

## Is there a right way to teach physics?

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### Background

An important development in university physics teaching in the last two decades has been the emergence of a worldwide Physics Education Research community. In physics departments at relatively large numbers of institutions throughout the world, particularly the USA and Europe, academic physicists are doing research into the difficulties associated with teaching their subject.<sup>1</sup> Among the many directions this research has taken is the identification of ‘misconceptions’ (sometimes referred to as ‘alternative conceptions’). These are ideas or concepts which students have constructed for themselves, based on their own experience of the natural world, which are often in conflict with the agreed view of practicing scientists. Research has shown that these ‘misconceptions’ are very widely shared, very often in conflict with other concepts the student holds, and very difficult to change.

Following on from this research, as it were, a lot of work has been done to develop special diagnostic tests to uncover which, if any, of these misconceptions particular students hold. They normally consist of series of multiple choice questions, in which the ‘right’ answer is hidden among very tempting distracters, each one targeting one or more common misconceptions. Among the best known of these tests, in the subject area of kinematics and dynamics, are the Force Concept Inventory (FCI)<sup>2</sup> and the Mathematics and Physics Concept Evaluation (MCPE)<sup>3</sup>.

This research has, in turn, prompted the development of teaching strategies which target specific classes of misconceptions — in the (understandable) belief that, if students can get the fundamental concepts ‘right’, they have a better chance of understanding the rest of the subject. The results of these strategies are reported in the literature, and there is coming to be a consensus within the physics education community that, for example, traditional (chalk and talk, lectures plus laboratories) teaching is relatively ineffective in changing misconceptions. On the other hand, one recent survey of over 7000 students in the USA has shown that teaching which employs interactive methods can result in significant increases in understanding (as measured by these diagnostic tests).<sup>4</sup>

It would seem important therefore that teachers everywhere should take these findings seriously, and, where possible, test whether the same gain in understanding can be achieved in other teaching contexts.

### Interactive lecture demonstrations

Many of the new techniques just mentioned involve quite elaborate teaching materials and preparation time on the part of the teacher. In today’s university climate, increasing workloads and student numbers often mean that time is just what university teachers do not have. Therefore many of these new techniques are destined to be little used. However, one particular new technique, which originated at Tufts University, Boston, involves the use of **Interactive Lecture Demonstrations**,<sup>5</sup> and which is designed to be used in a traditional teaching context, that is in an ordinary lecture. They consist of a number of simple experiments which use a microcomputer to log data from a motion sensor, and to display it in graphical form on a data projector, while the instructor performs a number of simple ‘experiments’. Students are told what is going to happen, and write their predictions of what the graphs will look like on specially prepared sheets. Only when they have done this and



resolved by discussions among themselves any disagreements, are they shown the actual experiment and the data the computer has collected and graphed. After this, class discussion is devoted to where any incorrect predictions went wrong.

Clearly such a technique means that the instructor must follow a pretty rigidly imposed scenario. Although the demonstrations are done in an ordinary lecture setting, there is little scope for the instructor doing what he or she wants to do. Questions of ‘covering the syllabus’ and ‘giving good sets of notes’ have to take second place. Luckily there are only four one-hour sessions specified, and the instructor has the rest of the allotted periods to do what is normally considered necessary in a lecture course (and which, it will be remembered, research shows to be not very useful).

Results from this teaching technique have been reported in the literature over the last five or six years. Typical are those reported from the University of Oregon in 1996, shown in Figure 1<sup>4</sup>. The diagnostic instrument used was the MCPE, and student responses are reported for four groups of questions concerning Newton’s Laws, though it is not particularly relevant what material the questions covered.

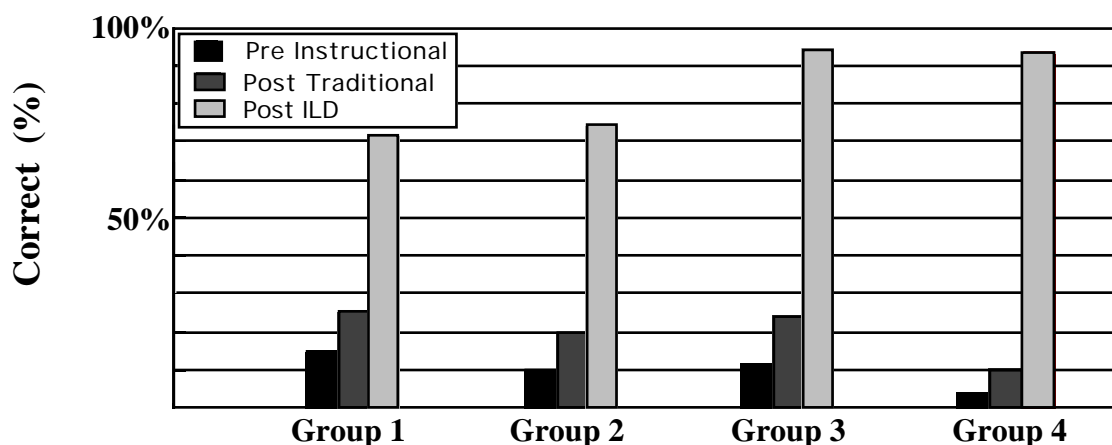


Figure 1. Showing the percentage of correct responses to questions in four groupings, as published by Thornton. Results are (1) responses from students in all classes before instruction, (2) responses after instruction from classes taught by traditional methods, and (3) responses after instruction from classes taught using ILDs. The figure is adapted from reference.

