Learning Botany: Evaluation of a Web-Supported Unit on Plant Diversity

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Executive Summary

This document reports on a study of the effectiveness of a basic botany unit (N265 Plant Diversity), 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 results reported in this report 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 study examined the nature and structure of Plant Diversity. Some valid, but relatively unimportant findings were:

- A close relationship was found between theory and practice in the unit.
- Although overall unit objectives were not explicitly stated, these were, somehow, understood by students.
- Some laboratory sessions were found to be too long, while others were too short.
- A tension existed between the terrestrial and marine streams. This has been addressed in 2002 by offering two separate units with some common lectures.

However, a further finding is fundamental to the success of the unit. The structure of N265 encouraged students to adopt a surface approach to learning. There is too much content, relatively high class contact hours, and students and staff find the material uninteresting. The emphasis in both examinations on rote learning is also likely to lead to students taking a surface approach to learning, despite the intention of the unit coordinators to foster a deeper understanding in students.

However, research indicates that 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. The factors can have a significant impact on the quality of student learning.

Independently of this research evidence, academic staff associated with the unit saw an opportunity to comprehensively redesign the unit, by introducing a common theme to the unit, reducing the number and nature of lectures, and giving students activities to do in the rest of their study time. 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.

A range of areas of improvement were identified:

- The introduction of the online materials made it possible to introduce an experimental, or manipulative, component to the practicals.
- WebCT usage was seen as appropriate, but could be expanded and enhanced, by adding self-tests for students, by using existing materials in the lecture component of the unit, and by increasing the use of video resources.
- CFL materials were not used in lectures, because appropriate technology was not consistently available in lecture theatres.

Learning Outcomes

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.

Students clearly prefer studying N261 Animal Diversity to N265, and an analysis of their performance over several years indicates that N261 has significantly higher pass rates and grade point averages. The survey and other data presented here supports the view that student motivation is the major factor in the differences between N261 and N265. If students are not interested in a subject, it is harder for them to motivate themselves to study the topic. They may invest more time in studying an interesting subject, and have lower success rates in the uninteresting subject.

However, since the introduction of online materials in N265 in 1999, N265 grades have trended towards those in N261. This has been caused by an increase in the number of high distinctions in N265.

Cost-benefit Analysis

A cost benefit analysis was carried out. The initial setup cost of $5 293 was funded by a grant. Annual, ongoing maintenance cost of supporting the on-line material in N265 are estimated at $1 577. However, the total cost of running the unit was estimated at $46,806. Maintaining the online materials is only 3.4% of the total cost of the unit, and the previous analysis has indicated its benefits. It could be argued that the largely intangible benefits of improved student motivation and performance outweigh the costs of providing the online materials.

Evidence has been presented that the learning environment for students (and staff) could be enhanced by re-engineering the unit to become more student-centred, and less content-oriented. As part of this re-engineering, there is the potential to replace content transmission through lectures with seminar sessions, and to support problem-solving with online resources. In such a case, the online materials would become integral, rather than supplementary, and cost savings can be made by reducing other aspects of the financial equation.

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.

1. Introduction

The work described in this report was funded in 1999, jointly by the Division of Science and Engineering's Teaching and Learning Committee, and the central Teaching Development Fund administered by the Teaching and Learning Centre. The funding was for an integrated project examining the potential of Computer-facilitated Learning (CFL)[1] to replace conventional laboratory teaching in a range of science disciplines.

Many innovations in the use of CFL 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.

1.1 Context

The CFL application evaluated here consists of online enhancements to a second year Biology unit, Plant Diversity, with the unit code N265, 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 unit of the Bachelor of Science (Conservation Biology) and Bachelor of Science (Marine Science) majors at Murdoch University in Perth, Western Australia. Students study both Plant Diversity and a related unit, Animal Diversity. Anecdotal evidence indicates that students find Animal Diversity more motivational, because animals are intrinsically more interesting to most students.

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. These five, and others, act as demonstrators for the practical sessions.

Several years ago, in an effort to explicitly include graduate attributes in the degree course, additional, non-content-specific materials were added to each core unit in the degree. The assessment for Plant Diversity therefore includes an assignment on library skills.

An analysis of the unit by lecturing staff in 1999 revealed that students were not engaging deeply with the practical materials, and a decision was made to introduce a practical exam, focusing specifically on material covered in practical classes. This also enabled the theory exam to become more focussed on broader questions. 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.

1.2 The Online Materials

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

The technology used was not particularly sophisticated. The WebCT learning management system was used to make the printed practical manual available to students. However, after each laboratory session, the relevant page is replaced with a new one containing digital images of the specimens studied in that practical. The feedback from

[1] Many terms and acronyms are used to describe the use of computers in education. In this work, the term CFL is used, because it places emphasis on learning, not on technology. However, other terms, such as Information and Communications Technology (ICT), may be used interchangeably.

the practical sessions also provides answers to questions and exercises posed in the laboratories. The intention was not to replace the practical session, but to enhance it.

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

The evaluation study was carried out *post-hoc*, after the online environment had been designed and implemented. Nevertheless, it was found appropriate to focus on formative, as well as summative, aspects, in order to identify potential improvements to the envronment, in addition to studying its effectiveness.

1.3 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, 1994) ideal teaching learning model, illustrated in Fig. 1, and discussed in Phillips (1997, pp23-26). Laurillard posits that learning consists of a theoretical part (top of Fig. 1), arising from "Discussion between teacher and student"; and an experiential part (bottom of Fig. 1), arising from "Interaction between student and world" where students interact with an environment created by the teacher. An important part of learning occurs when students link the theoretical and experiential parts, by reflecting on their understanding based on their experiences, and adapting their conceptual knowledge accordingly (right side of Fig. 1).

Laurillard argues that teachers should continually reflect on the success of their teaching and adapt their learning activities accordingly, as shown (left side of Fig. 1), and the results of this study may well provide an impetus for this.

In N265, relevant aspects of the model are:
- a largely one-way transmission of conceptual knowledge from the teacher to the student through lecturing;
- an interaction between the teacher's constructed world and the student's experiential world, through participation in laboratory classes;
- efforts by students to integrate theoretical and practical knowledge by a process of reflection and adaptation of understandings.

