UniServe Science

Proceedings of

Evaluating the New Teaching Technologies

Workshop

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UniServe Science

UniServe Science was established in 1994, under a grant from the then Committee for the Advancement for University Teaching (CAUT), with considerable help from The University of Sydney, to act as a national clearinghouse for the dissemination of information about teaching software in the experimental sciences in Australian universities — specifically in the disciplines of Biochemistry, Biology, Chemistry, Geography, Geology, Physics and Psychology. That grant was for three years. UniServe Science is now fully funded by The University of Sydney and has added Computer Science, Mathematics and Statistics to the client base.

UniServe Science aims to enhance the quality of university science teaching in Australia by collecting, maintaining and disseminating information on up-to-date and innovative teaching materials. UniServe Science publishes regular newsletters which include product reviews and articles on developments related to teaching and learning materials in the earth, life and physical sciences. A database of software packages used in teaching is maintained and is accessible via the UniServe Science web site. Along with software details, the database includes UniServe Science solicited product reviews, usually done by Australian academics. Other activities include: the maintenance of electronic mailing lists for each of the nine disciplines covered; conducting workshops for teaching development; producing software guides and maintaining Australian mirrors for frequently downloaded overseas software.

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Pearson Education Australia

Pearson Education Australia was a proud sponsor of this UniServe Science workshop. Pearson Education supports UniServe Science's aim to promote the use of technology in science teaching and learning.

Evaluate, Evaluate, Evaluate

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Our fifth national workshop

For many reasons, now seems a good time to pause and take stock. UniServe Science is six years old. It's eleven years since the establishment of the Web. It's a new millennium. Whatever.

Over the past decade we've heard many times that university education is going to have to change to meet the new demands that threaten it, and that we must adopt the new technologies that are supposed to support it. Unfortunately, from where we sit, there isn't much evidence that this change is happening very fast. A lot (the bulk?) of university teaching is going on as it has done for generations. Lectures, laboratories, homework assignments, examinations. Those of us who have been the advocates for change cannot help getting a bit dispirited sometimes. Why haven't the new teaching methods and the new teaching technologies been taken up more enthusiastically?

There are lots of answers to that question, and lots of people to blame. But every now and then one feels the insidious worry: is it our fault? Is it really obvious that the CAL packages, the Web material and the computer assessment schemes that we have been working on all these years really deserve to be taken up? All those simulations and visualizations that looked so great to us, were they really successful where it counted? Did they improve student learning?

For many years now, the educationalists have been warning us that we must **evaluate** the teaching materials we produce. And they mean more than testing whether things are laid out properly, or whether the interface is intuitive. They mean we must also find out what students learned from using all this stuff. And that's hard to do. Which is why so few of us have done it properly. But it's time to change our ways. If we want to tell our colleagues that they should learn from what we did, then we must be able to say with confidence that what we did, worked. We've just got to spend a lot more time evaluating.

So this annual UniServe Science workshop targeted evaluation, not just of IT materials but of teaching techniques in general.

Issues raised at the workshop

There were two keynote speakers: Professor Mike Prosser from La Trobe University (at that time), talked about the educational aspects of evaluation, and Professor Ann Sefton, the leader of the Graduate Medical Program at The University of Sydney told us about one of the largest Internet-based teaching programs in the country, which has had evaluation built in from the start. There were 82 academics attending from most states of this country, including one visitor from New Zealand and seven from Thailand. There were seven contributed papers. All these papers appear on the succeeding pages.

As is now the tradition at UniServe Science annual workshops, the last session of the day was devoted to an open-floor discussion of issues raised during the day. Three questions occupied most of the discussion. As usual, opinions differed, and a variety of interesting points were made.

(1) How can we who value innovation in teaching convert our colleagues?
There were those who felt that it had to happen by example. Innovations that are successful will impress others and a ripple effect will ensure that these new ideas will be accepted by the more conservative teachers. Others were less optimistic and felt that successful innovations had to come from the top down. If they are not promoted by heads of departments or deans, they are unlikely to be widely adopted. Perhaps the main need was for more professional development to bring the information to those who do not perceive there is a problem in the first place.

(2) How can we assess whether learning is 'deep'?
Among the ideas brought out by the keynote speakers was the thought that students needed to have more ownership of their studies. In discussion it was felt that we should make students aware of the approaches to learning and get them to think about how they study, and perhaps then they might adopt a more responsible approach to assessment.

It was believed that IT had the capacity to allow for variation in ways of examining, and this could lead to assessment for deeper learning. However it is important not to trivialize assessment. Lastly, while there is a need to make students enthusiastic about the subject matter, it must be remembered that depth of learning is a desire to understand. It is not the same as enthusiasm for the subject.

(3) Are universities under threat from commercialization of tertiary education?
There is a foreseeable threat that private companies could seek to take over the teaching of the more popular first year courses. If that happened, it would mean that universities would have to specialize much more in what we offer students. Certainly there is a decline in postgraduate student numbers, and we need to investigate more aggressively web delivery of graduate courses. Maybe, in the end, there will be a need for some kind of liaison between the smaller universities and large consortiums or franchises.

Pearson Education UniServe Science Teaching Award

At the workshop, an award that recognises teaching that improves student learning outcomes via the innovative and integrated use of information technology, was launched by UniServe Science Deputy Director, Bob Hewitt and Susannah Bowen, Pearson Education Australia, co-sponsors of the award. The winner of the award will be an invited keynote speaker at next year's workshop and will receive $1000. For more details on this award visit http://science.uniserve.edu.au/about/award/.

Evaluating the New Technologies: A student learning focused perspective

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Introduction

There has been a growing impact of the new technologies on the processes and outcomes of teaching and learning. The developments are occurring faster than they can be properly evaluated.

Much of the evaluation that is being conducted has been from the teacher's perspective, focussing on:

- learning gains by students on tests produced by teachers; and
- improvements in the productivity of teaching and learning (Alexander and McKenzie, 1998).