Several points will be noticed from this figure. Firstly that student ‘understanding’ (or whatever is being measured by these tests) is very low on entry. It must be noted that the physics course in question was calculus-based, and the students would be planning on a physics major. Some of the more prestigious universities in the USA have students who attain higher scores on entry, but nevertheless, scores similar to the above are not untypical of students just out of high school in the USA.

Secondly it will be noted that there is no very great improvement after a semester of traditional instruction. Such results are also typical of universities and colleges reported in the literature, and are part of the accepted body of evidence which suggests that traditional teaching is relatively ineffective in generating this kind of understanding.

Lastly there is the very impressive improvement in ‘understanding’ demonstrated by those students who were exposed to 4 one-hour sessions using the ILDs and the stipulated interactive teaching. The results reported here are not the only ones who show such improvements. Therefore this particular teaching technique seems able to claim, *prima facie*, to be one which promises that other teachers can expect similar improvement. It would obviously be important to test this expectation in another context – for example, with a class of Australian students.

## Evaluating the effectiveness of ILDs

In March 1999, such a test was held with physics introductory students at The University of Sydney. The roughly 450 physics students are divided into four calculus-based classes, one at the 'Advanced' level and three at 'Regular'. Of the latter, one group was taught using ILDs, and the other two, taught by a different lecturer, were regarded as a control. The structure of the course is similar to most physics departments in the country. The areas of kinematics, force and motion, work and energy, collisions, rotational dynamics are taught over five weeks, usually by 15 one-hour lectures with a weekly tutorial and regular homework assignments. For the trial being reported, the experimental class had 11 one-hour lectures and 4 one-hour ILD sessions, but everything else was the same. All classes shared the same assignments and end-of-semester examination.

All 450 students were tested during the first lecture period, using the MPCE diagnostic test, and two weeks after the end of the module, in the seventh week of semester, all were asked to take exactly the same test again.

## Results

Results of the experiment are shown in Figure 2, in which student responses are reported for ten groups of questions on that test, including the four groups singled out in Figure 1.

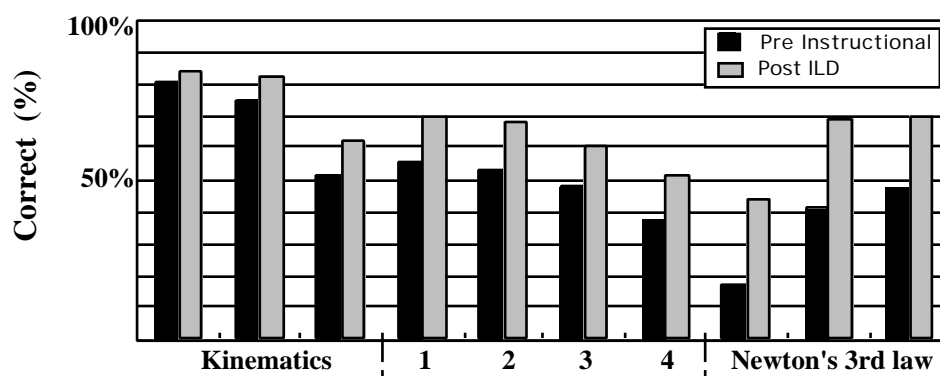


Figure 2. Showing the percentage of correct responses to questions in ten groupings, (including the four groups represented in Figure 1) as found in the current experiment. Results are (1) responses from students in the experimental classes before instruction, and (2) responses from the same class after instruction using ILDs.

The first point to be noted is that Australian students are clearly very well prepared when they enter university. The on-entry scores are comparable with, or better than, the very best US institutions. In these times when high school teachers are being criticised, this finding deserves to be better known.

The second point, however, is less palatable. It is immediately obvious that the same gains in understanding, as were reported in the literature, did *not* occur. There was some gain, but the absolute values for the fraction of students answering the questions correctly fell far short of those in Figure 1. And the *relative gain* – the proportion of students who were unable to answer the questions before instruction, who were able to answer them after instruction – was even worse, considering that the Australian students had so much better scores on entry.

The teaching effectiveness of the ILD method, *compared with the control classes*, is shown in Figure 3, in which the *relative gain* for both groups of students is shown.

On the basis of this data, a case can be made that the new teaching technique is more effective than traditional methods, at least so far as student understanding (as measured by the MPCE test) is concerned. However it should be pointed out also that when comparisons were made between end-of-semester marks between experimental and control classes, no significant differences were noticed.



In fairness, it should be further added that end-of-semester examinations were testing learning which took place during the whole 13 weeks of semester, not just the 5 weeks the mechanics module lasted.