The first two of these aspects are relatively easy to describe. However, the third aspect is more problematic, requiring knowledge of the way in which students actually learn. It is informative to consider research on the nature of learning at universities, particularly surface and deep approaches to learning.

Ramsden (1992, p46) has summarised the characteristics of surface and deep approaches to learning (see Table 1). The tertiary learning literature strongly supports the view that deep learning is more appropriate than surface learning (Biggs, 1999, Gibbs, 1992, Ramsden, 1988, Ramsden, 1992). "Good teaching implies engaging students in ways that are appropriate to the deployment of deep approaches" (Ramsden, 1992, p61).

Table 1. Surface and Deep Approaches to Learning[a]

1. Surface approach Intention only to complete task requirements. Student distorts structure of task. External emphasis Focus on the 'signs' Focus on unrelated parts of the task Memorise information for assessments Associate facts and concepts unreflectively Fail to distinguish principles from examples Treat the task as an external imposition
2. Deep approach Intention to understand. Student maintains structure of task. Internal emphasis Focus on what is signified Relate previous knowledge to new knowledge Relate knowledge from different courses Relate theoretical ideas to everyday experience Relate and distinguish evidence and argument Organise and structure into a coherent whole

[a] Adapted from Ramsden (1992, p46).

Students choose either a surface or a deep approach 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 or part of a unit is designed to elicit a surface learning strategy, then students will use this strategy. Gibbs (1992, p9) has identified characteristics of a unit which are associated with a surface approach:

- Heavy workload;
- Relatively high class contact hours;
- An excessive amount of course material;
- A lack of opportunity to pursue subjects in depth;
- A lack of choice over subjects and a lack of choice over the method of study;
- A threatening and anxiety-provoking assessment system.

Other relevant factors are:

- 'spoon feeding', particularly in lectures and practical work (Gibbs, 1992, p1)
- assessment which relies heavily on memory (Gibbs, 1992, p1)

While many university units may set out to develop understanding and critical thinking in students, Ramsden 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" (Ramsden, 1992, p72).

However, based on evidence from a series of case studies, Gibbs 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).

2. Evaluation Plan

A comprehensive evaluation plan was developed to guide this study. The overarching research question (What is the cost and educational effectiveness of online material in Plant Diversity?) could be easily broken down into two subordinate questions:

- How does inclusion of CFL affect student learning and understandings in Plant Diversity?
- What is the cost effectiveness of including online material in Plant Diversity?

The online materials are part of the broader learning environment, and it is not possible to evaluate their effectiveness without investigating the effectiveness of the unit as a whole. The evaluation plan, therefore, investigated not just the CFL, but the unit as a whole.

2.1 Evaluation Paradigms

Evaluation of the educational impact of CFL is a complex field: different evaluators employ different paradigms and hence ask different questions when designing their evaluations. Whenever a measurement or observation is made, the situation being evaluated intrinsically alters (Keeves, 1988). This issue is rarely addressed. One must ask the extent to which the outcome of the evaluation was due to the evaluation design selected?

There is an extensive literature about paradigms of inquiry (Guba, 1988; Guba & Lincoln, 1989; Patton, 1990; Salomon, 1991; Shulman, 1988), but Reeves (1997) has summarised the dominant paradigms which are used in evaluation studies:

- The Positivist-Quantitative Paradigm
- The Constructivist-Interpretive-Qualitative Paradigm
- The Critical Theory-Postmodern Paradigm
- The Eclectic-Mixed Methods-Pragmatic Paradigm

The Positivist-Quantitative Paradigm has been used in the majority of articles about evaluation of CFL projects. Surveys of articles in journals and conference proceedings were carried out by Reeves (1993 & 1995) and Alexander & Hedberg (1994). They found that the majority of articles reported the use of experimental approaches, with control and treatment groups and quantitatively measured outcomes. Reeves (1993) and Alexander & Hedberg (1994) identified a range of serious methodological deficiencies in such studies and pointed towards the Constructivist-Interpretive-Qualitative Paradigm (Guba & Lincoln (1989) and Patton (1990) as being appropriate for evaluating the complexity of CFL materials.

Such evaluation is conducted in a naturalistic way (avoiding manipulation of the environment) with data produced largely through qualitative methods (sacrificing wide generalisability for richness and better understanding). While these characteristics can be contrasted to the experimental approach (manipulating the environment) with quantitative data collection (everything is measurable), Reeves (1997) proposes an Eclectic-Mixed Methods-Pragmatic Paradigm, involving a mixed approach to data production and analysis, with both qualitative and quantitative information obtained in the evaluation process. This is the approach taken in this study, although the nature of the evaluation questions has required largely qualitative evidence.

2.2 Learning-centred Evaluation Framework

The development of the evaluation plan for this study was informed by the Learning-centred Evaluation (LCE) Framework described in Phillips (2000, Section 2), and Bain (1999). This framework, derived from earlier work by Alexander & Hedberg (1994), has four main characteristics:

- it presumes that evaluation will occur in each of the major phases of an educational development project (see Table 2);
- it focusses attention on three aspects of learning:
    - the learning environment (*where* people learn, or the CFL innovation);
    - the learning process (*how* people learn)
    - the learning outcome (*what* people learn)
- it encourages evaluators to frame appropriate and answerable evaluation questions;
- it outlines the types of evidence and methods that may be appropriate for each question.

The effectiveness of the LCE Framework in evaluation of CFL innovations has been reported in Phillips (2002), in a report on the outcomes of a national staff development grant funded by the Australian Government, and particularly in Valdrighi, Fardon, & Phillips (2002). In this work, the use of the LCE framework resulted in an evaluation matrix (Table 2) which summarised all the specific questions to be asked, and the (multiple) data sources which could provide evidence to answer the questions.

The first column of Table 2 lists the four phases of an educational development project: design, development, implementation, and institutionalisation. Within each phase, there is a number of foci of evaluative activity (second column of Table 2). The LCE framework acts as a scaffold for the development of specific questions, by breaking down the lifecycle of an educational innovation into phases, and explicitly distinguishing the roles of the learning environment, the learning process and the learning outcome. It is important to note that not all phases nor foci are appropriate for all evaluation studies. The framework acts as a scaffold for the evaluation design, rather than as a prescription.