There has been little research or evaluation focussing on the students' experiences of using the technology – a student rather than teacher focused perspective. For example, questions such as the following are rarely addressed in the evaluation reports I have seen:

- how do the students experience the new technologies?
- what do they think are the aims?
- what do they believe they are learning?
- how do they approach the use of such technologies? and
- very importantly, how do they see the relationship between the new technologies and other aspects of teaching and learning?

This is surprising, given the impact of the research and evaluation in teaching and learning in higher education from a student learning perspective (Marton, Hounsell and Entwistle, 1997; Ramsden, 1992; Prosser and Trigwell, 1999). It is from this perspective that the major Australian teaching and learning benchmarking instrument – the Course Experience Questionnaire (CEQ) – was developed and is being used (Ramsden, 1991).

One such evaluation of a number of on-line learning packages at La Trobe University recently concluded that there was less variation between packages from a student learning perspective than variation within packages (McShane, 2000). The issue was what was done with the packages by the teachers rather than differences between packages.

This paper will address the issue of evaluation of the new technologies from a student learning perspective. In doing so, it will outline the characteristics of the evaluative research being conducted in university science education from this student learning perspective, show examples of research and evaluation from that perspective, and outline some strategies for the future evaluation of the new technologies in teaching and learning. In passing it will summarise the theory and research underlying the development of the CEQ.

Student learning in higher education

Over twenty years of research in teaching and learning in higher education has shown that student learning outcomes – examination results, concept maps, open-ended responses, etc. – are closely related to how students experience their studies. Figure 1 summarises the result of much of this research in terms of an heuristic model of student learning in higher education. It shows that student learning outcomes are closely related to how they say they approach their studies. How they approach their studies is, in turn, related to how they perceive and understand the teaching and learning context. How they perceive and understand that context is in turn, related to their prior experiences of teaching and learning and to the context itself. The key issue is, however, that students perceive the same context in different ways. These different ways are systematically related to how they approach their studies and to the quality and quantity of their learning outcomes (Prosser and Trigwell, 1999).

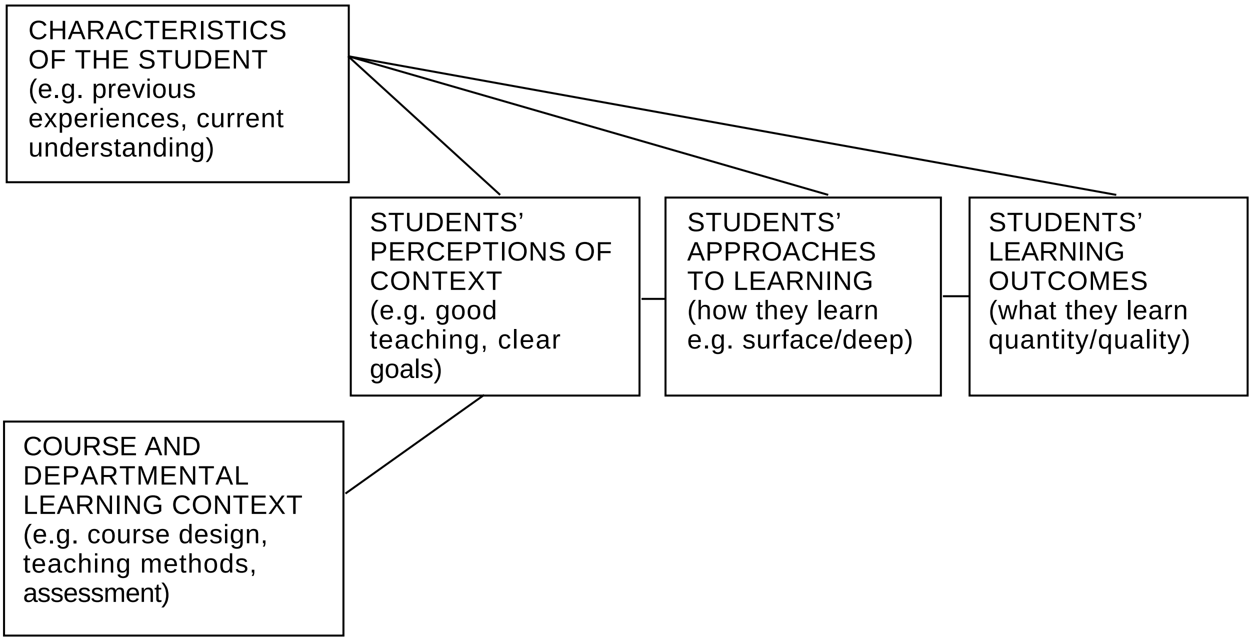

Figure 1. Model of student learning

In terms of the evaluation of new technologies in teaching and learning, the model would suggest that student learning outcomes from the use of the new technologies would relate to how the students approached their studies with the new technologies. This would depend, for example, on how they saw the aims of the new technologies in their learning – not how well the new technologies met the teacher's aims, how they saw the use of the new technologies relating to their perceptions of what was to be rewarded in the assessment, how they experienced their workload associated with using the new technologies, etc. These perceptions would depend on how well the new technologies were designed and integrated into the subject and course structure, what the aims were for the use of the new technologies, and importantly what the student's prior experiences were of using similar technologies.

In the remainder of this section I wish to use the results of some of the previous research in university science education to examine this model of student learning before returning explicitly to the evaluation of new technologies.

The research has identified two fundamentally different ways in which students approach their studies in higher education. These are the so-called surface and deep approaches to study. A surface approach is characterised by an intention to reproduce what is being learned for assessment purposes. There is little intention to try to understand that material. On the other hand, a deep approach is characterised by an intention to understand the material being studied. This research suggests that it is the student's intention, rather than the observed or reported strategy, which is important in terms of the quality of student learning outcomes. A given strategy can have a different meaning depending on the intention.

