AN EVALUATION OF STUDENT LEARNING IN A WEB-SUPPORTED UNIT ON PLANT DIVERSITY

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Abstract

This paper reports on a study of the effectiveness of a basic botany unit, which has been enhanced by online support materials. A WebCT site was developed to provide digital access to materials studied in practical sessions. Whereas previously, students only saw practical material once, now they have access to high quality, colour images, to study at their leisure.

The online materials were evaluated in the context of the unit of study. The nature of the unit encouraged students to adopt a surface learning approach, but the evaluation process encouraged teaching staff to explore alternative teaching strategies. Students found the online materials very useful, and some students used them for deep approaches to learning. However, the majority of use of the online materials was for 'cramming' prior to examinations. The use of the online materials, in this case, reinforced the surface-learning nature of the unit.

Keywords

Evaluation of Learning, Computer-facilitated Learning, Biology Education

Introduction

Many innovations in the use of Computer-facilitated Learning (CFL) – this term is used because it places emphasis on learning, not on technology – in education have been accepted uncritically, with little effort put into identifying their impact on student learning. For example, Alexander and McKenzie (1998) found that evaluation of learning outcomes was poorly treated in the majority of the 104 Australian CFL projects investigated. A subsequent, Australian government-funded project (Phillips, 2002) provided staff development in the evaluation of CFL projects, supported by an evaluation handbook (Phillips, 2000). The study reported here has been derived from these developments.

Context

This paper reports a selection of results from a larger study, seeking to answer the overarching question: "What is the cost and educational effectiveness of the online material in N265, Plant Diversity?" Plant Diversity is a required, second-year unit of the B. Sc. (Biology) and B. Sc. (Marine Science) majors at Murdoch University in Perth, Western Australia.

The unit gives a broad overview of the diversity of the plant kingdom, from the most primitive plants to the most fully-evolved. Students need to learn and remember a large amount of factual information about plants, but the lecturers also expect students to have an understanding of the various plant groups and their evolution.

Plant Diversity is taught using the traditional lecture/laboratory approach. It consists of four 45 minute lectures and a 4 hour practical session each week over 13 weeks. Several academic staff contribute to the delivery of the unit: four staff present lectures on different topics, and a fifth staff member coordinates the laboratory component.

In 1999, a decision was made to introduce a practical exam, focusing specifically on material covered in practical classes. The introduction of the practical exam led to an impetus for students to revise practical material, and this led to a decision to digitise all the practical materials and provide them online.

Teaching and Learning at University

The Plant Diversity unit has been taught at Murdoch for many years. While it has evolved over time, the influence of the scholarship of teaching and learning has been patchy, at best, deriving from common, implicit understandings by various lecturing staff about what constitutes a unit of study, in the traditional lecture/ practical mode.

The nature of the unit can best be conceptualised as a subset of Laurillard's (1993, p103) ideal teaching learning model. Laurillard posits that one aspect of learning is conceptual, arising from "Discussion between teacher and student". In N265, the 'discussion' is largely a one-way transmission of conceptual knowledge from the teacher to the student through lecturing.

The second aspect of Laurillard's model is experiential, arising from "Interaction between the teacher's constructed world and the student's experiential world", implemented through participation in laboratory classes. A third aspect concerns efforts by students to integrate theoretical and practical knowledge by a process of reflection and adaptation of understandings. This leads to a consideration of the way in which students actually learn, and one way of characterising this is through surface and deep approaches to learning.

The tertiary learning literature strongly supports the view that deep learning is better than surface learning (Ramsden, 1988; Gibbs, 1992; Biggs, 1999). "Good teaching implies engaging students in ways that are appropriate to the deployment of deep approaches" (Ramsden, 1992, p61).

Students choose either surface or deep approaches depending on the circumstances, and one of the determinants of the approach taken is the nature of the academic task (Ramsden, 1992, pp48-49). That is, if a unit is designed to elicit a surface learning strategy, then students will use this strategy.

While many academics may set out to develop understanding and critical thinking in students, Ramsden (1992, p72) contends that "it is in our assessment practices and the amount of content we cover that we demonstrate to undergraduate students what competence in a subject really means".

The Online Materials

The decision to provide online access to laboratory specimens met two of the key criteria for a successful CFL innovation identified by Alexander & McKenzie (1998), in that the innovation was designed to address a specific area of student need and improve the student learning experience.