The third column of Table 2 displays the specific evaluation questions developed by working through the framework. The use of the LCE framework aided us in *focussing* on the types of questions to ask.

The final columns of the evaluation matrix shown in Table 2 outline the sources of data which were appropriate to provide evidence to answer each of the specific evaluation questions. In accordance with the Eclectic-Mixed Methods-Pragmatic Paradigm, both qualitative and quantitative sources of data are used. The data sources will be discussed in more detail in the following section.

2.3 Data Sources

For each question in Table 2, the most appropriate source(s) of data to provide evidence to answer that question were considered. This analysis resulted in six generic data production methods: 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 shown in Table 2. 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, over a number of weeks during the semester.

Table 2. Evaluation Matrix, including summary of data sources

Phase	Focus	Purpose	Assessment	Documentation	Staff Interview	Observation	Survey	WebCT Data
Analysis and Design	Curriculum analysis	- What are the objectives and learning outcomes of the unit?		*	*		*	
		- How closely linked is the unit theory and practical content?		*	*		*	
		- What assessment is used in the unit?		*				
		- What does the assessment measure?		*				
	Teaching-for-learning analysis	- How is the unit taught, what teaching and learning strategies are used? How has the unit evolved over time?			*	*		
	Specification of innovation	- Why were CFL materials introduced? (what were the motivations/reasoning behind introducing CFL?)		*	*			
		- Why did you use WebCT?		*	*			
		- How is WebCT used? (How do we expect that the CFL will impact on understanding of Plant Diversity.)		*	*			
		- What are staff assumptions about Computer Facilitated Learning (CFL) ?			*			
Development	Formative monitoring of learning environment	- What are the shortcomings of the unit? How could the unit be improved?			*	*	*	
		- What improvements can be made to the way WebCT is used?			*			*
		- How do students use WebCT? (include Rates)		*			*	
		- Do lecturers use online material or WebCT in lectures or when planning lectures?			*		*	
	Formative monitoring of learning process	- How does CFL help students access Plant Diversity (in order to learn)?				*		
		- What strategies are students using to learn Plant Diversity?		*	*	*		*
Implementation	Summative evaluation of learning process	- How does CFL help students understand Plant Diversity?				*	*	*
	Summative evaluation of learning outcome	- Did students achieve unit outcomes?	*		*			
		- How well were learning outcomes achieved?	*		*			
		- Which outcomes were achieved well and why?	*		*			
		- What other unexpected learning outcomes occurred?			*			
	Summative evaluation of innovation appropriateness	- Cost benefit analysis		*				
		- Do students still turn up at lectures?			*	*	*	
		- Is lab time used more effectively? Are there fewer individual teacher/student consultations?			*	*	*	
Institutional-isation	Impact evaluation	- Longitudinal comparison of retention rates and grades from animal and plant diversity.		*				

2.3.1 Stakeholders and Participants

This evaluation study has implications for the future use of online learning resources in the field of science education. The primary stakeholders are science students who may find science learning more accessible, and may obtain a better understanding of the material and concepts in the unit.

The unit coordinators and lecturing staff clearly have an interest in the results of this study, as it will influence the way in which university science units are presented to students. In addition, decision makers within the University have an interest in the results, as a significant finding will have implications for the distribution of funding for teaching resources. On a larger scale the findings may be relevant to the broader educational community, as there are many lessons yet to be learned about best practice in the use of computer facilitated learning, and about teaching and learning at university.
Participants in the study were the 153 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, from the Teaching and Learning Centre, designed and carried out the evaluation plan. Baudains observed laboratory classes throughout the semester, using direct (or passive) observation (Zin, 1994), pp84-86), during which casual data collection in the form of short open-ended interviews took place. These observations were recorded in a journal. Baudains' previous experience in having studied Plant Diversity enabled her to have a solid understanding of the content and nature of the unit.

The evaluation plan was designed in accordance with Murdoch University's human ethics protocols, and approved by the Human Research Ethics Committee (HREC). The HREC is responsible for ensuring that all Murdoch University research involving human participants is conducted at the highest possible ethical standard. Any research that collects data from or about human beings is considered to involve human participants. Whether the research involves direct intervention in a person's life, or indirect involvement by observation, interview or survey, there is likely to be a requirement for Human Research Ethics Committee approval[2] .

Approval for this project was requested through completion and submission of a Human Research Ethics Approval Form (Form A). A copy of the application is attached as Appendix.A.

3. Evaluation Results

3.1 Background to the Unit

This section discusses the curriculum of N265 and how it is taught. This aspect of an evaluation, corresponding to the curriculum analysis and teaching for learning analysis foci of the analysis and design phase of Table 2, is often overlooked. However, it is important to be able to describe the teaching innovation which is being evaluated, to provide a baseline against which the evaluation questions may be judged.

This section discusses specific background information relevant to the study. The overall nature of the unit is discussed in the following section.

3.1.1 Learning Outcomes

A preliminary stage of the evaluation was to determine what outcomes students were expected to achieve in N265. Learning outcomes need to be clearly identified before it is possible to determine if they are met.

It was soon apparent that explicit outcomes and broad unit objectives did not exist for N265. Most staff agreed that it was "just assumed that the objectives were obvious" and there had been no need to write them down. There was, however, a series of 50 specific objectives, one set for each topic, each lecture, and each laboratory. These were printed in the course materials and generally referred to by lecturers at the beginning of each lab or lecture.

The teaching staff shared a common understanding of the broad learning outcomes:

[2] Murdoch Human Ethics guidelines are available at http://wwwadmin.murdoch.edu.au:80/research/ethics/hrec/hrec.html.

"…the primary objective is to develop the students with an overview of the diversity of plants in the broad sense … and with an understanding of the evolutionary processes…by focussing on aspects of life histories,"
"to become familiar with the plants that make up the plant kingdom and the diversity of their groups. Also the functions of the various groups, how they have developed and how they have evolved"

Manual skills for handling plant material were also identified as important.