Strategies associated with a surface approach include:

- rote memorisation of information needed for assessment;
- failure to distinguish principles from examples;
- treating tasks as external impositions; and
- focussing on discrete elements without integration.

Strategies associated with a deep approach include:

- vigorous interaction with content;
- relating new ideas to previous knowledge;
- relating concepts to everyday experiences; and
- relating evidence to conclusions.

What needs to be noted here, especially in the context of science education, is that memorisation can be associated with either a surface or a deep approach. It depends on the intention the student has when engaged in memorisation.

In terms of the use of the new technologies, the quality of learning outcomes depends on the student's intentions when they come to use the new technologies. For example, whether they approach the new technologies with the intention to learn and understand, or whether they approach it with the intention of just completing the task.

The research has identified that the key perceptions of context related to these approaches to study are perceptions of:

1. quality of teaching;
2. clearness and nature of the goals;
3. nature of assessment;
4. heaviness of the workload; and
5. amount of independence in learning.

It needs to be emphasised that it is students' perceptions of these aspects of the teaching and learning context that are important, and that different students in the same context will form different perceptions of that context. These are the scales of the Course Experience Questionnaire, the questionnaire being used to survey all graduates of Australian universities about their experiences of studying.

In the remainder of this section, I intend to draw upon the results of recent research in university science education to illustrate the relations referred to previously.

As part of a recent study involving over 1500 first year university science students in Australia, some colleagues and I were interested in looking at the relations between students' perceptions of their teaching and learning context and their approach to study. We used a modified version of John Biggs' Approaches to Study Questionnaire to get indicators of their approaches to study (Biggs, 1987) and a modified version of Ramsden's CEQ to obtain indicators of their perceptions of their teaching and learning contexts (Ramsden, 1991). The questionnaires were modified to get the students to focus on their approaches and perceptions in relation to the subject they were studying rather than overall indicators. Examples of items from the Approaches to Study Questionnaire are:

Surface Approach

32. Although I generally remember facts and details, I find it difficult to fit them together into an overall picture.
35. The best way for me to understand what technical terms mean is to remember the textbook definitions.

Deep Approach

28. I try to relate ideas in this subject to those in other subjects, wherever possible.
34. In trying to understand new ideas, I often try to relate them to real life situations to which they might apply.

Examples of items for the perceptions of context are:

Good Teaching
3. The teaching staff of this subject motivated me to do my best work.
15. The staff made a real effort to understand difficulties students might be having with their work.

Clear Goals
6. I usually had a clear idea of where I was going and what was expected of me in this subject.
26. The staff made it clear right from the start what they expected from students.

Inappropriate Workload
4. The workload was too heavy.
25. The sheer volume of work in this subject meant that it couldn't all be thoroughly comprehended.

Inappropriate Assessment
8. To do well in this subject, all you really need is a good memory.
19. Too many staff asked me questions just about facts.

Student Independence
16. This subject has encouraged me to develop my own academic interests as far as possible.
20. Students had a great deal of choice over how they learned in this subject.

The results were analysed using factor analyses, and are shown in Table 1.

Scale	Factor	
	1	2
Perceptions of Context		
Good teaching	.82	
Clear goals	.63	
Inappropriate workload	-.34	.66
Inappropriate assessment		.64
Student independence	.60	
Approach to Study		
Surface approach		.82
Deep approach	.60	

N=1557 first year science and technology students

Table 1. Factor analysis of perceptions of teaching and learning context and approach to study

1994-1996: *Australian Research Council,* Academic Departments and the Quality of Teaching and Learning, Paul Ramsden, Griffith University, Elaine Martin, RMIT University, Michael Prosser, La Trobe University, Keith Trigwell, University of Technology, Sydney

A factor analysis is designed to show the structure of the relationship between variables. The analysis shows two clear factors. The first relates perceptions of good teaching, clear goals and independence with a deep approach and the second inappropriate workload (too heavy) and inappropriate assessment (measuring rote learnt material) with a surface approach. It is clear that the way students perceive their teaching and learning environment or context is associated with the way they approach their studies in that context.

In a further study at La Trobe University, the University included a set of more client centred questions along with the CEQ in our survey of graduates. Table 2 shows the results of the factor analyses of this data in 3 separate years.

This analysis suggests that students' perceptions of the teaching, goals and generic skills development – those perceptions related to the way students approach their studies, are independent of their perceptions of the administrative procedures, student facilities, teaching and learning facilities, library facilities and student services – the more client or customer centred items. It also shows that their satisfaction with the course is independent of the client or customer centred items, but that their overall experience loads equally with both perspectives. The workload and assessment scales are independent of both sets of perspectives. Thus, combining this with the results of the previous study, it is clear that it is students' perceptions or experiences of the teaching and learning context that are important in terms of the quality of student learning outcomes.

	1995 Factors			1996 Factors			1999 Factors		
	1	2	3	1	2	3	1	2	3
Student focused learning perspective									
Good teaching	75			78			78		
Clear goals	64			74			72		
Inappropriate assessment			63			79			66
Inappropriate workload			84			74			83
Generic skills	80			76			77		
Satisfaction course	*80*			*80*			*83*		
Client or customer centred perspective									
Administrative procedures		(38)			43			(34)	
Student facilities		78			77			77	
Teaching and learning facilities		69			69			71	
Library facilities		60			63			69	
Student services		64			67			70	
Overall university experience	*51*	*58*		*49*	*59*		*49*	*62*	

1995: n=2352; 1996: n=2591; 1999: n=2390

Table 2. Factor analysis of CEQ and Extra Questionnaire items

In a separate study some colleagues and I looked at how these perceptions and approaches relate to prior and post knowledge and understanding and achievement in first year university science courses. We used open-ended questions and concept maps to obtain indicators of first year physics students' understanding of key concepts in electricity and magnetism, and their examination results to obtain an indicator of their achievement. We also used the questionnaires previously discussed to obtain indicators of their perceptions and approaches. Table 3 shows the results of a cluster analysis of all these variables. (While a factor analysis looks at the relationship between variables, a cluster analysis results in clusters of individual students with like scores.)