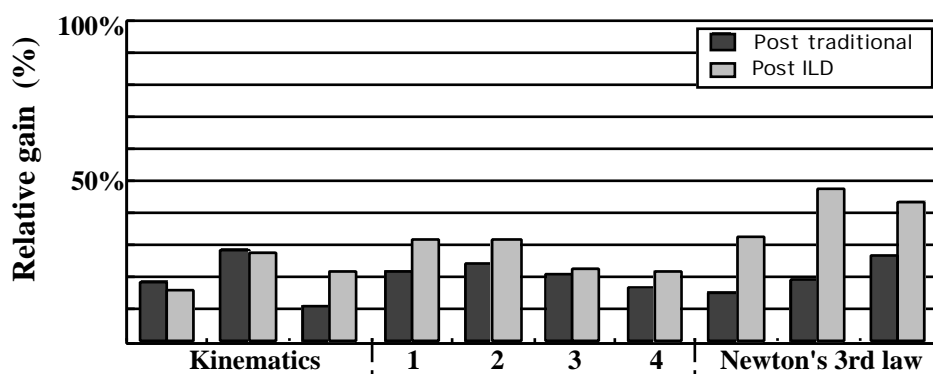


Figure 3. Showing the relative gain, as determined by post- and pre- testing (results expressed as a percentage) as a result of instruction for (1) students in the control class, taught by traditional methods, and (2) students in the current experimental class, taught using ILDs.

## Conclusions

The inescapable conclusion would seem to be that this new method of teaching, while effective in itself, does not yield the very impressive results claimed for it. There are of course many possible explanations for this. The teacher (IJ) may not have done things properly; the students may have been atypical; the testing protocols may not have been careful enough. To answer some of these, the experiment was repeated in 2000, exactly as in the previous year, but results are not yet available for analysis.

However the fact remains that the unstated hope driving the experiment in the first place was that the ILD method might have been a teaching technique that could in some sense *guarantee* student learning, given only reasonable teachers and teaching administration. The previously published results seemed to suggest that that might have been the case. We are tempted therefore to speculate on why this experiment did not come up to expectations. Three questions immediately suggest themselves.

- Is there a cultural difference between US and Australian students which would allow a particular teaching technique to be successful with one and less so with the other? If this is the case, the hope expressed above can still live. It simply remains for us to find the technique that will work for Australian students.
- Did the fact that the Australian students did so much better on entry mean that those who did *not* know the answers on entry had their own brand of particularly immovable misconceptions? Again this still allows hope. We must work hard at uncovering and eradicating these misconceptions.
- Is the whole exercise pointless? Is there no such thing as a magic bullet, no right way to teach physics (or any subject for that matter)? Many believe this to be the case, but it is a depressing conclusion to come to. It leads many university teachers to conclude that no form of teaching is better than any other. Therefore they are justified in the all-too-common strategy of ignoring what education research has to say and continuing to teach as they themselves were taught.

## References

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# Innovative teaching of the experimental sciences in regional Queensland

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*Central Queensland University offers a range of experimental science courses both by distance education and by 'face to face' teaching. The latter is spread over four regional campuses using various technology. In recent years there has been a blurring of the boundaries between full-time, part-time and distance education. More significantly the increasing use of technology has seen a blending of the styles and modes of delivery so that all the traditional terms are in need of redefinition (or perhaps abandonment). The actual teaching practice behind terms such as 'mixed mode' and 'flexible delivery' is starting to make a real difference for students. Despite the plethora of acronyms, e.g. VAL (Video Assisted Learning), ISL (Integrated System-wide Learning), students now have access to a range of technology based resources and we can cater for a range of learning styles (and lifestyles).*

*This paper outlines briefly the innovative technology being used and its influence on teaching techniques. At CQU courses are not evaluated systematically by the University but individual lecturers are encouraged to survey students in their courses. The results from these surveys are allowing us to optimise the flexible delivery models for teaching science in regional areas. The influence of factors such as class size, communication medium, student age, course level and support mechanisms are now reasonably well documented. The limitations of different models as perceived by staff and students are briefly explored.*

## Introduction

The experimental science departments at Central Queensland University have been at the forefront in developing a range of innovative teaching methods for students in regional areas. Students and staff now have considerable choice and flexibility in their mode of interaction. While there is little systematic institutional evaluation, surveys by individual lecturers have provided data for demonstrating the strengths and weaknesses of the different modes of delivery. The new flexibility is having a considerable impact on teaching styles and learning styles (particularly at first year level).

The nature and impact of technology in distance education has been discussed in numerous papers (see for example, Comeaux, 1995; Daunt, 1997; Kampmueller, 1996; Knox, 1997). Similarly there are a number of papers on the evaluation of academic performance (see for example, Binner et al., 1997; Burke et al., 1997). Many of these relate to the use of technology to teach smaller classes of later year students. It is not my intent to review the field but rather to provide an account of our experience with new technology in teaching first year experimental science at a widely distributed regional university.

