sometimes tend to diminish the effects of how visual presentation of images, such as graphs, charts and concept maps, (which are means of informing and supporting learning) support distance learners. So far, little research has focussed on how such visual and expressive means can foster thinking and reasoning processes. Graves (1993) draws attention to the ways in which design of visual tools support cognition, differentiates experiential from reflective cognition. The former includes recognition of situations and meanings, and experiences of the here and now. Tools for reflective cognition, on the other hand, foster analysis, synthesis and metacognitive awareness. Similarly, Norman (1993) believes that reflective learning had been shortchanged and that we have tended to value entertainment and experience over reflection. For example, television is a more popular medium for experiential learning than academic textbooks, but does not support reflection.

The following case study of distance learning classrooms using audiographic conferencing provides initial insights not only into teaching and learning in these environments, but also considers the role of graphics tools available to students to support visual representation of ideas and reflective learning.

## Visualisation in the electronic classroom

In 1996, The Education Department of Western Australia (EDWA) decided to expand its curriculum delivery via telematics, to enable academically gifted students in rural and remote areas to access the curriculum via audiographic conferencing. This project offered an opportunity to observe first hand how students utilised the technology to support communication, visual thinking and higher order learning (McLoughlin & Oliver, 1998).

Telematics classrooms are asynchronous learning environments where verbal communication is achieved via a two-way audio-link. Documents, diagrams, drawings and pictures can be sent between computers via the telephone lines. In this real time environment visual tool combined with two-way audio can support dynamic exchange of ideas and information. In telematics classrooms, the teacher is not physically present in the classroom, and with the lack of gestures, cues and facial expressions, there is a consequent reliance on oral and verbal means of communication. Laurillard (1995) characterises such environments as 'discursive', as they enable interactive voice links through asynchronous communication while providing a shared, adaptable visual focus through use of computer technology.

Typically, a teacher would have a distributed classroom spread over several sites, with 3-6 students at each site. Interaction and communication between sites is achieved via the audio link and the computer which is used as an interactive whiteboard. Using the software "electronic classroom" the teacher can interact with students in geographically dispersed areas. Students have at their disposal a keyboard and graphics tablet with which they can draw, write, present and display visual representation of ideas. Each student can share his or her work, and the teacher can view the strategies used by students as they use the drawing tools to display their ideas.

Several observations were made about the quality of learning in this environment, to assess whether the technology can support visualisation and articulation of ideas in non-verbal modes. In one classroom, students collaborated around the computer, and took turns successively adding to or modifying their understanding of mathematical concepts. The objective was to create a plan for a report they had to write on an investigation of the octagonal links they had been working on in class.

Students were encouraged to depict their ideas graphically, rather than writing essays or lists of words. As they shared ideas and discussed a starting point for a report on their investigation, the drawing tool was used to create a concept map to display ideas and show connections (Figure 1).
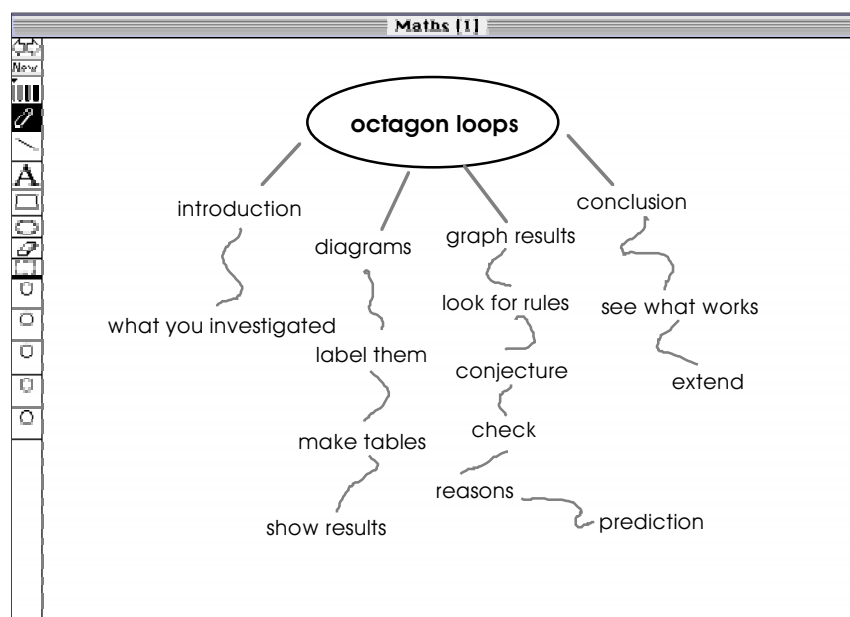


*Figure 1: Concept map of octagon loops investigation created by students*

This enabled students to display their own representation of the problem while talking about it and explaining it to students at other sites. The diagrams had a richness and

complexity that was greater than a traditional text-based document, and was a mental model of how students perceived the investigation of octagon loops. The concept map was not only a collaborative effort, it later became a focus for discussion and led students to reflect, modify and refine their ideas. In this case the computer became an extension of mind, and the monitor a looking glass and support for thinking. In constructing their conclusions, students used language a means of articulating and expanding their understanding of how to investigate octagon loops. Language provided a means of expressing ideas, but it was the capacity to use the technology to create visual images and representations on the computer screen which could be revised, referred to and shared provided a more powerful means of assisting their cognition. Figure 1 provides an example of a concept map created by one group of students to represent their understanding of the mathematical concept of an octagon loop. The provisional and dynamic nature of the conceptual map also instigated reflection and discussion by students at other sites, and they reconstructed the information presented in the drawing to help them identify the main aspects of the topic.

Audiographics technology up to has been an under-utilised resource, largely because of the inherent limitations of the technology to support graphical representation for reasoning and generative thinking. In many distance learning settings, the technology mediates learning and communication, and has the potential to support discussion, adaptation, reflection and interaction, all of which are components of the learning process (Laurillard, 1995). In the classrooms observed these elements were present as students displayed their ideas, while they could also remodel and adapt them, gradually constructing new versions and depicting them visually, as a means of expressing their own understandings and creating new knowledge.

Observation of the learners using the drawing tools while they interacted showed that they moved through a continuum from visual thinking through visual learning, to visual communication (Figure 2).
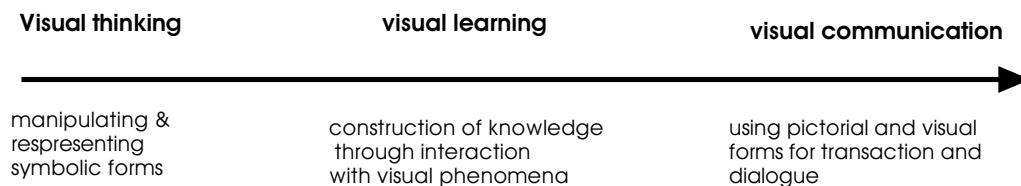
| Visual thinking | visual learning | visual communication |
|---|---|---|
| manipulating & respresenting symbolic forms | construction of knowledge through interaction with visual phenomena | using pictorial and visual forms for transaction and dialogue |

*Figure 2: Continuum of visual thinking*

This progression, from manipulation of visual forms, to construction of knowledge through interaction with visual representations, culminated in the sharing and communication of these ideas, in both visual and verbal form, to other students in the extended classroom. When learners collaborate in geographically isolated sites, using the telematics software, their verbal interactions initiate conversations but it is the act of representing these thoughts that leads to extension and amplification. The visual tools enable students to display ideas, open them to multiple interpretations and them revise them in the light of feedback from peers. These processes of exploratory dialogue are part of the process of higher order thinking (Mercer, 1996), while the visual dimension of experience and expression is an integral part of the verbal reasoning that occurs. This is an example of how in telematics environments, technology mediates the learning process and offers support for visual thinking

## Conclusions: visualisation tools in telelearning

Telecommunications and computer tools can support the dynamic nature of reasoning, by supporting dialogue and articulation of ideas in multiple forms. In the telematics classrooms observed, the software tools allow dynamic expression of ideas in visual form, and is provides a powerful means of collaborative knowledge building. These preliminary findings suggest another dimension to learning in telematics environments. For learners in a distributed classroom who participate in synchronous audio communication, the expressive and visual mode of representing information and understanding can play a critical role in learning and reasoning. The software tools and the computer screen can serve as a *scaffold* or support for dialogue, reflection and learning, becoming in effect "cognitive tools" for learning (Jonassen & Reeves, 1997; Lajoie & Derry, 1993; McLoughlin, 1999).

These observations, though limited, underline the current research in many areas calling for students to have multiple skills and forms of expression that include the capacity to understand and convey information visually (Greeno, 1997; Salomon 1997). Increasingly, learning must take into account the range of symbolic and visual forms that enable construction, analysis and refinement of ideas. In telepedagogy, where teachers are at a distance from students, visual and discursive media can support the learning process by enabling active participation, while encouraging dialogue and construction of knowledge by students. One of the most promising technologies currently in use for increasing student spatial ability is VR technology, which provides interactivity aimed at enhancing human cognitive abilities. One of the most successful video-based VR technologies is QuickTime VR (QTVR) which is an extension of Apple's QuickTime (QT), which can generate three-dimensional models to improve visualisation ability. Learning enhancement is achieved by providing learners with tools and activities where meaningful relationships between concepts can be explored both verbally and pictorially, so that visual thinking progresses to visual communication, which is at the heart of long-term learning achievement. As educators we must therefore be aware that technological tools to support visualisation and representation are currently available and that Apple Technology is a major provider in the field.

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# An E-learning solution to creating work-related skills and competencies for the knowledge-based economy

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**Abstract**  This case study presents a description of Web-based tertiary unit of study developed in collaboration with employer, industry and university stakeholders with a view to fostering skills in interactive multimedia and project management. The course utilised a range of learning approaches, including peer teaching and integrated assessment in which participants provided feedback to colleagues. The paper also discusses how electronic communications and Apple-based technologies can be used effectively to create environments for professional learning. The intention is to describe the design of the learning environment, the curriculum approach adopted, the types of learning activities and assessment tasks that were designed to foster work-related skills.

## Introduction

In response to employer expectations and economic demands, many universities in Australia are now deliberately focussing of the development of generic skills, core competencies and graduate attributes. This can be explained by the demand for knowledge in the information age, which is prerequisite for economic growth and development. The key skills included in the mission statements of most universities tend to include higher level aims relating to critical thinking, inquiry and a capacity for lifelong learning. These skills are often referred to as 'sticky', meaning that institutions will attempt to provide learners integrated, lifelong learning skills and services that enable continuous learning. These generic skills described from the basis of continual updating of skills and include the following:

- skills students need to become successful and self-sufficient learners. For example, information literacy and skills in self-regulation (eg. Candy & Crebert, 1991);

- intellectual and imaginative powers, understanding and judgement, problem solving skills, critical thinking skills and an ability to see relationships (eg. Ramsden, 1992);

- personal and interpersonal skills needed for communication, cooperative and collaborative teamwork, and leadership (eg. Assiter, 1995);

- skills required for successful work practices including time management, task management leadership and self-evaluation (eg. Collis, 1998; Nicholls, 2000).

Bennet, Dunne & Carre (1999) offer a concise model to conceptualise key skills in the higher education sector by suggesting a framework comprising four broad managerial skills. (See Table 1.) The authors argue that the important key skills are fundamentally those associated with being able to manage self, others, information and tasks. They propose that such a model can be applied "to any discipline, to any course and to the workplace and indeed to any other context" (p. 77). Table 1 displays this framework and shows the various elements within.

| Management of Self | Management of Information |
|---|---|
| Manage time effectively | Use appropriate sources of information |
| Set objectives, priorities and standards | Use appropriate technologies |
| Take responsibility for own learning | Use appropriate media |
| Listen actively with purpose | Handle large amounts of information |
| Use a range of academic skills | Use appropriate language and form |
| Develop and adapt learning strategies | Interpret a variety of information forms |
| Show intellectual flexibility | Present information competently |
| Plan/work towards long-term goals | Respond to different purposes/contexts |
| Purposefully reflect on own learning | Use information critically |
| Clarify with criticism constructively | Use information critically |
| Cope with stress | |
| **Management of Others** | **Management of Task** |
| Carry out agreed tasks | Identify key features |
| Respect the views and values of others | Conceptualise ideas |
| Work in a cooperative context | Set and maintain priorities |
| Adapt to the needs of the group | Identify strategic options |
| Defend/justify views and actions | Plan/implement a course of action |
| Take initiative and lead others | Organise sub-tasks |
| Delegate and stand back | Use and develop appropriate strategies |
| Negotiate | Assess outcomes |
| Offer constructive criticism | |
| Take the role of chairperson | |
| Learn in a collaborative context | |
| Assist/support others in learning | |

*Table 1: Project management competencies*

Underlying the current debate about generic competencies and preparation of graduates for the workplace, there is a common concern with the development of cognitive competencies such as problem solving, critical thinking, information literacy and management of information. Given these demands, it is incumbent upon tertiary educators to develop powerful environments, which encompass generic skills and lifelong competencies. But, ask Candy & Crebert (1991), "Can the learning that takes place in the cloistered atmosphere of a tertiary institution be realistically transferred into other, more rough and tumble learning contexts"? In this case study we present an example of an environment that fosters transferable skills and competencies (as depicted in Table 1) through the integration of several services that offer students a 'value chain' or enhanced experience

- Technology applications for e-learning, whereby independent learning is fostered;

- partnerships with industry that help create purpose and meaning in learning activities leading to professional skills development;

- peer partnerships, in which learners participate in an online environment where collaboration is encouraged and motivation is enhanced.

## Using technology to facilitate e-learning

Today, computer software programs are examples of exceptionally powerful cognitive tools (Jonassen, 1996a; Lajoie & Derry, 1993). Also referred to as "cognitive technologies" (Pea, 1985), "partners in cognition" (Salomon, Perkins, & Globerson, 1991), and "mindtools" (Jonassen & peck, 1999), they are not simply delivery vehicles for prepackaged knowledge. As computers have become more and more common in education, researchers have begun to explore the impact of software as cognitive tools, and of designs and environments that engage learners (Reeves, 1994). Computers as intellectual partners represent quite a different approach from technology as vehicles for educational communications. In the case of a partnership between learners and technology, the cognitive responsibility for performing is distributed to the part of the partnership that performs it best. Web-based environments may be intentionally adapted and developed to function as intellectual partners to enable and facilitate critical thinking and higher order learning (McLoughlin & Luca, 2000; Oliver & McLoughlin, 2001).

How do Web tools enhance the quality of the learning experience? Technology is more than hardware, and become a tool to support knowledge construction. Several qualities of the Web are having an impact on e-learning:

- technologies become intellectual partners in the learning process when they share the cognitive responsibility for learning. For example, the technology can store and retrieve information and enable easy access to data

- technologies are partners when they neither prescribe nor control learning. In the case study presented here, the conferencing environment of the Listserv, scaffolds learning by supporting communication

- technology acts as learning partner by supporting learning by reflection by enabling learners to represent what they have learned and how they came to know it.

In the case study described in this paper, Apple-based technologies enable a definable set of activities that engage learners in active, constructive, intentional, authentic and cooperative learning. In this environment, instead of using narrowly defined learning outcomes tested by examinations, technology offers a total environment where real life skills, such as project management and verbal communication, collaboration and team work can be assessed by the team and tutor by giving learners multiple channels of expression, such as visualisation, multimedia presentations, audio and video. Thus, the technology was able to provide the 5E's of quality learning (Oblinger, 2001).

**Exploration:** The Web offers e-learners a range of tools to access and explore data, information and resources

**Ease of use:** The World Wide Web is easy to use and the navigation capabilities enable learners to access and

**Engagement**: The World Wide Web enables teachers to create engaging and motivating environments for learning by applying constructivist approaches.

**Empowerment:** The Web gives learners greater control over the learning experience and provides choice and self-paced learning.

**Experience**: Assuming that instructors give adequate attention to instructional design, the Web offers learners a total learning experience that encompasses communication,

collaboration, synchronous and asynchronous learning opportunities, information access, self-pacing and personalisation of content.

## Peer learning at university

Traditional university education has operated within a "transmissive paradigm", emphasising the transfer of knowledge from lecturer to student. Such a view of learning is not conducive to meaningful, active learning where students take a pro-active role in questioning, sharing ideas and applying prior knowledge to new ideas. However, the increased emphasis on generic transferable skills has required a re-alignment of teaching practices with desired learning outcomes (Biggs, 1999). This means that if independent lifelong learning and critical skills are expected of graduates, teaching methods must foster such processes and skills. Figure 1 summarises the potential of peer learning to support transferable skills.

In contemporary education one influential group of researchers has identified students' approaches to be either surface level or deep level (Biggs, 1994; Ramsden, 1992). A deep learning approach is consistent with a search for knowledge and understanding, whereas a surface learner is concerned only with passing exams by memorising facts. Applied to assessment and teaching approaches in higher education, the implication is that the creation of an appropriate learning environment can foster a deep approach. This can be achieved by enabling learners to take an active role in learning by initiating, managing, monitoring, reflecting and evaluating learning tasks and processes. Gibbs (1992) emphasises that a focus on process, rather than content, is essential in promoting active learning and that evaluation and assessment procedures are central to these issues as students interpret the objectives of a course of study according to the demands of the assessment system. For example, an exam requiring recall of facts will encourage learners to adopt a surface approach, whereas assessment of collaborative problem-solving or teamwork on a project will emphasise communication skills, planning and decision making and foster a deep approach.

The relevance of the process-based approach is that the adoption of learner-centred pedagogies increases learner interdependence and equips learners with professional skills and attributes as shown in Figure 1.
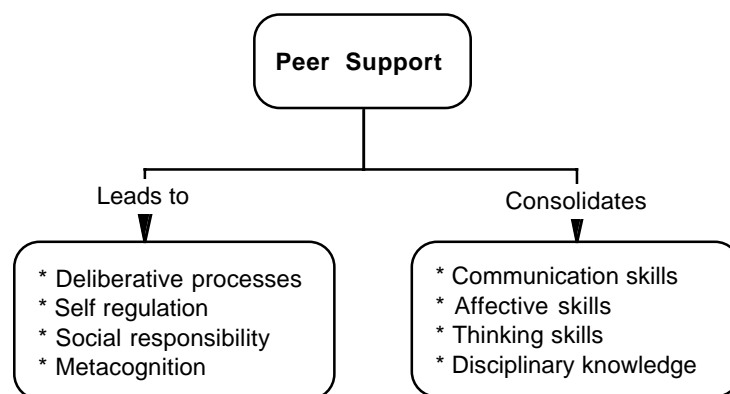


*Figure 1: Schematic overview of how peer learning approaches can support generic skills*

In addition, by integrating collaboration and peer feedback as a "learning event" that develops process knowledge we bring learners closer to the context of the workplace, where professionals are expected to have self-management skills, and be able to make judgements about their own and other's work (Erhaut, 1994).

The strengths of collaborative peer learning flows from the argument that the synergies available through group work create multiple perspectives on learning and problem solving. There is a growing body of research on group work in higher education with an emphasis on participative and peer learning, with the realisation that students are more likely to learn from experience than from transmissive pedagogies. There has also been an increased awareness so the importance of catering to the needs of diverse range of students by providing varied learning experience. Research shows that collaborative learning and peer partnerships augment learning because:

- peer learning moves away from traditional educational contexts which are transmissive;

- learning webs exist in society and are highly productive and a major source of learning;

- adult learning principles require acknowledgment of prior knowledge and sharing of ideas;

- peer work brings positive socio-emotional benefits.

(See Kitchen & McDougall, 1998; McConnell, 2000; English and Yazdani, 1999).

The relevance of these findings to enhancing the e-learning experience is that we can use the attributes of technology to increase the benefits of peer work and interdependence by designing authentic assessment tasks in order to enable the development of professional skills and attributes.

## Context of the study

At Edith Cowan University, final year multimedia students are required to complete IMM3330/4330 "Industry Project Development". The aim of the unit is to consolidate core multimedia skills learnt in other units, while at the same making industry contacts and developing a portfolio item to assist with job applications. Students are provided with industry projects made available through the Faculty, or they can negotiate a project of their own, as long as it fulfills the course requirements, that it is team-based, commercial in nature and not trivial. As part of the unit requirements, students are required to perform a needs analysis, provide a design specification, develop the web site, evaluate it, implement it and produce the required documentation (legal, procedures, metrics, templates and standards).

The unit runs over a fifteen-week semester, with three hours allocated per week for tutorials and lectures. There are no formal face-to-face classes, the unit is largely run online from a Listserv, which provides a rich arena for advice, comments and feedback as there is about one hundred participants subscribed on the List, including industry representatives and ex-students. The Listserv allows student to post questions and ideas and to receive response form industry experts to guide them in creating suitable web designs and multimedia products. This apprentice-novice was intentionally organised so that participants would be able to receive support from an industry partner. The constructivist rationale used in structuring the project work and the Listserv activities was that students should benefit from the experiences of other students, industry representatives and academic tutors in an environment that promotes collaboration, negotiation and the exchange of ideas. Figure 2 shows a screen dump of the home page.

**IMM3330**
Industry Project Development

[Coordinator]
Mr Joe Luca

[Tutors]
Mr Serge Walberg Mr Mark McMahon Mr David Wilson

This unit provides students with the opportunity to participate in the development of a multimedia project located in an industry environment, and to make a significant contribution to the team based development. Students negotiate with their lecturer regarding the nature of the project, which is aimed at fulfilling an industry need. The unit content includes: significant contribution to the development of a multimedia product; critical analysis of the project management method used; design and implementation of evaluation, testing, implementation and maintenance strategies; and establishing clear metrics, templates and standards.

[other stuff]

Unit Outline

[messages]
**Listserv Access**
Send email to: discussions-on@scam.ecu.edu.au and put SUBSCRIBE in the body of the messa...

[links]
Post an URL :

[semester schedule]
1 **Introduction**

2 **Finalise Projects & Use of Listserv**
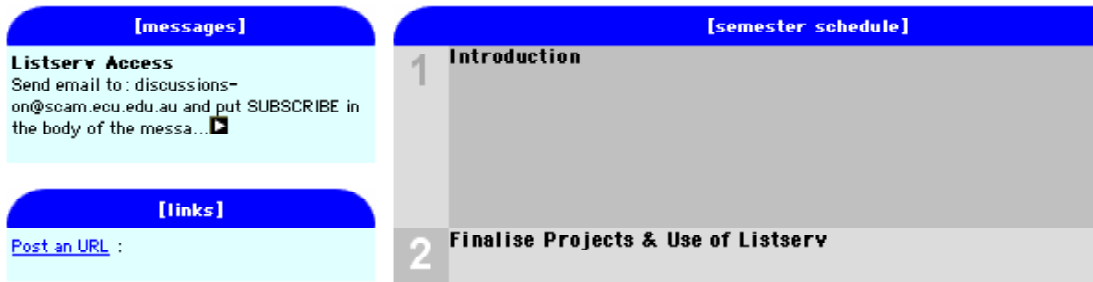
*Figure 2: Screen Dump of Web Site created using Apple Technology*

## Integrated assessment

To ensure a motivating environment, assessment acknowledges individual contributions to the listserv (eg., seeking feedback and advice) as well as team progress reports, which included students posting design ideas and prototypes to a shared workspace and requesting feedback from others. Students were given templates to use in preparing these reports as well as rules or "netiquette" they were required to use when posting information to the Listserv. Encouraging students to initially use the Listerv by monitoring postings was necessary, and where appropriate moderators responded and encourages conversations dynamics. However, in all cases, as the semester progressed, students became more comfortable with using the Listserv, and were posting on a variety of topics (Figure 3).
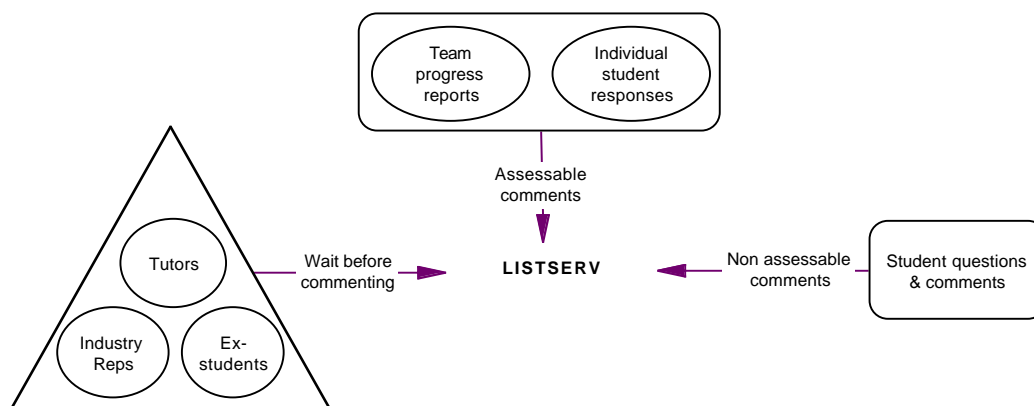


*Figure 3: A model for online discussion based on peer partnerships*

The tutors' involvement on the Listserv was structured to be non-interventionist so that they acted more as facilitators by focusing discussion, rather than as the "fonts of all wisdom". Figure 3 outlines the model used for promoting discussion on the Listserv. Issues were generated from team progress reports or from individual queries about

technical, content, procedural, client, communication, team/peer issues sent to the Listserv. Tutors, industry experts and ex–students then responded. Also, student had the opportunity to post other open questions, comments and reflective statements. As the semester progressed, students more freely contributed to the Listerv with many other issues, some of which were more philosophical in nature.

## Project based learning and use of multimedia technologies

As part of the project requirements, students were responsible for making contact with the client and discussing the scope and legal aspects of the development (educational software, IP, etc). These had to be negotiated so that the client had their needs satisfied, while at the same time the students were involved in producing a web-site that conformed to the requirements of an academic unit. This often involved firstly understanding the client's needs and "educating" the client about web production, maintenance and costs. In this online unit, project based learning enabled students to develop a relationship with a client, create solutions to a design problem and develop a project brief. In addition, project teams who worked on creating the had to report on progress to other teams, compare project plans and reflect on learning processes, assessment processes and team dynamics. Each of these involved partnerships with industry clients as and resulted in the development of multimedia products (usually websites) as shown in table 2. The final web site can be viewed at http://www-scam.ecu.edu.au/projects.

| Team No | Project Description |
|---------|---------------------|
|         | Oil and Gas Resource Web Site |
|         | On-line course module for Westone |
|         | Benchmark Furniture Online Catalogue |
|         | Curriculum Council web site |
|         | Medical web site for Edith Cowan University |
|         | Cancer Foundation web site |
|         | Race around Edith Cowan University |
|         | Indigenous Art 1 |
|         | Indigenous Art 2 |
|         | SCAM Website |
|         | Photomedia web site for Edith Cowan University |
|         | Ecotourism web site |
|         | Solo Travellers Club |
|         | Wine Club |
|         | iMac Touch Screen |
|         | Scammers Association |

*Table 2: Multimedia projects created by the students*

## The student learning process

The framework used in this course to promote the student-learning process is shown in Figure 3. It is focused on using learner-centred strategies, which encourage learner independence and peer support, which in turn promote the development of professional skills and process knowledge. These then directly contribute to deep and meaningful learning experiences.

Also, as part of the authentic learning task, students had to share their knowledge with their industry partners, who in many cases were not fully informed about online design and the potential of technology. This experience raised industry awareness about

opportunities for business promotion using the web, while industry partners assisted students by briefing them on market needs, business practice, commercial, legal and ethical constants. So, not only do the students gain experience by liasing with clients, but the clients also benefit by the reciprocal relationship and exchange of knowledge. In this way the learning transaction was based on the notion of partnership.

## Development of management skills online

An example of how the Listserv was used to promote peer learning and collaboration is as follows. The unit had 72 students, and the number of posts made to the Listserv over the semester was 1035 in total. In the example given below, a student is seeking help on a difficult issue i.e., how do you develop web sites which are compatible across all browsers? This problem has no real solution and is also a problem for professional developers in the industry. So this is a rich, authentic topic for discussion, in which students can assist their peers by giving their opinions or help on the issue. In this case, the students received 12 responses.

These examples shows how students support each other through a virtual community and in doing so develop skills in communication, problem solving, and giving/accepting positive criticism. In the final evaluation of the course, both industry experts and students were asked to self evaluate their own performance and to give examples of how they had demonstrated management skills. As the process had been team based, this as undertaken in teams rather than individually. The partnership approach was therefore taken to its logical conclusion and used for evaluation purposes. Rather than seeing the group as a barrier to individual learning, we saw the learning opportunities in an expanded way and give groups the opportunity to talk about their achievements. Table 3 show some comments made by students on the skills they developed.

| *Management of Self in a team context* | *Manage information to benefit the team* |
|---|---|
| Manage group time<br>Agree on objectives, priorities and standards<br>Take responsibility<br>Listen actively<br>Be patient and sensitive<br>Allow other ideas<br>Be flexible<br>Plan ahead<br>B constructive<br>Cope with conflict | Find up-to date information<br>Know ho to interpret information<br>Check that information is correct<br>Present information professionally<br>Respond to client needs<br>Test ideas first |
| *Management of others in a team context* | *Manage the task to ensure team success* |
| Listen to the views of others<br>Work cooperatively<br>Give feedback to others in the group<br>Lead by example<br>Negotiate and talk openly<br>Try to reach consensus<br>Give an take ideas<br>Try to reach agreement | Keep track of time<br>Don't; overspend<br>Set deadlines priorities<br>Identify options<br>Plan a course of action<br>Track changes<br>Assess the product |

*Table 3: Self-evaluation comments by students*

Other feedback received form student shows how they valued the partnership approach:

*The example is a brainstorming session our group had at the beginning of this multimedia skills and expertise accumulated over the period of the brief. I know you are probably saying, so what! Or that's the way it's supposed to happen! But as we all know... how well the team works as a team becomes crucial to the success of the project and/or your own personal learning and goals… In this situation the learning and/or achievements (successfully applying knowledge, skills and expertise) are not through individual pursuits but are attained only as a group. In other words, it wasn't one individual but the group as a whole that realised the depth of the problem and devised the solution for our site. A long winded way of saying that the "wheel" was a collaborative team effort where thoughts and ideas were explored, elaborated, refined, abandoned, perfected, etc, etc, etc. until a final solution was reached.*

## Critical success factors

In this partnership project, all the strands and activities were integrated so that all stakeholders felt a sense of achievement and participation. It was important too that clients felt part of the process, and this was achieved by having an evening launch of the project completed by the students, with clients and industry representatives invited to view and comment on products.

The success of the unit can be attributed to the following factors.

- A virtual community was formed through the use of a Listserv, which encouraged collective and collaborative learning rather than individualistic. The online social environments provided scope for group interaction, sharing and discussion and in depth exploration of issues.