Variable	Cluster (Standardised Means)			
	1 n=36 Understanding	2 n=55 Disengaged	3 n=20 Disintegrated	4 n=20 Reproducing
Pre conceptual knowledge				
Open-ended	0.46	0.20	-1.43	0.04
Concept map	0.80	-0.41	-0.47	0.17
Approaches and perceptions				
Surface approach	-0.22	-0.39	0.47	1.01
Deep approach	0.46	0.01	.36	-1.1
Surface perceptions	-0.56	-0.09	0.29	0.96
Deep perceptions	0.49	-0.10	0.45	-1.06
Post conceptual knowledge				
Open-ended questions	0.82	0.05	-1.50	-0.10
Concept map	0.90	-0.34	-0.62	-0.08
End-of-semester achievement				
Institution 1				
n=	18	15	10	10
Overall – end-of-semester	0.43	0.13	-1.04	0.08
Electricity and Magnetism	0.51	-0.16	-0.92	0.26
Institution 2				
n=	18	40	10	10
Overall – end-of-semester	0.87	-0.01	-1.07	-0.47
Electricity and Magnetism	0.63	0.01	-0.72	-0.4

N=131 first year physics students
Surface perception: mean of Workload and Assessment items
Deep perception: mean of Good Teaching, Clear Goals and Independence items

Table 3. Summary statistics of a four cluster solution for the pre and post measures of conceptual knowledge, the approaches to studying and the perceptions of the learning environment for the combined physics files
Source: Prosser, Trigwell, Hazel and Lyons (2000)

For the purposes of this paper, I wish to focus on cluster 1, the understanding cluster. These results show that in both institutions, those students with the highest achievement and highest quality understanding were those who reported adopting a deep approach, and who perceive the context as providing good teaching, clear goals and independence with appropriate workload and assessment.

What do these studies and this model say about the evaluation of new technologies in teaching and learning? They highlight the importance, in terms of student learning outcomes, of trying to see how the students perceive and understand the use of new technologies, not how they judge them or how we, as teachers and developers, judge them.

But how can this be done without developing specially designed questionnaires or in-depth interviews? I wish to turn now to two examples of work that I have been associated with in mathematics and physics. The first is from a study of first year students' experiences of studying mathematics. In that study we asked students to respond to two open-ended written questions. The students were given these questions on a single page and given half a page each to respond. The questions were:

1. Think about the maths you've done so far. What do you think maths is?
2. How do you go about learning maths?

The first stage of the analysis was to develop a set of categories of description based upon the responses themselves. The second stage was to return to the responses and to categorise them in relation to these categories. The results of the analysis of these two questions are shown in Tables 4 and 5.

Category of Description	Representative Quote
A. Maths is numbers, rules and formulae. (n=62)	*Maths is the study of numbers and the application of various methods of changing numbers.*
B. Maths is numbers, rules and formulae which can be applied to solve problems. (n=124)	*Mathematics is the study of numbers and their applications in other subjects and the physical world.*
C. Maths is a complex logical system; a way of thinking. (n=32)	*Mathematics is the study of logic. Numbers and symbols are used to study life in a systematic perspective and requires the mind to think in a logical and often precise manner.*
D. Maths is a complex logical system which can be used to solve complex problems. (n=18)	*Maths is an abstract reasoning process which can be utilised to explore and solve problems.*
E. Maths is a complex logical system which can be used to solve complex problems and provides new insight used for understanding the world. (n=6)	*Techniques for thinking about observable, physical phenomena in a quantitative way and also for thinking more abstractly with little or no relation to the directly observable universe.*

Table 4. Categories of description of students conceptions of mathematics
Source: Crawford, Gordon, Nicholas and Prosser (1994)

The tables show that when we asked students what they thought mathematics was – their experience of mathematics, we identified a range from a very unsophisticated conception – about numbers – to a very sophisticated conception – helping to explain and understand aspects of the world. Similarly, when we asked students how they study mathematics we identified a range of approaches two of which represent surface approaches and 3 represent deep approaches.

The analysis showed a strong relationship between the way they approached their studies of mathematics and how they conceived of it. The important thing to note is that the results were obtained from an analysis of open-ended written statements by students collected in class, and represent the way the students experienced mathematics, not a judgement by them of our predetermined ways of experiencing it.

Category of Description	Representative Quote
A. Learning by rote memorisation, with an intention to reproduce knowledge and procedures. (n=17)	*I liked calculus because I could remember formulas which is how I used to study. I would rote learn all the formulas and summarise all my theoretical notes.*
B. Learning by doing lots of examples, with an intention to reproduce knowledge and procedures. (n=215)	*The way I go about studying for mathematics is by doing a lot of questions and examples. Firstly I would study the notes and learn formulas, then I put all of that to use by doing heaps of exercises.*
C. Learning by doing lots of examples with an intention of gaining a relational understanding of the theory and concepts. (n=30)	*To understand a topic well it was important to gain an understanding of the basic concepts involved, backed up by some problem solving on the topic. However, concepts which were not fully comprehended could become well understood through extra work on related questions, i.e. it is essential to do a wide range of questions on a topic to fully understand it.*
D. Learning by doing difficult problems, with an intention of gaining a relational understanding of the entire theory, and seeing its relationship with existing knowledge. (n=15)	*After listening to an explanation of how a particular maths works the most essential features of repetition to develop speed (this usually consists of boring menial tasks) and an equal component of very difficult problems which require a great deal of thought to explore that area and its various properties and their consequences.*
E. Learning with the intention of gaining a relational understanding of the theory and for situations where the theory will apply. (n=6)	*Read the relevant theory and try to get the same 'wavelength' as the person who actually discovered it. Before I attempt any problems I try to think where you can use the concept, i.e. what the concept was invented for. Then I attempt problems (on my own).*

Table 5. Categories of description of students approaches to studying mathematics
Source: Crawford, Gordon, Nicholas and Prosser (1994)

A similar study was also conducted in first year physics with very similar results. Those results are shown in Tables 6 and 7.