## Evaluation policies and procedures

Despite years of talk (some at senior levels) Central Queensland University does not have an institution-wide policy on evaluation. Some faculties (e.g. Business and Law) have a common evaluation instrument but these are the exceptions rather than the rule (see Appendix 1). Within Science, only the School of Biology and Environmental Sciences has a single evaluation instrument which is applied across all courses (see Appendix 2). This is a minimum set of questions and lecturers may add additional questions (usually selected from an extensive question bank). In addition, individual lecturers may from time to time use special questionnaires for promotion purposes or to investigate a particular issue. For example I always carry out a student survey if I have a new course or if I have changed a course significantly (see Appendix 3). One of the studies upon which I will comment shortly, was undertaken specifically to evaluate the relative advantages and disadvantages of VAL and ISL in a service course to health science students (McKillup and



Dalton, 1999) (see Appendix 4). In addition to surveys, information has been gathered by various ad hoc or semi-formal means. For example, I have held a number of positions in the Faculty which have allowed me to interact extensively with students in individual interviews. This has allowed me to solicit comments and feedback on the different teaching modes. In some cases this has been akin to an action research model.

## **Brief historical context**

Central Queensland University is headquartered in Rockhampton and began life in the 1970s as a fairly typical College of Advanced Education. The original name was Capricornia Institute of Technology and until recently there was a significant commitment to making science education accessible to people in regional Queensland. In the mid seventies there was a move into distance education by the science faculty (and later by others) and by the mid eighties we had a reasonably sophisticated and efficient system of distance education operating for several disciplines. This expertise was reflected in our designation as one of a relatively few Distance Education Centres. This mode of teaching was supported by traditional print-based study guides and a commitment to residential schools (typically 4 or 5 days of intensive practical work per course (subject) held during the school holidays. Physics and Computing moved early to incorporate kits and on-line teaching. Biology and Chemistry trialled kits but these were largely abandoned because of legal and logistic problems. (Some introductory courses still use kits).

In the late 80s under the influence of the Dawkin's reforms, CQU moved to establish campuses at a number of regional locations. The distances involved are quite large and the centres included Gladstone (1 hour's drive south), Mackay (3 hours to the north), Bundaberg (4 hours to the south) and Emerald (4 hours to the west). For a variety of social and political reasons, a full range of first year science was only seriously developed at Mackay and Bundaberg. A small computing and physics presence was established in Gladstone but this has struggled to maintain viable enrolments. More recently experimental science 'lectures' for health science students have been available at Gladstone but students must travel to Rockhampton weekly to do practicals. The main mode of teaching delivery developed during this period was VAL (Video Assisted Learning). In essence the lectures in Rockhampton were video taped live and sent overnight to the regional campuses. The local tutor added value to the tapes by providing additional commentary and running practical sessions. We had the advantage in science of having well developed sets of study guides to supplement lectures. The lecturer was not responsible for camera work and the taped lectures were dispatched unedited. Throughout this period information technology played an increasing role (although there were some notable failures such as Aragon and KeyLink).

The late 90s saw a move to other campuses including fee paying ventures in capital cities and overseas. The advent of the so called 'quality funds' from the Federal Government in the late 1990s assisted a move to exploit new technology for delivery to the regional campuses. In particular, microwave links were used to establish what is called ISL (Integrated System-wide Learning) networks. In essence this is videoconferencing with all the frills. Teaching sessions (lectures) are transmitted live and the teacher (lecturer) is responsible for driving the system and in fact for the whole production. The teacher can use a touch pad to switch between the following:

- class camera;
- lecturer camera;
- document camera;
- video recorder;
- computer;
- web links; and
- others.

The teacher also has control of camera angles and focal lengths (if they choose to over-ride the pre-sets). The remote cameras are voice activated and the remote sites are equipped with document cameras. Not all remote sites have a full range of accessories. With the new wider bandwidth and generally improved technology, immediate and meaningful interaction between teacher and learner is reasonably effective. The main limitation is the need to recognise that at any instant there is a single channel of information (plus sound). The move towards ISL has seen a move away from traditional lecturing (and hence the switch in usage from 'lecturer' to 'teacher' in this paragraph).

## Current status

A wide range of experimental science courses are now offered in the regional campuses. They are taught using various delivery models. In fact some courses mix the mode of delivery and may rely on any or all of the following:

- external study guides (only);
- VAL tapes (with tutor and/or study guides);
- ISL (with study guides and/or tutor);
- face to face lectures (from any site); and
- WWW/CD-ROM.

A summary of the delivery modes for science courses appears in Appendix 5.

Even where the mode of delivery is constant within a course, a full-time student in any one term may do one course involving face to face delivery, one which relies on study guides alone, one course delivered by VAL and one delivered by ISL.

More recently we have been developing courses using team teaching involving regional tutors for some of the delivery. Some courses are effectively delivered from one of the regional campuses to the rest of the network. For example, environmental science students in Rockhampton take a course called Environmental Economics which originates out of Emerald (even though there are no environmental science students in Emerald).