The technology used was not particularly sophisticated. The WebCT Learning Management System was used to make the print-based practical manual available to students online. However, after each laboratory session, value was added to the print materials by replacing the appropriate page with a new one containing digital images of the specimens studied in that practical. The feedback from the practical sessions also provided answers to questions and exercises posed in the laboratories.

Whereas previously, students only saw practical material once (apart from some black and white diagrams), now they have access to high quality, colour images, to study at their leisure. They also have access to small, digital videos of algae, so that they can observe their movement.
The online materials were designed:

- to provide **flexibility of access** for students who could not attend practical sessions because of work or other commitments;
- for students to **check their work** by providing an accurate source of information so that students can reassure themselves that they had observed the correct botanical structure;
- for **ongoing study** by enabling students to revisit specimens previously only seen once;

- to provide **access** to plants which flower at inappropriate times of the year;
- for **revision** for the practical examination.

Evaluation Plan

A detailed evaluation plan was developed to guide this study. The design of the evaluation plan was informed by the Eclectic-Mixed Methods-Pragmatic evaluation paradigm (Reeves, 1997), where the focus is on choosing the most appropriate evaluation tools for the problem at hand, using both qualitative and quantitative sources of data. The development of the evaluation plan was scaffolded by the Learning-centred Evaluation (LCE) Framework described in Phillips (2000, Section 2).

The LCE framework enabled the development of specific, answerable evaluation questions, expressed as an evaluation matrix in Table 1, together with their relevant focus in the LCE framework.

Focus	**Question**	Assess-ment	Docum-entation	Staff Interview	Observ-ation	Student Survey	WebCT Data
Curriculum analysis	What assessment is used, and what does it measure?		*	*			
Learning environment	What are the shortcomings of the unit, and how could it be improved?			*	*	*	
	How useful is the online environment, and how could it be improved?			*	*	*	*
Learning process	How do students use the online environment in order to learn?			*	*	*	*
Learning outcome	How well were learning outcomes achieved?	*		*			

Table 1. Evaluation matrix, including summary of data sources.

Data Sources

Table 1 also lists the most appropriate sources of data to provide evidence to answer each specific evaluation question. Six data production methods were used: analysis of final assessment results, analysis of documentation associated with the unit, staff interviews, observation of students in laboratory classes, a student survey and analysis of WebCT student tracking data.

These data sources combine a mixture of quantitative and qualitative data production methods, enabling the internal consistency of the data to be checked, through triangulation (Patton, 1990, p.187). Qualitative data was transcribed and entered into the NUD*IST program. An analysis tree was constructed based on the evaluation matrix, and the data was then coded and reduced.

The student survey was constructed and refined through peer review. It contained a mixture of closed- and open-ended questions and was delivered online through the WebCT survey tool. It was intended that all students respond to the survey, and students were reminded to do this by the observer during practical classes. There were 47 responses to the survey.

Participants in the study were the 163 students enrolled in N265, Plant Diversity, in semester 1, 2001, and seven teaching staff from the School of Biological Sciences, including one author (van Keulen). The other two authors designed and carried out the evaluation.

Evaluation Results

An earlier paper (Phillips, Baudains, & van Keulen, 2002) reports further on the underlying nature and design of the learning environment.

Assessment

While the unit assessment has been developed and altered over time, the current situation is summarised in Table 2. The assessment associated with the practical component has been significantly reduced over time, for budgetary reasons. Previously, all practical work was marked, rather than just three times, and this reduction in feedback to students was of concern to staff.

“It definitely harms the students’ learning ‘cause if they get it wrong then, they have got no check, and then we give them a prac exam at the end.”

Assessment	Weight	Additional information
Practical Work	15%	To provide feedback on practical skills – 3 lab reports are assessed.
Library Exercise	15%	To assess library skills in locating and referencing resources.
Practical Exam	30%	Closed book exam.
Theory Exam	40%	Closed book exam.

Table 2. Plant Diversity assessment scheme

The practical exam questions in N265 in 2001 focussed almost entirely on surface learning. All questions asked students to name or label specimens and describe their functions. Only one part of one question required students to compare specimens in terms of their ‘primitiveness’. The theory exam questions also largely assessed the students’ ability to recall, although some question options asked students to discuss and compare.

The Learning Environment

In the context of this study, the learning environment comprises the unit itself, and the use of WebCT within the unit. The nature of the unit will be discussed first.