- The content of the course was opened ended, and students had access to a website where they could add resources or choose the most relevant ones (see Figure 3). Access to relevant knowledge resources was one of the "just in time" approach to planning, i.e. the choice of selecting resources is left to students who have to identify a learning need;

- The development of networked collaborative learning requires a focus on the processes of collaboration, and the well-being and development of the collaborative group (McConnell, 2000). In summary, this involves:

    o openness in the educational process

    o self-determination in learning

    o a real purpose in the cooperative learning process

    o a supportive learning environment

    o collaborative assessment of learning

    o assessment and evaluation of the ongoing learning process.

The notion of professional development and growth was recognised by learners to be more important than learning facts, figures and project management procedures. Students had to work closely with an industry client, develop a project brief and then communicate and negotiate the final product to a group of peers. Reciprocal learning and peer partnerships enabled students to reflect on the experience and learn from it. This was

reinforced by students competing a contract in which they specified their topic, team role and project deliverables.

- The Listserv was treated as a mainstream activity which replaced face-to-face classes, and was integrated into the assessment system.

- The industry partnership involved students dealing with authentic commercial, client and technical problems in the workplace and using the Listserv to ask for advice and share experiences.

- The tutors acted as a facilitators and not experts by fostering discussion rather than responding to questions; dealing with inappropriate responses offline and identifying underlying issues and redirecting these as questions back to the Listserv for students to reflect on and discuss where appropriate.

## Evaluation of the environment

In additional to a successful useability study of the learning environment, the evaluation questionnaire conducted at the end of the unit it appeared that the students were very positive about the structure of the unit and the use of the Listserv. Almost all the students wanted to remain subscribed on the List as a form of graduate Listserv (as well as offering advice to other students who will be enrolled in the future). Grounding the industry project in a commercial environment with the use of a Listserv for inter-team and inter-student communication was clearly successful, and added value to the students' experience in this unit.

## Conclusion

The study illustrates an effective approach to developing professional skills through e-learning, which was integrated into the final year of tertiary multimedia course. Through authentic settings, students were engaged with real industry projects, clients and assessment tasks. This was complemented with a virtual environment in which students exchanged ideas and helped each other cope with these authentic tasks. The online environment, in combination with client negotiations, promoted the development of professional skills and process knowledge, which supported the process of professional knowledge building. The design of this partnership project was motivated by the realisation that the needs of learners are changing rapidly and continually in response to an environment that is characterised by change at economic, political and technological levels. There is greater pressure on universities to work more closely with employers in contributing to the development of a skilled workforce, with relevant transferable skills.

Perhaps the most significant effect of e-learning is the rise of different conceptions of learning and of knowledge production. In contrast to the value placed on factual knowledge in traditional programs, *just-in-time* developments mean that competence and skills may depend on rapid responsiveness to industry needs and opportunities. While customisation is important, student must connect with faculty and classmates and develop community via e-learning. In the case study presented here, project based learning via the Web was blended with face-to-face seminars to bring about significant learning outcomes for participants, and supported personal, professional and interpersonal skills.

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# CHOREOGRAPH3D: collaborative innovation through dance and multimedia.

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**Abstract**   This paper discusses collaborative project which has been integrated into a course in 3 Dimensional Modelling and Animation at Edith Cowan University. This has traditionally proven to be a difficult unit to teach because of the complexity of 3D modelling applications and the need for students to work on an authentic project. This year has seen multimedia students collaborating with students of Dance at ECU's Academy of performing Arts to create an abstract dance piece that integrates real-life choreography with student 3 Dimensional animation. This work, CHOREOGRAPH3D, is demonstrating a potential for enhancing motivation with the use of a highly situated task and improved learning outcomes through the process of Collaborative Innovation that has been instigated.

## Introduction

IMM2224 is a unit in 3 Dimensional Modelling and Animation using Newtek's *Lightwave* software that is taught as part of the second year core of the Multimedia stream in Edith Cowan University's Bachelor of Communications degree. For some students, it is a unit that they would prefer never existed. To describe it as challenging is something of an understatement. Previous unit evaluations have characterized issues with regard to both the conceptual and technical aspects of the course, as well as negative perceptions of the students' own expectations of themselves.

To understand the reasons for this, it is worth examining the nature of 3D as a field within Interactive Multimedia. Of all the media components, it tends to operate on a visceral as much as intellectual level. Students are used to seeing high quality animation used in films such as *Toy Story 2* and *A Bug's Life*, as well as the use of 3D as an attention grabbing tool within advertising. It is also a key component of contemporary video gaming and is prone to much of the same hype that surrounds Virtual Reality, with its promise of photo-realistic 3 dimensional imaging (Reingold, 1992).

The reality for students, however, is more modest. As figure 1 demonstrates, the sheer complexity of professional 3D modelling environments have compounded with the lack of experience of students to make it a unit that can be quite frustrating. Most students perceive their career path to be one in Web Development, Multimedia Programming, or Project Management. While some students show a definite interest in 3D as a development tool, few have any experience in this area, indeed having students work conceptually in a 3 Dimensional environment rather than designing for a two dimensional screen proves to be one of the greatest initial challenges each year.
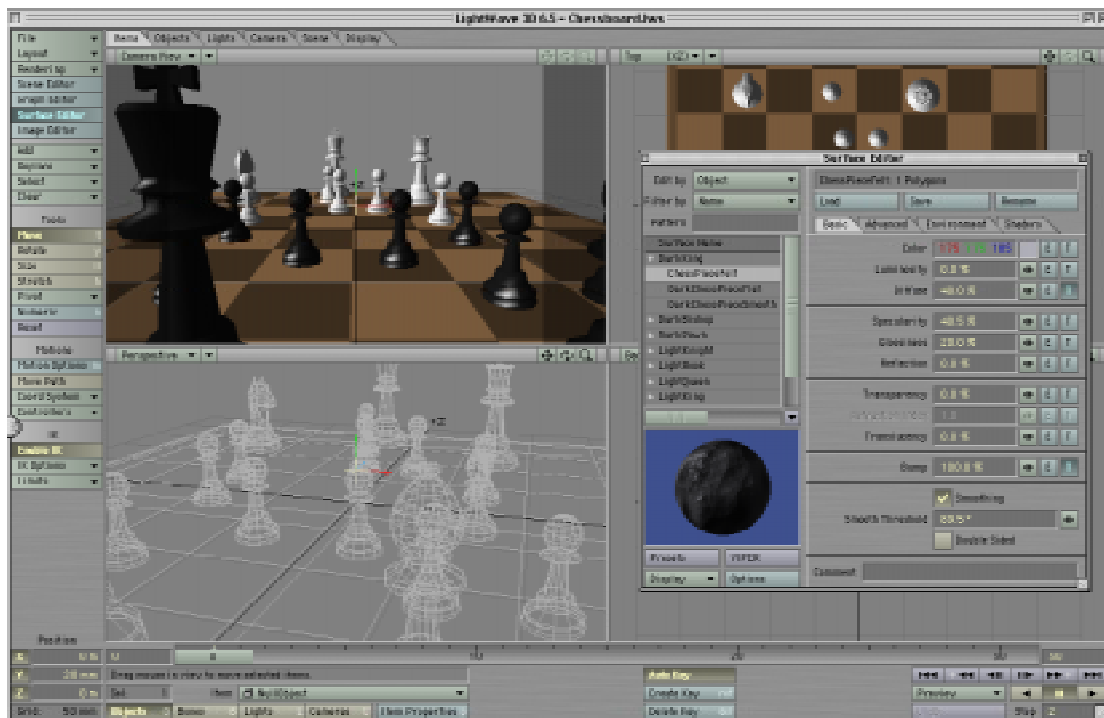
*Figure 1 - The Lightwave Environment*

The traditional approach to teaching this unit has endeavoured to compensate for these issues. In order for students to have a 'real' learning experience, there has always been a focus on having students develop actual video product, typically this has been done with students individually creating 3 dimensional models of toys then developing a story around them which is animated and edited as digital video. In taking students from the modelling of primitive forms to the creation of fully animated video, however, students are immersed in a complex and somewhat intimidating learning experience. Group work has been used to overcome some of these issues, but since other than their tutors most contact is with other students who are novices themselves, the learning curve has proven to be very steep.

This year, a different approach is being adopted through having students work on a collaborative Dance project with students from Edith Cowan University's Academy of Performing Arts. While the unit has remained the same in terms of its scope and conceptual outcomes, the actual complexity of student activity has been made more manageable. Learning outcomes have been enhanced by having students develop conceptual and practical 3D skills through motivating and authentic tasks, with a focus on collaborative innovation.

## About CHOREOGRAPH3D

The CHOREOGRAP3D project had its inception in a work produced by Chrissie Parrott which uses keyframe animation generated by the software *Life Forms*. The actual modelling that *Life Forms* does is unsophisticated, however it provides a highly effective medium for creating animations of human movement, with preset templates for physical motions such as running, bending, falling and so on. These movements are then seamlessly joined by a powerful interpolation engine that is built into the software.

The current iteration involves second year diploma students of the Academy of Performing Arts' Dance department. CHOREOGRAPH3D is an abstract work that is

grounded in the aesthetic that is generated by the *Life Forms* software. Phrases are created by *Life Forms* and then reconstructed in real life by the dancers.
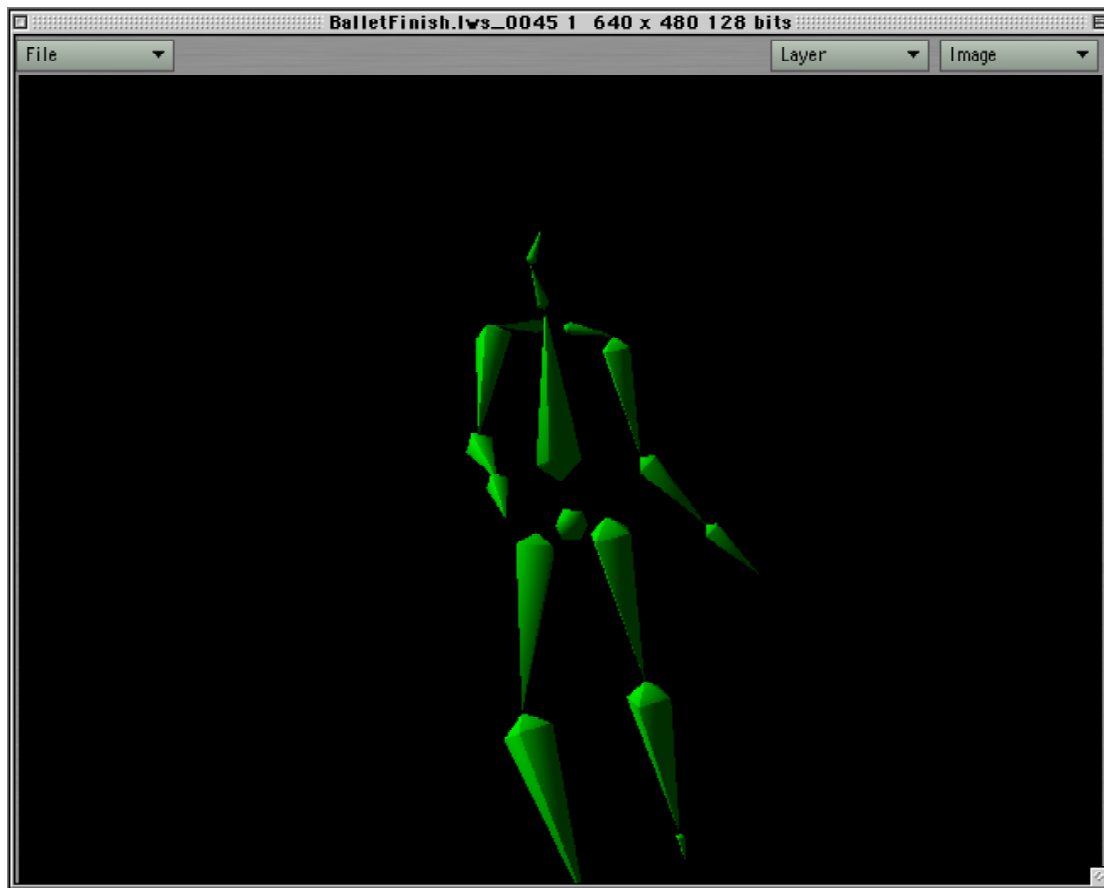


*Figure 2 - Life Forms Geometry*

The role of the multimedia students is to take the very basic geometry for the human form that is output by *Life Forms* (figure 2) and to use another 3D package to recreate the models. *Lightwave*, with its highly sophisticated approach to modelling and surfacing and its impressively photo-realistic render engine is the ideal medium for enhancing the characters which are then animated according to the *Life Forms* keyframe data (figure 3).

The work is guided by an aesthetic focusing on the subtle distinctions been organic and non-organic movement. While *Life Forms* animation is somewhat realistic, it is not *quite* convincing. The software curtails the boundaries of natural movement and when this is manifest in real human motion on stage the effect for the audience can be somewhat startling.

The overall impression is one of distance. A proscenium is generated that is larger than the performance on the stage. 3D video created by the multimedia students is projected behind the dancers on a large screen. The human becomes an artefact subordinate to the technology, while at times the reverse is true — the animation is given a palpable human quality by its interaction with the real life dancers.

*Figure 3 - Enhanced Modelling in Lightwave*

In summary, this is a project which has potential benefits both for dance and multimedia students. The opportunity is provided for each to engage in each others' realm and learn from that. The learning approach is grounded in an authentic activity but is not bound by the conventions of a traditional curriculum.

## Theory of Teaching & Learning

### Situated Cognition

Situated Cognition argues that knowledge is developed as the product of the activity, context and culture in which it is developed and used (Brown, Collins & Duguid, 1989). The enabling processes for this knowledge development are apprenticeship, collaboration, reflection, coaching, multiple practice, and articulation. To an extent, such processes have always been integral to IMM2224. The role of collaborative development teams articulating knowledge through the creation of 3D video has allowed many of the higher order outcomes associated with situated learning to develop. However, there were shortcomings in the original iteration of the unit which need to be addressed. In particular, it could be argued that the learning situation is still somewhat abstract and lacking in apprenticeship.

The main issue of IMM2224 is that while the task of creating a 3D movie is a fairly complex one, time constraints within the unit mean that it is still inauthentic, being abstracted several layers from the real world of film-making. While the learning is anchored in the microcontext of creating a video, the actual act itself is somewhat fatuous in that it provides nothing for the students beyond a portfolio item. They do not actually get to see their work used in an authentic situation. This *macrocontext* (Williams & Dodge, 1992) is provided by the CHOREOGRAPH3D project. Instead of having students create their own short movies, they work to a brief provided by Chrissie Parrott and

eventually see it demonstrated in a fully realized creative form. As a development group in a larger project they work as collaborative teams to produce an artefact of which they feel a sense of ownership, and for which they perceive a relevant use.

## Motivation

This issue of relevance is a central concept in enhancing students' motivation for the subject. While for some, the process of using 3D software is inherently motivating, many who do not perceive themselves as 3D artists. While rendered product has the potential to provide (almost) instant gratification, other dynamics can play a negative role on students' satisfaction with their work.

The concept of student motivation is a 'slippery' one (Williams, 1996) but a number of theories have been developed to identify the key processes involved. Keller (1983) describes it in terms of Attention, Relevance, Control, and Satisfaction (ARCS), while Malone (1980) discusses motivation in terms of Challenge Curiosity, Control and Fantasy. Implicit in both of these is the assumption that students are in control of their learning. Unfortunately *Lightwave*, while fundamentally an empowering piece of software (it is, after all a development application rather than a tutorial program) is often viewed in terms of a loss of control with students. When the software does something that is not expected, it is the software itself that is often blamed. This lack of perceived 'fairness' of the system also ties directly in with Keller's concept of satisfaction. Also, the mathemagenic nature of creating a model from a real-life toy, while a useful exercise in terms of computer aided drafting is a limiting activity for many of the students.

The importance of fantasy in creative work is highlighted by Czikszentmihalyi (1990) who identified a number of characteristics of 'flow', or optimal user experience when engaging in activities. Those with flow:

Require learning of skills

- Have concrete goals

- Provide feedback

- Let person feel in control

- Facilitate concentration and involvement

- Be distinct from the everyday world.

The initial iteration of IMM2224 was simply TOO challenging for many students. The requirement to develop skills in modelling, surfacing, camera, light, and animation AS WELL AS video, has meant that several put it off until their final semester. To a certain extent animation is one of the main stumbling blocks. It is very difficult for students to create a realistic animation from their limited experiences. The use of existing keyframe information has the potential to ameliorates this. In CHOREOGRAPH3D students get to see their models immediately animated in naturalistic ways. Also, it is most definitely distinct from the every day world. Students were briefed to create something 'beautiful' and abstract using a basic bipedal form. Working within the constraints of an existing object geometry, students still had the ability to lend their own level of interpretation to the materials offered.

**Shifting the paradigm: Collaborative Innovation**

For these reasons, the approach to IMM2224 has been to frame it in terms of collaborative innovation. This approach acknowledges the constructivist tenets of situated cognition, while promoting generative activities to enhance learning outcomes.

The collaborative aspect of the project is a crucial one. While collaboration is often associated with intellectually superior performances that can not be easily accounted for by individuals' cognitions alone (Salomon, Perkins & Globerson, 1991), it plays another important role in that it promotes a process of enculturation and the development of consensual knowledge. This is important at a process level since working in teams and for clients is integral to the Multimedia Design and Development as it is actually practiced. Perhaps more importantly though, it makes students aware of alternative approaches to their work. The focus of Interactive Multimedia at ECU is primarily geared towards preparing students to work in an industry dominated by e-commerce and information-based Web development. By collaborating with students of dance, an aesthetic as well as a functional outcome is articulated. This is something of a paradigm shift for many students. Instead of focusing primarily on the practical 'use' of their products, students are encouraged to think creatively.

Creativity can be defined as 'producing something novel an appropriate' (Martindale, 1981, cited by Battacharya & Chatterjee, 2000), with innovation as the culturally accepted end product of the process. Rutherford (1992) identifies key aspects that require attention to ensure innovation. These are: task; responsibility; resources; recognition and rewards. Each of these will be discussed in terms of the process undertaken within IMM2224

## The Process

The task for students is two fold. Their first assignment is to create a 3 dimensional model based upon existing geometry in *Life Forms* and to create several renders from different perspectives which highlight the qualities of their models. The second assignment requires the students to work in groups, using their models and the *Life Forms* animations provided to create short (1 minute) video presentations that could be used as a back drop to a real-life dance performance. Students have clearly defined roles in the development of these — the first being an individual activity, while the second involves students taking specific responsibilities with regard to the 3d animation and video production.

The resources provided are the learning materials used to teach *Lightwave*, as well as two iMac labs running both *Lightwave* and *iMovie* software. Students are well resourced in that they have 24 hour access to these facilities. They also have occasional access to the Academy of Performing Arts, gaining the opportunity to view rehearsals and to question Chrissie Parrott about the choreographic approach and aesthetic driving the performance design.

Having both individual and team components allows students to be recognized for their own unique work within the final product. Also, the actual performance is intrinsically rewarding as it provides a public outlet for their work.

Challenges

The actual process involved is not without its difficulties. The system specifications for *Lightwave* are very high. Existing as two separate applications, Layout and Modeller, it is difficult to have both running at the same time on a machine with only 128 Mb RAM. *Life Forms*, too, has some inflexibility in terms of the output generated. It takes a segmented approach to 3D modelling, outputting the various components as separate objects that are

then assembled in the Layout program. While this is an effective way of working, using hierarchically parented objects to create the characters' movement, *Lightwave* also offers a sophisticated 'single mesh' approach to animation where the joints of the characters are articulated through a 'bone' structure. This is covered in the course, and students are encouraged to use this approach within their final videos, however it does not work with the character movement as generated by *Life Forms*.

While it would have been ideal to have Multimedia students actively interacting with the dance students, the numbers involved, and workload required from each group made this impossible. This issue is tackled by students having access to examples of each other's work as it developed, to enhance the innovation process. For example video is made available in digital format for multimedia students to observe dance rehearsals if they are unable to attend. Having teams work collaboratively but in a distanced mode also means students are less bound to the expectations of the other group, which enhances the freedom of expression afforded to both.

## Opportunities

For the multimedia students, CHOREOGRAPH3D provides a palpable opportunity to think different. Unconstrained by traditional expectations of the course by working at a purely aesthetic level, some students are finding a creative vein that they previously may not have been able to tap. While the original assignment of modelling real toys was an effective approach to 3d drafting, the opportunity to create a fantastical character more abstract in nature has already manifested a great deal of enthusiasm from the students.

Also, traditional 3d animation, particularly in the gaming world, is characterised battle simulations and spaceships; indeed some of the class activities have involved creating robots and other such artefacts. To a certain extent this may have disenfranchised the female students (who actually make up more than half of the multimedia cohort.) Some 3D environments are starting to break this mould, for example the Tombraider game, which uses a strong female character as its central character, however a brief examination of the physique of Lara Croft quickly identifies her as a projection of male fantasy rather than a realistic female role model. The non-violent but open ended nature of the CHOREOGRAPH3D project is one which is appealing to both genders.

Best of all, students who normally would be quite distanced from each other in their approaches are having the opportunity to interact, albeit in a sporadic form. Suzie Esiner (2000) writes of a liberating effect of a project which was designed to get dancers and musicians collaborating, and the benefits to each in the secondary learning outcomes which result from being exposed to each others' craft. In IMM2224, students are able to develop a stronger conceptual understanding of Human Movement through seeing it modelled and modifying it themselves, while the dance students are exposed to the possibilities of technology and the aesthetic opportunities of non-organic movement to enhance their own work.

## Conclusions

Futurist and VR innovator, Jaron Lanier (2000) has spoken about the role of creativity in bridging the bounds between technology and humans:

> *What I am hoping to do [is] promote a sort of a balanced attitude towards technology and aesthetics, in which you neither shy away from nor worship technology, but enjoy the rush of being able to create entirely new things with it,*

*and also be able to appreciate its potential for bridging the gaps between imagination in ways that not could be done without it. I think that makes it a wonderful thing, but its only value is in its ability to bridge gaps between people. All the ultimate value comes from people still. That's where I think the relationship between artists and technology goes wrong so much. People try to treat technology as an object, and it can't be. It can only be a channel.*

The project is still in its early stages but it has been gratifying to note that although only a recommended approach to their modelling work, nearly all of the IMM2224 students have chosen to create models that can be used as part of CHOREOGRAPH3D. By the time that this paper is presented, examples of the final work will be shown. At this early stage, students have been enthusiastic about it. It has provided a motivational 'hook' for those that may normally be uninspired by 3D animation as a subject, both as a result of the situatedness of the activity and the ability to reduce some of the complexity of the learning while still ensuring sound educational outcomes. Most importantly, through the dynamic of collaborative innovation that is being generated, it really does provide and opportunity for students to work together using technology as Lanier would like it to be — a channel for bridging gaps between aesthetics and functionality, but also between people.

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# MacQT$_E$X: self-testing quizzes, using PDF

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**Abstract**   The MacQT$_E$X quiz system uses JAVAScript [1,6] embedded within PDF documents [4] to allow students to do multiple-choice style quizzes. The internet may be used to supply the quiz document, and to record results. But even when not connected, there is immediate feedback as to how many questions were answered correctly and what are the correct answers, as well as providing worked solutions indicating how the correct answers could be deduced.

The highest quality of typesetting is employed in the quizzes by using the T$_E$X typesetting software [7], via the pdf-T$_E$X variant [9], to control the generation of the PDF documents [4]. Other software, such as *Perl* [10] and *Mathematica* [11], can be used to control the production of unique instances of a particular quiz so that each student gets slightly different questions to answer.

## PDF Quizzes

At Macquarie University the Mathematics Department has been developing[1] a web-based system for producing quizzes which allow students to test their knowledge of mathematical ideas required in the courses that we teach. Currently these quizzes are used mainly at the most elementary level, for revision of the basic skills which the students should have acquired from mathematics courses at high school.

The current version of this quiz facility provides students with a multiple-choice answer quiz, of typically 10-12 questions, as a PDF document [4] downloaded from a web-site (figure 1). This document is an interactive form, controlled using embedded JAVAScript [1,6], which allows a student to read and work with the document, using the Acrobat Reader [2] plug-in to his/her favourite web-browser (figure 2). After starting with the "Begin Quiz" button (figure 3), answers may be selected and changed until the quiz is completed. Upon pressing the "End Quiz" button (figure 4), results of the student's attempts are submitted to a server for recording, provided that the network connection is still available. The embedded JAVAScript then provides a means for the student to see which were the correct answers for each question (figure 4). Worked solutions, which were hitherto hidden, become available for reading and/or printing. A high quality presentation, both on-screen and when printed, is achieved by using the most up-to-date method of generating PDF documents [4] using the T$_E$X typesetting software [7,9]. This is especially important for the presentation of mathematics. Figures 3 through 7 show a sample of quiz questions and worked solutions.

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## Training not Testing

The aim of the quizzes is not so much for assessment as for self-testing and practice of material covered previously in lectures or back at school. At Macquarie, this is very valuable as our students come to University with a wide range of abilities and mathematical backgrounds. For many students it has been several years since they last studied any mathematics, but perhaps only a refresher is needed. For others, their main area of study is not mathematics at all, so there may be gaps in their mathematical knowledge which need to be identified. We do not have sufficient staff to bring every student up to the level that would enable them to most easily cope with new material in the courses which they are about to undertake. The quizzes can be used by students to identify for themselves where they are weak and may need to seek the extra help that can be provided.
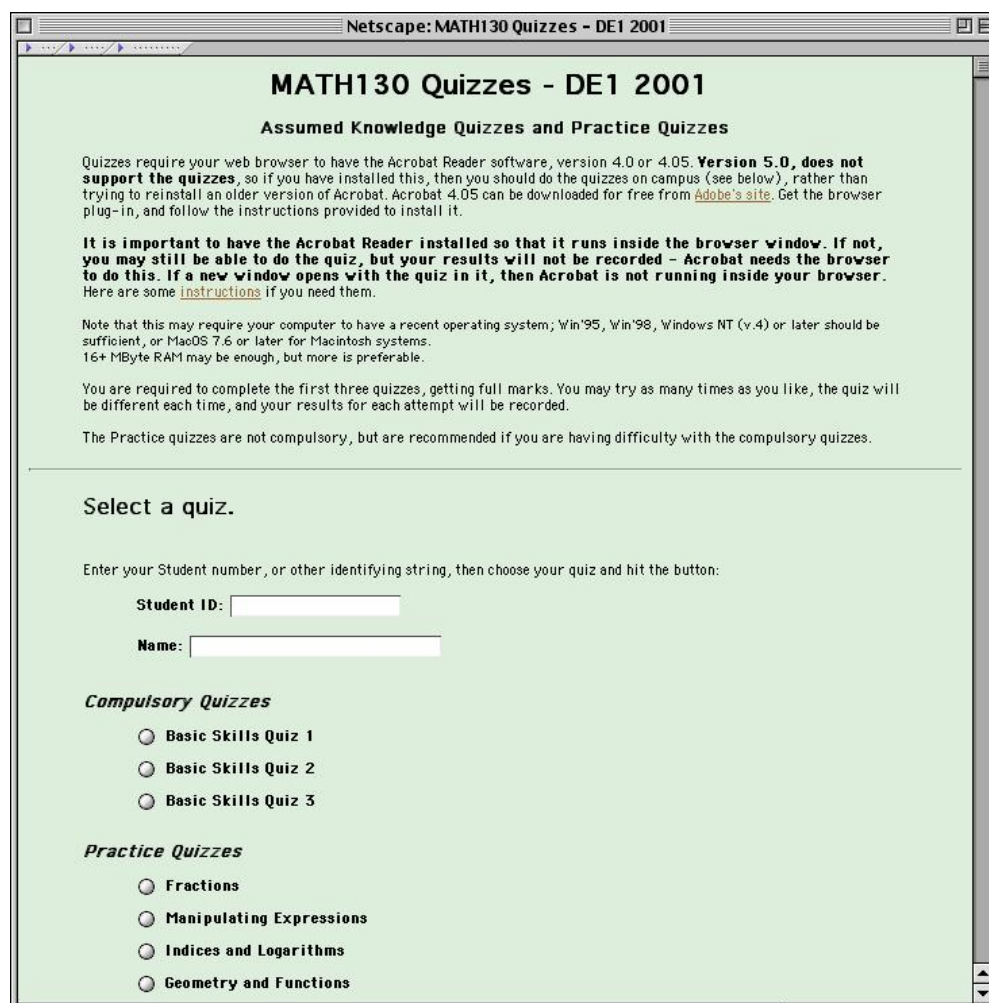


*Figure 1. Quiz-site (at http://www.maths.mq.edu.au/~chrism/math130/MATH130quizzes.html) from which students can download the compulsory quiz documents. Username/password are required for recording accesses and results. Also from this site they may download practice quizzes, devoted to a particular mathematical concept. Guest access is also allowed for all quizzes.*

## Each Quiz is Different

An element of randomisation has been incorporated into the generation of the questions for the quiz documents. Thus a student may attempt the 'same' quiz many times; but each time it will be slightly different. Since we teach mathematics, it is not hard to have some numerical aspect of the quiz being different for each instance. On the system that we

currently employ for the elementary-level mathematics course, this is achieved using the *Mathematica*[2] software [11] to generate the exact contents of each question and its worked solution. Randomisation is applied also to the specific choices presented as possible answers to a particular question, and to the order in which the choices are presented. Thus a student cannot 'cheat' by presuming, for example, that the correct answer to question 5 will always be 'b'. Indeed students are encouraged to repeat the same quiz as many times as is necessary to achieve a score of 100% correct.