As a direct result of this evaluation study, the unit coordinator, in conjunction with his colleagues, developed the following set of learning outcomes:

- To acquire an understanding of the evolution of algae and plants.
- To have some knowledge of the diversity of the algae and plants.
- To develop competency in the laboratory, and to develop the skills of observation, interpretation, drawing, and dissection.
- To have an awareness of both electronic and non-electronic sources of information in the plant sciences and skills to utilise them effectively.

These may need to be refined further in consultation with colleagues.

A most interesting observation was that, despite the absence of explicitly-stated overall objectives, students seemed to have an understanding of what was required in the unit. Some students took a relatively superficial approach, focussing on skills and knowledge, for example:

"The distinguishing characteristics and life cycles of different plants and how they relate to each other"

A number of other students had an appreciation of the higher-order knowledge required in the unit, e.g.:

"…I believe I will be expected to know about what makes up a plant, and the main different types of plants, the overall evolution of plants, and how the main types of plants differ and why (environmental factors etc.)"

"To understand the ways in which evolutionary pressures and opportunities have given rise to diversity within the Plant kingdom. To use this knowledge as a tool for interpreting how different groups of plants are related to each other. To be able to coherently appraise some aspects of plant evolution eg chlorophyll pigments, development of tissue, life cycles and reproduction, as a means of comparing different plants."

3.1.2 Relation between Theory and Practice

Because the CFL innovation in N265 was developed by the practical coordinator specifically for the practical component of the unit, the evaluation plan sought to determine the degree of interconnection between the theoretical and practical aspects of the unit. If there was a lack of connectivity between theory and practice, then the effect of the CFL may not transfer to improved learning outcomes.

Interviews with staff, and student survey responses, indicated that there was a close relationship between theory and practice. 98% of student respondents felt that theory and practice were closely or very closely linked. Staff saw integration of theory and practice as an essential teaching strategy, and students saw it as a useful learning tool which aids understanding of the course content:

"Everything we do in lectures seems to be backed up at the end of the week and explained in more detail in the pracs"

"The general stuff taught in lectures is usually backed up by the labs. For example, we were told the theory behind the life cycle of a typical Rhodophyta in a lecture; we then got to study them for ourselves and mainly note the reproductive structures, but it put the whole theory into a little more 'real' perspective, since we physically saw these structures for ourselves"

Students suggested that sometimes lecturers referred to the online material, or mentioned that it was available, but this was not supported by the self-reported behaviour of the staff.

> *"I link quite strongly to the labs and, but I don't specifically say look, you can see this bit on the Web, and maybe I could do that."*

3.1.3 Assessment

While the unit assessment has been developed and altered over time, the current situation is summarised in Table 3. The assessment associated with the practical component has been significantly reduced over time as in the past it was standard practice to assess each week during the practical either through a short 10 question quiz or assessment of the drawings and worksheets from the day's practical.

Table 3. Plant Diversity assessment scheme

Assessment item	% of grade	Additional information.
Practical Work	15%	To provide feedback on the practical skills expected of students – 3 reports will be marked for assessment
Library Exercise	15%	To assess library skills in locating and referencing resources and to test if students have mastered the use of those resources.
Practical Exam	30%	Closed book exam held during assessment period, to assess students' understanding of the practical material
Theory Exam	40%	Closed book exam held during assessment period, to assess students' theoretical understanding of the lecture material

There was some concern amongst staff about this reduction of feedback for the students from the practical sessions due mostly to limited staff and time resources:

> *"because of cost cutting we have had to reduce the number of times we assess the students prac work and give them help and feedback. That's not an improvement - that's a cost. Because of cost cutting a shortcoming in the unit has developed. We have reduced the feedback the students get. 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."*

The questions for the practical examination are shown in Table 4, while the theory examination questions are shown in Table 5.

Table 4. Practical examination questions, semester 1, 2001.

Number	**Question**
1	Name the cell/tissue/organelle types labelled A-J in the photograph provided and state the main function for D, E and F.
2	Examine the specimens provided. Name the structures labelled and give their main function.
3	Examine the photograph provided of *Triticum*. What organ has been sectioned? What is the ploidy level (n,2n) of the cells labelled A,C, D? What are the names and functions of the parts labelled A, B?
4	What are the reproductive structures shown in the micrographs (A-C)? Are they products of mitosis or meiosis? Name one other stage in the life history of this alga.
5	Name the order of the aquatic protist whose reproductive structure is shown in the picture provided. What is unusual about it?
6	What Division does this alga belong to? What are the structures labelled a, b and c?
7	For the specimens a, b and c, answer the following: name the structures A1 and A2 and state whether they are n or 2n what is the structure labelled B, what is its function and what is its ploidy level (n, 2n)? what is the structure labelled, what is its function and what is its ploidy level (n, 2n)?
8	Examine the three specimens provided. What type of plant is this? What is the name and function of the structure labelled? Briefly describe the characteristics of this plant. Give the name of the structure that is labelled. What would you expect to find inside the labelled structure?

	Briefly describe the characteristics of this plant and give the name of the labelled organ.
9	Examine the specimens provided. What are the names and functions of the structures labelled a, b and c? What are the names and ploidy levels (n, 2n) of the tissue labelled d and e?
10	You are provided with three bulk specimens and one slide. What kind of plant would you expect to find specimen A attached to? What do you think is the stage of sexual reproduction in specimen B? What is the name and function of the organ labelled on specimen C? What is the plane of section on slide D? Name the main transport cell.
11	You are provided with four specimens. Describe the type of vascular tissue you would expect to find in these specimens (e.g. type of stele, whether the vascular tissue is from primary or secondary growth). List the specimens in the order from the most 'primitive' to the most 'advanced'.

The practical exam questions in N265 in 2001 focussed almost entirely on surface learning and recall. All questions asked students to name or label specimens and describe their functions. Only the last part of question 11 required students to compare specimens in terms of their 'primitiveness'.

Table 5. Theory examination questions, semester 1, 2001.