This comment is also true for Rockhampton based students. We no longer necessarily have face to face lectures from the on-site lecturer. I run a third year course in insect biology where the mode of delivery changes as the term progresses. By the end of term the students are working quite independently with minimal supervision. (I note parenthetically that there is some student resistance to this; many students actually like lectures).

The old dichotomies of 'full-time' or 'part-time', and 'internal' or 'external' are losing their meaning (much to the chagrin of our administrators). Instead we talk in terms of mixed mode enrolments and flexible delivery. The way students get information is changing and the notion of independent learning is being practiced as well as preached. In addition the way we teach is changing. There is less emphasis on chalk and talk and more on genuine dialogue with students. The University has made a considerable investment in staff development to support these changes.

The experimental science courses are distinctive in that they have retained traditional practical sessions, which on the regional campuses are run by a local tutor. This provides a common contact point that is not necessarily available in other disciplines. The need for practicals has also limited the extent to which advanced level science can be offered to regional students. There have been some schemes developed within chemistry to bring advanced instrumentation to this group. In non-experimental courses there is emphasis on email and chat lists but for many experimental courses these are little used by students. This is presumed to be due to ready access to the regional tutors.



## Evaluation outcomes

Rather than present a raft of tables and statistical summaries I would like to draw together some of our experiences and some of the feedback from our evaluations of the different teaching modes.

To a large extent we have avoided looking for correlations based on academic performance and other variables. We know that regional students do as well as (or better than) main campus students but we recognise that there are numerous uncontrolled variables (class size, tutor access, etc.). Similarly with distance students, those that remain in the course tend to do better on average than full-time students (but there is a well documented high initial attrition).

If we consider the different media we can make the following comments based on our evaluations.

**Study Guides** – there are no surprises here except that the responses lack symmetry. To a large extent, a well structured study guide will be well received by students but they often give it a middle ranking score. By contrast students will quickly let you know if a set of study guides is not up to standard by ranking it very severely. Our students have become quite discriminating (and expect high quality study guides).

From the point of view of academic performance (including attrition) we find school leavers cope poorly with this mode of learning. For mature aged students or later year students, the academic results are comparable (or better) than for the internal students. School leavers who attempt full-time distance study almost invariably fail some of their courses. This appears to be due to poor study skills and time management. In academic advising we usually advise such students to attempt no more than a 75% load in their first year. It was for this sort of reason that we avoided a traditional distance education model when setting up at the regional campuses.

**VAL** – the main feature about VAL that students appreciate is the flexibility with respect to time. They can watch the tapes at any time (and can of course review them later in term). This feature makes the courses available to part-time students who might not be able to attend lectures because of work commitments.

In some surveys, VAL lectures are ranked equally highly with face to face lectures. We have had some deserved criticism from students where there were technology deficiencies (e.g. small screen, poor sound or narrow bandwidth) but generally these are beyond the control of the lecturer.

The main criticism from students arises from poor camera work and a feeling of exclusion. If the camera lingers on a wide angle shot for too long or fails to switch to the document camera in a timely fashion, then the students become quite frustrated. From a teaching point of view the best technique is to develop a good relationship with the camera person and anticipate your moves. Simple leaders like ‘We will now have a look at this simplified diagram on the document camera’ allows both the technician (and the students) to anticipate what is about to happen.

Similarly, students at remote campuses comment favourably on even small gestures that recognise their existence. Because there is no feedback in VAL, the students can easily become passive and it is difficult to enliven lectures beyond putting on a stimulating performance with variety and some rhetorical questions directed at the remote campuses.

**ISL** – we have less data on evaluation of this mode of teaching but some of the preliminary student feedback is useful. Students appreciate the immediate feedback and life-like lectures but they miss the loss of flexibility with respect to time. Since ISL sessions are not taped by the University, a missed session is a lost opportunity.

Local tutors have commented that they now feel excluded to a degree since they are no longer involved in the minute by minute progress of the lecture. By contrast there are quite enormous demands on the teacher/director who must hold the entire performance together.

Many people indicate that videoconferencing should be limited to 20 persons per site and six sites per session. Our experience is that this can be extended, particularly where the delivery is coming from the main campus and/or is well executed. In making this comment I also recognise that quite often in science we still spend quite a bit of time on content. There is generally less interaction than in a humanities course. For more interactive sessions the limits of 20 x 6 are probably optimistic.

Students on the main campus comment unfavourably where there are substantial amounts of lecture content coming from a remote site. It would appear that this is based partly on expectations in that main campus students (in a large class) expect the delivery to originate from there. A recent student comment drew our attention to the fact that large main campus lecture theatres are often not equipped to facilitate student participation that can be relayed to the remote campuses. For example in smaller lecture theatres, students may have individual microphones but large lecture theatres may have only four microphone sites for 120 students.

It is of course quite possible to structure a lesson so that there are breaks for discussion at each campus (and perhaps reporting back responses). By the end of each term in first year environmental science we have students making a presentation by ISL. Science lecturers report that the greatest limitation in terms of a well structured ISL lesson is the loss of 'teaching time'. The content has to be reviewed thoroughly in moving from a conventional lecture to ISL.