The Unit of Study

Both students and staff felt that there was too much content in the unit.

> “… I’m not sure that students need to know everything that we teach in the course. This is heresy isn’t it! … I think it’s much better that students should come away with having their interest stimulated, and if we can do that with selected material then it is better to do that than not stimulate students interest.”(Staff comment)
>
> “Maybe content is more in depth than it needs to be. I feel like what you take out of here at the end of the day is not relevant in the field.” (Student comment)
>
> Staff were cognisant of the tension in the unit between surface and deep approaches to learning, discussed in the Introduction:
>
> “ there is a lot of new terminology and every day has got different one … it's the nature of the beast - I think we try to minimize it but you cant totally. There must be a way to improve teaching what is partially a Greek telephone directory - because the difficulty is always the students can’t see the forest for the trees. You need to know the terminology, but you also want to see where that leads you.” (Staff comment)

Potential Improvements to N265

Both staff and students identified a range of ways in which N265 could be improved. However, most feedback was positive in nature. Students liked the ‘atmosphere’ of the unit and generally appreciated the staff. Teaching staff recognised the need to motivate students. They felt that the content was potentially boring both for themselves and students, and they needed to make the material interesting by being entertaining, by providing examples, by linking to practical material and by encouraging higher-order understanding of evolutionary processes.

Students requested more field work and more video materials. One student felt that the unit needed to be made more relevant:

> "Just make it a bit more interesting! ie how the plants are relevant to our environment, the interaction of plants with [their] surroundings, but that's probably another unit all together."

Most staff made suggestions about how the unit might be improved, although some suggestions were more radical than others. Three staff, separately, suggested a thorough re-engineering of the unit, changing it from the traditional, teacher-centred mode to a student-centred, or problem-based approach. This involved reducing the number and nature of lectures, and giving students activities to do in the rest of their study time:

> "You might for instance say in a unit like plant diversity – I'm really free wheeling now and perhaps some of the staff would be shocked to hear me say it - but maybe you give one lecture a week instead of four, and the one lecture that you give focuses on overarching concepts and how things fit together, and then there are alternative activities that students follow through to get the detail. So you basically create the skeleton off which they hang the flesh!"

In addition to focussing on broad concepts in lectures, a further suggestion was to develop a continuous theme about adaptation and evolution throughout the duration of the unit, and that this should be backed up by online material.

Usefulness of the Online Environment

Student perceptions about the usefulness of the online environment have been reported in Phillips & Baudains (2002). Almost unanimously, student survey respondents felt that the WebCT course was useful to their study. They felt that it added another perspective to their learning. The ability to revise material not fully-understood in the practical session was valuable to a number of students, as was the ability catch up on material not observed in the laboratory. The self-paced nature of the online materials gave some students time to build up their understanding. However, while some students observed in laboratories concurred with the above survey responses, others saw WebCT use as a tool to assist surface learning strategies (see below).

The Learning Process

A wide range of learning strategies were employed by the students. Some students were highly prepared and confident with the material, while others seemed to struggle with the basic concepts. Students tended to use WebCT as designed, to complete and check their laboratory work and for revision. However, two aspects of revision were apparent. One type of revision is closely related to checking laboratory work, involving students working through material in the days immediately following the laboratory classes. Such behaviour shares similarities with the reflection and adaptation aspects of Laurillard's model, and a deep approach to learning. On the other hand, many students used the online materials for surface learning, 'cramming' in the days before the exam. Some students used a mixture of both strategies. These two strategies will be discussed further in the following sub-sections.

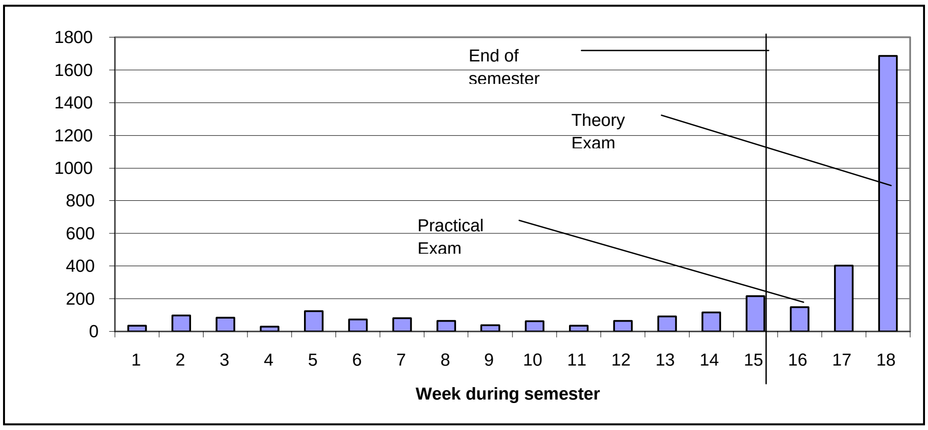

Figure 1. Distribution of hits on WebCT content pages in each week of the semester.