Number	Question
1	**All students except Marine Science students.** Answer <u>one</u> of the following. 1. Discuss how seeds may have evolved. Describe the differences between the seeds of living Gymnosperms and Angiosperms. 2. Discuss three of the following: How *Rhynia*-type morphology could have been a precursor of most modern plants. Contrast the life cycle of a liverwort with that of a fern Spore dispersal mechanisms in plant without seeds. Morphology of *Equisetum*, *Welwitschia* and *Marsilea.* The evolution of xylem in plants. Changes in the female gametophyte during evolution of seed plants.
1	**Marine Science Students, only** Answer <u>one</u> of the following. 1. "The evolution of the algae illustrates the importance of endosymbiotic events in the evolution of plants". Discuss this statement and either support or refute it. Support your statements with examples from the algae. 2. Describe the characteristics of the Haptophyta with particular emphasis on those features which differentiate them from other algae.
2	Answer <u>one</u> of the following. 1. Describe the events that occur after an angiosperm pollen tube penetrates the synergid cell of an embryo sac, and the subsequent development of a non-endospermic seed. 2. Discuss three of the following The importance of coevolution of angiosperms and animals. Parasitic and hemi-parasitic plants in the flora of Western Australia. The problems in determining an ancestral group for the angiosperms. Explain why the 2-celled angiosperm pollen grain is considered to be the 'gametophyte generation'. Structure of phloem. Secondary growth of angiosperms.
3	Answer <u>one</u> of the following. 1. Compare the Euglenophyta with the Dinophyta. 2. Describe the 'typical' life history in the Rhodophyta, as exemplified by *Polysiphonia*. In what major way does it differ from the life histories of the green and brown algae? 3. The Chlorophyta are regarded as ancestral to the land plants. Discuss this statement, giving examples of evidence that supports it. What group of green algae are most closely related to the land plants?

The theory exam questions (Table 5) were analysed by a colleague with expertise in assessment. An edited response is shown below:

> *If students have seen all the material in the exam (and they most likely would complain if they hadn't) the exam mainly tests recall (there were one or two analytic questions) and I wondered if this is the intention of the unit coordinators. For example, the word "discuss" was used frequently and in most instances without qualification and I suspected that the unit coordinators probably wanted more than description, even when they used the word "describe". Is this type of learning appropriate for the year of study? And does that match the unit coordinator's intention?*
>
> *I thought the exam could be more student-centred in the language used to indicate the type of activity that students should be engaged in. The words 'contrast' and 'describe' do this, but as mentioned already, they may be used inappropriately, and perhaps used unintentionally.*
>
> *Alternate questions 1, part 1 are not equivalent in that they require different levels of thinking. All students (with the exception of marine science students) are required to 'describe' whereas marine science students need to construct an argument with evidence which requires analysis and synthesis. Neither is the second part of this question equivalent. Marine science students don't get an option and they are required to compare whereas only one option in the questions for all students requires comparison. I don't consider this fair (see Murdoch University Assessment Policy). I wondered how this is taken into account in the marking scheme, and whether students are aware of the inequality?*
>
> *The third question contains the same kinds of inequalities in the options, e.g. the third option required evidence and construction of an argument. It would be better to have the questions scaffolded in terms of difficulty with the first question being the easiest, to give students confidence and then make the questions progressively more difficult in terms of the kinds of learning outcomes required. The difficulty of the exam questions needs to reflect the kinds of learning activities during semester so that most students have the opportunity to pass the exam.*

In summary, the predominant use of recall in both examinations was found to be inappropriate, especially given to intention of the unit coordinators to foster a deeper understanding in students (see §3.1.1). The work on surface and deep learning discussed in §1.3 indicates that this examination structure will lead to students taking a surface approach to learning.

3.1.4 Introduction of CFL

A strong feeling was expressed by several staff that, over several years, the unit had become impoverished in the learning opportunities it offered, because funding cuts had led to the removal of educationally valuable parts of the unit, such as field trips and assessment of all laboratory sessions. As these activities, which were once an essential part of learning in science, were no longer available, the CFL was allowing some learning which would otherwise not be possible.

The intention of the practical coordinator was to provide access to materials for students who had missed a practical session, for whatever reason. Providing flexibility of access and overcoming student time constraints was seen as an important characteristic of the use of CFL in N265:

> *"Increasingly it seems that students are holding down jobs of often 10 to 20 hours a week, outside of class time, and they find it increasingly difficult to come to timetabled classes... In that context, being able to cover some of that laboratory material via internet learning in your own time, allows people to time shift, and get some flexibility in dealing with the material."*

For each practical session, the relevant section of the practical manual is provided online as a WebCT *path page*. After the practical session, this page is replaced with an enhanced page, containing images and examples observed in the practical session, as well as answers to exercises and questions.

The online materials in N265 provided access to plant specimens for study and revision, whereas, previously, students may only see the specimen once, or not at all. All staff recognised the importance of the resource as a revision tool:

> *"the ability to go back and revisit specimens outside class time would allow them to reinforce material, make themselves confident that they really understood the main points, just that continual exposure that helps people to make concepts their own as opposed to something that they simply learn parrot fashion."*

Two staff members explained that the CFL was an essential tool to ensure students had the opportunity to check their work.

> *"It [CFL] gives them an accurate source of information, so that if they have been spending the lab class looking at totally the wrong structure they will get it straight."*

The online materials also provided access to plant material at any time of the year. In some cases it is difficult to provide specimens of plants in flower at the times required by the curriculum:

> *"the ability over time for us to record information that is difficult to show well in the lab, for example it might be the wrong time of year." (Staff comment)*

The development of the online resources arose from serendipity, because one of the teaching staff had the required set of technical and content skills:

> *"it's simply because a person with the motivation and skill happened to be there at the time…. Not only is X extremely good at the technical side of things … but X obviously also has the great subject matter knowledge and skill, to be able to understand what is most important and how to get some of that importance across to the students." (Staff comment)*

In addition to the online practical resources, students use the Quiz Tool in WebCT to complete their library assignment.

3.1.5 Staff Perceptions about CFL

Since there were a number of teaching staff contributing to the unit, the evaluation plan investigated staff assumptions about Computer-facilitated Learning.

Some staff felt strongly that there was an imperative to use CFL. These feelings were based on a perception that computers made learning more interesting, relevant and flexible, and therefore students learned more effectively with computer based material.