## Logging Access and Answers

Part of the site administration is to keep a record of all attempts to download quiz documents from the site, and the return of results from completed quizzes. As well as this, records are kept of each student's access, which instance of a randomised quiz they received, what were the correct answers for that instance, and what results were obtained by the student.
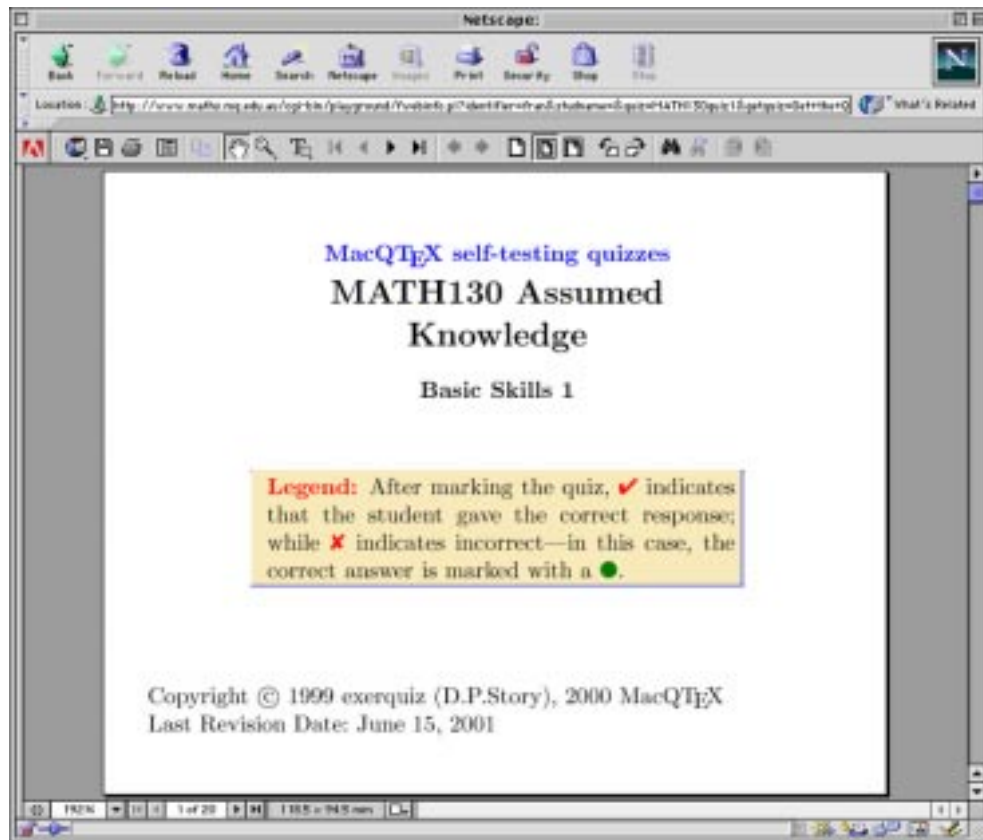


*Figure 2. An opening page to a typical quiz.*

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[2] *Mathematica* is a trademark of Wolfram Research Inc. [11]
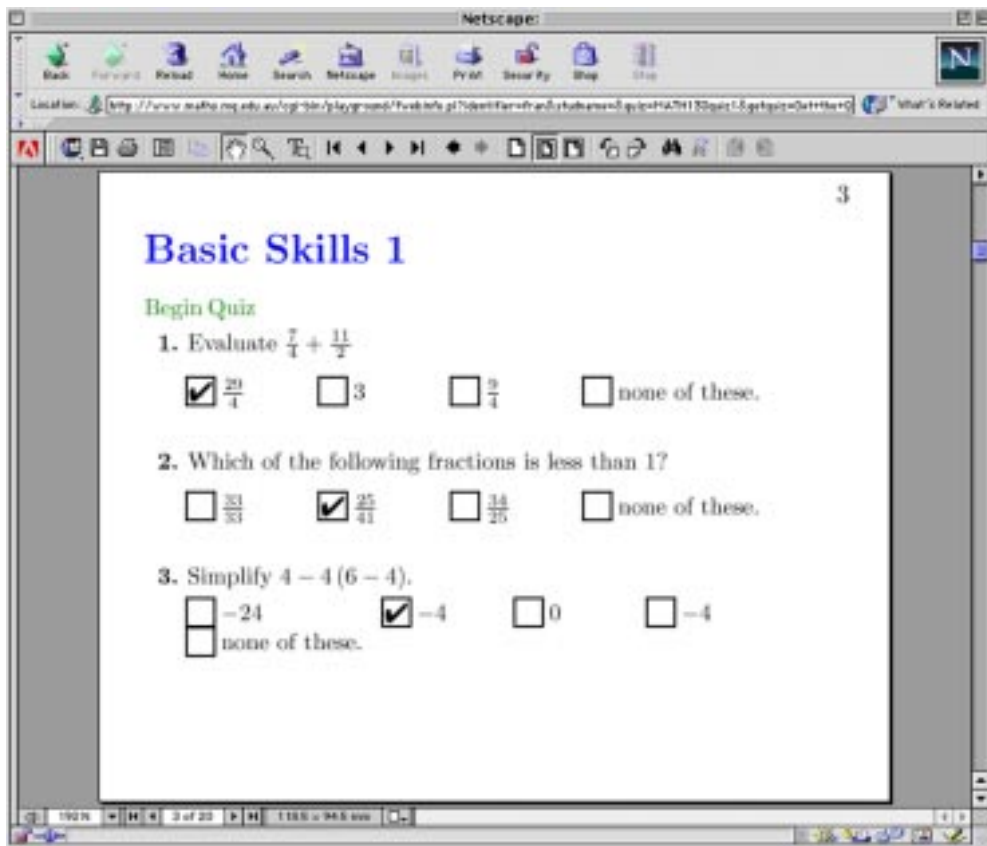
*Figure 3. First page of questions, with "Begin Quiz" button and user-selections.*

8



End Quiz Score: 11 out of 11     Correct

Congratulations Frances, on scoring full marks. There should
be no need to repeat this quiz, unless you wish to do so for
further practice.

*Figure 4. Last page of questions, after having selected the "End Quiz" button, showing the
total score, and confirmation message.*
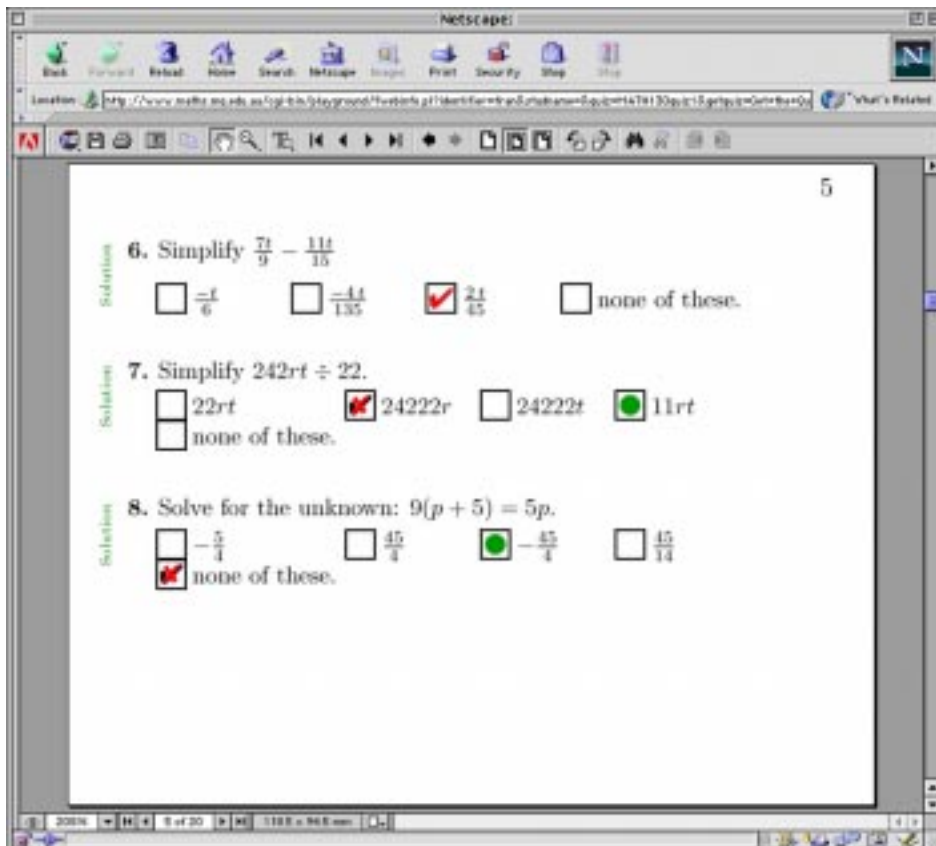
*Figure 5. Embedded JAVAScript [1,6] is used to show the correct answer, when the student has made an incorrect choice. Also visible are buttons, previously hidden, which link to worked solutions.*
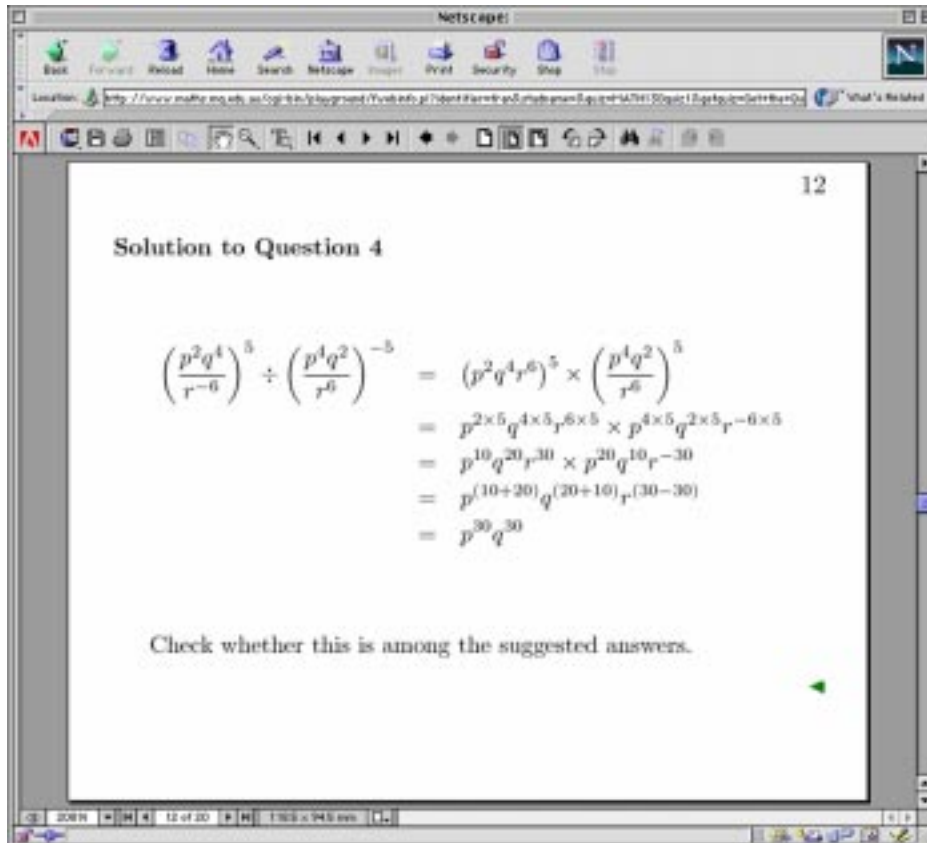


*Figure 6. Worked solutions use properly typeset mathematics, as do the questions themselves. This one makes substantial use of mathematical symbols and equation alignments.*
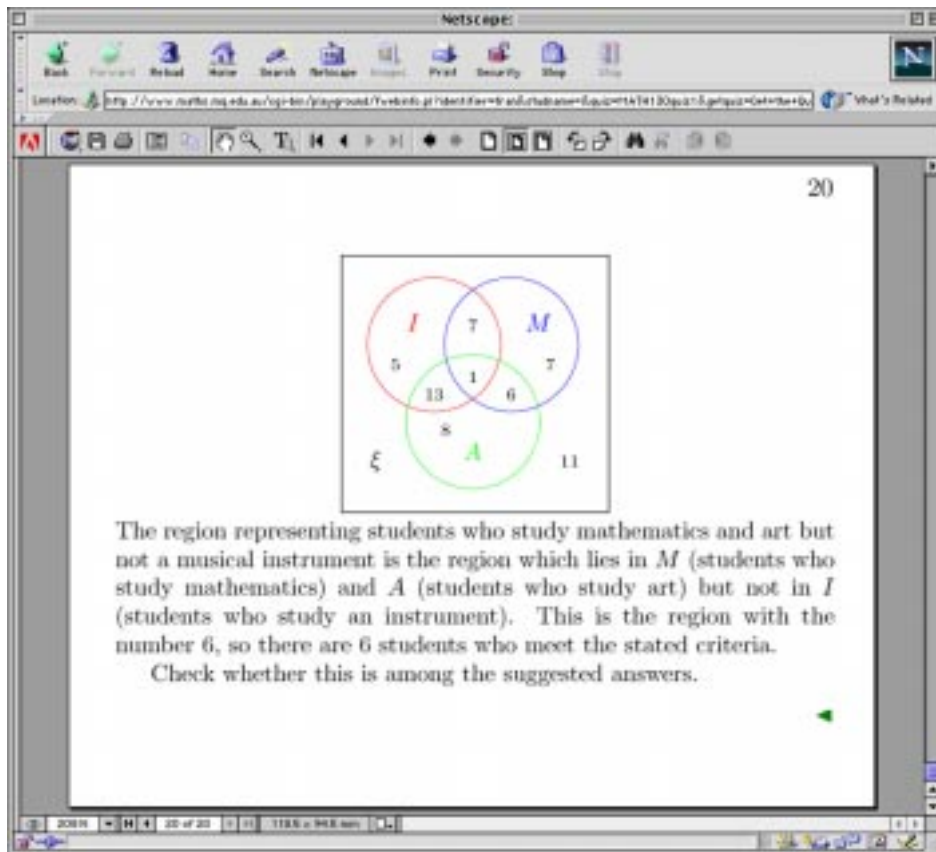
*Figure 7. Elegant mathematical diagrams can also be used, both in the quiz questions and worked solutions.*
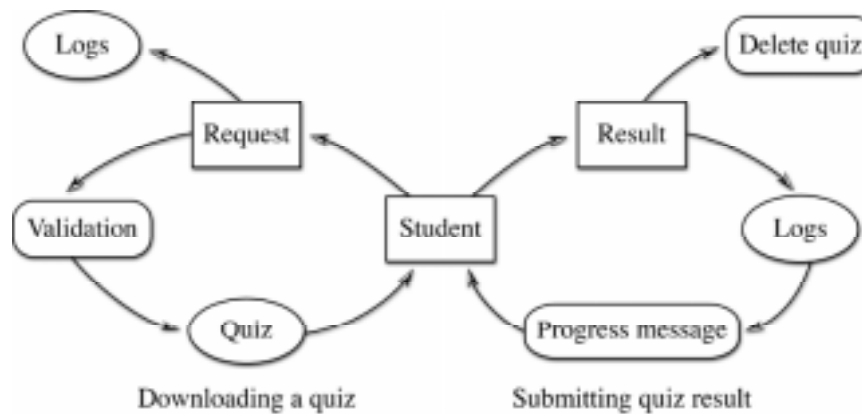


*Figure 8. When a student requests a quiz, the student's identity is first validated; if authorised, the quiz is sent to the student's browser. A record is kept of all request details. After completing the quiz, submitted results are recorded in the student's log and in the overall quiz log. A personalised message concerning the student's progress is returned as FDF data [3]; this appears in a form field at the end of the PDF quiz document.*

The flow-chart in figure 8 indicates the interaction that a student has with the delivery and recording aspect of the overall system. Part of the "Validation" step is to set up the personal log-file for the student, or to append the new access information to an existing log-file. This same log-file is used to record the results obtained in each quiz instance accessed by the student. The information is available to the student, as shown in figure 9. Such pages can be reached from the initial quiz-access page (figure 1).

*Figure 9. Students can view the contents of the file which logs their own attempts at the quizzes and records their results. Such pages are produced "on-the-fly" using a CGI interface, based upon a student's ID code. Instructors can also produce such pages, to easily see where a student is having difficulties.*

## Evaluating Student Progress

The student log-file pages are also accessible from the staff interface page (figures 10 and 11); in fact all quiz logs can be viewed from here, including the raw log for any student and HTML formatted data extracted from all the logs (figures 12 and 13) for a particular course. This includes information such as the number of students who have attempted and/or completed the quizzes, the average number of attempts needed to complete each quiz, the maximum number of attempts taken, and the number of students who have downloaded each quiz, even though they have not been able to return any results (e.g., due to incorrect set-up of Acrobat Reader [2]).

Thus an instructor may assess the levels of usage of the quizzes, how difficult the students are finding them, and how the class is progressing in general. The ability to view the raw logs makes it possible to diagnose technical problems that students have, such as using browsers which don't support Acrobat forms [1,3], accessing quizzes on campus from computers known not to be configured appropriately, and even tracing crashing problems on a student's computer to the day the browser software was upgraded!

## Designing a Quiz

A bank of questions is available for constructing new quizzes. These cover 12 areas of basic mathematics, with up to 6 specific types of question in each area. Currently a new quiz is designed by choosing options in a form at a web-page (figure 15) accessible only with a password. This is only the first step in the process of creating quiz instances to be

available for student use. The flow-chart in figure 14 indicates the main steps in the whole process.

After the choice of questions has been submitted, along with a directory name for the new quiz, a sample quiz document is generated and returned to the instructor for inspection. Editing of the L^AT_EX sources for the quiz is allowed (figure 16), as is adjusting the selection of quiz questions. When completely satisfied with the format and layout of the quiz, 50 randomised instances of the PDF quiz document are generated. Student log-files are set up. Now the quiz is ready for general access.

Each student access delivers the next in the sequence of 50 prepared instances. When the store of quizzes runs low, a script is triggered to automatically generate another 50 instances. (This number can be changed as desired.) Each instance of the quiz is unique, with the random aspects to the questions being created by *Mathematica* [11]. An interesting problem exists here, in that it is easy to program correct answers; but the incorrect answers must be believable also. By studying common mistakes that students make, it is possible to program *Mathematica* to make these same mistakes, thus providing some very tempting wrong answers!

Further development of the system will be to create an easier interface for all of the stages of generating and checking new quizzes. For MacOS X, this will be an application[3] that can be run on the same server on which the quizzes are built. This should be much faster than using the existing web-based interface.

## Other Features

To facilitate managing the quiz system there are several options available. These include the following.

- An old quiz instance can be recreated from its numerical identifier. This is important so that an instructor may recover the exact questions that confronted a student who is seeking further help. It is also useful in case a student reports a problem with a particular instance of a quiz, indicating some sort of programming error (e.g., duplicated alternative answers, or a correct answer being declared incorrect, or vice versa).

- Existing quizzes may be edited in a number of ways. A quiz can be duplicated or edited in place, and alterations made to the title, topic or question choices. In addition, certain text-only files may be downloaded for hand edited to change aspects of wording or layout, then returned to the server. After a quiz has been edited, the logs and quiz counters reset, and existing logs archived. This is desirable when the quiz is to be reused for a new class.

- House-keeping activities, such as removing quizzes that are no longer needed, can be done through the web interface. It is also possible to reset the quiz logs, archive these logs or delete old log archives.

- An HTML student-login page can be designed automatically. This includes the form fields and JAVAScript [1,6] necessary to reduce user error (e.g., omitting the login name, forgetting to choose a quiz, checking for the browser plug-in, etc.). The page can be downloaded and edited further to include information specific to the course for which the quiz is intended. It is not necessary to store the login page with the quizzes themselves; for example, it can be kept with other online materials for the course.

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[3] The authors and development team wish to thank the AUDF for providing an Apple server and another machine for the development and testing of this application interface.

*Figure 10. This page shows the interface for staff and instructors. It allows access to all of the log-files for the available quizzes, and for individual students. Information can be viewed in the raw text form, formatted as HTML tables, or some statistics can be collected from the logs. The page can be quite long; figure 11 gives the continuation after scrolling.*
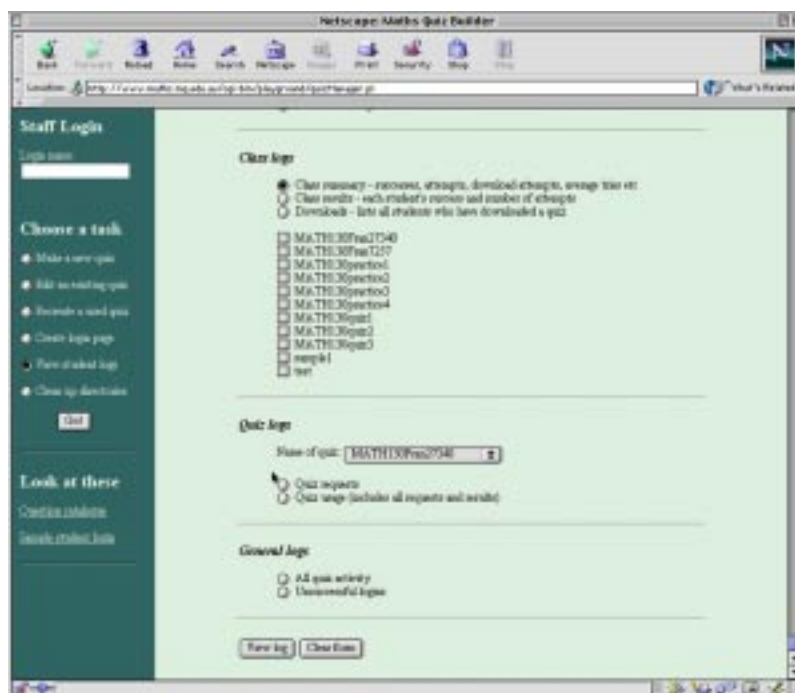


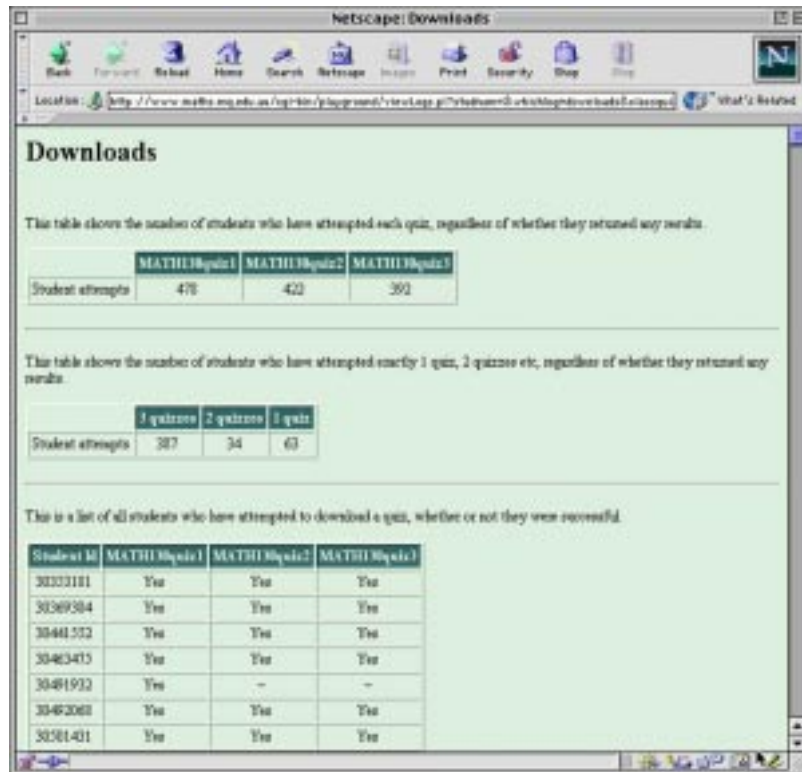*Figure 11. Continuation of the "staff-access" page, as described in figure 10.*

*Figure 12. Summary statistics of the results of the quizzes for all students taking a particular course.*
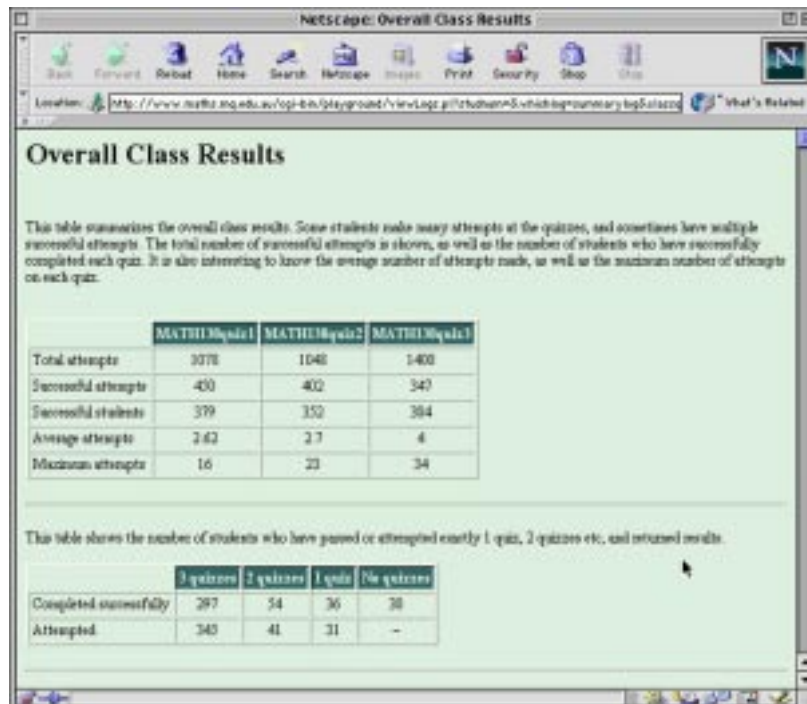


*Figure 13. This page gives, for a particular course and set of quizzes, information concerning which students have attempted which quizzes.*
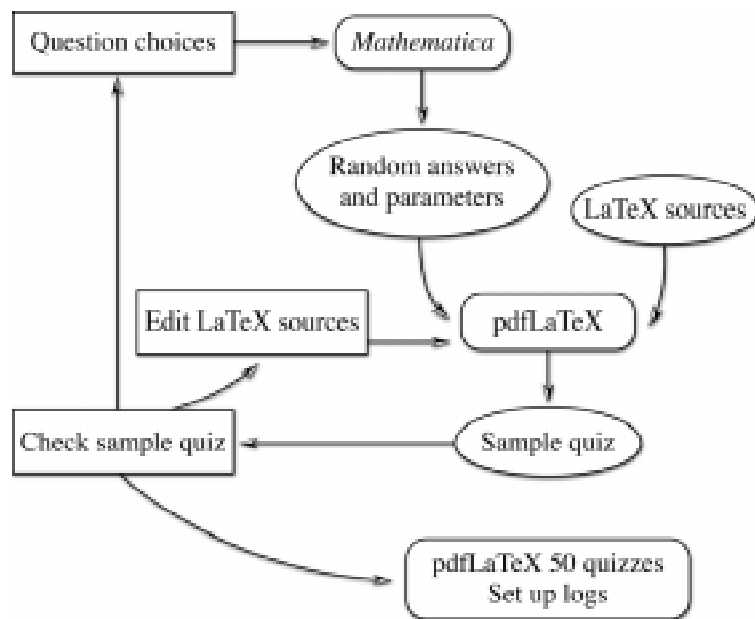
*Figure 14. The questions for a new quiz are chosen using an HTML form. When randomisation is required, these selections are used to create input for the Mathematica [11] program, which outputs parameters specific to each quiz instance, both for the answer options to each question, and for the worked solutions. These are combined with existing L^AT_EX [7] sources which control the overall layout, and processed with pdf-L^AT_EX [9] to produce a sample quiz in PDF format [4]. This is checked by the user, who has the option of making detailed edits to any of the L^AT_EX source files, changing selections, or rejecting the whole quiz and making completely different selections. When the sample PDF is finally deemed to be acceptable, the first 50 quizzes are generated, to be available for student access.*

## Software & Programming Languages

For the MacQT_EX quiz system to work, many different programming languages have been used to automate the various tasks. Here is a brief summary.

### web interface

This is done using HTML, with some static pages and other pages (e.g. pages showing the class activity and individual student's log-files) being generated "on-the-fly" via CGI interfaces, currently implemented using *Perl* [10]. Similarly *Perl* is used to respond to requests to access a quiz document; for recording student information and access-details, as well as selecting a unique quiz document to send via the web-server.

### typesetting

The high-quality typesetting and layout of the PDF quiz documents is done using pdf-T_EX [9], with the L^AT_EX macros [7] controlling most aspects of the page-layout. A modified version of the `exerquiz` macros [8] controls the specific layout of the quiz documents, and the inclusion of embedded JAVAScript [1,6] coding to control the interactive effects.

However, before any typesetting can be done, the complete job needs to have been carefully orchestrated. Dozens of files may be required to construct a single quiz. This is handled by *Perl* [10] scripts which, among other tasks, initiate the use of *Mathematica* [11] when randomisation is required, and collect together all of the resulting pieces.

**randomisation**

The uniqueness of different quiz instances is controlled using *Mathematica* [11], though other programs could be used instead. The requirement here is for a program that can do mathematical calculations as well as manipulation of character-strings, and be able to write the results directly into files as L^A^T~E~X source [7] capable of being understood by pdf-T~E~X [9].

**web browser**

Any web-browser can be used by students to access the quizzes, provided it has the appropriate Acrobat Reader [2] plug-in for reading PDF documents [4], or corresponding browser integration. (Alternatively, the quiz documents can be downloaded to disk and read as stand-alone documents, outside of a web-browser. However in this mode, there can be no submission of results back to the server for recording.) Similarly, instructors can use any web-browser for the interface to the sites for creating new quizzes, and for examining the quiz-logs, or the personalised student log-files.
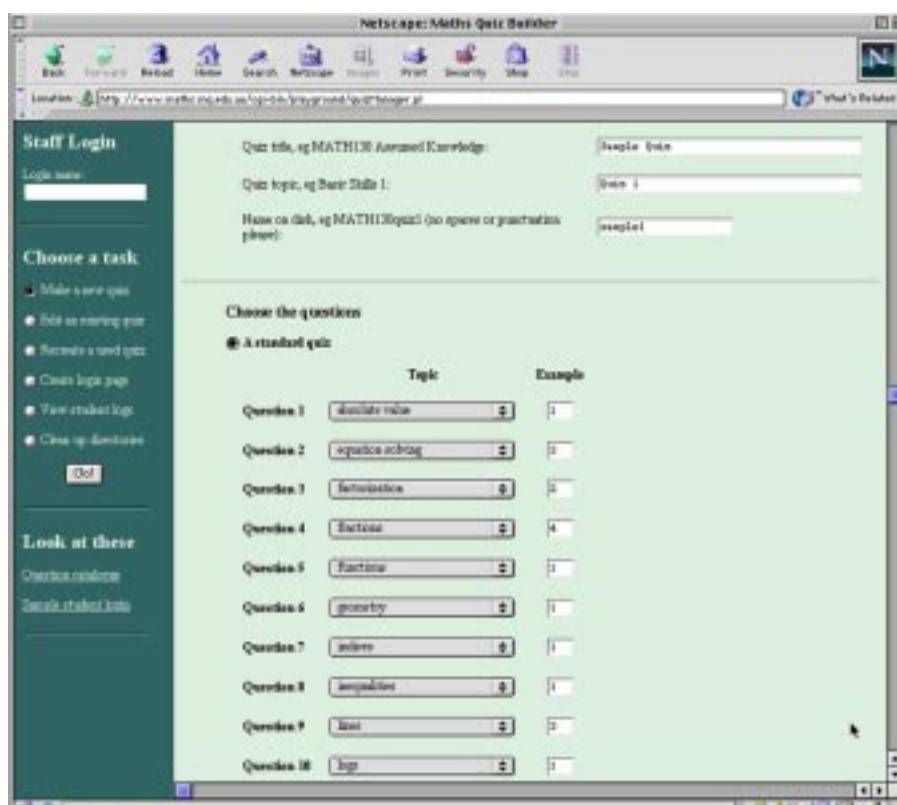


*Figure 15. The quiz-design page has pop-ups for the basic topics in which questions are available and a field to choose the specific question in each topic.*

*Figure 16. When a new quiz has been designed, this page provides access to the specific L^A^T~E~X [7] source files which control the appearance of each question. These files can be downloaded for detailed editing of the wording and page-layout, then up-loaded back to the appropriate directory.*

## Further Development

The software as described above runs on a SUN SPARC Ultra 5, under the SUN Solaris, Unix operating system. Thanks to support from the AUDF, we plan to implement everything also on a Macintosh OS X Server. Porting to MacOS X should not prove to be any great problem, as most of the software is already available for all Unix platforms.