Category of Description	Representative Quote
A. response based upon physics being about facts and formulas and/or hard work (n=37)	*Learning of formulas, a logical mind*
B. response based upon physics being about the study of the physical world (n=121)	*The study of the world around us*
C. response based upon physics being about the relationship between mathematics and the physical world and/or understanding the underlying principles governing the behaviour of the physical world (n=101)	*If you're clever it involves coming to understand principles about the physical world. If you're dumb it involves learning lots of rules and doing lots of questions even though you can't understand why they work*
D. response based upon physics being about an integrated, creative process of developing models and a language to describe observed behaviour of physical systems in the physical world (n=12)	*… 'A process of successive approximation, which attempts, to construct, an internally consistent, and experimentally consistent explanation of the phenomenon of the natural world.' It gives no pretence of delivering a 'true' representation of the universe.*

Table 6. Categories of description of students' conceptions of physics
Source: Prosser, Walker and Millar (1996)

Category of Description	Representative Quote
A. explanation based upon attendance and/or reviewing notes and/or learning formulas and/or doing exercises (n=218)	*Doing the assignments, listening in class, studying for examinations*
B. explanation based upon seeking understanding – seeing how principles work, discussing with other students (n=61)	*In class I take notes of the important details without being a slave to them. I try to understand the concepts there and then rather than adopting a 'she'll be right' attitude. Any areas which intrigue me or of which I have incomplete understanding I will ask questions about.*
C. explanation based upon relating to real world experiences, reading around the subject, etc. (n=12)	*Examples, applications to the physical world. To learn physics, better, to understand physics needs visualisation of many concepts so experiments and observations substantiate learning. Many areas just need various examples to explain it more clearly but in different context. Thus demonstrating the basics. Problem solving is the key.*

Table 7. Categories of description for students' approaches to studying physics
Source: Prosser, Walker and Millar (1996)

Tables 4-7 show a range of ways students in the same class conceive of the subject they are studying and a range of ways in which they approach their studies. The approaches fall neatly into the surface/deep distinction made earlier, and based upon that earlier research it can reasonably be inferred that those classifications relate to the quality and quantity of learning outcomes. The point being that it is reasonably simple to collect this more student focused evaluative information, and with a reasonably careful analysis, well substantiated results can be produced.

So far I have argued for a more student focused perspective on evaluation – trying to see the object of study – new technologies in teaching and learning – from the students' perspective. Not just finding out how they rate various parts or measure how much they learn but how do they see, perceive, experience the new technology and its place in teaching and learning. In the next section I will take an example of published work in the use of the new technologies in teaching and learning in university science subjects and show how such a student focused approach could have been included in the evaluation.

A case study for evaluation of new technologies

The example I have chosen is reported in a paper by Redfern (1999) in *UniServe Science News*. In that paper Redfern identifies two key issues in the use of the Web in teaching and learning. They are:

- that while there is a substantial amount of computer based learning materials available on the Internet, a key problem is how to integrate that material into a particular teaching environment – how to use it in a particular subject; and
- how to find time in traditional courses to integrate the Web and CFL material into the teaching environment.

Redfern decided to explore this issue in the teaching of an Honours statistics course at the University of Leeds. Redfern developed a web site to link all the various components together. The site was used:

- as a source of information;
- as a means of communicating with students via email; and
- to provide links to CBL modules designed to help students understand key statistical concepts.

In the article, Redfern describes the innovation and reports on the results of the evaluation of students reactions to this teaching. He noted that they:

- liked the freedom to organise their own learning;
- used email because they felt freer to ask questions;
- maintained lecture attendance; and
- found the CBL material interesting and useful.

But from a student focused learning perspective, he does not seem to have addressed in the evaluation the key issues of concern that he identified in the opening of the paper. There is little or no evaluation of how the students perceived or experienced the integration of the various components or of the aims of each component – the key focus of the innovation. Interestingly, in the article the author focuses on integrating the various components, not on helping students experience an integrated curriculum. The curriculum may have been very well integrated from the teacher's perspective, but not necessarily from the student's perspective. Furthermore, how the students saw and experienced that integration could have been very different to how the teachers designed the integration.

Questions such as the following remained unanswered:

1. How did students see the relationship between the lectures, CBL, web-based material, etc.?
2. What did students understand the role or aims of the CBL and web-based material to be in the subject as a whole?
3. How did students approach their studies in the subject – what were they trying to learn from the various components?
4. Did they feel as though they had enough time to deal with the various components?
5. What components did they perceive to be of most importance and what were of least importance to their learning, and most importantly why?

The questions raised by Redfern in the Introduction are very important ones, but ones not answered by the subsequent evaluative discussion.

From a student learning perspective, a modified version of the CEQ could have been administered to find out how they were perceiving the teaching assessment, workload and goals overall. An open-ended questionnaire, with 4-5 open-ended questions could also have been distributed to find out from the student perspective, how they were experiencing the integration of the various components.

Examples of items included in the questionnaire could have been:

1. If you were to explain to a friend how the CBL helped your learning, what sorts of things would you say?
2. How did you approach your learning using CBL? What sorts of things did you do and why did you do them?
3. What sorts of things did you learn from attending lectures?
4. What sorts of things did you learn by using the CBL?
5. What sorts of things did you learn when using the emails, etc.?

The important point to note from these questions is that they are written from a student perspective, and are designed to elicit from the student how they perceive or experience the innovations, not getting them to make judgements on how the teachers and or designers designed the innovation.

Conclusions

In this paper I have taken as my point of departure a student focused perspective on learning and have argued for a more student focused perspective in the evaluation of new technologies in teaching and learning. I have argued that the quality of student learning outcomes – conceptual understanding and achievement – is closely related to how they perceive and understand the teaching and learning environment that they are in. It is not how well we have articulated the aims and objectives, but how well and what the students understand those aims and objectives to be. It is not how well we have designed assessment to test understanding rather than reproduction, but what our students believe the assessment to be about.