In general the use of technology has enabled CQU to widen the study options of science students on regional campuses. We have evaluated the different models and refined them progressively. In terms of change models it is probably true that the 'early adoption phase' is coming to an end and that the 'late adopters' are now beginning to use the systems available.

## Conclusion

Central Queensland University science courses are taught across multiple campuses using a variety of modern technology. Evaluation by students and staff has allowed us to optimise our teaching models. Flexible delivery and mixed mode enrolment are making significant changes to the way we teach and the way students learn. Time and space are no longer limitations but there is a need to consider carefully the advantages and disadvantages of the different systems.

## References

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## Appendix 1. Sample Questionnaire

Y13AEVALLRC1.EKT

**CENTRAL QUEENSLAND UNIVERSITY  
FACULTY OF BUSINESS**

**OFFICIAL DISTANCE EDUCATION UNIT ASSESSMENT SURVEY - LECTURES**

Lecturer: \_\_\_\_\_ Unit Title: \_\_\_\_\_ Unit Code: \_\_\_\_\_

*Please read each of the statements below and indicate which square corresponds most closely to your experiences in this unit.*

1 - STRONGLY AGREE	2 = AGREE	3 = SLIGHTLY AGREE	4 = SLIGHTLY DISAGREE	5 = DISAGREE	6 - STRONGLY DISAGREE
1. The unit requirements contained in the Unit Profile were clearly explained.					
2. The study materials were well planned and structured.					
3. Concepts were clearly explained in the Study Guide.					
4. The Study Guide was useful.					
5. The Study Guide stimulated my interest in this unit.					
6. The Resource Material book/s helped me to further understand the basic concepts in this unit.					
7. I was encouraged by the study materials to produce high quality work.					
8. I believe the lecturer would have welcomed me seeking advice, if needed.					
9. I felt that the lecturer showed concern and regard for any difficulties that I faced with learning of the unit.					
10. I was able to establish contact with the lecturer within a reasonable period, if needed.					
11. Whenever contacted, I found the lecturer to be positive and helpful.					
12. I believe I received adequate information and good administrative support.					
13. The feedback I received on my assignment assisted me in understanding the unit.					
14. I feel that, to date, I have been assessed fairly in this unit.					
15. Assignments submitted by due date had an acceptable turnaround time.					
16. Overall, I was very satisfied with this unit.					
17. This unit has contributed to my professional development.					
18. The study material components (tele/video conference, workbook, computer disks, audio tapes) was/were well integrated and useful.					
19. This questionnaire has given me reasonable opportunity to express my point of view.					
20. The suggested schedule for each module was: <input type="checkbox"/> overestimated <input type="checkbox"/> adequate <input type="checkbox"/> underestimated					

PLEASE TURN PAGE OVER  
FOR COMMENTS AND RECOMMENDATIONS

## Appendix 2. Sample Questionnaire

**82249 – Invertebrate Zoology**

**FEEDBACK FORM**


1. We are interested in your comments and suggestions. Please take a few minutes to answer the following questions. The results of this evaluation will be used to improve future offerings of this course (unit).
2. Did this course (unit) meet your expectations in the following areas:

	Definitely No				Definitely Yes
• quality of study materials	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• time required to complete assignments	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• feedback on assignments	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• support from tutor(s) and lecturer(s)	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• knowledge gained from course (unit)	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• enjoyment of course (unit)	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• difficulty of unit	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• time required to complete the course (unit)	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• suitability of the textbook	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• usefulness of non-print materials	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
• overall satisfaction with course (unit)	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5



## Appendix 3. Sample questionnaire

82928 Aquatic Physiology

Course.....

**Introduction**

The unit 82928 was offered for the first time in 1999. The target audience was primarily BTech and BEnvSc students in the second and third year of their course.  
The purpose of this questionnaire is to provide feedback for the progressive improvement of this unit.

**Responses**

Please respond to each statement on the scale provided where 1= strongly disagree, 2=disagree, 3=neutral, 4= agree, 5= strongly agree.

	S/Disagree			S/Agree	
1. The unit profile accurately described the requirements of the unit.	1	2	3	4	5
2. The content/curriculum of the unit was appropriate.	1	2	3	4	5
3. The study notes provided for the unit by the lecturers were useful.	1	2	3	4	5
4. The practicals were relevant.	1	2	3	4	5
5. The amount of work expected in the unit was appropriate.	1	2	3	4	5
6. The assignment (essay on topic of choice) was a useful exercise.	1	2	3	4	5
7. The practical write-ups were appropriate	1	2	3	4	5
8. This unit has extended my understanding of aquatic animals.	1	2	3	4	5
9. The unit was too theoretical.	1	2	3	4	5
10. The unit required more tutorials (needs to be 2L+1T/week).	1	2	3	4	5
11. The prerequisite (82249/82925) adequately prepared me for this unit	1	2	3	4	5
12. There was adequate emphasis on ecological topics.	1	2	3	4	5
13. The unit content was too similar to other units.	1	2	3	4	5
14. The lectures/lecturers were well organised.	1	2	3	4	5
15. The lecturers were adequately prepared.	1	2	3	4	5
16. The unit presumed too much biochemistry knowledge.	1	2	3	4	5
17. The unit requires a textbook in future years.	1	2	3	4	5
18. I would prefer more readings from scientific papers.	1	2	3	4	5
19. I would prefer fewer lectures.	1	2	3	4	5
20. The unit fitted in with the overall aims of my course.	1	2	3	4	5