> *"I feel really strongly we have to get computer based learning into the courses… I see with my own children that they learn much more effectively when there is some computer based material… it provides an opportunity to in fact improve the linkage in the course because the prac material is there for students to look at, independently of … a three hour lab session. So they could learn when they wanted to learn…. it was great for revision."*

However, there was a range of views about how to use CFL in the science classroom. There was a strong feeling that face-to-face teaching was still necessary, to look at plant material in real life: "this unit would be nothing without the practical interaction with the materials". Interaction between students and lecturers was also valued.

There was concern that administrators 'assumed' that teachers could be replaced by technology, and that this would reduce costs. There was also concern about the cost of producing online materials. The following quote encapsulates staff concerns and beliefs.

> *"People (like VCs) think that because we can use computers in the classroom we can have cheaper teaching online and do away with staff. That's a load of bull. It is a tool, but this unit would be nothing without the practical interaction with the materials. The computers make revision easier and more effective and allow us to teach some things which would be otherwise inaccessible. If we*

had more computers we could do more things, but the hardware, software and maintenance needed is not cheap..."

Staff felt that the use of CFL should add value to the educational experience:

> *"there is a problem with perception of CFL by other people. Some people think it is a way to put lecture notes on line, but I see that as a waste of time."*

3.2 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 as a whole will be discussed first.

3.2.1 The Nature of the Unit

Both students and staff felt that there was too much content in N265.

> *"… 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 §1.3:

> *" 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." (Stam2, 228)*

Most staff believed that providing a framework, or broad base, was important, but felt the other staff members did not agree with them:

> *"The function of lectures is not to give them minute details about exceptions and so on, but to give them the framework. Now not all staff agree with my philosophy on that. "*
>
> *"I used to give broad brush intro and wrap up lectures to try and tie things together, and tried to introduce evolutionary principles that applied both to plants and to animals. When I got to a point in the unit where I thought it was good to backtrack and to show a trend going from the algae or wherever you were in the course to wherever you are now I would do so, but I don't think X does that."*

A common staff perception was that, while staff 'hoped' that students would learn deeply, they expected most students would use rote learning:

> *"I think they use rote learning of characteristics of the group, then in my most optimistic mind I would like to think they use the major evolutionary trends to try and put together the details of the different groups and how they might have evolved … we hoped everybody would come out with the broader understanding and the capability of answering questions which really tie everything together."*

3.2.2 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. Another staff member felt that, with some thought and creativity, the dry nature of the lectures could be overcome. Students requested more field work and more video materials. One student felt that the unit needed to be made more interesting and 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 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!"*
>
> *"I think it would be much better if we actually threw all that out, and we started with a challenging practical and said OK - so this is the diversity of plants on earth in the past and now, there's a whole set of demonstration material where they could walk through geological time."*
>
> *"The ideal thing would be to actually teach the material with the students in the lab and have no lectures (which is impossible) because it is not particularly interesting hearing about plants in theory compared to actually having them actually in front of you…"*

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.

A clear tension was observed between the marine and terrestrial streams in N265. A marine stream was introduced in 2000, but students and some staff felt that they needed to be separated into units more relevant to each of the two cohorts of students. This issue has already been addressed in 2002 with the introduction of a new unit for Marine Science students, although students will attend some common lectures.

It is apparent from the evidence presented here that there is a need and a willingness to thoroughly restructure the curriculum and lecture format in Plant Diversity. 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.

3.2.3 Improvements to the Laboratories

The laboratory section of the unit is less problematic, based on feedback from staff and students. However, significant problems are present. The major problem in terms of student learning is that the number of times that practical work is assessed has been reduced, because of cost cutting. That is, students get less feedback on their work, and "if they get it wrong, they have no check". While the online materials provide feedback on laboratory work, it is possible that not all students will access the WebCT materials if there are no marks for this.

While staff did not identify this as a problem, students and laboratory demonstrators perceived that some sessions were too long, with too much to do in them. On the other hand, some sessions were too short. Laboratory demonstrators thought that the laboratory sessions could be redesigned to have more equal volumes of work in each.

Typical student comments about the laboratory sessions are:

"Shorter labs, and make so that they are more interesting"
"Perhaps by shortening the volume of some of the lab materials so the important aspects could be concentrated on."
"The labs have too much to do and not enough time to do it in."
"Less drawing in the labs and more handouts of drawings that we just have to label."
"I think if we were to have more field work rather than lab work. I found that the only thing that I have properly learnt was from the seaweed practical out in the field. However that is me, an outside person."

Staff expressed the view that the introduction of the online materials made it possible to change the nature of the practical sessions. At present, these consist of largely observation activities, which are available online. Three staff felt that it was possible to introduce an experimental, or manipulative, component:

"I would like somehow that there would be more experimental rather than observation … do something that involved a process rather than just looking down a microscope … they are the things which get taken away because they are more difficult and more expensive - again I think its more a discovery process - If they were given Ecklonia and growing them and to me that s much more exciting - if you go through the process and get the satisfaction it gives much more perspective. Much more satisfying."

3.2.4 Usefulness of the Online Environment

Staff felt that the introduction of WebCT had paid off with demonstrated success.

"It was a long shot - it was either going to be useful - they were going to get something out of it or react positively to it, or they were just going to play computer games. And it worked - it engages them… it breaks up what they are doing so they're looking at things differently, observing."

Students also felt that there were few issues with the use of WebCT. In general, the comments were positive as the students used the material for revision and assessment purposes. The general feeling was that, compared to other units, Plant Diversity used WebCT very well:

"the webct for plant diversity is great its one of the most interactive pages I've used on webct. Others are sometimes a bit like ghost pages...."

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. These issues will be discussed in more detail in the section on Learning Process.

One staff member commented equivocally on the usefulness of the online materials. The online resources enabled students to cover laboratory material much more quickly than in the laboratory, but this came at a price. That is, students miss the experience of finding the right structure under a microscope.

Student responses to closed questions in the student survey are summarised in Table 6. Of the survey respondents, there was a strong perception that the online material was useful and aided understanding. However, students still felt that there was a need to attend lectures and laboratories. Given that the online materials were designed to supplement the traditional teaching experience, this perception is reasonable. A majority of students felt that WebCT enabled them to use their time more effectively, and they had more confidence with the laboratory material. A student response supports this *"It reinforces what I have seen in the lab and makes me more confident in my conclusions."*

However, student respondents had mixed feelings about whether the online materials made the unit easier. Some felt that it was easier and others disagreed. However, the majority of students felt that the online materials helped them to learn more effectively. More evidence of this will be presented in the subsequent section on the Learning Process.