Furthermore, we plan to build a new administrative application to run under MacOS X. This will provide an alternative interface for generating new quizzes and viewing log-files, which will not require web-based access. Since PDF is already the graphics engine for MacOS X, it is expected that some major parts of the quiz-generation system may be able to be reworked with other software, to allow greater flexibility in the nature of the quizzes that can be produced.

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WOLFRAM RESEARCH INC *Mathematica* http://www.wri.com/ .

# The Apple is ripe, but the connection gives us the pip!

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This paper describes a research project being undertaken, in which two remote North Western Australian Primary schools were the setting to determine if it would be possible for a student to study using online materials.

More and more tertiary distance education units are moving online, with the incorporation of online study guides, with streamed video, chat groups and video conferencing. These features make the units much more dynamic and help to make the learning experiences of the external student more like those of the on campus student.

In many small remote Western Australian communities the local school has the best connection to the Internet and is the logical location for a tertiary distance eduction student to go in order to undertake an online unit. The results obtained so far have indicated that while technically the schools have Internet access in reality it is too tenuous and slow to be useable for much beyond simple email.

## Introduction

Technological advances over the last millennium have helped to break down communication barriers between city and country. Remote areas are no longer considered to be so isolated with the advent of new technologies. But on a practical level is this the case?

This paper describes a research project being undertaken, in which two remote North Western Australian Primary schools were the setting to determine if it would be possible for a student to study using online materials.

More and more tertiary distance education units are moving online, with the incorporation of online study guides, with streamed video, chat groups and video conferencing. These features make the units much more dynamic and help to make the learning experiences of the external student more like those of the on campus student.

In many small remote Western Australian communities the local school has the best connection to the Internet and is the logical location for a tertiary distance eduction student to go in order to undertake an online unit. With the cooperation of the teachers in the selected schools, tests were made to determine the practicality of using online materials and tools or whether students trying to study in these areas are in danger of dropping into the widening digital divide.

## External (Distance) Education Issues

The learning styles of external students in remote areas differ from the pedagogy surrounding the modes of study offered by mainstream universities throughout Australia. For many students there are no alternatives for study other than the external mode, due to

isolation, ties to the family, community and land and the sheer expense of relocating. For many Aboriginal students the difficulties of interpreting external course work is compounded by the lack of culturally appropriate materials and little acknowledgment that Standard Australian English is not their first language.

The major difficulty of external course work is interpreting materials. This takes hours of self-disciplined reading to ascertain requirements for a successful completion of the unit. Careful forward planning for the whole semester has to be undertaken. It is imperative that a work programme is devised with realistic goals for weekly success. A calendar of important dates has to be referred to regularly. Adequate time needs to be allowed for requests for resources to be processed and delivered to ensure assignments can be completed by the due date.

External students become independent learners devoid of personal human interaction. The depersonalised nature of communication between the external student and their lecturer is exemplified with the use of voice mail, snail mail and email. These methods of communication all impinge upon the student's learning experience and subsequently educational outcomes. Success or failure is a pendulum that swings between the quality and relevance of the course work, the availability of the lecturer and the determination and commitment of the student.

Employers however seek graduates with the ability to work effectively in teams, with specialist knowledge and problem-solving skills. At present, there is limited opportunity for off-campus students to interact, work cooperatively and communicate with other students in units whereas most units in on-campus mode are workshop-based, emphasise team and group work, and use a variety of assessment modes. In particular, off-campus students have traditionally been denied the "experience of community" available to on-campus students. The external student has traditionally only worked on their own only with paper based resources. This means that two students completing the same unit, one in internal mode and one in external can have very different learning experiences.

This is not a new problem for educators, Telematics a hybrid online/telephone based system was being used in the early 1990s' to enhance the learning experiences of rural high school children (Oliver R., Reeves, T. 1995). But it has been the Web that has taken off as the educators' online tool of choice. Australia's universities have embraced the Internet with gusto, placing any and all units online. This has been done at various levels. From the straight conversion of paper based materials to Web pages with scant, if any regard to pedagogy, to the use of the web as an online teaching tool (Pagram, J, Rabbitt E., Fetherston T., April 2000).

The new university paradigm for distance education is one that follows the computer industry "client-server " model. The university being the server of these courses and the students being the remote clients. Edith Cowan University being based in the largest and most sparsely populated state potentially has some very remote clients indeed.

The researchers set out to revisit some past graduates from Edith Cowan who had been the subject of a previous research project. These teachers had as part of their undergraduate degree, been taught with and how to use a wide variety of online technologies. (Pagram, J, Rabbitt E., Fetherston T., May 2000). These students are now in their second year of teaching and are potential candidates for Edith Cowan's MEd online program. In this course the entire MEd by coursework is studied on the Internet.

The three teachers visited are teaching two schools set in very remote locations in the far north west of Australia. The researchers set out to see if it would be possible for these

teachers to study this online course and to see if the tools that the students had been taught to use at university were available at these remote schools.

The students had been trained at ECU's Broome Regional Centre using Apple iMac computers fitted with an Iomega zip dive and a QuickCam camera. The computers were networked and connected to Perth via a router and a 64K ISDN telephone line. The students also had extensive experience in using the following software, MS office, Netscape Navigator web browser, iVisit video conferencing software, QuickTime and RealPlayer as an audio and video web broadcast player, and TopClass web teaching environment. (Fetherston T., Pagram, J., April 2000).

During the visits to the schools a number of tests were carried out to determine the practicality of undertaking online study. These are described below:

## School One:

School one is a three-teacher school primary school. This includes the principal who teaches in the areas of physical education and maths. There are 33 students at the school, which caters for pre primary students through to year 7.

This school is 27 kilometres by unsealed road from the nearest town with a population of 1300 people. It is 2,500 kilometres from the state capital and head office administration base. It is situated within a kilometre from one of Australia's major river systems, it is not unusual for the community to be flooded during the seasonal wet season, from November through to April. The road access become completely cut off and community members have to stock up on supplies, as there is no operating community store. The major form of communication is telephone. Two of the ECU graduates are based at this school.

### Computers

The two classrooms are well equipped for the size of school, with one classroom having 8 iMacs (one of which is a DV model), one Performa and 2 Wintel PCs' one of which is used for school administration. The Teacher uses an iBook for lesson preparation and record keeping. All computers in this classroom are networked and have access to the Internet. Classroom 2 is less well equipped with 4 non-networked Performa computers.

### Other computer tools

Both classrooms had laser printers and shared a digital still camera and a digital video camera.

### Internet connection

The schools small Ethernet network is connected to the Internet by means of a router and 56K modem which connects via a radio telephone system. This connection is very slow intermittent and its speed varies with atmospheric conditions. At the time of visiting the speed appeared to be around 28K. The teacher commented that the observed speeds were about average and rarely improved. Consistency of connection was also noted, with the connection speed and existence varying from day to day and hour to hour. This is often due to factor such as storms and other atmospheric conditions. Because of this the teachers' noted that the phone is the most reliable and preferred method of communication and that they don't always check their email.

**Internet Connection Tests**

*Test one — Email*
The participating teacher was able to send the researchers an email without problem and receive replies.

*Test two — Web surfing*
The authors visited a variety of Web sites including Edith Cowan to observe download speed. All were very slow at down loading with many so slow that navigating the sites was impractical.

*Test three — Web download*
A test download was attempted of a 1.2 Meg file from a large American site known to be fast. The download failed with a time out error.

*Test four — connection to an external server*
The researchers Appleshare IP server based in Perth was contacted, logon was successful and the server drive appeared on the monitor. When an attempt was made to open the drive window the window was drawn but the contents never did appear even after 20 minutes at which point the researchers gave up waiting.

*Test five — video conferencing trial*
An attempted was made to videoconference with a colleague in Perth using iVisit software and a QuickCam camera. The result was no video a very distorted, unusable audio and a working chat window.

## School Two

This school is 180 kilometres from the nearest town with a population of approximately 12,000 people. There is only one unsealed 13 kilometres road into the community. It is 1,500 kilometres from the state capital and head office administration base. The major form of communication is telephone.

School two is a larger school with 160 children. There are 12 teachers plus the principal. It is teacher three's second year at this remote community school. He has a split year 2/3 class with a severe gender imbalance. Overall there are 21 pupils, 17 boys and only four girls. Nine of the boys are in year two and the other eight are in year three. There are three girls in year two and only one in year three. There is only one non-Aboriginal child in the class, a boy in year two who is the son of the deputy principal. 16 of the 21 students attend school regularly. One of the ECU graduates is based at this school

### Computers

All classrooms are equipped with two iMac computers and one iBook intended for teacher use for lesson preparation and record keeping. None of the computers in the school are networked although this is planned for the very near future, as is Internet access in each classroom.

### Other computer tools

None of the classrooms had a printer, but each was provided with a digital camera.

### Internet connection

The school's one Internet equipped computer was located in school library. This computer is connected to the Internet by means of a 56K modem which connects via a

radio telephone system. This connection is very slow intermittent and its speed varies with atmospheric conditions. At the time of visiting the connection was not working due to cyclone damage. Teacher comments indicate that when working the quality was no better than school one.

## Conclusions

These teachers in many ways represented the ideal online MEd students. They are highly computer literate and have access to computers that they are familiar with. Having been trained on Macintosh computers they are all using them in their teaching and for their personal computer (Pagram J, Rabbitt E., 2001). However none of these students could undertake an online course. Since the most modest online unit makes use of web based material, made up of a combination textual and pictorial elements, combined with an online bulletin board system. The more sophisticated units add to these, synchronous technologies, such as video conferencing and video streaming and interactive multimedia elements. None of these elements would be available over the sort of Internet connection available at these schools.

The simplest solution to this poor Internet connection problem is the hybrid solution that makes use of satellite download and landline upload. This type of connection would allow all but the video conferencing to work. However the Principals of the schools in question, knew of no plans for this to be provided.

It is very unlikely that the schools in question are isolated cases, and that the type of Internet connection described is not uncommon in many parts is outback Australia. Governments both State and national have improved the quantity and quality of the hardware provided to schools in remote communities but the internet connection still has room for improvement. At the schools examined the Apples were indeed ripe, and the connection did give us the pip!

Universities and other providers need to be aware that beyond the major centres internet based courses are far from a Higher education panacea and can be more of a no go zone. The Federal Labor party please note that the proposed "low cost online university" for all Australians has the potential to be the most elitist yet, without big dollars being spent on improved access for the bush.

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# Decoupling the WebObjects application from the EOModel — a case study in OO design

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**Abstract**  This paper reports on the development of a Web-based system for controlling the development process. The project is now at the stage of having the bulk of the design completed and is being implemented using the WebObjects framework. While the WebObjects framework greatly simplifies the development of such a system, we did encounter difficulties in applying our traditional OO design methods. In particular the EOModel allows only limited use of the inheritance mechanism. This paper shows a way to use full OO modelling whilst retaining the major benefits, such as automatic database update, provided by WebObjects. It does this by using an intermediate layer of classes (following the Facade design pattern), which carries the further benefit that a variety of complex application-level objects can be invisibly mapped to a common database structure. As a consequence we were able to put the bulk of the code for relationship maintenance into a few generic classes. This would also allow new types to be added without rebuilding the database.

## Introduction

A previous paper (Aitken 2000) introduced a proposal for a Web-based environment for teaching programming within a disciplined software engineering process. The major intent of this system was to discourage students from using a trial and error approach whereby they would repeatedly edit and compile until the program did what they wanted — a process commonly referred to as "hacking". Such an approach is probably of exponential complexity and so will not scale up to projects of realistic size. Rather we wished to encourage a disciplined process of successive refinement through analysis and design before coding could be attempted. An important feature of the proposed system is that of enforced dependencies between the different phases of the development process. For example, every Java class must be related back to a corresponding analysis class. The student is unable to define new classes at implementation stage. Nor can they add new public methods at this stage — the public interface must be the same as that declared during the design phase. As we shall see, this implies a complex underlying representation. A Web-based environment was chosen so as to remove the platform specific requirements of most commercial IDEs. The WebObjects product is the leading state of the art package for the implementation of such systems.

We have now progressed to development of the proposed system (yes, we followed a disciplined process to do so!). A substantial grant from the AUC enabled us to purchase suitable hardware (G4 processors) and software (OSX server, WebObjects, Frontbase) to develop the system. Of these, the central element is the WebObjects framework, which enables development of Web-based solutions with data stored (inter alia) on standard commercial relational databases. Two important frameworks form part of developing a system in this environment; the WebObjects framework itself (Apple 1998b), which handles the dynamic generation of HTML, and the Enterprise Objects framework which is

responsible for the EOModel, an OO representation that lies between the application and the relational database.

The EOModel allows specification of objects and relationships between them. When an object is read from the database, these relationships are typically made available to the programmer either as object references or arrays of references. WebObjects will automatically track modifications to the data fields within each object and arrange for the update of the corresponding database tables (when requested). However, it remains the programmer's responsibility to call the appropriate methods when modifying relationships: simply modifying the reference or array is not enough. Failing to call the appropriate method (the most popular of which has the jaw breaking name of addObjectToBothSidesOfRelationshipWithKey) can cause all manner of obscure run time errors.

The EOModel does a good job in decoupling the application from the details of the particular database engine used to achieve persistence. This allows a different engine to substituted with minimal disruption to application code. However, the requirement to support persistence on a traditional relational database places restrictions on the extent to which OO modelling can be used. In particular the inheritance mechanism is supported only in a somewhat limited fashion. Although a number of options are open to the developer for the representation of inheritance trees (Apple 1998a), we have not found any of them to be fully satisfactory. This paper describes the development of an intermediate layer of virtual classes which lie between the WebObjects application and the EOModel which allow the unrestricted use of OO techniques and additionally permit a variety of objects to be stored using a generic database structure, thus greatly simplifying the EOModelling process and allowing the addition of new object types without changing the database structure.

In our original design we were faced with a complex arrangement of classes representing the deliverables from each stage of the development process (Actors, Use Cases, Domain Classes, Object Model and so on). The task of individually representing each of these with an appropriate EOModel structure was rather daunting, especially since we could not gain the full benefit of the inheritance relationships. Furthermore, we anticipated adding new deliverables in later versions, which would normally involve changing the database structure (not a light undertaking in a production environment).

Our first problem, then, was that we had a number of conceptual entities with complex relationships between them that implied complex relationship maintenance code at the application level. Secondly, each of these entities had a different and potentially complex internal structure. One alternative would be to represent each of these independently as an Enterprise Object in the EOModel but this would have entailed substantial work for each separate entity, much of which would be repeated. We therefore looked for an approach that would eliminate this duplicated work and enable us to simply and elegantly represent complex OO models in the EOModel, without sacrificing the automatic modification tracking and database updating provided by the WebObjects framework.

## Solution

Recognizing that all deliverables were fundamentally textual structures, we sought a generic database representation that would support any deliverable item. Our OO design is shown in Figure 1.
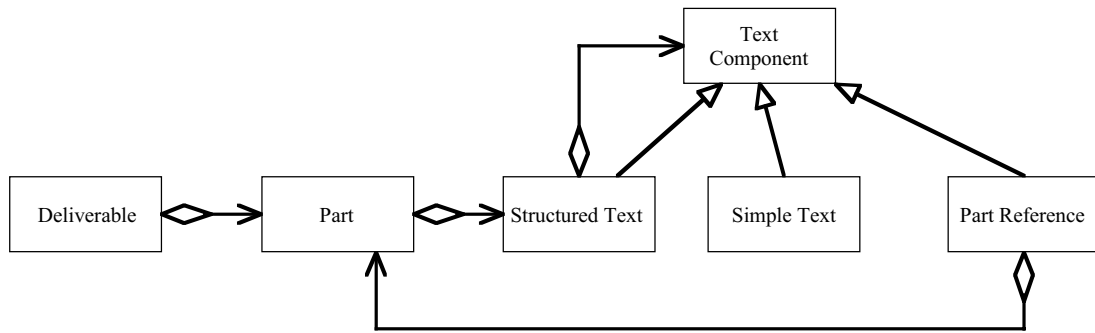
*Figure 1 — OO Design*

The OO design is based on the Composite design pattern (Gamma et al 1995) which allows a part to be represented as a collection of text components, each of which is either a simple text field, a structure of text fields (which we use for example in representing classes which can recursively include other classes) or a reference to another part (which we use to enforce the requirement that later phases in the development must be based on earlier ones). Later enhancements would be to include additional types here, such as graphical components.

When mapped to an EOModel, we chose to collapse the inheritance hierarchy, resulting in only three classes, as shown in Figure 2. Every single Part in our application can be represented using some structure based on these generic EOModel classes.
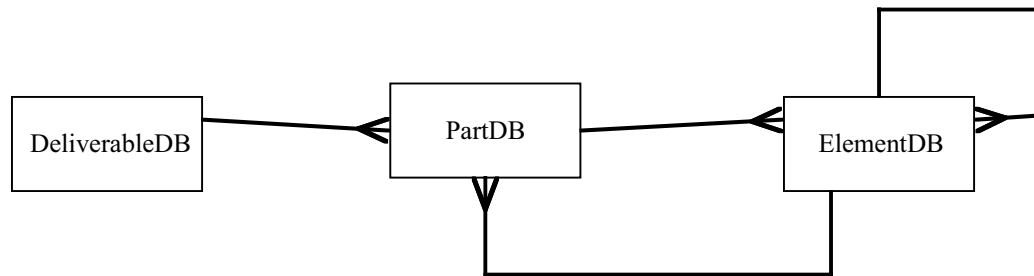


*Figure 2 — EOModel*

The application does not, however, interact with these objects but rather with a set of virtual objects which represent concepts and entities in the application domain (such as Actors, Use Cases, Classes etc.). Figure 3 shows an example of the object structure at run time. It represents a single UseCase object with a name, a description and a dialog which references two Actor objects, each with a name and a description. The arrows on the diagram represent references from one object to another. The references between PartDB and ElementDB are provided, and partially maintained, by WebObjects as a manifestation of the relationships declared in the EOModel (the self-referencing relationship on ElementDB is not used in this example and is omitted for clarity). The references from Actor and UseCase to their corresponding editing context objects are set as required in a manner described below.
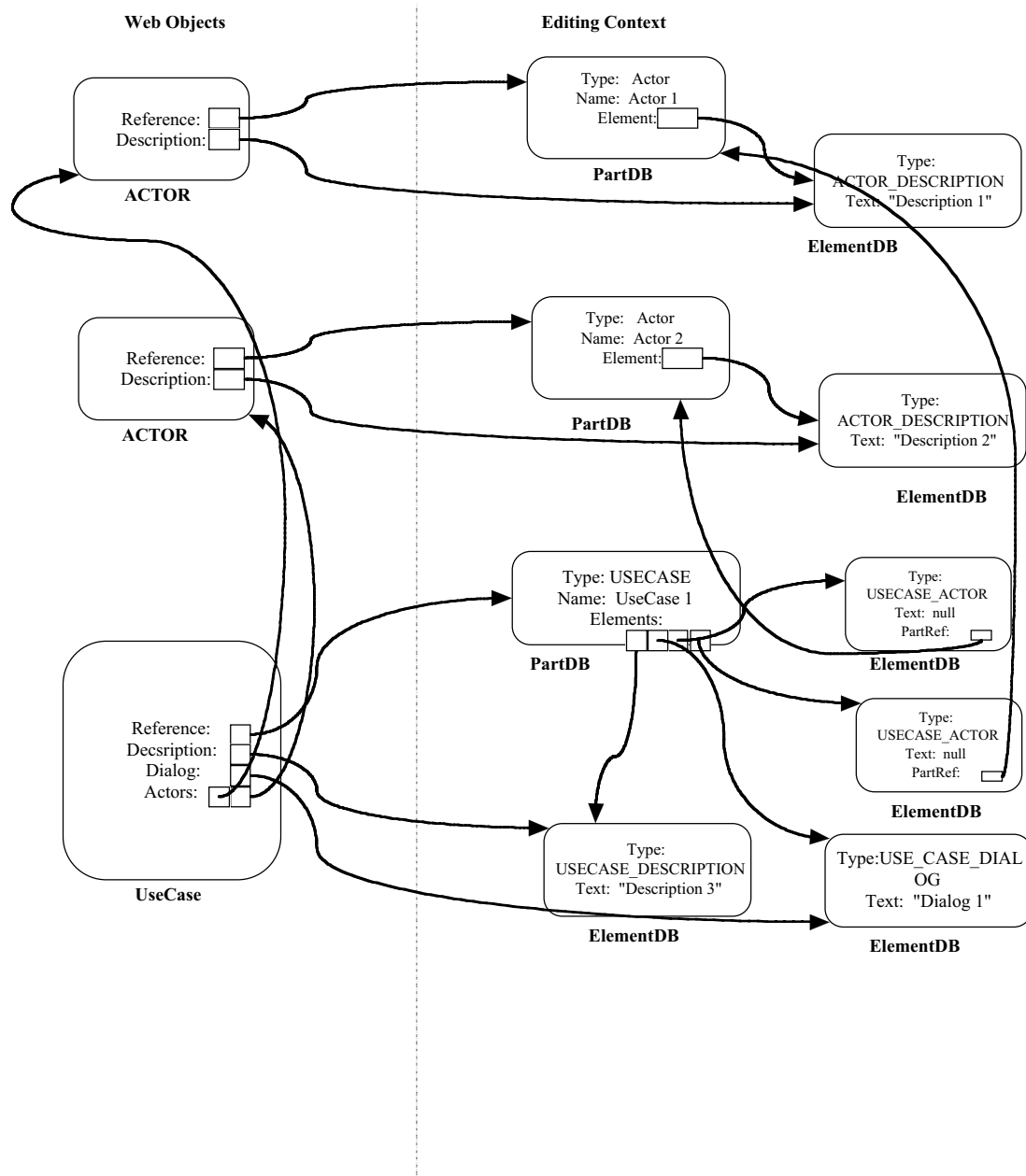
*Figure 3 — Example Object Structure*

Note that the objects used by the application (Use Case and Actor) lie outside the editing context, but that all the data they reference lies within it. Therefore WebObjects will still take responsibility for maintaining the relationships and will update the database as contents change. This design is an example of the Facade pattern (Gamma et al 1995). The virtual application objects (Actor, UseCase and so on) now form part of a more complex hierarchy, with most of the code in a superclass. The actual content of the individual classes is very small; basically they simply contain fields appropriate to the class which reference appropriate ElementDB objects within the editing context. In use, you simply connect the field in WebObjects Builder through the references in the intermediate objects to the corresponding text field, going via the reference elements if required. This is no more time consuming than using an object directly represented in the EOModel, but the work required to generate the class is substantially reduced.

Links between objects in the editing context are representative of declared relationships in the EOModel and are handled by the usual mechanism. Links between fields in the application level objects are all created on demand using code such as the following, which represents the accessor method for the description field within an Actor object:

```
public ElementDB getDescription()
{
  if (description == null)
  {
          description = findElementDBByType(ACTOR_DESCRIPTION);
  }
  return description;
}
```

Here the method findElementDBByType is a utility method inherited from the super class which identifies the appropriate object. The overhead of initialising the reference is thus deferred until it is actually needed. In fact we use this technique for most of our data fields since it carries the additional advantage that we can always use a default constructor (which is the only one that WebObjects will call automatically). Construction of array fields (such as the Actor array in UseCase) is achieved in a similar manner.

In fact this design has encouraged us to develop generic code to maintain the structures (this is possible only because all objects share a common underlying database representation). The array fields, for example, use a specially written collection class that enables a simple replacement of one array by another. This requirement arose frequently as a result of the browser user interface, which encourages making selections in bulk rather than one at a time. The collection class is in a position to handle this in a database efficient manner (ElementDBs are reused if possible).

## Discussion

The use of the virtual objects has enabled us to reduce the number of tables in the database from a possible twenty-two (being the number of deliverable classes in the application) to only three. The price we pay for this is that the database is no longer a simple mapping of the application domain, so it is hard, for example, to write SQL queries against it. This does not cause a problem for the WebObjects application itself, since that is essentially insulated from the database details anyway. The only need for SQL is in the writing of fetch specifications, which we now do generically. It would, however, limit the use of third party report generators and the like.

On the plus side, however, we can easily add new application types without any modification to the EOModel whatsoever, subject to the constraint that the structure is representable by the EOModel (and we contend that this would permit most likely structures). The major advantage to us is that we are now free to use any arbitrary OO model to represent the application objects, without the limitations imposed by the EOModel. In particular we can use inheritance hierarchies of arbitrary complexity and make full use of dynamic polymorphism when appropriate. We have also the additional advantage of database simplicity, with far fewer tables and relationships.

Although the code to manipulate the internal database structure is rather involved in places, this code needs to be written only once, since it is common to all classes. The virtual classes can now be written using tried and tested lower level code which handles

almost all the programming of relationships (which we have found to be an area particularly prone to errors).

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# *MotionWorkshop*: tracking motion in an on-line environment

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**Abstract**   This paper describes an AUDF funded project to produce a Java applet to help with the teaching of physics. The applet, called *MotionWorkshop*, allows students to track the motion of an object in a video clip, display the resulting data in a spreadsheet and manipulate graphs representing the motion. The spreadsheet supports the generation of a numerical model of the motion that can then be compared with the actual video data. Innovative features of the program let the student manipulate the spreadsheet in a manner that facilitates exploration of the model. The use of *QuickTime* with embedded *Flash* tracks is described as a convenient way of adding comments and help information to the program.

## Background to the project

This project has a long history — it began as a 1996 National Teaching Development Grant project called *Real-World Physics* (for an early description see Pearce and Livett, 1997), which aimed to help teach first-year physics students about physics in the real world. One component of that project was to create a Java applet to allow students to track the motion of an object in a video clip. This applet was to be embedded in a web environment comprising learning exercises, video-clips of real-world events, and video interviews of the main players in the events.

The Java applet, called *MotionWorkshop*, became the focus of much further design and development work. Other stand-alone software was developing at this time to carry out video analysis, and some of these packages still are available: see, for example, *VideoPoint*   www.lsw.com/videopoint
*Measurement in Motion* www.learn.motion.com/lim/mim/Measurement1.html
and *World in Motion* www.members.aol.com/raacc/wim.html .

However, these could not be run via the Web, and generally did not have the sophistication of modelling and analysis tools that we required.

In 1996 Java had only recently been released and we suffered through the various vagaries of the early versions. Although video was central to our needs, the early Java did not support *QuickTime*. To overcome this deficiency, we had to export our movie clips as sequences of GIF images and hence emulate 'movies'.  As *QuickTime for Java* became a reality, we applied for funding from the Apple University Development Fund to implement *QuickTime* in the project and to add various other features. We received a major AUDF grant in 2000 and, after a slow start, have been making progress in redeveloping aspects of the program.

## Overview of the project

The aim of *MotionWorkshop* is to enable students to analyse the motion of real-world events captured on video, and use their knowledge of physics to describe and analyse the events.

*MotionWorkshop* allows students to analyse events such as the motion of a long-jumper or the swing of a golf club. The event must first be videoed and saved as a *QuickTime* movie. Students use the applet to track the motion of a point or points on the moving object(s) by clicking, frame by frame, on the video image on the screen. The resulting position data are recorded into an on-line spreadsheet that automatically calculates values of velocity and acceleration. From the spreadsheet students can plot graphs and enter formulas to carry out numerical analysis of the motion, or model new motions.

The spreadsheet has been designed to simplify the generation of data using numerical modelling techniques. This allows students to create a mathematical model for a motion they are studying and see the model's results overlaid on the analysed video data. This form of modelling is a powerful method of "completing the loop" in helping students to understand motion; it enables students to set up their own models of the causes of motion, and compare the outcomes with reality.

## How is *MotionWorkshop* used?

### Analyse the video

Typical use of the software starts with a student choosing a video clip; several have been produced specifically for this project, such as falling balloons, bouncing balls, juggling clubs and sprinters. The student would then choose an object within the video whose motion she wants to analyse. For example, in analysing the motion of a falling balloon, she would choose a point on the balloon and click on it frame-by-frame to enter its (x,y) position coordinate data into the spreadsheet. The coordinate axes on the video can be moved, rotated, or even changed to a polar coordinate system, and the data in the spreadsheet will update automatically.

Having entered the data she could choose to have the software display other kinematic values such as velocity or acceleration. These would be listed in new columns in the spreadsheet. She might choose to calibrate the data so that screen pixels are converted into units of metres or centimetres. It might be of interest for her to see other quantities derived form the displayed ones, for example, kinetic energy. To do this she would enter a formula into a column of the spreadsheet using syntax similar to *Excel's* 'row-column' syntax. It has been a deliberate design decision to let the system calculate and display only 'kinematic' quantities only (position, velocity and acceleration); the student must define the relationships for other 'derived' quantities (force, energy, momentum, etc.) for herself.

Having set up the spreadsheet in this way she could display one or two graphs of any columns against any other column. In the balloon example she might choose to view velocity versus time and acceleration versus time to see how the balloon quickly reaches a terminal speed as the acceleration drops to zero. These graphs are easily scaled or shifted by dragging the axes.

**Model the motion**

Having been able to observe and analyse the nature of this motion, the student can construct a numerical model by entering the relevant equations of motion into new columns in the spreadsheet. For our balloon example, she would want to explore how air resistance affects the acceleration of the balloon. She would do this by entering formulae relating the forces acting on the balloon to the motion of the balloon; these would appear in new columns in the spreadsheet. The data she constructs in this way can be overlaid as position data on the original video motion to test its validity. *MotionWorkshop* provides easy ways for her to change variables in her model and immediately see the effects. "What if" type questions are asked in accompanying worksheets whereby she is motivated to consider variations on the motion and test her hypotheses by calling up a related movie clip and again comparing this real motion to her analysis. Further information on this style of modelling is discussed below.

## Learning: the importance of the activity

We have been engaged in investigating the use of *MotionWorkshop* to enhance students' learning about the relationship between forces and motion (Pearce et al, 1998; Rodrigues et al, 2001). Although the primary purpose of *MotionWorkshop* is not to replace hands-on laboratory experience, our initial investigation focussed on its use as an alternative to a parallel lab activity. This research indicated that *MotionWorkshop*-based learning activities can improve student understanding. However, it emphasised that good learning outcomes are not simply due to this software but are the result of carefully crafted learning activities in which the software use is embedded.