## Appendix 4. Sample Questionnaire

**School of Biological and Environmental Sciences****STUDENT EVALUATION OF TEACHING**

This questionnaire seeks information about your experience as a student taught by video assisted learning "VAL" in the unit Human Functioning 1 at Bundaberg in 1998

Please answer each question by circling the number or choice that most closely corresponds to your view. If you feel you cannot answer a particular question, please circle the "NA" category.

**DO NOT WRITE YOUR NAME ON THE QUESTIONNAIRE**

Unit: **Human Functioning 1**

VAL lecturer: **Dr Steve McKillup**

*Question 1 asks for your overall evaluation of McKillup's effectiveness as a VAL teacher, regardless of your views about personality or the content of the unit*

**1. All things considered, how would you rate this person as a VAL lecturer?**

(outstanding) 7    **6**    5    (average) 4    3    2    (very poor) 1    NA

*Now, please evaluate the following characteristics of the VAL lectures in this unit.*

**2. Organisation of teaching.**

(outstanding) 7    **6**    5    (average) 4    3    2    (very poor) 1    NA

**3. Quality of the video production (e.g. sound and picture).**

(outstanding) 7    6    **5**    (average) 4    3    2    (very poor) 1    NA

**4. Would you prefer to be taught by VAL or have live lectures in Human Functioning 1? (Please circle the appropriate choice).**

**VAL**

**live lectures**

**no preference**

**Why? Please comment in the box below.**



## Appendix 5. Diversity of Regional Campus Delivery Modes

Course	Distance Education Material	VAL	ISL	Other	Team Teach *
First Year Biology	Y		Y		
First Year Chemistry	Y	Y	Y		Y
Environmental Science	Y		Y		
First Year Physics	Y		Y		Y
Fundamentals of Computer Technology				WWW	
Human Functioning I	LN	Y			
Human Functioning II	LN	Y			
Human Functioning III	LN	Y			
Intro Science (Health Science)	LN	Y			
Concepts of Science (Education)	LN	Y			
Introduction to Biomedical Science		Y	Y	CD	
Human Anatomy				CD	
Introbiol/Introchem (bridging)	Y				

\* Indicates at least some delivery from regional campus

## Why am I evaluating this thingummygig?

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### Introduction

Why do I need to evaluate the new technologies? In my undergraduate days I doubt if anyone evaluated their teaching and my learning was in spite of their teaching! The long slow haul to change the teaching and learning culture has put excessive pressure on some forms of learning experiences and new technologies is one of them. This makes sense when you consider the amount of money we have been investing in developing computer based learning materials. Ever since we, in First Year Biology, started to develop teaching and learning materials using information technologies we have endeavoured to understand how these materials are being used and what, if anything, do the students gain from using such materials. Early on we did a lot of usability studies and checks on accuracy of content (formative evaluations) and so improved the materials. We also developed expertise in instructional design. With this in place we concentrated more on the impact of the materials on student perceptions (Did they like using them? Did they help them in their understanding?) Whilst this is also a type of formative evaluation it gave us some ideas on how students were using the materials. The big issue, however, is 'Do the materials have an effect on student learning outcomes?' such that one would argue they are better than other forms of learning material? This is difficult to answer without fairly exhaustive studies on the use of the computer based learning materials by students. By the time the formative evaluation stage is over, there is often little time available to ask these questions; we are too busy; there are too many students to cope with; etc.

In a recent CUTSD-funded study, Shirley Alexander reviewed 104 teaching development projects and reported that in approximately 90% of cases the project leaders indicated that they had the intention of improving student learning outcomes, but only a third could report this as an actual outcome as only this third actually evaluated student learning outcomes (Alexander, 1999; Alexander and McKenzie, 1998). Alexander goes on to argue that most of the project evaluations fell within the first level of the four levels of outcome on which evaluation evidence should focus, as described by Kirkpatrick (1994), that is, 'reaction to the innovation' and a minority of evaluations fell within the second level 'achievement of learning objectives'. Only one project fitted the third level 'transfer of new skills to the job or task' and no project evaluated the 'impact on the organisation', (Alexander, 1999). It would seem that we all need to lift our performance in this area and ensure that at least levels one and two are fulfilled.

### Categories of evaluation

Much has been written on the methodology of evaluation and on evaluation studies themselves, (more recent examples include Flagg, 1990; Kulik and Kulik, 1991; Reeves, 1991; Laurillard, 1993; Draper et al., 1994; Learning Technology Dissemination Initiative (LTDI), 1998). For future evaluation studies I propose using a modification of a model from the Learning Technology Dissemination Initiative (1998), funded by the Scottish Higher Education Funding Council, in which four phases of evaluation are considered (Table 1). These are formative, summative, illuminative and integrative.