Completing Laboratories and Ongoing Study
The self-paced nature of the online materials gave some students time to build up their understanding. They used WebCT to finish parts of the laboratories which they didn't have time to complete in class:

> "Definitely, because it gives me the time to sit there and absorb a lot more than I would in the lab."

> "It reinforces what I have seen in the lab and makes me more confident in my conclusions."

A number of students recognised the usefulness of the WebCT materials, both in terms of reinforcing what they had just done in the laboratory, and to check that what they had done was correct. Another student felt that the online materials explained content not fully covered in lectures.

It seems clear that these students are conscientious about their study. Because the anonymous survey responses could not be matched against final grades, it was impossible to determine which of these students were high-achievers. Nevertheless, some students appeared to be having difficulty in coping with the volume of laboratory work in the time available, and the WebCT resources enabled them to cover material which could not have been covered in any other way.

Surface Learning
Earlier in this paper, staff identified a tension between deep and surface learning in this unit. Despite the evidence of deep learning presented directly above, this was not the case for all students. Survey responses and observations indicated that some students were indeed intending to use cramming and other rote-learning strategies:

> "The answers for the lab are available online so therefore help me to prepare for the theory exam."

Staff were ambivalent about the approaches that students would take to learning:

> "for some students it would lead to shallower learning, because they wont take the practical classes seriously, making that a superficial experience, and then they will simply use the web based material, and its not a full substitute. … For other students I would imagine it would be a greatly enriching learning experience, … So I can see both of those possibilities arising, depending on the motivation and attitude of the student"

WebCT Usage Logs
Another approach to investigating students' study approaches is by analysing WebCT usage logs. The WebCT system records the date and time at which each page of content is accessed (or 'hit'). Overall, during the semester, students accessed WebCT content pages 3458 times. Only one student did not use WebCT at all, and 12 students did not access any content materials in WebCT. The remaining 140 students used WebCT content pages an average of 27 times each.

Figure 1 displays the distribution of content page hits for each student during each week of the semester. At Murdoch University, the 13 week teaching semester includes two weeks without class contact. There is then a further study week and two weeks of exams. The end of formal teaching is indicated on Fig. 1, as are the times of both the practical and theory exams. A striking feature of Fig. 1 is the number of hits during the theory exam week. It is clear that a high degree of cramming behaviour took place in the two weeks prior to the theory exam. It should be remembered that the WebCT materials were developed specifically to support the practical work and the practical exam. While there were approximately 350 hits in the two weeks leading up to this exam (weeks 15 & 16), these are significantly less than the hits received in weeks 17 and 18.

Despite the intentions of the designers of the online materials, students chose to use them to study for the theory exam.

Closer analysis of Fig. 1 indicates that there was significant ongoing use of WebCT during the teaching part of the semester. Between 31 and 217 pages were hit each week, with an average of over 81. Given that there is only one relevant page of content for each laboratory session, this usage is significant. An average of over 27 students accessed WebCT in any one week of the teaching part of the semester.

Observation of the data indicated that there was a great range of patterns of WebCT use, and an attempt was made to quantify the nature of this usage through a Cramming Ratio and a Hit Frequency measure. Representative data for three students is shown in Table 3.

The Cramming Ratio is the ratio of the number of content page hits during the study period to the total number of content page hits during the whole semester. Students who used WebCT only during the study break are characterised as ‘Crammers’, and would have a Cramming Ratio of 1. Students who used WebCT only during semester, ‘Revisers’, would have a Cramming Ratio of 0. While these students did not use WebCT during the study break, there is no evidence to suggest that they did not also cram for the exam, using other resources, such as lecture notes and textbooks. They may also have printed these web pages. However, they *did* use the WebCT resources during the semester to revisit laboratory materials.