Table 6. Summary of student survey responses to the usefulness of the online materials in N265

	Yes		No
Did you find the online material useful?	38		2
Does the online material help you to understand the course?	33		5
	Yes	Perhaps	No
Do you feel that, because of the online content, you have less need to attend lectures?	1	4	36
Do you feel that, because of the online content, you have less need to attend lab classes?	1	10	30
Do you feel that, because of the online content, your lab time is used more effectively?	22	12	7
Do you feel that, because of the online content, your confidence with the lab material is greater?	20	15	6
Do you feel that, because of the online content, the unit is easier?	14	14	12
Do you feel that, because of the online content, you are learning more effectively?	24	11	6

Figure 2 displays the results of a survey question asking students to select (multiple) reasons that they used the online material. The results reinforce other findings reported above. However, in addition, 14 of 47 respondents indicated that WebCT was used for preparation for laboratories. This is supported by evidence from laboratory observation:

> *"The students do seem to come prepared with some of the drawings already completed, and reading done. It makes it easier to do the lab so it is really in their interest to prepare."*

The survey results support further evidence reported in §3.3.

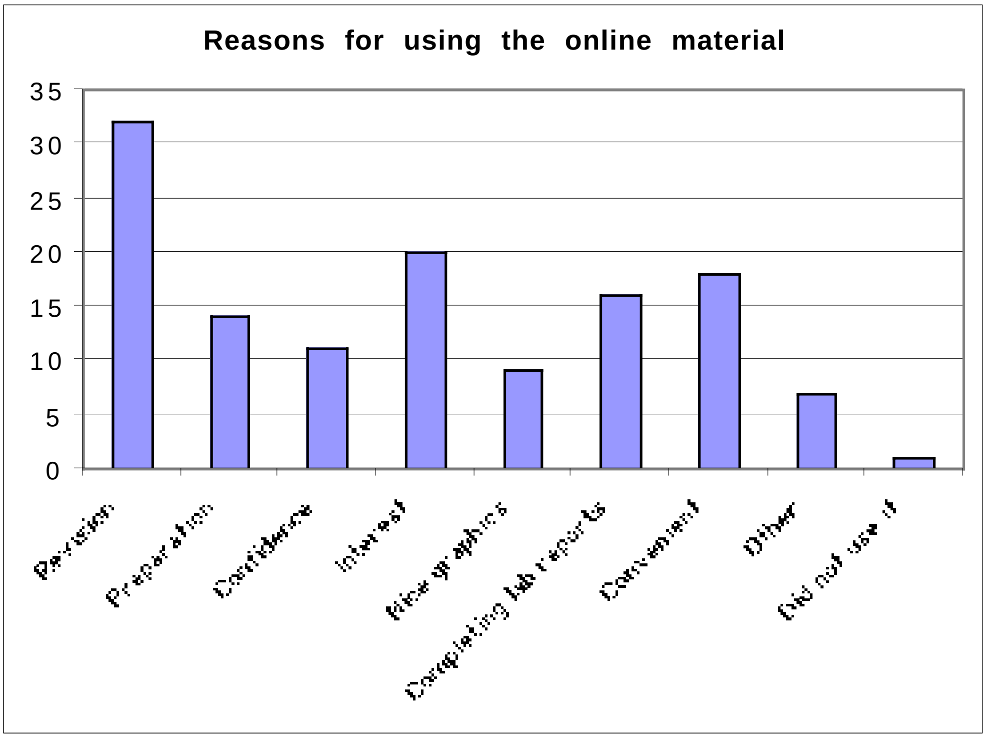


Figure 2. Reasons why students used the online materials. Multiple responses were possible.

3.2.5 Improvements to the Online Environment

Technical and logistical issues were mentioned by some staff:

> *"…what the problems are - that you can't re-enter a quiz, it can't randomize questions … they're technical glitches - what it is supposed to do on paper it does not quite achieve"*
>
> *"I would like to find some better way of doing the glossary so that when the keyword comes up they can click on it and the definition just pops up."*

Some staff mentioned strong feelings about how *not* to use WebCT:

> *"I have seen uses of Web CT … I don't see particularly valuable at all, like basically replicating material that is available to students through the study guides … especially when you have to double check things for accuracy, … standardise the delivery and save yourself the trouble of having to do things twice over."*

Most staff felt the use of WebCT was appropriate, but suggested ways its use could be improved in the context of N265.

> *"I would like to see some way in which the WebCT could be interactive, where the students had some way of assessing their knowledge, their understanding, … but its just look and see - it doesn't challenge you to think, to pose questions."*
>
> *"I would like to see the material that is outside the labs go into it so it is not just the lab material but some real live sequences from outside."*

While the WebCT materials were overwhelmingly seen by staff as useful for *students* to use, not all staff used the online materials when working with students in practical sessions. Junior staff were observed to frequently refer to the online materials, while senior staff tended not to look at them at all. This indicates that some staff were not fully engaging with the innovation in N265.

Related evidence is that the N265 materials were used sparingly, if at all, in lectures. The limited availability of technology in lecture theatres was cited as a strong factor in not using the materials in lectures:

> *"Main good reason why we don't is because we cant guarantee that you've got access to it in the lecture theatres. You cannot presume to be able to use online material in a lecture because you don't know where you're gonna have your lecture. Its total logistic - that's why I don't even use power point for the same reason because I cant guarantee that. When the university eventually has standard facilities then we might consider it."*
>
> *"the main reticence I have had has been about whether or not it is going to work. I have been stung enough … to be reticent to do that [use the web] in a teaching context."*

Expertise in Information Technology was seen as a barrier to expanded use of CFL by staff. Related issues were workload, and funding and recognition for staff to innovate in their teaching:

> *"There's no incentive to actually go and do online teaching, or to make videos, or to run field trips. We spend most of the time spoon feeding and throwing information in front of students that they could equally get out of a textbook. … it's also the fact that we don't have a lot of time, you know…"*

However, despite barriers to its adoption, CFL was seen as potentially useful in providing access to dynamic material (such as algae which swim out of microscope view), or visualised material (such as the three-dimensional structure of the cell). The use of (digital) video of plant habitats could also increase the richness of the lecture experience for students.