<b>Evaluation</b>	<b>Outcome</b>	<b>Methods</b>
Formative	Helps to improve design; to identify problems before the final release of the material	Surveys; bug reports; observations; focus groups
Summative	Helps user choose material to use	Review by external peers; as done by UniServe Science
Illuminative	Uncovers important factors that show up during use; sometimes called surprise detection	Investigator (not developer) watches students and teachers using materials to identify how they think and feel about it
Integrative	Helps to make the best use of the material	Careful planning for integration within the curriculum; requires support for users

Table 1. Evaluation classification

In this model summative evaluation is used for external product review, the equivalent of a book review and this is done after the courseware has been finalised. A schematic plan of the relationship of these phases is presented below.

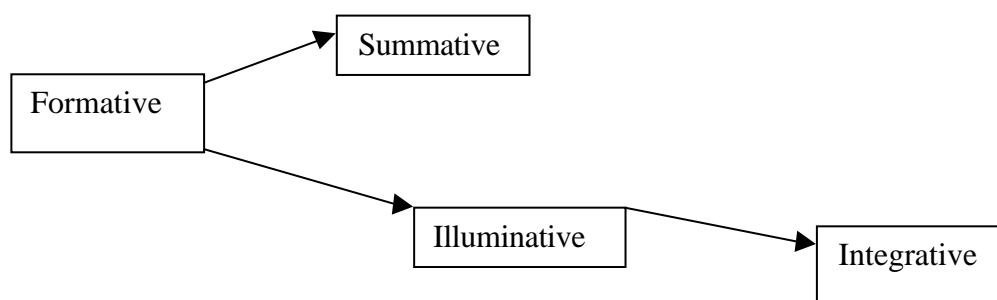


Figure 1. A schematic plan of the relationship of these phases

I believe this model helps to set up a workable methodology for validating expectations of any courseware and how it fits into the overall course or part of a course (integrative evaluation) and in revealing important factors which we have no preconceived ideas about (illuminative evaluation). Illuminative evaluation uses anecdotal reports, observations, interviews and open-ended questionnaires. Integrative evaluation requires analysis of all course materials and their assessment, along with investigating how students use all materials.

## Current project

Currently, in First Year Biology, we have an evaluation project to look at the way computer based learning modules have been integrated into a human biology course, which is taken by 800 first year students in second semester. This evaluation is part of an ASCILITE-CUTSD project 'Staff Development in Evaluation of Technology-Based Teaching Development Projects'. The project uses an action inquiry and mentoring approach in which participants will be helped by their mentor to set up appropriate evaluation. The human biology course consists of lectures, laboratory sessions, and independent study modules. The software modules used in this course, 'Nervous System', 'Reproductive System', 'Digestive System', 'Cardiovascular System', and 'Structure and Function of the Ear', have been developed over a number of years. The materials have been produced to replace animal cadavers in university undergraduate classes in line with the current climate on these issues. One of the modules was funded by the New Educational Aids in Medicine and Science (NEAMS) Trust which funds one project each year in Australia for the development of teaching materials to replace animal cadavers. Each module is written as an interactive exploration of the content and with

a quiz section for students to self-test their understanding of the content and concepts. All of the modules, along with other teaching materials, are available on the Web in the First Year Biology Virtual Learning Environment. (<http://fybio.bio.usyd.edu.au/vle/L1/ResourceCentre/>). Students can thus have access to the materials during the formal teaching time and at any other time they choose.

Formative evaluation of the software modules has already been done including external peer review. The module 'Structure and Function of the Ear' was a finalist in the ASCILITE 1998 Awards. The current project will concentrate on trying to answer the question 'Is the inclusion of software modules within the curriculum an effective way to teach human biology?'. Evaluation will involve looking at the overall curriculum, its content and assessment, finding out how the students are using the materials, identifying if the intended learning outcomes are met, and identifying if the innovation is educationally appropriate in the unit. These are summarised in Table 2.

Item	Outcome	Process
Curriculum analysis	Breakdown of components within the unit	Qualitative and quantitative description of components
Assessment analysis	Breakdown of assessment linked to components	Qualitative and quantitative description of assessment components
Courseware's influence on learning process	Understanding of how students use the materials to learn; and what they learn	Teach-back methods; reflective journals; interviews
Intended learning outcomes	Correlate teachers' expectations of learning outcomes with students expectation of learning outcomes	Use curriculum and assessment analyses for teachers' expectations and confidence ratings; concept maps and assessments for students
Educational appropriateness of courseware in its immediate context	External peer review of the inclusion of the courseware into the curriculum	Set up evaluation forms for external peer reviewer; provide evidence of the four items above

Table 2. Evaluation process

The information gained from the process outlined in Table 2 will be used to answer the question 'Is the inclusion of software modules within the curriculum an effective way to teach human biology?' More importantly, 'Do the materials have an effect on student learning outcomes?'

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