## Innovations: thinking differently

During the early stages of developing *MotionWorkshop* some asked why we did not use an existing spreadsheet, such as Excel, and export data to it for analysis. There were two reasons for this. This first was that it was important for us to have tight integration between the video component, the spreadsheet component and the graph component. The students can see the position of an object, e.g. a juggled ball, on a frame of the video, and simultaneously see its corresponding points on a graph as well the value in a cell in the spreadsheet. The links between these representations of the motion help her to construct her understanding of the motion. She could also drag an object in one component and see the corresponding change in the other. Manipulating these multiple representations of objects in this fashion is an important pedagogical feature as students can directly observe how changing one representation affects another.

The second reason relates to not being satisfied with the way that existing spreadsheets allow the user to model physical events. But first, a few words about the nature of the modelling that students do. The modelling is referred to as "numerical modelling". It is a powerful technique when you want to model a motion of something for which you cannot write an explicit formula: maybe it is too complex, or maybe an exact analytical solution does not exist at all. Instead, you regard the motion as comprising hundreds of tiny 'steps' in time, where each 'step' is calculated from the previous step by applying the underlying laws of motion. Hence the whole motion of the object is simulated by carrying out many calculations, each representing changes during very small time intervals (maybe one hundredth of a second, for example). With each calculation a new value is entered into a spreadsheet column. An example of a motion well suited to this form of analysis is a falling object — say a balloon — for which the exact mathematical solution is complex,

but the physical laws to be applied at each small step in time are relatively straightforward. One advantage of this form of analysis is that constructing the mathematical model relies very heavily on understanding basic laws of physics at each time interval, rather simply applying mathematical techniques; the student stays focussed on the physics rather than the mathematics.

Hence, given the nature of the modelling that students would do with the spreadsheet, we required an improved interface between student and spreadsheet. There were two issues here: firstly the spreadsheet would have a large number of rows due to the very short time intervals required to accurately model a few seconds of motion; and secondly, students need an easy way to 'tweak' variables in the spreadsheet and compare the results with the real data as captured by the video clip.

The problem of a large spreadsheet is compounded by the fact that data from a video would usually be at 1/25 second intervals (frame rate for PAL video). The data generated numerically by the modelling process could be at 1/100 second interval, or even more frequent (as determined by the desired accuracy of the model). This results in many rows of the spreadsheet that nobody really wants to see, and which do not line up with any 'real' data from the video. We needed a spreadsheet in which the rows could be collapsed to display only, say, every $10^{th}$ or $20^{th}$ row, yet the calculations still be valid in the hidden rows. *MotionWorkshop* allows the student to adjust the number of rows displayed to be fewer than, or more than, the original number determined by the video clip.

The second issue, the 'tweaking variable' requirement, is an attempt to give students a better way to manipulate their models. To make good use of such a spreadsheet and use it to explore a model in comparison with real video data, we needed an easy way for students to change the value of variables and see an immediate update to the spreadsheet and accompanying graphs. For example, when modelling the motion of a falling balloon, the student must consider three forces: the weight of the balloon, drag (friction) and buoyancy. Values for the weight of the balloon and buoyancy are easy to obtain, but the coefficient for drag is not so easy to find out. However, students are able to make an initial guess and link this spreadsheet constant to a slider in order to be able to vary its value easily and see the displays update in real time. In this way, the student's model could be tweaked to obtain a better match between model and observation.

Figure 1 shows an early screen shot of *MotionWorkshop* set up to analyse the motion of a sprinter. Effort is currently being put into implementing Java's "*Swing*" features. This gives the appropriate GUI look-and-feel for whichever platform is being used (*MacOS*, *OS X*, *Windows*, *Linux*). The figure shows the look-and-feel under *OS X:* transparent menus; *Aqua* sliders; etc. Using *Swing* offers many other benefits apart from look-and-feel.  It simplifies programming considerably by providing objects such as sliders, tables, drop-down menus, as well as features such as tool tips. The programmer has less code to write and produces a more consistent product. The disadvantage is that the initial download of the *Swing* library is quite large, but this is now included in most standard Java installations (including *OS X,* but not *OS 9*).
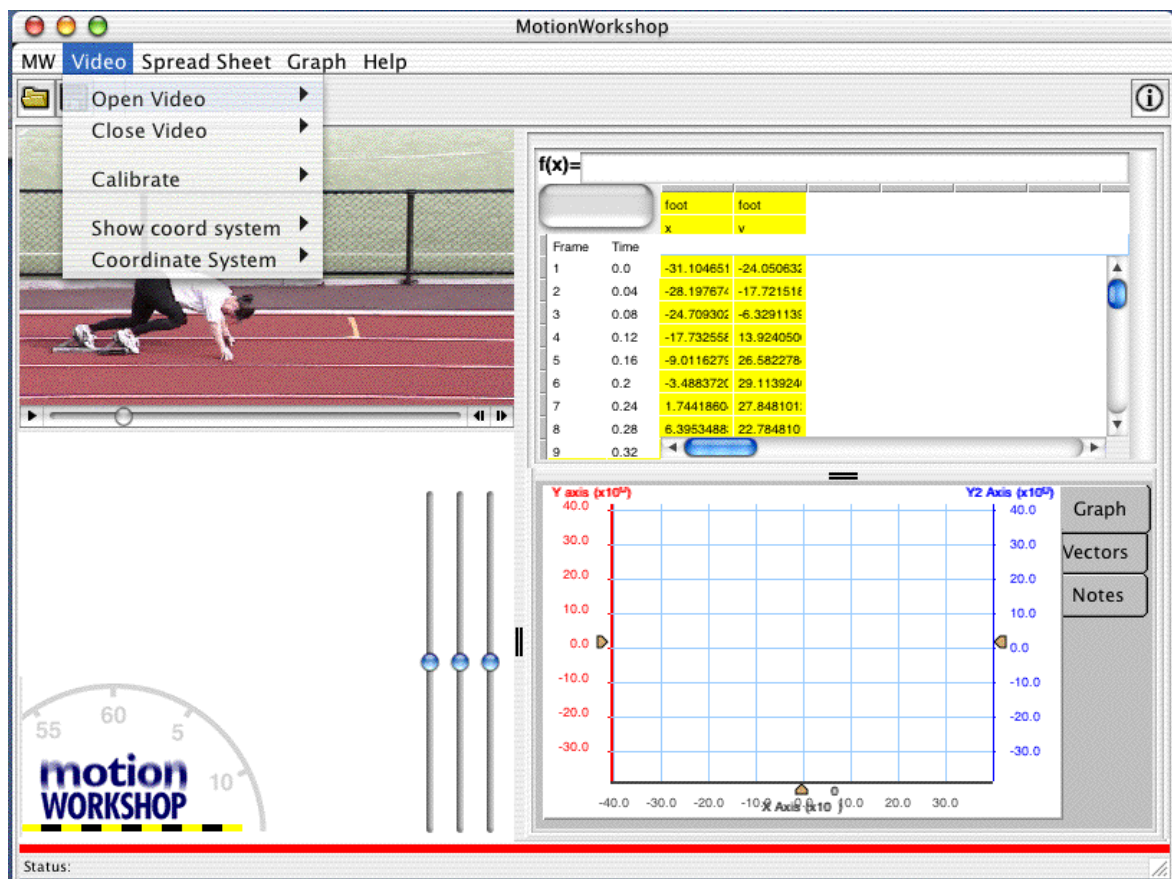
*Figure 1. Early* MotionWorkshop *screen  showing* Aqua *look-and-feel.*

The two features mentioned above make the *MotionWorkshop* spreadsheet very different from the likes of *Excel*. It allows a different approach to numerical modelling in which one can see the important data within a model and easily make changes to values in the model, watching graphs update in real time. There is now a tight integration between video, spreadsheet and graph providing a very powerful modelling environment.

## Integrating *QuickTime* and *Flash*

One requirement for this project, which became apparent only after much of the design work was already complete, was the ability to display information about each movie the students chose to load. Students need to view data such as background information, frame rates, scale, time duration, etc. Requirements such as these that come *after* the Java programmer has finished present a problem for academics who have no Java programming experience. There were also other areas in which we needed the flexibility to be able to change things without employing further 'hard' programming expertise: adding help support, 'how-to' instructions, links to related web sites, etc.

A solution to this problem was to use *Flash* tracks embedded within each movie-clip (see Figure 2). This menu-like feature at the start of a movie can also be used to present some general 'what to do with this movie' information to give students some further support. It can also link to web pages to give more detailed help. The advantage of these is that they can be added to the movies at any time and require no re-coding of the applet.

*Figure 2.* QuickTime *movie showing a* Flash *drop-down menu*

This use of *Flash* in a *QuickTime* movie can be extended by having a blank movie placed on the screen (by the programmer) as a background graphic that we can use at a later date to add instructions, acknowledgements, help information, tutorials, etc. It provides us with a very flexible way of adding changes to the applet later using the more common skills of a multimedia programmer rather than the expensive and rare talents of a Java programmer.

## Conclusion

*MotionWorkshop* has undergone a long development process, evolving in response to several significant external technology changes. From its start as a small Java component embedded in a web-based learning environment, it has grown into an application in its own right. It is still evolving and nearing the stage where it can be released for others to use.

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# The use of QTVR for teaching Radiology and Diagnostic Imaging

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**Abstract**   This paper reports on the preparation of a technology-mediated alternative to print-based external study of a postgraduate unit in veterinary diagnostic imaging. A number of innovative uses of technology had to be developed in order to meet the educational requirements:

- Large radiograph images were converted into QuickTime VR format, which enabled them to be zoomed into and navigated, with significant savings in file size. The authors are unaware of any similar application of QTVR to flat images;
- An electronic whiteboard was developed using multi-user ShockWave, which enabled users to share and annotate QTVR images across the internet, while still retaining the QTVR navigation functions;
- A FileMaker Pro database was used to maintain details of images and associated clinical information;
- Web pages were generated from the database as interactive case studies, delivered on CD.

The conference presentation will demonstrate how these technologies are linked together in novel ways to meet the learning needs of the students.

**Keywords:** Veterinary, radiography, ultrasound, case studies, QTVR, multi-user ShockWave, electronic whiteboard

## Introduction

This paper reports on the innovative use of QuickTime Virtual Reality (QTVR), multi-user ShockWave and web databases in a CD-ROM-based database of radiographs (X-rays) and ultrasound images, for use in the Veterinary Diagnostic Imaging (V620) unit in the Master of Veterinary Studies offered by Murdoch University. The Master of Veterinary Studies is an advanced coursework Masters degree available internationally through distance education, and targeted at professional veterinarians in practice. In the past, the Masters was offered solely in print format, but, increasingly, electronic and online aspects have been added.

V620 is fundamentally a practical unit, with students required to work with and diagnose radiographs and ultrasound images. In external, print-based mode, this led to several problems:

- the costs and inconvenience of bulky study materials and teaching aids sent to students in remote locations;
- delays in feedback to students working on case-based problems;

- difficulties in communicating with students having difficulties with images.

Veterinary Diagnostic Imaging includes four sections:

- radiographic technique and ultrasound principles;
- the imaging and interpretation of, in small animals:
    - the skeletal system;
    - the abdomen;
    - the thorax.

The major teaching strategy is for students to work on case studies in their coursework and assessment, using large numbers of radiographs and ultrasound images demonstrating different patterns of disease in the various anatomical regions. The case studies are supported by print-based materials. By using the radiographs and ultrasound images, students learn the principles of recognising normal and abnormal structures and learn to define the patterns of change present in disease processes, and make diagnoses from these. If students experience difficulties in recognising radiographic or ultrasound changes or diagnosing an abnormality, they need to be able to discuss this with their lecturer.

Students work through non-assessable worked case studies in each section, and then undertake marked case evaluations using radiographs or ultrasound images and complete case-related assignment questions.

## The Teaching and Learning Problem

In offering V620 in external mode, there are several ongoing practical problems. These have been discussed in more detail in Phillips, Pospisil & Richardson, (2000) and Phillips, Pospisil & Richardson (2001), and are summarised below.

### High costs and administrative load in producing and distributing radiographs.

In 2000, it cost $2,748 to produce each new set of hard copy materials, and the average cost of providing radiographs to students was $334 per student, mainly in postage costs.

### The inconvenience to students of handling and transporting bulky radiograph files.

The package of materials sent to students is of the order of 43cm x 35cm x 30 cm in size. The use of hard copies of images means that students require access to a viewbox, usually located at the veterinarian's workplace. However, most students preferred to do their coursework from home. They found the transportation of radiographs in bulky files from one location to another to be a considerable inconvenience.

### Teaching problems caused by lack of interaction between teacher and student.

The external mode presents difficulties in achieving a satisfactory level of interaction between teacher and student. There is an unavoidable delay in students receiving feedback on assignments sent by post. In previous years, attempts have been made to improve contact between teachers and students by using email and individual telephone discussions. Teleconferencing has been used for group-based discussion of case study radiographs. However, this proved to be costly and often unsatisfactory, as it was difficult to discuss images without being able to pinpoint or highlight areas of interest.

# Requirements for an Electronic Solution

Given the problems with the print-based version of V620, it was thought worthwhile to pursue a technological solution, essentially by making the radiographs and ultrasound images available to off-campus external students in electronic form. Because many students are in extremely remote locations, fast and reliable internet connections could not be relied upon, although it was a condition of enrolment that some form of internet access be available. Therefore, the images were to be provided on CD-ROM.

The requirements of the project are summarised in Table 1. In a nutshell, this project aims to build a system to generate problem-based learning interactive tutorials on demand. The interactive tutorials will provide immediate feedback to student input, and assessable work will be submitted for marking. In addition, an electronic whiteboard is required for discussion of problems students may experience. As much as possible, the system should be able to maintained by veterinarians, with minimal input from technical staff

There are four major components of the project, which are displayed in column 1 of Table 1. The technical solution chosen for each of these components is given in parentheses, and discussed in detail in the following section. Column 2 of Table 1 summarises the requirements in more detail.

| Requirement | Description |
|---|---|
| Image presentation and format (QTVR) | Radiograph and ultrasound images are to be presented in electronic format images are physically large. File size is potentially a problem the required diagnostic detail within the image must be maintained the normal viewing process for hard copies of radiographs should be simulated at multiple levels including the viewing of images from a distance and close-up, without restricting the decision-making process involved in determining the regions that require further examination in fine detail students need to be able to compare several images at the same time in a similar manner to displaying them side by side on a viewbox students should have flexibility in choosing which images to view images should be clearly labelled to facilitate referencing images are to be delivered on CD |
| Image storage and maintenance (FileMaker Pro database) | Images should be stored in a database, so that: case details can be associated with images large numbers of images can be maintained lecturers can easily add new cases and images and edit existing cases lecturers can choose which images to use each time the course is offered new CD's can be automatically generated from the database |
| Interactive case studies (static HTML generated from database using Grab A Site) | Images are to be presented to students as part of case studies, in the form of problems to be solved. case studies will be presented in one or more standard layouts, with contextual information and one or more images. images must be able to be made larger and viewed side-by side in any way the student requires students need the facility to build a report about the case, and to save this for future review and/or marking a self-assessment mode is needed, in which students 'submit' their report, after which a model answer is provided immediately an assessment mode is needed, whereby student reports are submitted to the teacher. most of the features of the interactive case studies will need to be carried out offline, because of network bandwidth and reliability issues. |

| Addressing student problems (multi-user ShockWave electronic whiteboard) | Facilitate communication, both student-tutor and student-student, about specific features of an image. Both parties need to: see the same image on screen at the same time be able to draw on the image to highlight areas of interest, and see what the other has drawn choose another image to view type comments to each other or communicate in some other way <br><br> An online connection is necessary for this functionality. |
|---|---|

*Table 1. Requirements of the project*

## Implementation

### Image presentation and format

Hard copy radiographs are physically large, of the order of 43cm x 35cm (17in x 14in). When viewed at full size, they are larger than a normal computer screen, so some mechanism of moving the image around on the screen is necessary. Furthermore, it is professionally necessary for veterinarians to observe the whole image first, then to focus in on areas of interest. When attempting to apply these techniques with scanned images, it is necessary to be able to zoom out to view the entire image, and zoom in for fine detail.

The interpretation of X-ray images requires fine discrimination between diffuse areas of grey. To replicate this on the computer requires high resolution scanning at high colour depth, and careful attention to brightness and contrast settings to ensure relevant areas are visible. The combination of large physical size and high resolution implies that scanned images would take up large amounts of storage space on the computer. A 17in x 14in radiograph scanned at 300dpi[1] in millions of colours would occupy 63 Megabytes of disk storage, uncompressed. Only a limited number of such images could be stored on a CD-ROM, and opening a single image would place significant load on even the most up-to-date computer. In V620, students are provided with over 300 images.

At first sight, it appeared that it would be impossible to achieve the requirements (large size, high image quality, moving within the image, zooming in and out) with file sizes which were usable on standard personal computers. However, it became apparent that Apple Computer Inc.'s QuickTime Virtual Reality (QTVR) technology (Apple Computer Inc., 2000) might be applicable.

QTVR is a variant of the QuickTime digital video format, allowing the user to experience a form of virtual reality on their computer screen. There are two types of QTVR movies, panoramas and objects. In both panoramas and objects, the QTVR system software enables the user to move and zoom within the image. QTVR also allows important areas of images to be highlighted by hotspots, which enable annotation of images or the inclusion of hyperlinks to web pages or other images.

QTVR objects are created with the camera looking inward, and give the impression that the object being viewed is turning around, as if it is held in your hand. A QTVR object is often created by standing the object on a turntable with a fixed camera location. A series of images of the object is taken, as the turntable is turned in increments.

In a QTVR panorama, the camera is looking outward, and a series of still images are taken through a 360 degree arc. The individual images are stitched together into a single large, flat image. It occurred to us that an X-ray is also a large, flat image, and the image

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[1] dpi — dots per inch

manipulation functionality of QTVR might be able to be applied to such images. QuickTime VR also provides inbuilt compression algorithms to reduce image file sizes.

However, the question remained whether QTVR could be persuaded to work with a single image rather than a sequence of images. After some research, we determined we could achieve this by creating a *virtual* QTVR object, with only one frame (setting the horizontal sweep angle to 0 degrees). We were then able to perform a feasibility study to determine whether the image quality was adequate and how great the image compression would be.

An obsolete XRS RSU1 X-ray Scanner (with a resolution of 146 dpi) and the Ray Vision software was used for scanning most large images. The resolution of the images was marginal for some images, particularly for bone detail and ultrasound images. Consequently, some images were scanned with a smaller UMAX A4 flatbed scanner at 300 dpi resolution. This gave a higher resolution, but with the limitation that insufficient light was able to pass through the image to provide the depth of grey scale across the image, to make the features visible. The radiologist needed to perform a quality check on each scanned image and, frequently, several different scans with different contrasts had to be made, to ensure that clinical features were visible. Eventually, the radiologist was satisfied that the scanning and QTVR technique was suitable for all but the abdominal and some thoracic images. However, a higher resolution X-ray scanner would have increased quality and reduced the amount of image preparation time.

Scanned images were 'cleaned up' in Adobe Photoshop, then imported into the VR Worx application to create the QTVR files.

Once it had been established that the approach described here was feasible, the remainder of the images was scanned. Although there were originally 200 hard copies, not all of these were scanned, but some new images were added. In total, 250 images, of varying type, quality and size, were scanned. In some cases, multiple images were displayed on the one X-ray film, but these were produced as separate QTVR files. In total, 319 individual QTVR movies were produced.

The compression offered by QuickTime also resulted in considerable reductions in file sizes. Given that there was a large range of image sizes, the average size of the scanned images was approximately 2Mb, while the average size of the QTVR images was approximately 300kb. This size makes it feasible to deliver images over the web, as well as on CD-ROM.

**Image storage and maintenance**

A filenaming convention was developed for storing and locating the large number of QTVR images. The characteristics of each image are able to be uniquely determined from its filename, and associated directory name. The images were divided up into five major categories, distinguished by a two letter abbreviation:

RT      Radiographic Technique

UT      Ultrasound Technique

SK      Skeletal System

TH      Thorax

AB      Abdomen

A directory was created for each category. Each directory was divided up into subdirectories, also with two-letter abbreviations — for example SK/EX was the Extremities directory of the Skeletal System. Within each directory, files were numbered and annotated with abbreviations for other relevant information.

FileMaker Pro was used as the database engine to store information about each case. FileMaker was chosen because of its cross-platform nature, and the ease with which web pages can be created to display the results of database queries. For each case, the database stores a title, a history and a description of the case. The database also contains four other fields, which contain different aspects of the lecturer's diagnosis of the case. These fields are password-protected and not normally visible to the student. Feasibility studies have been carried out to determine whether it was more appropriate to store the images within the database or to simply record their file locations. The latter is the case in the most recent version.

The FileMaker Pro database is intended principally to act as a managed storage location for the cases and images. A very important design consideration was that the information was not static, and that new images and cases had to be added at will. A password-protected interface was developed which allows radiologists to add and edit cases through the web. The database is thus dynamic, and as new clinical cases become available, they can be readily added, for incorporation in the unit the next time it is offered.

However, we also developed a read-only, online view of the database, whereby students could search out cases and have them presented as web pages. This function has not been used for this purpose, but could be, for on-campus students.

Because of the file sizes and internet bandwidth issues, an online database solution was not appropriate for the target students, at locations all around the world. Instead, the images and case information needed to be delivered on CD-ROM. It was therefore necessary to extract the information from the database into some format suitable for use on CD.

Our initial attempts to transfer the database information onto CD were not entirely successful (Phillips, Pospisil & Richardson, 2000, Phillips, Pospisil & Richardson, 2001). The method currently used is to specify a FileMaker query, such as "view all records sorted by category", and to create static HTML pages from the result using a utility such as Grab A Site. What was a search query on the live database becomes a browse list on the static CD, but the same material is available to the student. Several different views of the data can be created simply by capturing various search criteria.

Any QTVR images referred to on a page are displayed in moderate size on that page. A link is also present for each image which opens the QuickTime Player, so that images can be compared and resized at will. Other interactivity can be added by embedding Javascript into pages at the time they are created by FileMaker Pro.

## Interactive case studies

The CD-based solution described above presents students with static material about cases. Students can interact with the QTVR images, and attempt to make diagnoses. They can explore the images and relevant information can be displayed as hotspots are rolled over within QTVR. However, the CD, as described above, has no facility for the student to check whether they are correct in their diagnosis.

One solution is to embed an interactive track in the QTVR movie, and ask the student to click on areas of clinical interest, in a self-test mode. However, such testing only elicits lower-order knowledge, rather than the higher order diagnosis skills required by this unit.

For the interactive case studies to offer an appropriate learning environment, the student needs to enter their own diagnosis about a case. This may be in the form of a single text field, or as a number of fields in a diagnostic report. Student work needs to be saved for subsequent review.

In self-assessment mode, when a student is satisfied with a diagnosis, they submit their work, and a model answer is displayed for them to compare their work with. In assessment mode, work will be submitted to the lecturer either directly online or through an email attachment.

At the time of writing, a full specification of this functionality has not been finalised.

**Addressing student problems**

Perhaps the major problem experienced by lecturing staff teaching V620 to external students was the inability to determine whether the student was actually looking at the part of the image that the tutor was talking about. When students had problems with particular images, often the only option open to them was to telephone their tutor. However, with ultrasound and radiograph images, it is often difficult to describe exactly which diffuse area of grey one should look at. Often, many minutes would be spent in conversation, before it was realised that the discussion was about different areas of the image. In a face-to-face situation, on the other hand, a simple pointing gesture would resolve this issue in seconds.

This was the technical problem facing us — how to simulate the face-to-face situation with QTVR images. Electronic whiteboard solutions exist in the market place, but these typically involve static images. In our case, we wanted to be able to use QTVR features, such as panning and zooming, while at the same time being able to highlight key areas on the image.

The solution we chose was provided by MacroMedia's ShockWave Multi-user Server. This is an application which enables ShockWave movies on the web to communicate with each other. The Multi-user server comes bundled with the commercial version of MacroMedia Director. Code for an electronic whiteboard was embedded as a 'behaviour' within Director, and we modified this to work with QTVR.

At the time of writing, the prototype whiteboard enables users to load a QTVR image; zoom and pan within it; draw shapes and lines on it; and type text messages to each other. There is no restriction on the number of people who can interact with the image at the same time, so that it is possible to run tutorial classes as well as one-to-one help sessions with the tool. Users are allocated to groups, so it is possible for several whiteboard sessions to be carried on simultaneously within the class.

A second prototype uses Macromedia Flash as a means of displaying the radiographic images instead of QTVR. This was trialled because of technical problems in propagating messages sent from the built-in QTVR controller to the other participants of the whiteboard session.

The QTVR whiteboard will be progressively refined during the year and will be ready for demonstration at the AUDF conference in September.

## Conclusion

This paper describes innovative use of Apple technology in an educationally sound context.

QuickTime VR is used to simulate the process of viewing radiograph and ultrasound images. Images and case information are stored in a FileMaker Pro database. Case studies are created from the database as static web pages and delivered to students on CD ROM. A specification has been given for interactive case studies by which students can gain immediate feedback. An electronic whiteboard is described, which allows students and tutors to manipulate the same image at the same time.

While none of the technology used is new, this paper describes how existing pieces of technology can be linked together in new ways. These developments enable Veterinary Diagnostic Imaging to be taught more effectively and to larger numbers of students, by:

- providing immediate feedback to students;

- easing the burden of marking whilst enriching the learning experience;

- providing more opportunities for communication and discussion of diagnosis;

- enabling dynamic annotation of images;

- enabling case studies to become more challenging and educationally effective.

The approaches being developed in this project have wider applicability in the Master of Veterinary Studies programme at Murdoch University, in which many units are case-based. Indeed, these approaches are applicable to any image-based discipline, particularly those where learning has to occur at a distance.

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### Acknowledgements

# e-Learning for hearing impaired students

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**Abstract** Confucius, the Chinese philosopher, is of the view that "Learning without thought is labour lost; Thought without learning is Perilous". Education essentially includes the process of encouraging, strengthening, and guiding the students, whether of mind or body, so as to make them fit and ready. Wherever the need exists, it must include instruments for the work they have to do. Moreover the awakening for the first time into activity and usefulness of some students, might remain forever dormant. As regards intellectual development, the hearing impaired individual is the most handicapped of the afflicted class. Hearing impairment implies a radical defect in both the auditory and the vocal organism. Persons who are born hearing impaired, or who lose their hearing at a very early age, are unable to speak, although their vocal organs may be unimpaired. They become speech impaired because, being deprived of hearing, they are unable to imitate the sounds which constitute speech. We felt that this set of students should be given utmost importance. So we developed the software system named "You Can".

## About MCET

Dr.Mahalingam College of Engineering & Technology(MCET), Pollachi, is one of the leading Engineering Colleges in South India It is administered by Arutchelvar Dr.N.Mahalingam (Chairman) and Mr.M. Manickam (Vice-Chairman), respectively an outstanding industrialist and educationist, and Prof.C.Ramaswamy (Secretary). The college was started in the year 1998 as the latest addition to the management. The establishment of Apple Distinguished School (2000) in our campus, the first of its kind in SAARC Countries paves the way for the membership in Apple University Consortium (AUC) Australia. In continuation of this, MCET has joined hands with Edith Cowan University, Perth, Western Australia for the Masters Degree in Professional Communication as a summer sequential program, Our first batch of students have already completed the first semester in July 2001. MCET is involved with lot of projects, in the areas like Development in the Mac OS Platform, Interactive Multimedia tools and Networking. Realizing the remarkable features of Apple system in a short span of two years, the young faculty and students in our campus get a lot of exposure which has kindled our interest to adopt this system to the people who are in need of it. Keeping this elongated use of Apple technology in mind, we intend to extend the service by using this system as a tool in one of the charitable schools run by our management functioning under the name of Kasturiba Gandhi Oral School for Hearing-Impaired Students. In addition, to avoid the difficulties in traditional teaching for hearing-impaired pupils, we have decided to create this system "You Can" which is an Interactive Multimedia Learning Tool.

## Oral School for hearing impaired students

Kasturiba Gandhi Oral School for Hearing-Impaired is situated at Coimbatore, India, which was started on October the 2$^{nd}$, 1996 with 3 students and 2 staff. At present, there

are 100 students on roll for the standard from Pre-KG to VIII, and the faculty's strength is 20. The school has adequate infrastructure such as classrooms with black board & charts explaining details of letters, single & double syllable words, parts of the body, basic sciences, human actions, real world items. The way of teaching starts with introduction of sound, since most of the hearing impaired students are not heard the sound previously. So they are not able to take out the sound from their body. The traditional ways in our school of teaching to train them to overcome the hearing impaired difficulties are as follows:

- placing the hand over the chest and to feel the sound when we spell the word
- placing the hand over the cheek and to feel the sound
- keeping hand near the mouth while they are speaking
- observing the lip movement of the tutor.

## "You Can" System

In the traditional teaching of our school, we have observed the following

- no sequence of training
- physical strain on the staff is high
- content is not organized
- preparation of the modules is not adequate.

To overcome the above difficulties, the "You Can" system was developed to help the teaching staff to improve the performance of training.

## Interactive Multimedia

In the modern era, all the media are converging to put the information into an organised manner to teach the basic content to students. Apple Computers Inc., has created many Interactive Multimedia tools which induces us to develop this system on the Mac platform.

## Concept of "You Can"

The aim of the system, is to teach the hearing & speech impaired pre-kindergarten students, which will enhance the confidence level of the individual, by which we can motivate them to learn new things, and to communicate with others. The outcome of the system is to make them feel normal and learn new things by using the modern invention — "You Can". The system is developed with the behaviourist approach, where the concepts are directly explained.