Too much of the evaluation of, and research into, the new technologies in teaching and learning have been conducted from the teacher's or developer's perspective. There has been little research and evaluation looking at the teachers' or students' experience of the new technology and to my knowledge none from a student focused learning perspective.

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Evaluating the New Technologies

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Summary

There is an accelerating trend towards the use of new technologies in teaching; the challenge is to demonstrate its effectiveness.

In approaching the evaluation of new methods, what were the aims of the initiators? While their over-riding expectation or hope is usually to enhance learning in a specific area, other possible outcomes may include reaching more students, providing experiences otherwise impossible, offering flexible access to a wider range of information, encouraging rehearsal and practice in virtual environments, the development of more generic skills – including the use of computers themselves. Unless these expectations are made explicit, the impact or effectiveness of the technological solution cannot be measured against its own goals. Ongoing evaluation in use can subsequently feed into quality improvement cycles.

In other situations, comparative judgements are sought but in many ways this approach is difficult. There is by no means agreement on the best methods of evaluation, even for the most basic of questions: Is the technology more effective in enhancing students' learning than are the alternatives it replaces? Is it cost-effective? Is it received better by the students? Conventional teaching methods have by no means always been evaluated rigorously, so the baselines for comparison are lacking or flawed. Complex variables (characteristics of the program in which the technology is embedded, students, teachers) inevitably confound any differences found, so absolute judgements are rarely possible.

Nevertheless, some strategies for evaluation have evolved and are often very effective within a local context. Examples from fixed media and web-based technology will be discussed.

Introduction

New technologies are rapidly entering teaching and learning, yet in many cases the evidence for their effectiveness is yet to come. Evaluation of the technologies in enhancing learning is not easy, quick or cheap, yet we must do it well in order to plan appropriately. In thinking about evaluation, we have first to review what the educational purpose and rationale is.

The sorts of decisions that need to be made have different implications, depending on the size of the organisational unit that is concerned with the introduction of new technologies. At the broadest level, in the face of the technological revolution, institutions are increasingly forced to consider what their roles are: to remain campus-based with an emphasis on face to face experiences; to extend their reach using technology and rely on distance learning; or to embrace a mix of methods depending on local needs. The same institution might well distinguish between: undergraduate teaching; continuing professional education; postgraduate coursework qualifications; and research degrees. Different strategies and solutions may be appropriate to meet the distinct needs of each of these groups.

Below the level of the institution, faculties are now developing policies on the uses of technology across their various degree programs. In other situations, decisions are taken by departments or by those organising individual units of study. Further, some freedom of choice may be available to individual members of staff making only a small contribution to part of a unit of study. The costs and consequences of each of those decisions are necessarily very different. A poor decision at the level of an institution or faculty will be extraordinarily expensive in time, money and in lost opportunities; a poor decision at the level of an individual member of staff may cost that individual and the affected students some angst. Being so close to the action, however, problems can be identified early and remedial steps can be more quickly applied.

Whatever the level of decision-making, the technical context is clearly critical for both staff and students. It may be easy to offer high quality access on a fast intranet on campus, but for evaluating resources that will be accessed at home, we must put ourselves into the relevant environments. Issues include the sort of technology in use, with the likely constraints on speed and accessibility, as well as the resolution of the screens if image quality is important. To that end, we need to know something about the situation of both the students and staff, including their access to computers off campus.

Evaluation of local strategies

Whatever the organisational level, from the institution to the individual enthusiast, evaluation is essential, but its effective implementation may pose rather different sorts of problems. There are also issues that are common to the effective application of strategies for evaluation across the levels.

Meeting goals

Those who are engaged in the processes of developing whole educational programs that are based on or supported by information technology and those whose uses are confined to a single unit or 'lesson' are aware of the high costs for development and infrastructure. They have particular concerns to ensure that their students' learning is of high quality and effective. At both levels, teachers want to see the extent to which the technology helps the students to meet the goals of the degree program and/or the individual unit of study. In order to do this, the goals or outcomes – whether of a whole program or a smaller unit – must be explicit and achievable.

As an example of program goals, The University of Sydney Medical Program makes strong statements about critical reasoning for medical practice, effective skills in communication and clinical examination, a capacity to understand community concerns and population issues as well as to behave ethically and to be reflective practitioners. A set of statements about the values of the curriculum includes student-centred, independent learning, reflection and self-evaluation, cooperation in groups, evidence-based decision making, effective skills in clinical work and in information technology. Clearly, the technological support designed for use in the program must be consistent with those aims.

While evaluation against a defined standard is ideal, in practice it is often difficult, particularly for whole programs or yearlong courses. Unless the outcomes and goals are clear – and they are not always so – it is impossible to test whether they have been met. Countless variables inevitably intrude – for example students may access many forms of learning, so the impact of any one component cannot be teased out. Often the starting point is not identified or measured, so gains are hard to quantify. Many of the specific or generic skills may be acquired from other studies or outside of the university. The timing of evaluation is also an issue: many goals or outcome statements for degree programs refer to qualities or skills that will be possessed by graduates well down the track, or throughout a lifetime.

Small programs or packages often have more modest aims – e.g. understanding one or a limited number of concepts, solving relatively simple but relevant problems, applying knowledge to a new environment, acquiring a variety of skills including skills in information technology itself, stimulating interest. Some of these outcomes can be tested relatively easily, but others are more problematical. Even with a smaller package, the designer might be aiming for longer-term gains in understanding and the application or synthesis of knowledge into the future, but for logistic reasons, observation and measurement is often limited to the immediate end of the period of study.