Type of Student	**Content hits during study break**	**Total content hits**	**Cramming ratio[a]**	**Hit frequency[b]**
Reviser	3	20	0.15	11
Crammer	46	46	1.0	2
Mixed reviser/ crammer	21	44	0.48	9

[a] ratio of the number of content hits during the study period to the total number of content hits.

[b] number of weeks in which a student accessed at least one content page.

Table 3. Examples of WebCT usage pattern measures for three representative students..

A weakness of the Cramming Ratio is that it is not sensitive to the number of pages hit during the semester. For example, some students recorded a Cramming Ratio of 0, but accessed WebCT rarely. A second weakness is that a low Cramming Ratio does not necessarily indicate that a student is a ‘Reviser’, because that student could have made all their hits in a single week.

These considerations led to the Hit Frequency measure, the number of weeks in which a student accessed at least one content page. Both students who used WebCT infrequently, and Crammers, will have low hit frequencies. Revisers, on the other hand, will have high hit frequencies.

Learning Outcomes

In analysing student learning outcomes, it was helpful to consider the performance of students in both the B. Sc. (Biology) and B. Sc. (Marine Science) majors. In the following discussion , these are referred to as ‘main-stream’ and ‘marine-stream’ students, respectively. The grade distribution for N265 students in 2001 is shown in Figure 2, for both the main- and marine-streams. It is visually apparent that marine-

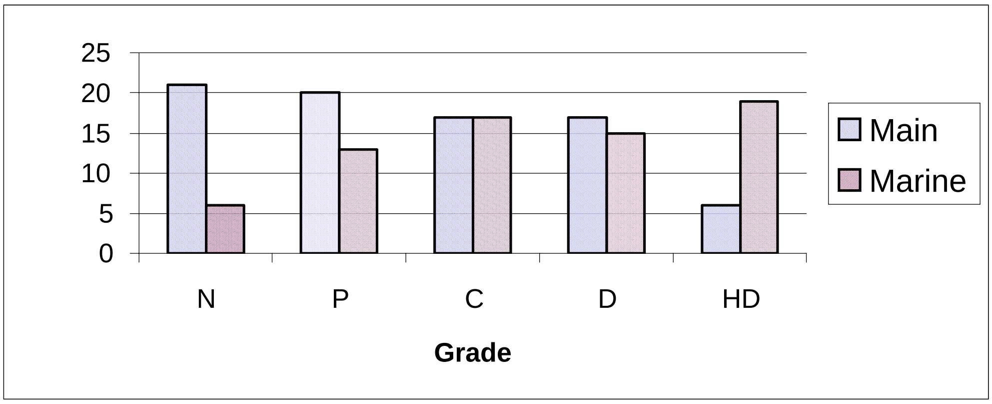

Figure 2. Distribution of final grades for the main- and marine-streams of N265 in 2001.

stream students performed better in the assessment than main-stream students. The difference is also statistically significant at the P<0.01 level, with marine-stream students averaging 70.0 compared to 61.0 for the main-stream students (see Table 4).

When the data was analysed for each of the four types of assessment in N265, it was apparent that the grade distribution was very similar for both streams for the Library assignment and for Laboratory performance. However, marine-stream students performed significantly better in both of the exams. There are several possible explanations why marine-stream students might have performed better in the examinations:

- they may have better natural talent as students, or may have better ability to perform well in largely recall-based examinations;
- they may have higher motivation to succeed;
- they may have used the online resources more heavily or differently (some additional online resources are also available to marine-stream students).

An attempt has been made, in Table 4, to compare the performance of the main- and marine-stream students in relation to a number of relevant factors. The course Grade Point Average (GPA) provides a mechanism to compare the native talent of students across their whole university study to date. While the GPA of marine-stream students is higher than that of main-stream students, the difference is not statistically significant.

Anecdotal evidence indicates that marine-stream students have a higher motivation to study, but, motivation is difficult to quantify. However, the extent of usage of online resources may provide a measure of motivation. The final three rows of Table 4 show the three measures of online usage developed in the previous section for both streams. Students with high motivation might be expected to show Reviser characteristics, and have a high Hit Frequency. However, Table 4 indicates that there is no significant difference between the Hit Frequencies of the two streams. On the other hand, the marine-stream students made significantly more Content Hits on the WebCT site than main-stream students. In addition, their cramming ratio was significantly higher than the main-stream students. This indicates that the marine-stream students made their extra hits largely during the study period.