### Simple images and animations

To increase the student understanding and to engage them, Graphic images & animations are used

### Lip movement

It will guide them to pronounce the alphabets, single, double & triple syllable words, etc.,

**Wave form representation**

On pronouncing a letter or word, the wave form of student is generated in the system to match the waveform of the staff.
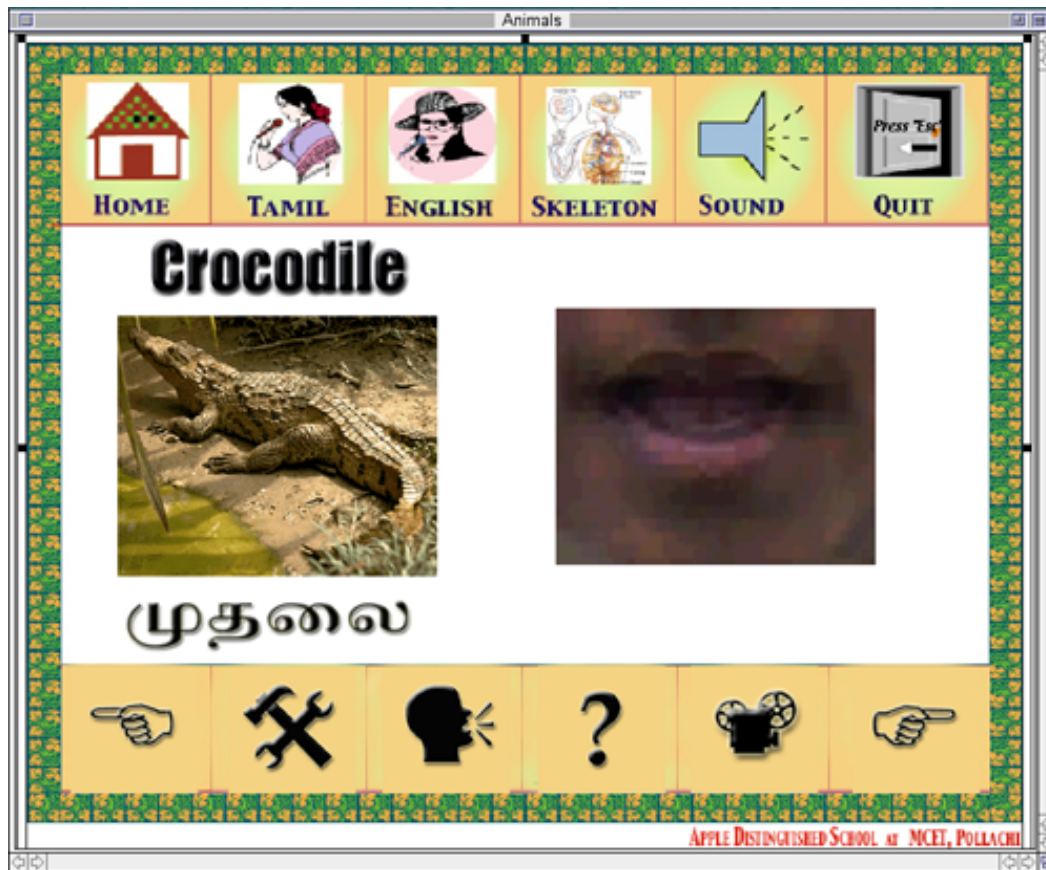


Based on this, the students can more easily try to correct themselves. The general strategies like simulation, tutorials, etc., are provided to view their performance. The contents covered will be accorded to the level of the kids with the local language Tamil as primary and English as secondary

- alphabets,
- numbers,
- spelling,
- Single, double & triple syllable words
- pronunciation,
- vocabulary
- real world items like animals, birds, household items, natural scenes etc.,
- basic mathematical concepts
- painting the artwork drawings
- fill in the blanks
- matching
- writing exercises

Colours and graphical animations are provided to attract and motivate the students with the view to concentrate themselves while working in the system. The requirements of the system are

- Apple Computer with Power PC Processor

- Software like Quick Time Player, Audio recording software (felt tip sound studio).

- Microphone

- Speakers

- Interactive Multimedia tool (Macromedia Director)

## How "You Can" Works

The system has been designed with a good interface and navigation tools. It has an introductory screen with good animation followed by a Main menu. The options can be selected based on the level of the students and the topics

The teaching content has been divided into various modules. Each module is summarised in various screens.

Teaching staff will guide the kids to train under each module in sequential manner. It will reduce the physical strain on staff, and also procedure is given in structured manner.

In this system we have added new features in which staff can record the sound and then kids can practice matching to the waveform of the staff.

During the training process, evaluation of learning is important. So, we have included review session at every level in this system. The steps to be adopted by the kids during the evaluation process will be as follows:

- Kids are asked to write the single/double/triple syllable words by seeing the images on the screen

- Match the similar images

- Select the correct word from the image

- Spell the words correctly

- Correct the mistakes

- Fill in the blanks

- Basic mathematical works

- Painting the artwork drawings
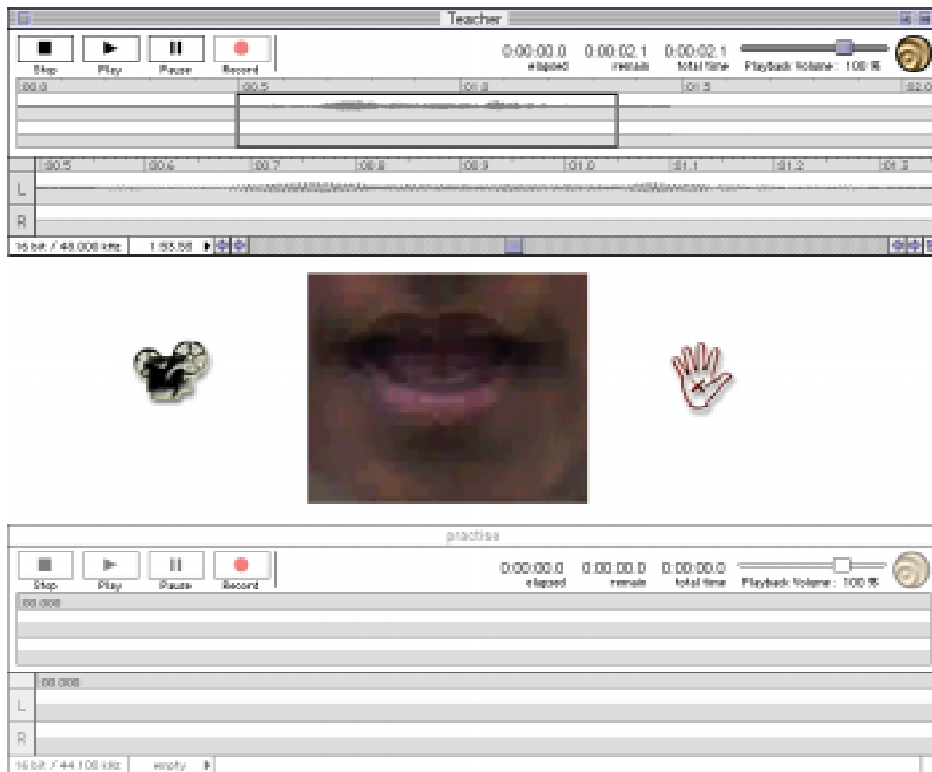
## Issues

*Engagement:* The kids are provided opportunities such as drawing the pictures, animation, colouring by means of which the attention of the kids will not be diverted.

*Performance evaluation:* To evaluate the performance of audibility of the kids with the aid of computers is difficult.

*Level of control:* The students are controlled by means of plenty of illustrations, examples.

*Teaching & Learning Process:* To teach the action words like *come*, *go*, *walk*, *move* is a problem to explain. In a traditional method, the teacher can demonstrate by means of gesticulations. Issues of this sort will be overcome by movies & animations.

## Features

- Search Engine
- Web links
- Teacher/Student sound screen
- Content — Split into modules for different level of users
- Learner control
- Better user comprehension and motivation
- Evaluation process
- Navigation
- Review session

## Further Work

At present, we are concentrating only on the Pre-Kindergarten kids because they are mild and tender by nature. Later we are going to do some more advanced features, based on the level of the students.

## Conclusion

Since education is the modification of behavioural changes, it occupies a place of prominence in moulding the character of the students. In this regard, we give a lot of importance to child education especially to the hearing impaired kids, because this is the period where the kids can easily pick up and understand the concept. Being a maiden attempt for a young AUC member like us, the effective use of Apple system will create a positive impact on the minds of the faculty and students, which in turn will tempt the people to make use of Apple Technology.

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# Exploring on-line learning communities: supporting Physical and Health Education professional development opportunities

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**Abstract**  In an era of limited resources across educational sectors, academics associated with faculties of education are under increasing pressure to find innovative ways to support their teaching and research activities — activities with which collaboration and interaction with pre-service teachers, practicing teachers and fellow academics is crucial. As such, developing a sustained community that involves such representative members is paramount for academics. A team at the University of Wollongong has initiated this concept through research and development of the *ActiveHealth* learning community for physical and health educators.

Whilst it is envisaged that such a project will take time to establish, a number of priority areas have been identified. One such area is a mechanism to develop and share physical and health education teaching and learning resources. This paper outlines the development of the *ActiveHealth* community and its supporting database-driven Web site, which has been developed WebObjects, to provide support for teachers and students through communication with university lecturers, practicing teachers and critical friends.

## Introduction

The nexus between teaching and research is paramount for academics associated with faculties of education who must concurrently be at the forefront of pre-service teacher training, innovation in multiple educational sectors and teacher professional development. It is therefore imperative that academics are active and leading members of their community of practice. Within the specialisation of physical and health education, key members of the community are: teacher educators (i.e., university-based academics), practicing teachers, pre-service teachers (i.e., university students).

This community has traditionally fostered successful processes for the exchange of ideas and mentoring newcomers in such collaborations as: policy and syllabus consultation, curriculum and resource development, and, practice teaching experiences. Unfortunately, these activities are often conducted on an ad hoc and irregular basis where individual members may not have a sustained role or commitment. As such, in an era of limited fiscal and social influences and calls for reform within the teaching profession (see Ministerial Advisory Council on the Quality of Teaching 1998; Ramsey, 2000) education faculty academics are seeking new approaches to sustaining and invigorating the community.

## Developing a technology-facilitated community

The affordances of information and communications technologies (ICTs) to support physical and health education include: time and place independent access to resources, instructors and peer learners; provision of tools and simulators for the construction and presentation of ideas and concepts; and communication vehicles that may allow for in-depth exploration of controversial or difficult to manage issues.

Recognising such affordances, academics within the Faculty of Education at the University of Wollongong have integrated technology use into aspects of the undergraduate curriculum with research evidence providing positive indications of effectiveness (see Lockyer, Patterson and Harper, 1999; Lockyer and Kerr, 2000). These experiences, coupled with growing accessibility of ICTs, provide academics with the opportunity to explore the extension of technology use from campus-based activities to innovative options for interacting with and supporting the wider community of practice.

This innovation begins with the transformation of previously ad hoc interacting groups of academics, students and teachers into an organised learning community. The benefit of such an organization is best summed up by Schwier (1999 p. 282) who states that the power of learning communities "resides in their ability to take advantage of, and in some cases invent a process for exchanging ideas and learning collectively."

There are identified characteristics of such communities. The hallmarks of a learning community that focuses on professional development and exchange include: a clear focus that is driven by members; employment of appropriate technologies and styles of communication; a social network where expertise, leadership, and contributions are valued; and, ongoing, regular discussion, sharing of and collaboration on commonly valued things (Hord, 1997; Stuckey, Hedberg and Lockyer, 2001).

The development of a collaborative rather than an individualistic culture for teachers is widely supported in the literature as necessary for learning to occur. The development of the concept of collaborative teams early in pre-service training of teachers and the opportunity for pre-service teachers to work with practicing teachers and lecturers will ensure "membership" in the physical and health education community.

## Designing the *ActiveHealth* framework

The initial phase of the project focused on discussions with stakeholder representatives; the design of the Web-based environment which supports the community; the prioritisation for implementation of components, activities or features; and the confirmation of learning contracts with pre-service teachers who contribute to the development of the community.

It was determined that the Web site (see Figure 1 www.activehealth.uow.edu.au) would: (1) provide access to a database of relevant teaching and learning resources; (2) act as an online gateway to the Physical and Health Education program activities at the University of Wollongong; and (3) support professional development activities and interchanges.
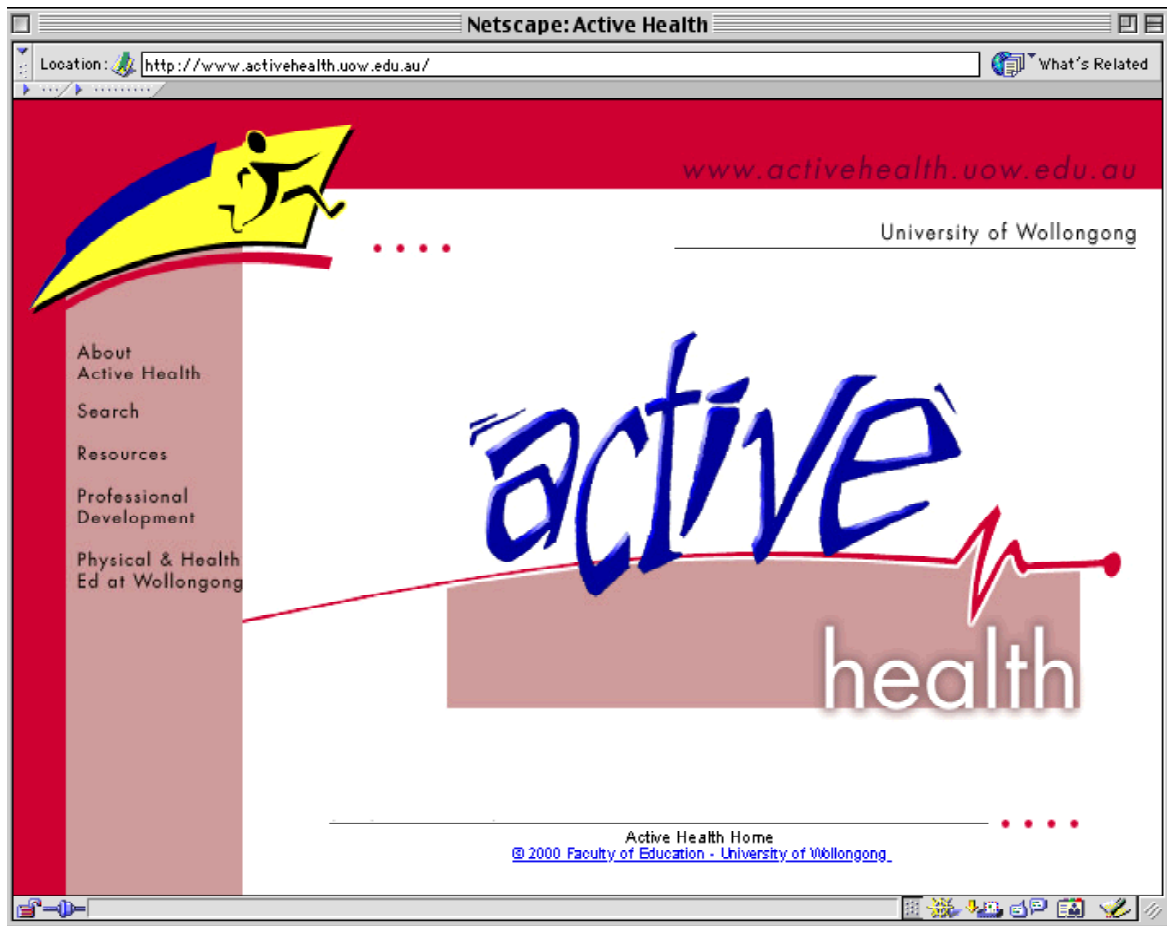
*Figure 1: ActiveHealth Web site home page.*

Prioritisation was given to the development of teaching and learning resources. Practicing teachers are under continuing pressure to stay in touch with current knowledge in physical and health education, demonstrate the use of information technology in their teaching as well as provide their students with opportunities for the development of information technology skills. A needs analysis conducted with teachers within the local professional organizations indicated the greatest need for resources lay in the identification of specific physical and health education Web sites, lesson ideas, assessment tasks, online learning activities, and teaching support sites. An important consideration is that these resources were of high quality and relevance suggesting the need for a peer-review process associated with resource contribution.

Given the underlying philosophy of active involvement of all participants in the learning community, it was envisioned that students, teachers and academics with varying computer skills would be involved in the contribution and maintenance of the resource base of the site. Therefore, it was necessary develop a solution that included a technology-transparent interface for users yet ensured data integrity.

To this end, an ActiveHealth WebObjects Application (AWA) was developed. Resource elements, descriptors and user data are stored in OpenBase databases. The AWA provides the facility to enter, edit, search and retrieve information thereby creating dynamically generated Web site content. Therefore, labour-intensive development of static html pages which have limited updating and storage options becomes unnecessary.

This technology combined with a resource contribution, review and view process (see Figure 2), supports efficient resource sharing within the learning community:

- Any user of the Web site may suggest a resource to add to the *ActiveHealth* collection. The ActiveHealth WebObjects Application serves a resource suggestion form page on which the user add information about the resource. Once submitted this information is stored in the *ActiveHealth* resources databases.

- When an authorised *ActiveHealth* reviewer (i.e., students, teachers and academics who have offered to review resources and have issued with an individual username and password) accesses the site, the AWA calls the database to provide the reviewer with recently suggested resources and provides the reviewer with a form to complete. Upon submission of a review, the suggested resource is tagged in the database as available for circulation to *ActiveHealth* users.

- When a Web site users wishes to access reviewed resources, the AWA generates dynamic search, retrieve and view pages.
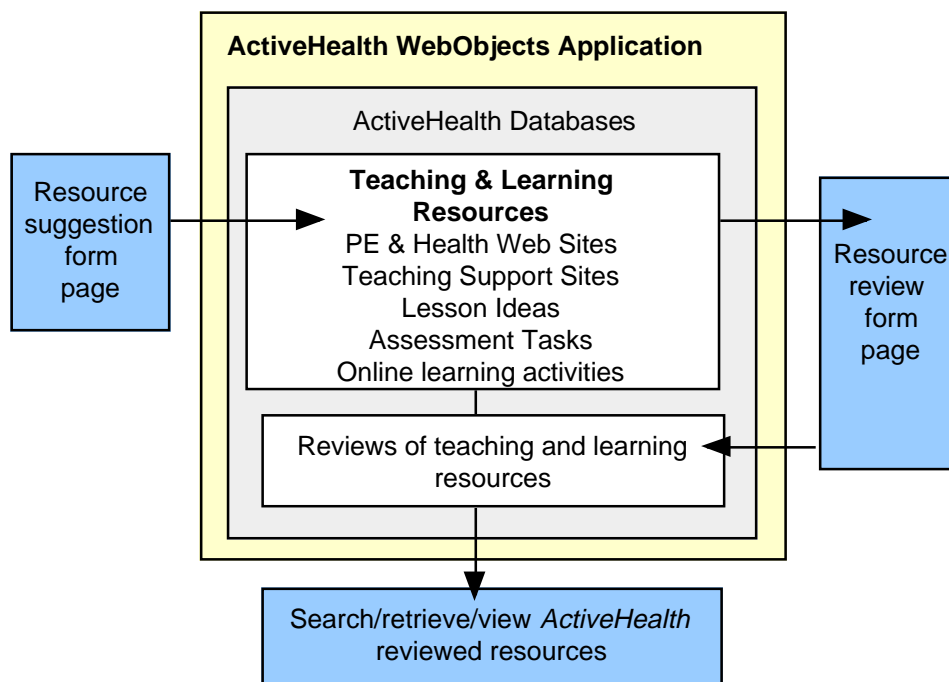


*Figure 2: ActiveHealth resource contribution, review and view process*

The design of the underlying framework for the *ActiveHealth* site and the functionality of the database and the ActiveHealth WebObjects Application interchange allows room for unfolding future learning community features such as events and conference announcements, position postings, casual teaching opportunities and availability.

The preliminary design and processes were presented to representatives of the learning community for feedback at a variety of professional development events including the Apple-sponsored Innovative Schools Technology Conference and National Education Faculty Conference (both held in Wollongong in December 2000), the Australian Association for Research in Education Conference and the Australian Council for Health, Physical Education and Recreation (ACHPER) Tertiary Educators Network (both held in Sydney in December 2000).

At each of these presentations, time was set aside for participants to discuss the project, clarify major issues of concern and make suggestions for future ideas and possible involvement. All groups represented gave their endorsement to the project and recognised its importance to the physical and health education profession.

## Initiating community member participation and leadership

A common theme arising from these discussions and validated in the vast amount of professional development literature is the need for teachers to be given the opportunity to work together, sharing and modelling their experiences and expertise rather than having to work alone. The bulk of literature supports the view that for teachers to grow and continue their learning throughout their careers they need to be supported and encouraged with this support and encouragement best provided by teachers working together either in collaborative projects, groups of peers or mentoring relationships (Hargreaves & Fullan 1992; Butt et al 1990; Little 1986).

It has been argued that such working relationships contribute to the effectiveness of professional development programs by acting as sharing and reinforcing mechanisms that extend individual learning and encourage risk taking with new approaches and strategies. In essence, this project has the potential to get physical and health education teachers to put pedagogy back on their agenda.

Based on these principles, the *ActiveHealth* project team has embarked on a developmental approach to the involvement of secondary physical and health education teachers and primary school teachers and the development of resources for specific content areas. Underlying research investigations are focusing on an ethnographic study of the development of the community and an accompanying study to indicate the translation of teachers' involvement in the online community to changing classroom practices in terms of integration of technology.

Initial activity involved a core group of teachers from four schools in the South Coast Region of NSW being invited to be part of the Crossroads Project — the development of online Personal Development and Health lessons for Year 11 students. Teachers from each school along with 12 other interested teachers were involved in a professional development workshop (Apple Innovative Schools Technology Conference 2000) focussing on the use of the Web-based environment in teaching. This core group have committed themselves to the development of resources and their involvement in the review process.

Through State physical and health education professional associations and the Alumni Association from the University of Wollongong, teachers across New South Wales are joining the *ActiveHealth* community and are contributing to the development and review of resources for specific content areas.

It is expected that after a critical mass of teachers have been involved in the project from across NSW, opportunities will be explored to actively pursue involvement at a national and international level. Ideally, increased community participation will also include primary school teachers. Given the lack of physical and health education specialists in primary schools, a similar process will be adopted in that firstly local South Coast teachers will be approached but through NSW DET professional development opportunities. Based on the results of the smaller South Coast group of teachers, plans will then be implemented to involve primary school teachers from across NSW and nationally.

## Concluding Remarks

There is nothing in the professional educational literature in Australia that suggests that school systems will move away from a school based management framework or that staff development will cease to be valued by teachers or schools. Indeed, as recently as 1998

the Australian Senate Employment, Education and Training References Committee conducted an inquiry into the status of the teaching profession with a focus on the professional development of teachers. Its main recommendations through the final report, A Class Act — Report on the Status of the Teaching Profession, were that funds be allocated by the Commonwealth Government to assist in the reinstatement of the National Professional Development Program (NPDP) and that teachers' participation in professional development be a prerequisite for their continued registration or for re-registration. The report also raised concerns that there will be a scarcity of resources for education with a diminution in the level of state government funds for staff development with reductions in funding at the school site leading once again to piecemeal and ad hoc approaches. Such a scarcity of resources for staff development will require that schools allocate time and spend their funds wisely.

Given such a background, the changing teaching environment in schools and universities and the rapid increase in the use of technology by both institutions, this project has the potential to show how a community of physical and health education teachers can use the technology-facilitated *ActiveHealth* framework to enhance their teaching, research and professional development opportunities. Whilst this project is in its infancy, the level of support and enthusiasm shown by community members thus far indicates the potential for the project on a large scale. It is envisioned that this online community will evolve to encompass increasing avenues for collaboration among the participants.

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## Acknowledgements

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# Developing a multimedia engine in QuickTime for Java

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**Abstract**   One of the challenges facing developers wanting to develop multimedia applications in Java is finding a suitable class library. Most of the class libraries are in the rudimentary stages of development at present. In contrast Apple's QuickTime for Java library offers the full power of the already well-developed QuickTime API to the Java developers.

In this project we have put the QuickTime for Java API to the test by using it to develop a multimedia authoring package. We aim to guide the reader through the process we have followed, giving reasons as to the use of certain implementation methods we have used. It will also indicate the challenges we have faced.

We will closely examine the different media handling capabilities available, the layering options and accessing of some QuickTime effects that are only available through the use of the API.

We will also look at the issues involved in porting this application to OS X and in particular the changes required to give the proper Aqua look and feel. At the time of writing this we are in the process of refining it to work with the Aqua interface.

## Introduction

When we set out to develop this multimedia-authoring engine we had to ask the question: "why develop another multimedia engine when there are commercial packages available on the market?" The answer to this is three fold: we wanted to develop a package (1) that is easy to learn and easy to use; (2) that can be extended to meet changing authoring needs, and (3) to conduct research into identifying the components needed to make a useful multimedia engine.

If we look at the leading multimedia-authoring packages available on the market, such as Macromedia Director, they are tools, ideally suited for professional developers working on large projects. This is not to say that they cannot be used to develop small projects but the amount of time required to master the package acts as a barrier for novice users. For example, a complex authoring tool may not be the ideal tool for a primary school teacher wanting to develop an interactive story.

## Objectives

### Easy to learn and easy to use.

In terms of the ease of learning, we wanted someone to start this package and be on the way to producing useful multimedia content in less than an hour. Ease of learning also

meant that the user should be able to use this package without having to learn a scripting language. We developed a graphical user interfaces to meet this ease of use criteria. Making a program easy to use in terms of user interface design can be a challenging task. This became apparent in the implementation stage of this project.

**Can be extended to meet changing needs.**

When using commercially available multimedia development packages, one is limited to the development options provided by those packages. Here, by virtue of having access to the source code, we are free to make changes as the need arises. There is also the potential to develop this further as an open source project.

**Identifying the components needed to make a useful multimedia engine.**

The term multimedia package implies bringing together a diverse range of media elements to form a single entity. In doing so, the author of the package aims to achieve a synergy and to enhance the user experience in some measurable way. But this is only one aspect of a multimedia package. What sets a well-designed multimedia package apart from traditional media is that it allows the user to interact with its environment, while it responds to the user's interactions.

Here we have endeavoured to provide enough functionality for media integration and user interaction at the same time as maintaining ease of use.

## Implementation Language

We have decided to implement this application using Java and QuickTime for Java API. We selected QuickTime for Java (QTJ) as the implementation environment because of the following:

- Extensive media handling capability of QuickTime — Basing our application on QuickTime allows us to leverage the media handling capabilities of QuickTime within our application such as codecs.

- Cross platform capability — As QuickTime is a cross platform product, we will be able to extend this package from the Macintosh OS 9 environment to other environments at a later stage.

- At the start of the project, we did not appreciate the full complexity of the QuickTime for Java API. At times it was a challenge to navigate through the rich feature set of QTJ. But, the end result was well worth the time spent in learning the API.

## Application

Multimedia applications can be subdivided into a number of genres in terms of the types of user interaction. Some of the widely known multimedia genres are:

- Twitch — Where the user interacts with a range of fast moving sprites on screen, such as Doom. In this environment the user relies on his or her reaction speed to accomplish the objectives, hence the term "twitch".

- Adventure — Where the user is expected to accomplish the objectives through reasoning and logic, such as Myst.

- Learning or simulation environments — Most of the computer aided learning packages fall into this category, such as Sim City.

The requirements of a twitch type environment are such that it would not be possible to develop such an environment without a dedicated scripting language, and this is a non-trivial task. So, in keeping with our stated objectives we decided to aim this multimedia engine for developing simulation and adventure type environments, suitable for educational packages.

## Multimedia Engine

We have called our multimedia engine the "MMBuilder". MMbuilder operates in two modes; edit mode and play mode. When you first launch MMBuilder it starts in edit mode and creates a new project for you. You use the edit mode to build your multimedia application. When you are ready to test your multimedia application you can switch to the play mode.

The interface of MMBuilder is divided into four parts as shown in Figure 1.

- Editor window

- Media catalogue
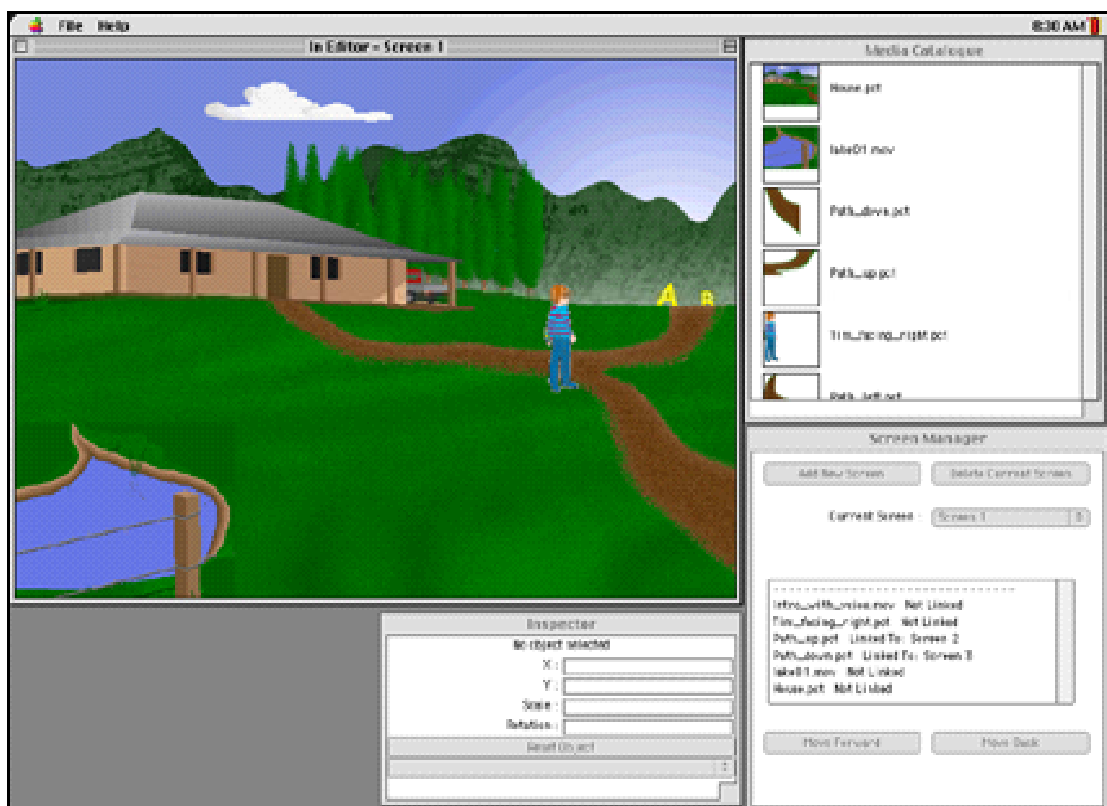
- Screen manager

- Inspector



Figure 1 - Interface of MMBuilder

**Editor window**

The Editor Window lets you construct multimedia screens. The name of the screen you are working on is shown on the frame of the editor window.

You select an item in the editor window by clicking on it. When an item is selected it has a green outline around it. It is possible to change the position of a selected object on the screen by dragging it. You can also change the position, scale and rotation of the selected object by using the inspector window.