Understanding learning processes

Teachers may also aim to understand something about the learning processes of their students from the ways in which they work through a program or package. Observing students at work on a program is expensive, but yields very valuable information about the quality of the program and its usefulness to the users. Thus, there is often an overlap between the specific evaluation of a component of information technology and more fundamental educational research. Obviously such approaches can generate important observations that go beyond the simple brief of evaluating a particular program or intervention. Such work is only in its infancy but in the longer term, the approach has the benefit of enhancing our understanding of how students learn differently – if they do – using technology rather than other tools.

Comparative studies

Comparative evaluation sounds attractive, but is a very difficult task. It is easy to pose the obvious question: is this use of information technology more effective than alternative methods of teaching? It is much more difficult to find ethical and practical ways of answering the question unequivocally. Students learn in different ways, and value different sorts of experiences.

Some new approaches to 'evidence-based education' are, however, drawing on the ideas of the very effective 'evidence-based medicine' movement. Shortly, in several leading journals of medical education, an approach to the weighting of educational evidence will be reviewed and presented. I hope that this step leads to a vigorous debate and to a more secure understanding of the value of different sorts of evidence.

By analogy with the medical literature, randomised controlled trial designs that involve dividing students into two groups inevitably raise issues of fairness, the comparability between the groups and indeed, the level of communication or collaboration between them. Further, it is difficult (and usually unethical) to contrive a placebo in educational terms. The common educational solution of comparing students in successive cohorts with and without an intervention introduces a range of uncontrolled variables. New strategies of meta-analysis have been applied in several educational cohort studies, however, suggesting one possible future direction. Unfortunately, an educational study cannot be carried out like an 'n of 1' trial of an individual with periods on and off a relevant drug (or program) since learning would be expected to be cumulative.

Any study design must access the students' responses directly. It is crucial to find out how students balance their learning between the range of educational activities undertaken; presenting students with a new strategy does not mean that they actually used it. Indeed, anecdotal examples give us pause for thought (e.g. some laser disks that were thought to have been spectacularly effective until it was realised that students found them so impenetrable that they resorted to small group self-directed learning in the library). Perhaps, in the end, we will come to rely on students' reports of their impressions of the comparative usefulness of a new tool for their own learning. We must aim to relate the evaluative information to students' learning styles so as to influence future educational design.

Quality improvement

Another obvious use of evaluation is to feed back into a locally produced program for ongoing quality improvement. The cycle of evaluation can feed directly back into a process of re-design and enhancement. Such an approach requires that appropriate academic structures and mechanisms are in place to effect the agreed changes.

Evaluation of imported 'solutions'

We may want to compare one technological intervention with another. On a small scale it may be readily apparent that one package is more effective or better received than another, but for larger scale decisions, the same caveats as were pointed out above apply.

With the burgeoning availability of information technology, our attention is increasingly drawn to disks or web sites that might provide useful teaching resources for our students without infringing copyright. We may be interested from the simple viewpoint of providing an illustration or a small teaching aid, or we may be considering the far more extensive adoption or adaptation of a whole unit of study or even an entire curriculum. Major developments worldwide suggest that programs from high quality institutions may become available for individual students or whole classes, some perhaps at affordable licensing fees. Given the acknowledged costs of developing even a fairly straightforward teaching unit, *not* re-inventing the wheel is obviously attractive. How, though, do we set about making judgements on the quality, likely effectiveness, ease of use and accessibility of learning packages or programs produced by others?

Once again, the key lies in identifying the aims of the program we are evaluating in the light of our own goals for the degree program and/or unit of study. What do we want the students to achieve at the end of the exposure to the 'lesson', unit or program? Is the design of the intervention compatible with both sets of aims? What relevant advances in learning will result from the program, activity or aid? Is the level and style of learning appropriate to our goals? Is the educational design appropriate? What local modifications might we seek? Are they feasible and permitted by the licensing agreement?

Costs are always an issue: up-front charges and licensing agreements vary, making some highly desirable programs (on-line or on disk) unaffordable.

Designing evaluation of IT

Teachers' concerns

The power of the technology lies in the capacity to bring information together in engaging ways. Computers offer access to almost unlimited information. They can also offer simulations, replacing experiments impossible in the average classroom. For example, students can learn to patch-clamp individual cells in simulation, achieving with an inexpensive computer and program what would require hundreds of thousands of dollars worth of equipment. They can analyse their data on the same machines and present their conclusions using text, graphics and images. In biological and medical sciences, observations become possible that were once only available in well-equipped laboratories, either using software to mimic expensive recording and analytical machines or to provide access to simulations. With increasing ethical barriers to experiments on animals or humans, such replacements are proving invaluable. To be effective, though, such programs must challenge and interest the students who must be clear on the goals they are to achieve. The limitations are obvious – computers don't bleed – but well done, they can open access to observations that mimic first-hand experiences. They can provide plausible data for later analysis, presentation and discussion.

What teaching goal(s) is the IT intervention designed to meet? Are these aims appropriate for the overall program or unit of study? Goals/aims such as:

- learn a new concept;
- apply knowledge already learned;
- offer access to information and databases;

- solve problems;
- provide feedback on learning;
- rehearse a skill; or
- access/simulate/replace an experiment.

Before asking the students, some questions need to be satisfactorily resolved. Are the program's strategies and approaches consistent with our overall educational objectives? Do they:
- encourage active learning?
- stimulate problem-solving?
- trigger 'what if' speculation?
- stimulate student-student discussion?
- support further exploration?
- offer quizzes and/or feedback?

As teachers, we need to be assured that the program is built around essential and appropriate content or skills, that the level of difficulty for the particular student group is reasonable and that the intervention is designed to meet both specific and generic skills consistent with those of the program.
- Is the material relevant/important?
- Are the specific skills essential?
- Is the level of knowledge/skill right?
- Does it enhance useful generic skills?
- Is it well-matched to assessments?
- Are the outcomes consistent with program goals?