	Main	**Marine**
Final score	61.0	70.0[a]
Course GPA	2.06	2.26
Content hits	20.3	27.2[b]
Cramming ratio	0.56	0.69[a]
Hit frequency	4.6	4.4

[a] P < 0.01 [b] P< 0.05

Table 4. Performance indicators for the main- and marine-stream students.

It can, therefore, be relatively confidently predicted, that the marine-stream students performed better in the examinations because they exhibited stronger cramming behaviour. Some of this cramming behaviour is apparent through the WebCT usage statistics, but it is anticipated that other, non-measurable forms of cramming would have taken place as well.

The high number of hits on WebCT content pages during the study period, shown in Fig. 1, indicates that not only marine-stream students exhibited cramming behaviour. To explore this hypothesis, the cramming ratio defined in Table 3 was reduced to a dichotomous variable. If a student had a Cramming Ratio of >0.5, they were characterised as a Crammer, while other values indicated a Non-crammer. It is clear that Crammers performed significantly better in each examination.

	Crammer [a]	**Non-crammer**
Theory exam	65.2% [b]	57.6%
Practical exam	61.0% [b]	54.5%

[a] A Crammer is defined as a student having a Cramming Ratio >.5

[b] P< 0.05

Table 5. Relationship between exam performance and cramming behaviour for all students.

Discussion

The results reported in this paper provide an insight into the conduct of a tertiary Biology unit and the use of online technology to improve student learning.

Unit-specific Issues

The nature and structure of N265 encouraged students to adopt a surface approach to learning. It is apparent from the data that the unit has relatively high class contact hours, and an excessive amount of course material, both of which are identified by Gibbs (1992) as leading to a surface approach to learning. In addition, the emphasis in both examinations on rote learning is likely to lead to students taking a surface approach to learning (Ramsden, 1992, p72), despite the intention of the unit coordinators to foster a deeper understanding in students.

However, Gibbs (1992, p11) cites Biggs' (1989) work, describing how appropriate course design, teaching methods and assessment can foster a deep approach through: motivating students; enabling students to become active learners; providing ways for students to interact with each other; and providing a well-structured knowledge base. Gibbs also concludes that "it is clearly possible to have significant impacts on the quality of student learning through changes in course design and teaching and learning methods" (Gibbs, 1992, p164).

Independently of this research evidence, academic staff associated with the unit have expressed a willingness to thoroughly restructure the curriculum and lecture format in Plant Diversity, to make it more student-centred. However, perhaps because of the number of relatively senior staff involved in the unit, it is not clear who should take the leadership in this redesign, particularly since university staff are so overworked in an era of reduced funding.

Online Technology Issues

Almost unanimously, student survey respondents felt that the WebCT materials were useful to their study. They functioned largely as designed, providing students flexible access to practical material, and compensating for the phasing-out of valuable learning activities caused by budget cuts. Some students used the online materials to check their laboratory work and to work through material in the days immediately following the laboratory classes. It was evident that some students exhibited a deep approach to learning.

The majority of use of the online materials was for 'cramming' prior to exams. Although the WebCT pages were designed primarily for revision prior to the practical exam, and were used for this, the usage data indicates that the online materials were used, unexpectedly, to a larger extent for the theory exam.

Students enrolled in the Marine Science stream performed significantly better than other students in exams. A conclusion was drawn that this was because Marine Science students were more motivated to use surface learning strategies. In fact, students who used surface learning strategies, as evidenced by their WebCT usage, scored significantly better in both exams.

In summary, the implicit nature of the unit favours surface learning, and students used the online materials to achieve what was expected of them – to recall botanical detail. If it is the intention of the unit coordinators to foster a deeper level of understanding among their students, then the unit structure will need to be changed, as foreshadowed earlier. With this restructure, the online materials would still remain a valuable resource, to be used in different, student-centred ways.

This study also highlights the efficacy of evaluating learning technology in the context in which it is used, rather than in isolation. If this study had concerned itself only with the online practical materials, many of the major issues would not have emerged.

University units tend to have a great deal of inertia, and are difficult to change, perhaps because of the many stakeholders and interrelationships with other units. However, this study found a strong degree of agreement about the shortcomings of the unit and some consensus about the direction in which to move. Time will tell if this opportunity is utilised.

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