**Media catalogue**

Any of the media types supported by QuickTime can be imported into the MMBuilder. The Media catalogue window let you keep track of the imported media elements. A media catalogue with a Flash button, Pict file and some movie files is shown in Figure 2.
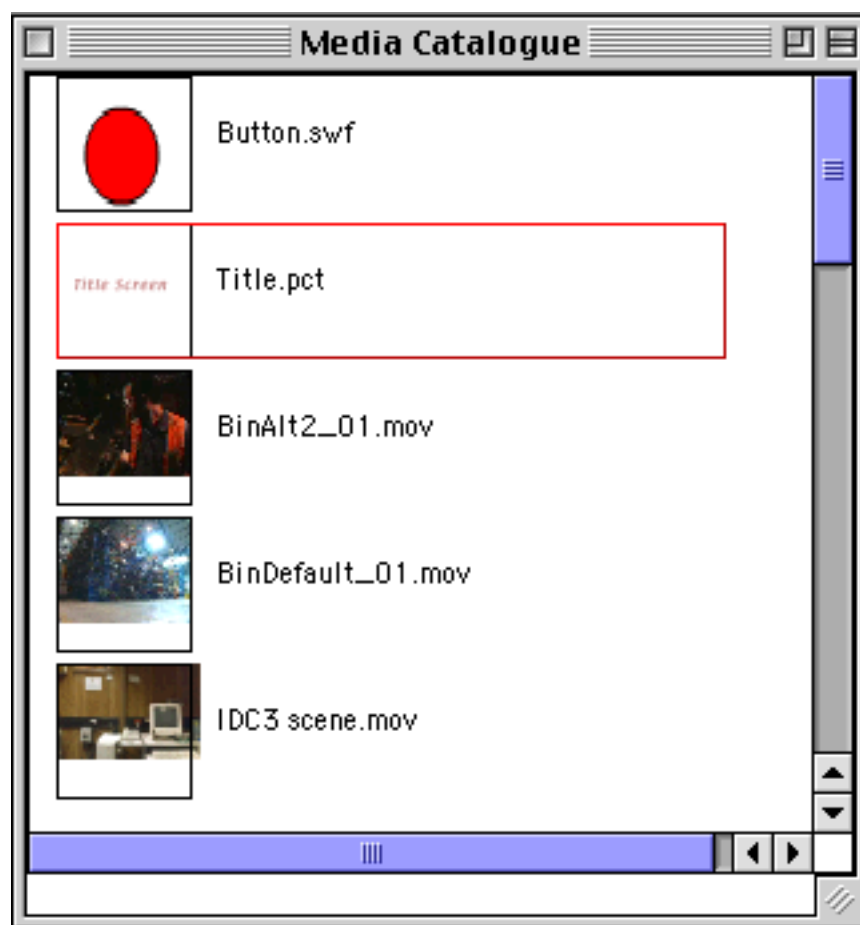


*Figure 2 - Media catalogue*

**Screen manager**

The Screen Manager Window shows all the media elements used in the current screen. In addition to this it performs three key functions. They are:

- Changing the layer order of media elements
- Creating new screens
- Navigate between screens while in edit mode.

**Inspector**

The Inspector Window displays the selected object's name, position, scale and its rotation. You can change the location, scale and rotation of the selected object by entering new values into the fields.
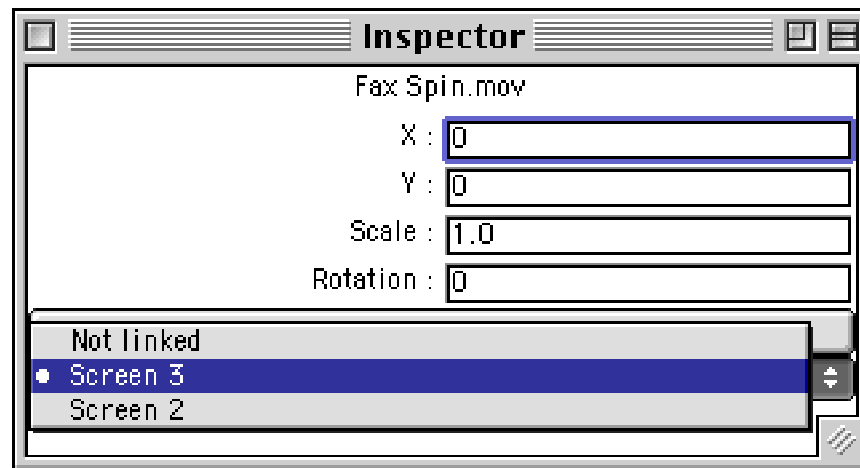


*Figure 3 - Linking to a Screen*

You can make the selected object, a link to another screen by selecting a screen name from the drop down menu as shown in Figure 3

## Types of interactions

There are a number of interactions available to the users of this multimedia engine. They can set up navigation between screens by selecting an object and then making it a link as shown in the previous section. A single mouse click on a linked object result in a screen transition.

When we include a QuickTime movie or a QuickTime VR on a screen we have the option to display or hide the movie controller. If the movie controller is available then users can interact with the movie using the controller, if not they can play the movie by pressing the space bar.

We can also use QuickTime movies as hotspots. This is done by displaying a movie without the controller and setting the playback to trigger on mouse enter. It is possible to create striking effects when this is combined with making the background of the QuickTime movie transparent. It is also possible to trigger QuickTime movies and sound effects on screen transition.

## Game

In order to have a simple demonstration of the concept we have developed a part of a multimedia application called "Tim's day in alphabet land" (Figure 4), using our multimedia engine. This multimedia application is aimed at preschool children who are starting to learn the alphabet. We hope this application will help children learn the alphabet in a fun and exciting way while introducing them to the computers.

The objective of this game is to navigate through a series of screens in alphabetical order. On each screen there are animations and sounds to keep the child interested. When the game starts the child is presented with the screen shown on Figure 4. After a small pause

the title disappears and a voice over asks the child to help Tim to find his way to the "Alphabet land" by clicking on the road.
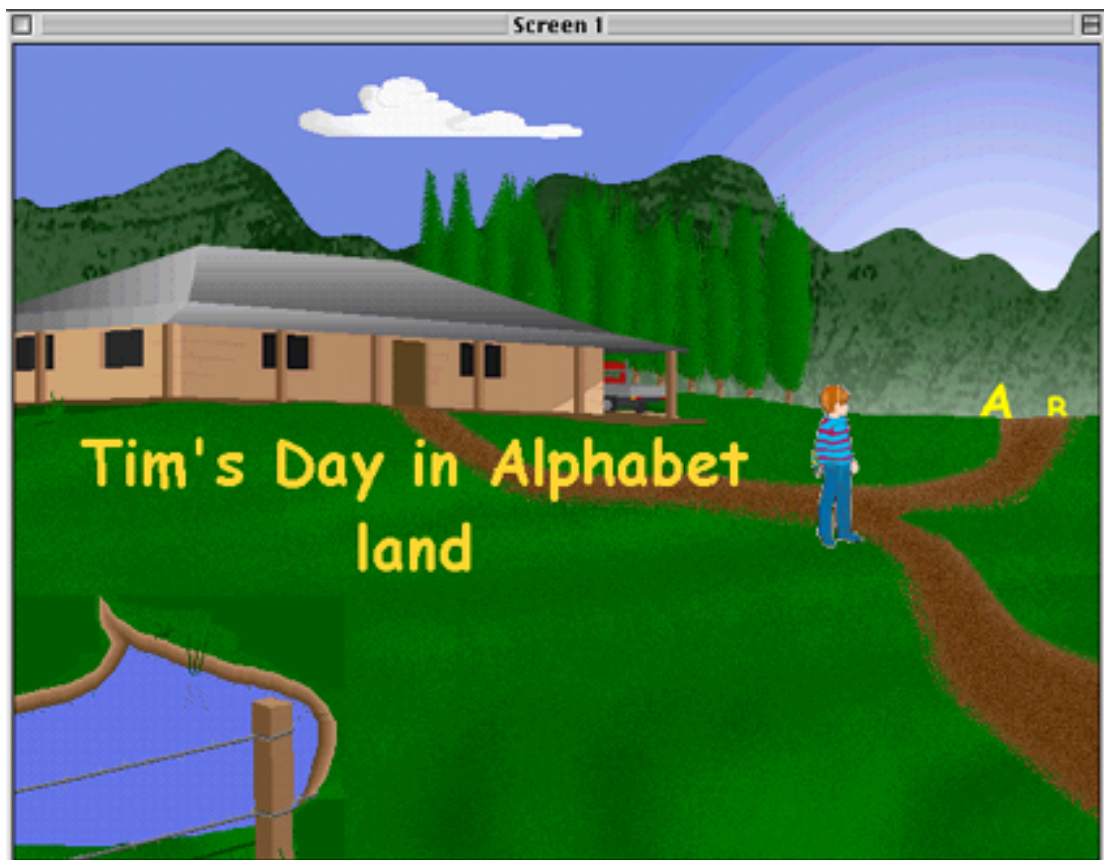


*Figure 4*

## Design of the Multimedia Engine

So far we have looked at the functionality of our multimedia engine and an example of what it could produce. In this section we will closely examine some of the design decisions and their implications.

### Design of the editor window

The editor window is designed as an AWT Frame containing a QTCanvas. The QTCanvas is a special canvas that interacts with the Java display and event system. It enables us to present QuickTime content in a Java window.

We have created a class called mmScreen to represent the content displayed on the editor window. Each time we create a new screen we create a new mmScreen. A mmScreen can contain any number of media elements. It is responsible for the layering and positioning of media items. It also implements a number of controllers and listeners to handle selection of objects, dragging of selected objects and navigation between screens.

When a mmScreen is created it creates a DirectGroup and adds it to the QTCanvas. The DirectGroup performs the actual task of media positioning and layering. When we add a media item to the editor window, it gets added to the DirectGroup. The DirectGroup maintains a Layerable object and a matrix for each of its members. We change screens by changing the DirectGroup associated with the QTCanvas.

But using the DirectGroup as the top-level container for our multimedia screens has its limitations. By definition all members of a DirectGroup draw directly to the screen and the DirectGroup handles the clipping of overlapping members to avoid flickering. This does not allow us to apply any Compositing effects to the media elements. In order to create a composite image it should be possible to draw two or more objects on to the same area. QTJ provides the Compositor class for this purpose. So we should pose the question, why not use a Compositor as the top-level container in mmScreen instead of using the DirectGroup?

Unfortunately the Compositor has its own limitations. We cannot use the Compositor to display a QuickTime object that uses the standard movie controller. This is because the MovieController cannot be drawn off-screen while the Compositor does its drawing to an off-screen buffer before blitting the image to the screen. This problem was posted to the QuickTime for Java mailing list. According to Apple engineers, they have no plans to modify this behaviour of the MovieController.

The approach we have adopted to overcome this problem was to keep the DirectGroup as the top-level container, and to embed a Compositor of the same dimensions into the DirectGroup. This way when adding items to the mmScreen, we can add any items with a MovieController to the DirectGroup and the rest of the items to the Compositor. Then we are free to apply image compositing effects to the items in the Compositor.

### Linking of screens

We decided to allow the media elements on a given screen to serve as the links to other screens. With this structure, it is possible for a screen to have any number of links to other screens. Each screen element retains its own link information.

A screen change is activated by a single mouse click on a screen element that contains a link. It is important to note that the screens do not retain any state information. So when moving to a new screen, any time-dependent media on that screen will always start from the beginning. At a first glance this may appear to be a major limitation of our authoring package. But in most cases we do want the time-dependent media to start from the beginning. For example, in a multimedia package when we return to a previously accessed screen, we do not want a QuickTime movie to start playing from the middle or for a sound effect to fail because the playback head was at the end.

### Saving a project

Saving of a project file is done through the Java Object Serialization. All the classes that need to save content or state information are declared as Serialisable. This approach has the advantage of not having to explicitly save out the content of all the internal data structures.

However Object Serialisation only provides half the solution to the problem because none of the QuickTime objects are Serialisable. So, in the classes which use Serialisation, QuickTime objects had to be declared as transient. If any of the QuickTime objects need to be saved, then the relevant information has to be extracted into primitive Java data types before the Serialisation could proceed. When loading a file, the saved information is used to recreate the relevant QuickTime objects. It is important to note here that this program does not save out QuickTime objects as "QuickTime objects" or use the QuickTime file format to save project information, instead we use Java streams for this purpose.

When using Object Serialisation, each class is saved out with a unique version "id" based on the method signatures of that class. This caused a problem when reading data files into the player, which were created by the editor. Even though all the relevant data structures were present in both the editor and the player, their method signatures were different. In order to overcome this problem it was necessary to override the version id. But no information on the version id is given in the JDK 1.1.7B API. According to the white paper released by Sun Microsystems on Object Serialisation. [Java Object Serialization Specification, 1997], a class wishing to override the version id has to declare and set the variable *static final long serialVersionUID.* We were able to overcome the problem using this implementation.

## QuickTime for Java

We found that many interesting and useful functions that are available in QTJ are not accessible from the QuickTime media player or other authoring tools. Here the challenge for us was to decide on how much of this capability we should uncover through the user interface. We used the ease of use criteria that we defined earlier when trying to decide on the appropriate features.

Some of the functionality we were able to incorporate into MMBuilder includes the ability to rotate QuickTime movies, remove the standard QuickTime controller from a movie, apply an ink effect to a movie such as making it transparent to the background.

## Porting to OS X

Using the ProjectBuilder we were able to get the same code to successfully work under OS X. The only modifications we had to make was to change the calls we used to display the import media dialogue boxes because the method standardGetFilePreview(…) is not supported under the OS X implementation of QTJ. So we had to change the code to use the standard Java method instead. The down side of this change is that it does not provide a preview option when importing media.

The other modification we have to do is to update the interface layout of the program. This is because the size of the fields, buttons and drop down lists have changed under the Aqua interface. We are in the process of using the InterfaceBuilder provided in the OS X developer tools to make these changes.

## Conclusion

In developing this multimedia-authoring package, we were to demonstrate that it is not necessary to have an extensive feature set to make a useable authoring environment. We were also able to demonstrate that the QuickTime for Java class library is a suitable candidate for multimedia development work.

It is also worth noting here that the robustness of the QTJ architecture became obvious when we ported the code OS X. Finally, we are looking for people who are interested in developing simulation and adventure type environments for education to try out our package.

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# QuickTime multi-track thea*tricks*

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**Abstract**  Digital media, corporate database applications and intranets provide efficient ways to create, store and deliver information and educational services. However some academics perceive new workload and other constraints eroding the potency of these technologies. Proposed corporate level information management systems for digital objects and their metadata are new complexities entering academics' thoughts about using online multimedia.

Few staff understand digital multimedia concepts and fewer still, the systems designed to deal with IP management, copyright law compliance and the tracking of digital resource creation processes. Faltering staff enthusiasm warns of their need to experience working models and tangible benefits from these new directions. A project in Deakin's Faculty of Education provides a case study showing how QuickTime is helping academics understand, and increase their use of, multimedia in e-learning environments with an integrated library of digital resources with metadata.

We also report our experience of QuickTime in creating interactive learning objects using multi-tracks. We discuss our idea of thea*tricks* as a performance drawcard — people *will come!* There is orchestration of multimedia and QuickTime conducts the events, its flexible functionalities providing a safer development environment for solving problems and grasping opportunities.

While difficult for some academics to comprehend, scripting automation and database connectivity through intelligent interfaces might facilitate QuickTime's use in building integrated learning environments with academics. These ideas are considered in relation to staff development, central to the case study project.

**Keywords**  QuickTime, multimedia, multi-tracks, e-learning, digital objects, Academic Professional Development (APD), Instructional Management System (IMS), online learning and teaching, interaction, transforming teaching.

## Introduction

'If you build it they will come.' This quote from the film *Field of Dreams* is used by Adobe ® in a 2001 flier for software upgrades. The quote expresses the hopes and fears of many software developers. Will the projected market eventuate? Will the buyers/users come? In referring to the film with the benefit of hindsight we know they (the baseball players) did come! In this paper we highlight the same concern for educational technology

adoption in higher education, citing a case study of Education Studies Online (ESO). Here we identify some of the technology *monsters* that staff development must deal with if average teaching staff, as mainstream 'settlers' of new technology domains, are to join the adventurous, early 'pioneers'. We advocate *project-based learning experiences* for teaching staff and report on QuickTime's role in assisting staff to understand many of the new concepts involved in multimedia learning resources (digital objects). We also illustrate how ESO and QuickTime helped staff to comprehend the significance of using digital libraries in hypermedia learning environments such as provided by Course Management Systems (CMS).

While an original purpose of Deakin's Comprehensive Online Research and Development (CORD) project and the resultant ESO environment was professional development in e-teaching, what ensued will be familiar to many developers and early pioneers in the use of information and computer technologies (ICTs) in Education. The small group of teaching staff from whom the project originated, were some way ahead of the majority of staff in regard to their conceptions and use of computer technologies, resource-based teaching and learning and more particularly in this case, web-based learning environments created with database back-ends with an integrated repository for digital resources and dedicated single purpose conferencing.

There has been varied acceptance of the many functions in ESO, but we are able to report QuickTime's strong contribution to helping academic staff better understand new concepts in hypermedia resources used in e-learning environments supported by Digital Object Management Systems (DOMS). We also report briefly on our new applications for QuickTime multi-tracks in current and future projects in Deakin. However our goal is captured in the paper's title — referring to multi-track the*tricks* as a winner for staff development. QuickTime technology is a facilitator and motivator — a drawcard in the tradition of theatre — the people **will come** to see it.

## Digital Object Management Systems and the tertiary teacher

Like many universities, Deakin is exploring options for installing a corporate level Digital Object Management System (DOMS) to facilitate the acquisition, creation and management of wide ranging digital objects for the university. Such a system must interface with other networked systems contributing to the creation of both physical and virtual teaching and learning environments which, among other services, deliver secure resources to teachers and students in multiple locations.

Deakin is actively developing policies, strategies, organisational structures and new staffing arrangements (The Deakin Advantage, 2000) for designing and creating the online courses delivered to students via an Instructional Management System (IMS) or more accurately, a Course Management System (CMS) such as TopClass, the one presently in use though not widely accepted. Traditional forms of library metadata about selected educational resources are presently held in a Lotus database in compliance with copyright and other such intellectual property matters. New approaches to metadata creation and management are being actively explored in alignment with developing international standards. However, a DOMS is the next *monster* (Segrave & Warren, 2001) we expect to confront tertiary teachers trying to come to terms with newly defined learning and teaching environments in higher education.

Teachers are now being told that a DOMS will be able to manage digital objects in all media categories and ranges from the *atomic* level, such as a single still image jpeg file, to

a highly aggregated package level, such as might comprise a streamed multimedia QuickTime based program calling on elements in the DOMS database.

Academic staff with responsibilities for staff, student and course administration have recently confronted new products in the macro cluster of corporate-level Oracle-based information management systems: for students (Callista), for staff (Concept), for finance (DFMS) and for courses (TopClass and FirstClass). Staff are now facing the prospect of at least some engagement with a DOMS and its related metadata system, hoping they match user interface qualities of the best of the existing library database systems.

A DOMS requires a metadata system working closely with access control and search systems providing authenticated access to both internal and external resources by Deakin staff and students. Each digital object in such a system has a unique metadata file profiling its content attributes, technical specifications, creation workflows, version history and descriptions of relations (such as parent and child) with other objects. This data enables perhaps timed release after IP clearance, currency monitoring, tracking and other controls, and of course searching for immediate use and in some cases for e-commerce.

As teaching staff are most often the initiators of resource acquisition or creation (this may be changing) and determine the purposes of resources in courses, they must be involved in elements of resource installation, particularly in specifying certain metadata. Hence, teaching staff need to embrace this new networked environment of knowledge, information and data if they are to influence and derive benefits. Naturally however, 'a chasm confronts mainstream settlers who follow the pioneers of e-learning environments', as followers consider the prospect of transforming their professional identities and practice as teachers. (Segrave & Warren, 2001). An IMS focus highlights authority, administration, efficiency, and IT concepts from the information sciences. Academic teachers can feel distracted, threatened and fearful of the knowns and unknowns. While APD is usually viewed as a bridge to improved human performance, traditional training workshops often fail. APD effort requires an appropriate vehicle. 'From the outset Education Studies Online was developed as a *vehicle* for APD, grounded in the reflective practice of renewing the profession of academic tertiary teaching.' (Segrave & Warren, 2001).

## Our interest in digital objects

Interest in digital objects, containers, content packaging and interoperability was initiated by a workshop conducted by the Global IMS consortium at Melbourne University in 1999. This significantly motivated a project proposal to investigate the kinds and functionalities of interactive learning digital objects, and the associated software, skills, processes and costs to produce them or source externally.

The goal of our centrally funded project of investigation was to 'provide contemporary data and analysis that enables the University to invest strategically in making learning and teaching resources available online, whether it be the conversion of existing items or the creation of new items. Items may include online learning environments, new media objects and the component elements of these, with *priority* being given to multimedia types of "containers" or solutions for delivery online.' (Segrave, S. et al., 2000)

The first two objectives of the project were:

- 'Identify then describe a targeted set of new media and online educational approaches (technology-based "model / generic" solutions).

- Produce a descriptive profile of types/levels of new media learning objects in terms of their size, functionality, modularity, reusability, other attributes and costs.'

(Segrave, S. et al., 2000)

Since then, QuickTime has been a significant platform of choice, running alongside developments using other proprietary authoring environments.

## Education Studies Online (ESO) — a case study

In December 2000, ESO was awarded the Vice-chancellor's Award for Outstanding Achievement —Outstanding Teaching (including curriculum/materials development).



*Figure 1: ESO, Module 3, Part 1.*

ESO is Deakin's first working example of a comprehensive and fully integrated and extensible e-learning *environment* (Fig. 1.). It was then an exemplar of the forecast university-wide learning systems, a suite of technologies scaled to meet the specific needs of a Major program in a Faculty. The Education Studies Major (ESM) is the only *major* program in the Faculty of Education and all undergraduate students must complete it. There are approximately 1700 students enrolled and 26 full-time and 10 sessional staff teaching in the Major across two campuses.

Initiated in 1998, under the auspice of Deakin's Comprehensive Online Research and Development (CORD) funding, ESO developed as an IT-based, R&D project expected to impact on the strategic directions of the ESM, its curriculum and resources, its staff and students. As a serious purpose of the project was academic staff development, additional impacts on faculty staff capabilities and work practices were expected. Tangible outcomes for the wider University can be seen and its change agency continues to unfold.

The ESO initiative is comparable to those in business and industry where considerable management effort and resources are expended to facilitate the necessary transformations in capabilities and work practices of staff. ESO integrates elements such as: unit content in flexible modules, a digital resources library with associated catalogue and metadata, streamed video and audio, multimedia learning objects, group and individual work areas

(such as private journal and professional portfolio), comprehensive search functions, and seamless articulation with FirstClass conferencing.

The ESO project proved to have been predictive of wider and fundamental University trends to imbue academic programs for the professions with quality IT based e-learning. This is now mandated in Deakin through its Teaching and Learning Management Plan. It is evidenced by the introduction of corporate IMS solutions and related e-learning environment proposals such as those for a DOMS and what is presently known generically as the 'Online Campus'. Staff involved in the ESO project received early and valuable experiences in these matters and have created a useful exemplar for Deakin.

In an evaluation of ESO (March 2001) Rice, reported:

> *Digital resources library*: The database delivers discrete learning resources that can be used for different purposes throughout the site. They can be integrated into a module or activity by being assigned to those, or the database can assign resources to one or more topics in any modules. At present, there are 213 of these discrete learning objects in the digital resources library with associated catalogue and metadata. They include photographs, streamed audio and video excerpts, multimedia learning objects, and text documents. (Appendix 3 of the report details the streamed QuickTime media.) (p. 6)

> ESO challenges existing assumptions about the type of content presented to students and the opportunities made available for participation and interaction. ESO asks academics to construct environments that invite students into the space to participate in the content creation process. (p. 21)

> The need to provide metadata (catalogue entries) for resources placed in the repository will be a challenge for staff, particularly if they do not have the time or interest to work with the site in that way. In addition to providing information about the author, title, date, key words have to be selected and a description of the resource from a technical point of view is required. The idea of using a search engine to find relevant resources in the database will also be a challenge for users. (p. 23)

The CORD project created this networked teaching and learning environment (Segrave & Holt, 1999) for all participants of the Education Studies Major at Deakin University, we can now say "We have built it — did they come?"

Did the teachers and students participate? Yes, in line with the 'Field of Dreams' and as asserted more recently by Adobe (2001), 'If you build it they will come'. But it was the digital resources library with the integrated metadata that captured their imagination. More than this, it was the http and streamed QuickTime multi-track resources that were constantly asked for and demonstrated. More recently, however, new copyright legislation has added complexity to the delivery of some resources, but QuickTime has assisted again in meeting needs.

## Trends troubling teachers

The IT revolution largely concerns data and information, that is, "content". Its management involves structuring, storage, retrieval, and of course the timely, easy and authorised communication of the protected information. Information management and communication is largely about connecting digital devices and moving content between them for people to use. Society is very clever at this technology and most commercial organisations and even social institutions and professions have realised benefits from its

use. Sadly, for educational purposes, IT has been misconstrued as an instant, ready made teaching and learning technology.

Some university administrators seem not to recognise the differences between communicating 'content' and facilitating learning. We are continuing to be caught up in 'library science' in the forms of 'content repositories', 'content shells', 'learning objects', 'content packaging and interoperability' and 'metadata'. We are also caught up in educational administrative 'efficiency' agendas (which legitimately aim to use the new digital information management technologies), but under the umbrella of terms such as instructional management systems (IMS), there is much confusion by non-educators (and quite probably now among recent inductees into the university teaching profession, about exactly what e-learning and teaching 'look like'.

Deakin has tried to embed professional development in centrally funded projects aimed at renewing curricula and their assisted implementation through technology. The related goals are to improve teaching and create innovative educational resources. But some staff are not genuinely transforming their teaching practices. While appearing to participate in new e-learning projects, some staff make token inputs creating online resources that add little value.

Given new learning technologies, new theories of learning and teaching, and life-long learning, all teachers face ongoing role transformations. The *tools and artefacts of culture* which impact on information processing and communication (Salomon G. ed. 1993), are seriously challenging our understanding or what it means to teach and learn. Considerable effort and money have been expended by organisations in general to facilitate the necessary transformations in employee capabilities, but how are universities facilitating transformations of teacher praxis? We advocate *project-based learning experiences* for teaching staff and projects using QuickTime have much to offer changing teachers' understandings of online multimedia.

## QuickTime elements of ESO project as staff development

During stage one the ESO project in 1999, teaching staff (and support staff in Learning services) frequently asked about the size and length of video and audio resources that could reasonably be placed on a website. Their concepts of online media were naïve, but the technical solutions and advice from support staff were also scarce. There were few examples to show staff.

As part of the ESO project management website, a demonstration page with AV clips of varying and scaled specifications was prepared and the limitations of serving via http were apparent. Interest from teaching staff continued however and a small NT server was commissioned as a pilot.

Pressure to deliver AV online to students involved use of existing media resources for teaching on-campus that required attention to copyright. As ESO was evolving a metadata catalogue for the resources in its digital library, attention was paid to assisting with copyright compliance and also providing students with information about resources they might consider downloading, particularly over a modem.

An early decision was taken by the Education Designer to extract the staff development benefits from integrating the QuickTime streaming server with the following ESO elements:

- Learning activities in the ESO ASP pages

- Resources database
- Resources catalogue
- Search engine

Staff and students could then experience a scaled down but fully integrated environment that gave them control over AV resources: uploading; allocating exclusively to modules in the course; linking to WebPages such as unique activities; smart searching; and media asset management in the repository.

Our emphasis on QuickTime is because it is a flexible platform, and exposure to it transforms the *traditional* media concepts of users. It has been particularly good for demonstrating to academic staff (unskilled in multimedia concepts and production) a wide range of what are now frequently called digital *objects* that can be re-purposed and used in multiple programming locations and perhaps in larger media entities. Our focus was on providing examples that improved staff's conceptions of digital e-learning objects in a database driven site rather than solving Deakin's main-streaming of online AV media for e-teaching.

Our recent experience of university-wide discussion has been that there is real uncertainty about digital libraries, metadata databases, IP management during development, production and e-commerce situations. QuickTime has helped demonstrate to as yet a small audience in the university, the provision of copyright compliance and some storage of metadata. But as Fraser rightly and simply states:

> 'It really comes down to education. The more you educate your friends, co-workers and clients about what is possible, versus what is the current standard, the more possibility there is that our future just might live up to all the hype.' (Fraser, 2001)

QuickTime has been a strategic tool for Deakin.

## Our QuickTime experiences in the ESO project

The use of QuickTime in the ESO project may be considered in three levels of awareness and a fourth level represents our current thinking about future directions:

| Awareness Levels | Description |
|---|---|
| 1 | Optimising movie files for http and rtsp serving, including the use of chapter track index points. |
| 2 | Creating a packaged digital object with tracks navigation and metadata to represent digital library concepts. |
| 3 | SMIL was used to orchestrate assemblage of three separate movies into one movie, automating the insertion of IP data into a movie to meet copyright compliance for streamed movies. |
| 4 | QuickTime 5 opens new possibilities because of the new XML–parsing feature, which creates the ability to deliver multi-track resource management from a database. |

**Awareness Level 1.**

| |
|---|
| Optimising movie files for http and rtsp serving, including the use of chapter track index points. |

In ESO during the first year nearly 150 unique AV files were delivered using QuickTime, with approximately 80 delivered by the Darwin streaming server. For every streamed movie, regardless of its nature, T1, 56k and 28.8k data versions were mounted on the streaming server. A reference movie was created and uploaded to the ESO digital media repository as the final step in the process of completing the metadata catalogue entries for the movie.

The first snatch of material requested or suggested is fairly represented by the following categories:

1. Deakin 'legacy' video and audio productions already used by teachers on-campus;

2. New Deakin productions commissioned but not intended exclusively for online delivery;

3. New Deakin productions commissioned exclusively for online;

4. Productions recorded from public transmissions under Screenrights copyright provisions.

To achieve a rapid response to staff requests, 'quickie' treatments and trial processes were conducted on a 180mhz 8500AV using QuickTime 3.0, VideoShop 3.0 and Media Cleaner Pro, with video and audio inputs from analogue decks. The movie processing specifications were roughly optimised to match the education purposes and the nature and technical quality of the content. The aim was to get the stuff online for staff and students and seek their comments.

The following strategies provide a sense of our approach:

- Audio-only movies were stripped from video programs with low image value;

- A still image would be used to provide context;

- 28.8k versions were selectively reduced to slide-show rates of 0.1 fps;

- High value excerpts were cut from long video material;

- Image sizes were rationalised;

- Colour was removed to provide more headroom for better frame rates or higher quality sound;

- Image sizes were explored for handling subtitles for foreign language material;

- Chapter tracks were provided on T1 versions to improve student access and use on-campus.

Our approach was to explore it in a rough way while directing the more important productions to staff in Deakin's central video & audio services (the Interactive Media Group of Learning Environments). They concentrated on refining process specifications, achieving high quality raw material, and higher quality outputs from smaller file sizes. These were usually for longer movies delivered via QuickTime streaming and CD. The Interactive Media Group have recently renewed their major Apple hardware and software production suites.