Other concerns lie with the technical issues and to some extent 'taste'. The importance of good educational design is only recently becoming recognised in tertiary education although its usefulness has previously been demonstrated in schools and technical colleges. The use of the information technologies has made issues of design and structure more apparent as we realise the need to match them with the overall goals and delivery of the programs. While some technical aspects can readily be analysed, issues of taste are more problematical. The generation gap often intrudes. That is, to me, a screen may be unreasonably cluttered, and the colours garish; to my students, iconic complexity is appreciated, indeed easily absorbed, and the colours are regarded as entirely acceptable or even 'trendy'. Thus issues of design and taste must be tested with the target population. Some simple observations, however, include:
- Is the program well constructed?
- Are the screens clear/acceptable to users?
- Is navigation easy?
- Are the instructions clear?
- Can the user exit easily?
- Is it too slow/fast?
- Does it include feedback?

Obviously, a program must be of high technical quality, without obvious quirks or glitches. It must be highly relevant to the group concerned to be maximally useful. These represent value judgements that can only be made in the context of the objectives of the overall program and of the technological intervention itself. Examples of fairly clear-cut issues of quality and relevance might be:
- Is the issue/task/learning important?
- Is the information accurate?
- Is the approach up-to-date?
- Are the examples appropriate?
- Are illustrations clear and relevant?
- If a simulation, how 'real' is it?

Central to the evaluation process is the experience and the views of the students concerned. Any process of evaluation must involve them directly, by providing adequate ways of tapping into their reactions and comments. First, though, it is necessary to establish some baselines.

- What are their expectations?
- What are their specific learning needs?
- What are their generic learning needs?
- Is the IT interactive and time-effective?
- Is the IT consistent with assessments?
- Does it offer helpful feedback?

Well designed questionnaires (on paper or on-line) and/or focus groups to follow up details, make it possible to gain access to their opinions. Other aspects are open to more objective observation – e.g. the number of times students choose to refer to a particular program out of class hours, the educational 'buzz' in the classroom when the program is in use, enhanced performance on standard tests. What do students and staff report?

Student views:	exciting, interesting? useful? boring? useless? easy to use? impenetrable? what aspects are valued for learning?
Objective measures:	does it stimulate discussion? do they seek it out frequently? can improved learning be measured?

For all of us in higher education, issues of costs become quite crucial. We need to be very clear in determining whether an intervention not only enhances learning, is well received by the students and staff, but is also cost-effective. Could the same result be achieved more cheaply? Discussions with those involved in the development of specific programs often suggests that the full costs are seldom calculated and made explicit. Educational and technological enthusiasts will cheerfully give up excessive time to development, over months or years, seldom counting the total hours and the costs of lost opportunities and other aspects of teaching neglected. The 'not invented here' syndrome leads to massive duplication as individuals are reluctant to accept a program from a colleague in another institution. In this important area, we must devise more effective means of communication to avoid such waste. Shareware programs, web sites and individual teaching items from databases like the National Teaching and Learning Database Project (including high quality images and diagrams) are becoming available, and we must learn to utilise these to our best advantage.

- Is the program effective and cost-effective?
- Is the students' learning increased?
- Do they enjoy the new learning?
- Do they rate it as high quality?
- Are they motivated to learn more?
- Are there cheaper but effective alternatives?

Using computers for program evaluation

Networked computers can be used effectively to present evaluation questions to students at the end of a period of learning, after particular interventions or experiences, or when difficulties are perceived to be developing. Feedback to staff is fast and can be interactive. Numerical responses can be automatically collated, stored, analysed and reported in tabular or graphic formats.

As an example, in The University of Sydney Medical Program, every web page has a 'feedback button' so that comments can be fed to the relevant staff member(s) and to curriculum developers. Students study one clinical problem per week in the first two years: at the end of each week the problem-based learning groups feed back their overall impressions of the effectiveness of the learning experiences during that week. This feedback is expanded in intermittent focus groups attended by group representatives. Students have access to on-line self-assessment questions: they can, and do, email the relevant writer if they have difficulties. Throughout the program, students fill in on-line questionnaires on a wide range of different aspects. Such rapid and effective feedback is of great usefulness to staff in refining the curriculum, and is valued by the students. Another feature of the program is the ‘staff site’ which allows teachers to review all on-line teaching materials, outlines and timetables. This site offers a powerful opportunity for evaluation of the quality and relevance of materials presented, as well as providing information for teachers on the program itself.

Teaching students the skills of evaluation

Encouraging students to approach evaluation seriously is important for their future educational development. Helping them to contribute usefully to the processes of evaluation often provides insights for them into the underlying structures and expectations of programs when these have not necessarily been made explicit. Good evaluation can turn students into enthusiastic collaborators with staff, enhancing collegiality and enriching the experiences of both groups.

More importantly, though, students will have to function in a future brimming with overloaded sources of information. The skills of critical appraisal and evaluation must apply not only to traditional texts or experimental data, but also to technology-based information. Information literacy is now being introduced in many contexts: the idea incorporates a complex set of generic skills – the capacity to locate, retrieve, use, modify, link, categorise, store and access information – applied to specific subject areas. It is increasingly essential for students to develop the ability to evaluate the quality, accuracy and usefulness of the computer based information they encounter. In the health sciences and increasingly in education, those interested in evidence-based practice are developing rational evaluative tools to judge the quality of evidence and perhaps similar approaches will develop in other fields. A conjunction is needed of those expert in information literacy (often librarians) and subject experts to contribute to the development of sophisticated critical skills in students. Only then will we meet the current and future needs of students who will be increasingly awash in a sea of information of very variable quality and applicability.

Conclusions

Effective computer based learning:
- meets a clear educational need;
- is consistent with program goals;
- is cost-effective and timely;
- avoids errors, misconceptions;
- is set at the appropriate level;
- interests and motivates students;
- engages students actively in learning;
- is well-designed, easy to use; and
- encourages collaboration.

Good evaluation:
- is essential to meeting educational needs;
- must justify costs (time, money);
- is difficult, expensive, many variables;
- depends on explicit program goals; and
- is time-consuming and may not yield conclusive results.