We are still facing the challenge of enabling teaching staff to create, upload and link their own AV resources to the streaming server and a learning environment system like ESO. The Education Faculty has recently commissioned two development labs for staff-only use.

**Awareness Level 2.**

Creating a packaged digital object with tracks, navigation and metadata
to represent digital library concepts.

Once the idea of a digital library was introduced to staff, we set about communicating the
idea of a digital learning object. With poor access to tools such as Flash for producing
multi-component, interactive objects, we worked again with QuickTime and created 50
multimedia resources for placement in the ESO SQL database with the ASP-based
learning management system behind ESO.

These digital objects *contained* up to 15 related images with text tracks for academic
comments and metadata. These objects were based on a single container model (Fig.2)
that we filled rapidly. They had the following characteristics:

- linear navigation through a sequence of frames in the object at reduced size;

- image size toggling between the reduced size for easy display (then rapid
sequencing) and the actual size;

- image surface area navigation on actual size;

- a separate image-track display as a pop-up (eg a teacher's remark on work
displayed);

- a commentary text-track display as a pop-up (eg lecturer's comments);

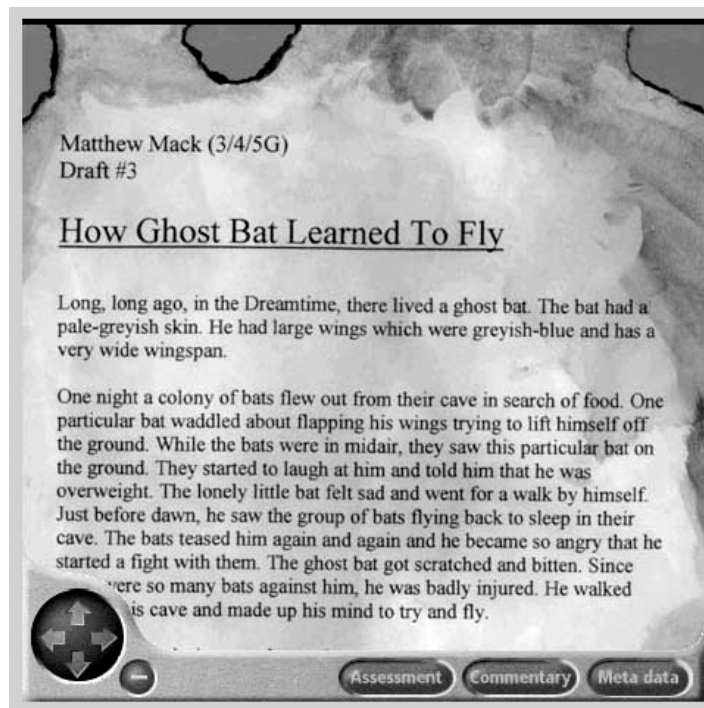- a metadata text-track display as a popup (eg IP data).



*Figure 2: Primary student's work as a navigable object in the database.*

These packaged resources were created using wired sprite movies and played as
QuickTime files downloaded from the http server. They are a simple exploration of the
following concepts:

- Discrete learning objects of the kind expected to be loaded into a resources
database;

- Learning resources created as objects installed in a repository at the same time their metadata is installed in a related database;

- Learning resources containing their own metadata (though not aiming for compliance with IMS standards implemented in XML.)

Waterworth, et. al. (2000) provides examples of these resources including one type presenting historical primary source materials in a way that enhances students' interaction with its elements. Students are able to interpret material and add their reflective writing in their private journal, portfolio or perhaps an associated web page in ESO or their two Deakin web home directories. Students also contribute threaded comments to ESO for others to share and a dynamic repository of such contributions are linked to unique individual learning activities where students' contributions become integrated with activities and their incorporated QuickTime resources.

**Awareness Level 3.**

SMIL was used to orchestrate assemblage of three separate movies into one movie, automating the insertion of IP data into a movie to meet copyright compliance for streamed movies.

The flexibility of QuickTime was appreciated when changes to Commonwealth Copyright Law in Australia impacted on the method of legal delivery to students of video and audio recorded by the university under the Screenrights provisions (Deakin University Copyright Guidelines 2001.).

In this instance SMIL has been employed to orchestrate the playing of text movies of copyright information up front of the movie intended for use by students.

The method presents data on the 7up-jackie.smil movie such as:

SEGMENT:  jackie segment

CHANNEL:  SBS

DATE:  12/3/91

TIME:  8:30 pm

DURATION:  23 mins

PROCESSED BY:  This copy produced by Learning Services for Deakin University.

This information is followed in the same way by a standard re-used Commonwealth of Australia copyright warning. (Fig. 3.)
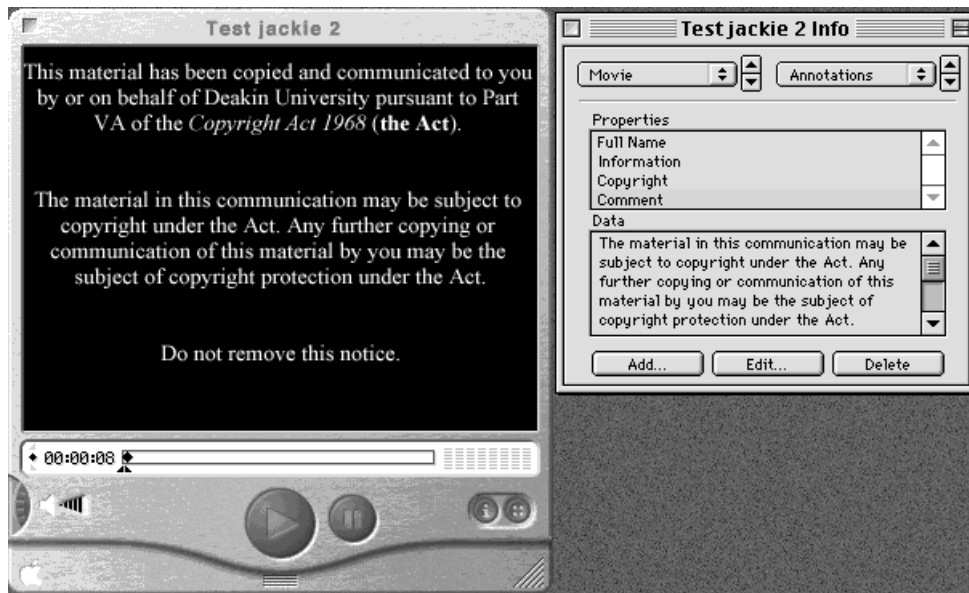
*Figure 3: Primary student's work as a navigable object in the database.*

Textual data is also contained in the SQL database and ESO users can preview the data on movie resources before choosing to view by streaming.

**Awareness Level 4.**

QuickTime 5 opens new possibilities because of the new XML–parsing feature, which creates the ability to deliver multi-track resource management from a database.

A new era of multimedia creation is emerging, summoned by those seeking even simpler interface tools to control certain aspects of the multi-media creation process.

QuickTime movies in their simplest form are time based layers of tracks and objects which have a defined set of properties such as height, width, start-time, end-time, layer etc. an object in QuickTime can have up to 50 different properties. Added to this complexity is the ability to have movies within movies (MIAM). Each of those movies can have its own set of properties. Theoretically there is no limit to depth of how many movies within movies there can be. Realistically this is not quite true.

If we wish to rapidly build movies from a variety of components such as different video tracks, audio tracks, images and even other movies which may contain their own interactions then it would be faster and more powerful to be able to build these movies from an external source which describes to the QuickTime movie (or movie builder) the parameters of how large, where and when an object should play.

XML means that extremely complex movie can be built from a simple text file or a series of text files in a very dynamic manner. Further to this the XML file can be built using the aid of a database, the database can then have an interface that content creators can use. While all or most of the components of the movie must exist in some form the way the tracks are assemble using this method can be endless.

An alternative method for building dynamic movies is to use the new QtList feature of QuickTime. In this case data can be transferred between a database and a movie directly in the form of a URL link. This is especially useful in the case of text that may be contained in the movie. No longer does the text have to be a static object in the movie. It can change depending on user interaction or a number of other parameters.

Dynamic movies are just about the best *trick* going and QuickTime delivers an incredible range of possibilities where others are still only seeing the possibilities of combining a image track with a video track from a locally produced file. With QuickTime's large list of different track types such as QuickTime, instrument tracks, tween track, modifier tracks, Flash® and even Movie tracks the possible outcomes, when you consider that they can be build on the fly from data described by a database, means that anybody can perform the *trick* and not just the technical Magicians.

Andrewartha & Wilmot, (2001) observed that:

'The design of a front-end program to automate the process of incorporating the content into the template would be beneficial. Designing an 'automatic builder' would mean that the lecturer would simply pour content into the relevant proforma box and then allow the utility program to build the sections. Much less knowledge of Macromedia Director software would then be necessary. (p. 17)

By using QuickTime, the degree of expertise required to conduct a performance from multiple elements has been made as accessible as street theatre with lots of participants — and yes — when you build the show with multi-track thea*tricks*, the audience will come!

## QuickTime in Summary

QuickTime is helping to increase use of certain educational online media, both pre-packaged media objects uploaded to a digital library and the more individual and ephemeral resources and presentations by teachers via http and streaming.

The ESO project in the Faculty of Education provided the initial impetus for wider use of QuickTime and the initial use of a streaming server. The ESO case study shows how QuickTime is helping academics understand the concepts involved in e-learning environments using integrated digital libraries and metadata. It is helping to dispel fears associated with complex environments with multiple database back-ends.

Our paper briefly deals with corporate information management imperatives such as:

- Managing intellectual property information and facilitating metadata within QuickTime media objects in the period leading up to properly integrated "Content Repositories" / Media Asset management solutions for the university; and

- Assisting in collecting and retaining copyright information within QuickTime Learning Objects and in association with the website's resources database;

it also explores how QuickTime assists university education imperatives such as:

- Student control of streamed movies using chapter tracks;

- Image and text based learning objects in QuickTime;

- Interactive movie building using multi-tracks and databases.

While many end users and some developers don't properly appreciate it, QuickTime provides a suite of inbuilt functionalities solving potential problems and grasping opportunities in the dynamic age of digital learning object management systems and QuickTime's flexibility provides a safer development environment.

While QuickTime's multimedia flexibility is difficult for some academics to comprehend, new approaches to automating movie assemblage through database connectivity through intelligent web-based interfaces might facilitate its use by academics.

## Conclusion

A persistent challenge in the ESO development is the transformation of conceptions of teaching enacted in learning environments either wholly or partly online. While the published rhetoric of academic staff might be about new teaching and learning opportunities online, some academic staff view as a problem, the prospect of transforming their professional practice. Environments and interactions for learning online do not replicate what some teaching staff are familiar and comfortable with either in the classroom, laboratory, lecture theatre, or through traditional media such as audio and video tape, telephone and print.

The ESO project group were given the brief to facilitate engagement, participation and interaction by students in an innovative e-learning environment to be built. Would the students come? The greater challenge however proved to be the ongoing nurturing of academic professional development to ensure the teachers came.

What does e-teaching look like? What kinds of experiences motivate teaching staff to change the way they make learning happen? Our experience has been that staff are not really confident about changing what they do face-to-face or in print, to another way of *being a teacher* online, particularly when they believe that they are already *being* a good teacher. They are unsure of how to motivate, engage, participate and interact online. They know these are critical practices, but they don't know how to practice them online.

Teaching staff in the Faculty of Education have been long time users of video and audio in the simple sense. They have used cassette tape programs in their lectures and tutes, and at Deakin University there is a long tradition of such AV use for distance students. QuickTime is a logical progression. We have used QuickTime not only to solve media construction and delivery challenges, we have used it to command performances that draw in the audiences.

If you build it in QuickTime — they will come.

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# Computational Marketing using an AppleSeed cluster

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**Abstract**   Computational marketing can be defined as the application of computational science techniques to modelling and understanding market behaviour. Computational science techniques are able to simulate phenomena that are too complex to be explored by existing forms of theory. The techniques are also able to extend the benefits of experimental science into phenomena that are not suited to traditional experimentation, such as the study of social and market processes. This paper reports two activities that provide examples of research using a computational marketing approach. The first example describes work we are currently undertaking with a data mining technique, rough clustering, which is based on rough sets theory. The second example outlines a more ambitious research program that we are also actively pursuing. This is the use of agent based social simulation (ABSS) techniques in modelling consumer markets. Agents can be defined as autonomous software entities that possess an individual representation of the environment with which they interact, a set of goals they wish to achieve in that environment, and various decision making capabilities. They are also capable of communicating with other agents existing in the environment. Both examples of computational science techniques involve numerically intensive computing which requires considerable processing power. Previously, such processing power was only possible using specialised computers (such as the Cray T3E or IBM SP2) housed in a centralised supercomputer centre. Such platforms are expensive, require support staff to maintain them, and are often hard to access for many researchers. The paper describes a comparatively inexpensive alternative using an AppleSeed cluster, based on a network of Macintosh G4 computers connected by an Ethernet switch. The cluster provides a relatively simple to operate "desktop supercomputer" allowing more ambitious data analysis and market modeling projects to be attempted.

The traditional theoretical and experimental approaches to science have been joined by a third, the computational approach. Computational science is able to extend the benefits of experimental science into new phenomena that are not suited to traditional experimentation, such as the study of social and market processes (Kohler & Gumerman, 2000; Krischke, 1999). It also offers new forms of theory formulation (Gropp, Lusk & Skjellum, 1994). The growth of this third approach has been stimulated by the rapid development of computing hardware and methodologies since the computational approach's beginnings in the 1940s.

The development of this computational approach can currently be seen in a wide range of academic disciplines. As computational science becomes adopted into each new discipline, a new sub-discipline develops. There is now a emerging literature in *computational biology and environmental studies* (Deadman, 1999; Rouchier, Bousquet, Barreteau, Le Page & Bonnefoy, 2001; Sumpter & Broomhead, 1998), *computational geography* (Auerswald & Kim, 1995; Besussi Cecchini & Rinaldi, 1998; Wu & Webster, 1998), *computational organizational theory* (Butel & Watkins, 2000; Chang & Harrington, 2000; Lomi & Larsen, 1996; Prietula, Carley & Gasser, 1998), *computational*

*anthropology and history* (Di Piazza & Pearthree, 1999; Mithen, 1994; Small, 1999; Tainter and Tainter, 1996), *computational sociology, social and political science* (Epstein & Axtell, 1996; Halpin, 1999; Johnson, 1999; Moss, 1998; Saam, 1999; Schillo, Fischer & Klein, 2001; Weidlich & Haag, 1983), and *computational economics and finance* (Arthur, 1991; Caldas & Coelho, 1994; Edmonds & Moss, 1997; LeBaron, 2000; Lettau, 1997; Stender, Tout & Stender, 1993; Terna, 1997).

Computational marketing can be understood as the application of computational science techniques to modelling market behaviour. It overlaps with computational economics, but extends the economics focus to consider other market mechanisms, such as the satisfaction of consumer needs and the development of, and communication through, social networks (Choudhury, 1996). In addition, the role of memory in consumer behaviour can be explicitly studied with this methodology (eg. the probability of future transactions being influenced by the memory of outcomes of previous transactions). Computational marketing can contribute to the discipline of marketing in both the development of marketing theory and in practical applications, particularly research and modelling. In this paper we present two examples of such contributions, one describing work we are currently undertaking, and a second speculative example outlining an approach we are actively pursuing.

Practical applications of computational science in marketing are mainly drawn from work in Knowledge Discovery in Databases (KDD), popularly referred to as data mining. Our initial example is from this area, and describes an approach we call rough clustering (Voges, Pope & Brown, 2001). This uses rough set theory (Pawlak, 1981) to identify clusters in marketing data sets. This work is described in the following section.

We are also developing a more ambitious research program, based on the use of agent based social simulation (ABSS) techniques to model the transactional and information structure of a market (Goldspink, 2000). Some management and marketing literature is beginning to reflect an interest in this approach (Chang & Harrington, 2000; McGeary & Decker, 2001; Schwartz, 2000). The justification for this work is outlined in the second section of the paper. We conclude the paper with a description of the computing platform that makes this research possible.

## Rough Clustering

The concept of rough, or approximation sets, was introduced by Pawlak (1981, 1982, 1984, 1991), and is based on the basic assumption that every object of a system has associated with it a certain amount of information, referred to as the attributes of the object. For example, in a survey of consumers, the objects of the system would be the individual respondents to the survey (or more correctly, their answers to the survey), and information could include demographic details (age, income etc.) and psychographic details (the respondent's score on satisfaction scales, propensity to purchase, etc.). Because the data is treated from the perspective of set theory, none of the assumptions of traditional multivariate analysis (normality, linearity, etc.) are relevant (Lin & Cercone, 1997).

Sets are formed from combinations of attributes. For example, in a set of different coloured objects, you could pick out those that were "red" and "triangular". This process would form a set of objects based the chosen values of the objects' attributes. In a study of consumer behaviour, a set could be formed from attributes such as "age less than 25" and "purchaser". Unfortunately, real world data does not divide as neatly as coloured objects. For example, attempting to identify the characteristics of purchasers from a set of

attributes would not lead to a uniform set. People less than 25, for example, could be either purchasers or non-purchasers. A rough set is a way of dealing with this ambiguity in research data, and allows for the identification of interesting combinations of attributes.

A rough set is formed from two sets, referred to as the lower approximation and upper approximation. The *lower approximation* contains objects that are definitely in the set. The remaining objects from the complete (universal) set are either definitely not in the set, or their set membership is unknown. The set of objects whose membership is unknown is called the boundary region. The *upper approximation* is the combination (union) of the objects in the lower approximation and the boundary region. If the boundary region is empty (ie. all objects are either in the set or not in the set), the set is crisp, not rough. However, if this boundary region is not empty (ie. some object's set membership is uncertain), the set is said to be an approximate (or rough) set. This deceptively simple idea has generated much interest in the computational intelligence and data mining communities. For a comprehensive introduction to rough sets see Pawlak (1991) or Munakata (1998).

Most published applications of rough sets have concentrated on rough classification, where at least one of the attributes is a decision attribute which partitions the information system into pre-existing subgroups (Pawlak, 1999). For example, the consumer information system may be divided into purchasers and non-purchasers. The results of rough classification are usually presented as rules that link the values of attributes in the information system to different values of the decision attribute. Rough classification is analogous to discriminant analysis in traditional marketing research, where there are known subgroups identified by a grouping variable. Similarly, rough clustering is analogous to cluster analysis in traditional marketing research, as the information set does not contain pre-existing subgroups.

Rough clustering is a simple extension of rough sets theory, using a distance measure. Clusters of objects are formed on the basis of their distance from each other. However, an object can belong to more than one cluster. Clusters are defined by a lower approximation (objects exclusive to that cluster) and an upper approximation (all objects in the cluster which are also members of other clusters), in a similar manner to rough sets. More details of the technique, and comparisons with the established *k*-means clustering technique can be found in Voges, Pope, and Brown (2001).

The technique can be computationally expensive for large data sets. We are currently exploring a data set of tourism preference data that is relatively large, at 6000 records. In addition, the basic technique is being extended through the use of an evolutionary algorithm. Both of these factors increase the computational load. This problem is being addressed by using a desk-top parallel computer system, described later.

## Agent Based Social Simulation

Agent based social simulation (ABSS) addresses the problem of modelling complex systems, such as markets, from a perspective that is quite different to traditional approaches (Balzer, Brendel & Hofmann, 2001; Davidson, 2001; Doran, 1996; Hegselmann, 1998; Krischke, 1999; Liebrand, Nowak & Hegselmann, 1998; Moss & Davidson, 2001; Sichman, Conte & Gilbert, 1998). Rouchier, O'Connor and Bousquet (2001, 2.2) describe the ABSS approach to modelling as one where agents are "entities that are autonomous and active and have a representation of their environment. Each agent is then defined by the way it perceives its environment and builds a representation of it, the actions it can perform and the processes through which it chooses its actions

according to its knowledge. Among the actions that the agents perform, some are interactions with others (for example sending messages, giving, asking, acting upon). A simulation is a series of time steps during which the universe evolves and the agents act and have their representation evolve by perceiving their changing environment". The environment can contain artifacts (resources, obstacles, etc) and other agents. Agents can also be trying to achieve goals, such as increasing wealth or prestige, as part of their interaction with the environment. Artificial societies built with this approach can model several real world characteristics of market systems (Casti, 1997b). These include such characteristics as market heterogeneity, differential access to information, and the linking of micro level actions to macro level effects, where macro level outcomes "emerge" out of micro level activities.

The *heterogeneity* of agents operating in a market, largely ignored by traditional economics, is of vital interest to marketing (Allenby & Rossi, 1999). The study of the different motivations and knowledge of consumers and their subsequent effect on purchase behaviour and satisfaction, is a major activity of the marketing discipline. This heterogeneity has been shown to emerge from the learning processes operating within the agent and the communication processes operating between the agents. Edmonds (1999) has demonstrated how this heterogeneity emerges in an artificial society of creative artificial agents.

In traditional economics, the *effect of information* in trading markets is usually held constant (i.e., all economic agents are assumed to have perfect knowledge of the activities of all other agents). In contrast, the information diversity that economics ignores is the substantive domain of the marketing discipline. This diversity arises from the different levels of access to market information possessed by consumers, the pattern of interactions between consumers and providers, and the effect of these interactions on the cognitive structures of consumers. This diversity can be modelled by ABSS approaches (Banathy, 1999).

Finally, ABSS models can produce outcomes that *emerge* out of the interaction between the agents in the model, that is, these outcomes are obtained from the dynamics of the model and not included in the initial assumptions (Casti, 1997a; Gilbert, 1998; Goldstein, 1999; Holland & Miller, 1991; Mihata, 1997). Kemp (1999), for example, presents a simple dynamic model of consumer choice, which produces unpredictable emergent switches in the patterns of demand. In a second example from Edmonds and Moss (1997), economic agents sometimes get "locked" into inferior courses of action for a considerable length of time. Edmonds and Moss compare this simulation result with locking behaviour in consumers. A consumer's early positive experience with the taste of a brand may mean that they never try other brands — their limited experience will never disconfirm their initial choice of brand, even though the taste of another brand might be preferable to them. Other examples of emergent outcomes include the development of socially defined reputations (Rouchier, O'Connor & Bousquet, 2001), collective identity (Lustick, 2000) and belief systems (Bhargava & Branley, 1995; Doran, 1998).

An important example of an emergent outcome is the observation that many complex systems, such as economies, exhibit a power law relationship between the quantity and size of objects in the system. This relationship was first identified by Pareto in 1896, and is considered a statistical signature of such systems (Bak, 1997). Moss (2001) has demonstrated the presence of this power-law relationship in the number and size of information traders in an artificial market using an ABSS. He showed that an economic modelling base such as game theory is unable to produce this same statistical signature.

He further suggested that traditional models don't have a framework for recognising emergent properties, let alone producing them. This suggests that ABSS based models may be more realistic than the models used in traditional research of the market. However, ABSS models are computationally expensive, particularly as the agent population size is increased, and as individual software agents become more sophisticated in their decision-making capabilities. The next section considers the computing platform that makes this type of research possible.

## Computing Platform

A reasonable level of processing power is necessary to undertake the research activities we have described above. To achieve this processing power, we are currently using a parallel computer platform based on an AppleSeed cluster, inspired by the pioneering work of Viktor Decyk and Dean Dauger of UCLA. As they state: 'In recent years there has been a growing interest in clustering commodity computers to build inexpensive parallel computers. A number of projects have demonstrated that for certain classes of problems, this is a viable approach for cheap, numerically intensive computing' (Decyk, Dauger & Kokelaar, 2000, p. 1).
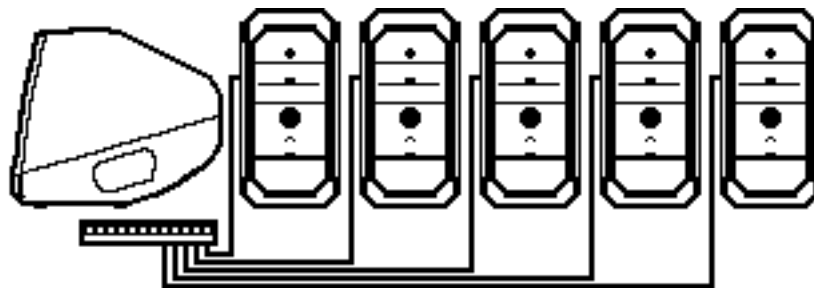


*Figure 1. AppleSeed cluster configuration.*

It is a relatively straightforward process to build a parallel computer cluster. Obtain a number of Macintosh computers with built-in Fast Ethernet, a Fast Ethernet switch containing a port for each Macintosh, and a corresponding number of Category 5 Ethernet cables with RJ-45 jacks. Plug one end of each cable into the Ethernet port on the Macintosh and the other end into the port on the switch. Attach a monitor to one computer, and connect power cables, etc. You have now built a parallel computer (Decyk et al., 2000). The AppleSeed cluster we are currently using consists of five Apple G4s (nodes) connected via a Cisco 12-port Ethernet switch (see Figure 1). We have also recently added a MasterView monitor switch, which enables us to view and control the desktop of four G4s from a single monitor and keyboard.

The available computational power of an AppleSeed cluster is very useful when multiple runs of a program are required, using different values for selected parameters every time the program is run. In this type of problem, each node in the network can be sent a complete copy of the program, and run it with a particular set of parameters. This process continues until all combinations of parameter values have been evaluated. The main node then collects the results from the other nodes, collates, and presents them.

In the ABBS work introduced earlier, the platform provides a computational test bed for running experimental simulations of a wide range of market behaviours. The process just described enables concurrent multiple runs of the proposed market simulations, which will speed up an exploration of the effects of various starting parameters and assumptions. We are initially applying this market simulation methodology to the field of mass entertainment marketing, including television viewing, tourism, and models of public attendance at sporting and cultural events. We are also planning to study the development of markets in an historical context, such as modelling the interactions in a medieval English market village. The methodology can also be applied in modelling electronic markets (Mahajan & Venkatesh, 2000; Terano, 2000), such as consumer transactions over the Internet.

Similar networks can of course be built using Unix or Windows-based machines, but substantial expertise is required to correctly install and maintain a cluster (Sterling, Salmon, Becker & Savarese, 1999). Many of these parallel computer systems use the Message Passing Interface (MPI) library for communication between the nodes. MPI is a common message-passing applications programming interface used on high-performance parallel computers, and provides a library of simple commands that can be added into computer programs to access and control the operation of the network. The similarity of the MacOS native Program-to-Program Communications (PPC) Toolbox message-passing facility and some low-level functions in MPI encouraged Dean Dauger at UCLA to develop a subset of MPI for the Macintosh, called MacMPI. Controlling an AppleSeed cluster running MacOS 9 only requires the MacMPI library and a single utility, Launch Den Mother (Decyk et al., 2000). Moving to MacOS-X will extend the range of possibilities. The full MPI Library is available under Unix, so it could be ported to the MacOS-X platform, although it remains to be seen how much more expertise will be required to operate the cluster in this new environment.

In our current research activities, MacMPI commands have been incorporated into various programs we have developed using Fortran95. For example, the cluster has been used to run a parallel evolutionary algorithm (EA). Common statistical analysis techniques, data mining techniques, and ABSS models often require the optimisation of a selected measure. An EA uses a very simplified model of an evolutionary process (generation of variety within a population and the survival of a restricted subset of the population) to solve such optimisation problems. In an EA, the fitness function provides a numerical measure of the effectiveness of a potential solution to the optimisation problem. For most problems, fitness function evaluations are the most computationally expensive part of the evolutionary algorithm. Fortunately, a parallel computer cluster is well suited for running evolutionary algorithms, using a simple process. A master node (the main G4 computer) controls the overall algorithm and the slave nodes (the remaining G4s) undertake the fitness function evaluations. The master node sends potential solutions to each slave; the slave evaluates the solution and returns the fitness value (see Figure 2). This process can be activated with a few simple MPI commands. The master node also generates new populations via the EA. This cycle is repeated until a suitable fitness value is reached. EA techniques are proving to be one of the best optimisation techniques available, and are continually being extended and improved. Our current cluster increases the number of fitness evaluations that can be performed by a factor close to 4 over a single G4.
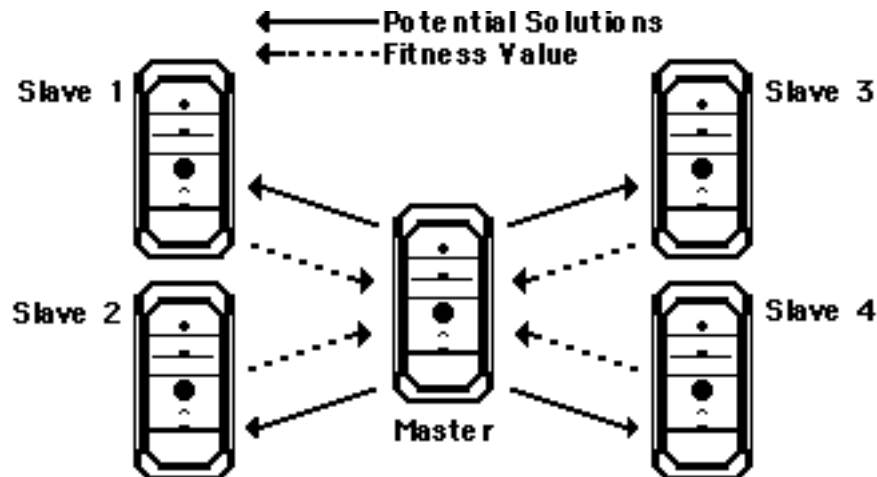
*Figure 2. Assessing the Fitness Value of Potential Solutions Using Master and Slave Nodes*

This EA technique is being used to explore and hopefully overcome one of the limitations of the rough clustering technique described above. The fitness function in this case is a measure of the size of the lower approximation compared to the upper approximation. In other words, the evolutionary algorithm is attempting to reduce the "roughness" of the rough clusters, while still allowing for multiple cluster membership in the cluster solution.

The usual ease of transfer of output into other programs for further analysis or reporting provides another reason to use an AppleSeed cluster. Because it does not require a dedicated network expert to maintain the system, the Macintosh cluster is very suitable for small groups with limited resources. For example, high school students in the US are learning how to run parallel applications using AppleSeed clusters (Taylor, 1999).

In the applications described in this paper, the choice of computer platform has enabled researchers with an extensive knowledge of market structure and consumer behaviour, but with limited knowledge of parallel computers and computer networking, to access very powerful computer technology. Most parallel computing centres don't encourage "amateurs" to experiment with their expensive machines in their attempt to learn how to use them. Even researchers who develop experience in operating clusters can benefit from the immediate feedback available with a desktop machine. This "supercomputer for the rest of us" enables us to develop more realistic market models, and undertake more sophisticated data analysis in a faster time frame. These activities offer better descriptions of the market characteristics and processes of interest to both marketing academics and practitioners.

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