> *"I would be quite happy to do some of my lectures in the field, but I cant do that for obvious reasons, cause I can't take the students to the field. But instead of me standing up and talking about ferns like I did today, if I did that [on video] in a rainforest in NSW you know, it would be far more interesting."*

"I would like to … use much more of the video clips and things like that to give a bit of life and movement to things..."

Nevertheless, there was a perception of the resource constraints involved in preparation of high-quality digital materials:

"I dislike the amount of time it takes to prepare a small amount of material, and how amateurish it looks compared to the sort of David Attenborough type stuff."

3.3 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.

As predicted by staff in §3.1.4, students used WebCT 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 (Fig. 1) and a deep approach to learning (Table 1).

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 sections.

3.3.1 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."

"You have to learn a lot in a small amount of time. And to keep up, you have set yourself a good pace however I find that I don't absorb or learn anything cos' it's kind of rushed, in terms of the lab contents."

"I sit at home and go through all the labs. If I couldn't do that they wouldn't get finished off and I wouldn't know if I had done it correctly."

A number of students recognised the usefulness of the WebCT materials in terms of reinforcing what they had just done in the laboratory, and to make sure that what they had done was correct:

"Sometimes you don't get something and then there are pictures online that make it all click."

"Some of the photos of the cells from the labs helps me to see the correct things and tells me what i should have seen and learnt from the labs."

"I mostly use the labs, to check the answers, look at the slides I might have missed. The pictures are really useful - I like the photos of the slides, they are very useful for revision, and double checking. I download the slides as pictures. I mostly use it for revision - they only put the answers up after the lab, not before. They put the questions up before which I sometimes find useful. If the answers were available earlier people might not turn up. Except that you do need to come to the labs - they don't show you everything on the web. You get an idea of scale, texture - what its really like and all that sort of stuff. I'm much more comfortable with it all out in front of me."

"I find that sometimes the diagrams are more clear, and also it gives me an opportunity to check my answers from the previous lab."

"It helps to check and make sure that the right answer was obtained (which saves time in labs) and also some of the images in the manual are clearer online than in the manual (the electron micrograph on page 4 of the manual being a good example)."

"More to make sure I am right - rather than filling in gaps. "oh I screwed that one up - if I fix it I will know for next time)."

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 is impossible to determine which of these students were high-achievers. However, some of the students quoted above appeared to be having difficulty in coping with the volume of laboratory work in the time available (see §3.2.3), and the WebCT resources enabled them to cover material which could not have been covered in any other way.

It was also apparent from student observation that some students were prepared for laboratory classes:

Students who are well prepared for the class quietly and unobtrusively already started drawing slides and writing answers in lab book during the pre lab talk. This seems an effective use of time for these students, who were also listening as they would periodically write down something the demonstrator was saying regarding the material. These same students seemed self motivated and appeared to need little support from the demonstrating staff.

The observer journal indicated that different responses to usefulness of WebCT seemed to be related to the motivation and progress of the students towards their assignment. Students who had already used WebCT tended to have a lot more of the assignment completed in terms of researching life histories of the algae they had collected, while one student had only just started researching his assignment:

"He still seemed to find it fairly interesting, but there was a much more achievement based motivation underlying his efforts compared to some of the more openly enthusiastic students. A number of girls said that the web was especially useful for getting a better idea about some of the algae." [lab journal]

3.3.2 Surface Learning

As the semester drew to an end, more students began to take revision seriously, although this tended to take a surface approach:

There appears to be a lot more students with the text book this week than I have noticed before. I wonder if this is related to revision? It seems from overhearing conversations that a few students (generally male) are asking others with books about which sections to use, where to refer to for answers , the most important bits to study etc. (Observer journal)

Earlier in this report (§3.2.1), we foreshadowed a tension between deep and surface learning in units of this type, and teaching staff in N265 understood that tension. Despite the evidence of deep learning presented directly above, this was not the case for all students. Staff were also sceptical that students would take a deep approach to learning.

One staff member felt that some students might use the online materials as a substitute for hands-on practical sessions, while recognising that other students, like those above, might benefit greatly:

"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"

However, survey data shown in Table 6 indicates that few students saw the online materials as replacing hands-on experience.

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."*
>
> *"I haven't really [used WebCT] but I can imagine coming up to the exam that I will use it for revision."*
>
> *"Yes [I expect I will use it]. Just haven't got round to it yet - its week 10 now so its time to start - business end of semester..."*
>
> *"It is definitely great for revision."*
>
> *"yeah - I've looked through it, it'll be useful when it comes to cramming at the end of semester".*

3.3.3 WebCT Usage Logs

Another way of 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 10703 times. These were divided into three types: home page access, discussion forum access and content access, as shown in Table 7. Typically, students access content and activities through the WebCT home page. Students then access the content module, quiz tool and discussion forum from the home page. An exception to this is that students can access new discussion forum messages directly from the myWebCT function. Access to the quiz function (used for the Library assignment) is currently not recorded by the WebCT system, although some of the home page hits are expected to be precursors to Quiz access. The 4322 home page hits are not particularly useful, therefore, in analysing learning behaviour by students.

Table 7. Access to the N265 WebCT course by students

Type of Access	Number of Hits
Home page access	4322
Discussion forum access	2923
Content access	3458

Usage patterns for the discussion forum were interesting. The discussion forum was not intended to be used formally for educational purposes, and its use was voluntary. Only 45 messages were posted to the forum, with 19 posted by students. Most messages were administrative in nature, about assignment details, etc. However, by far the majority of the 2923 forum hits were by students lurking (reading the messages but not contributing). This suggests that students are looking for more use of the discussion forum, and this could be built into the structure of the unit. As well as using the discussion forum for disseminating administrative information, there is an emerging literature on online tutoring. (See, for example, Collis (1996) and Higgison (2000).) The discussion forum hits are not useful in analysing learning behaviour by students.

The 3458 hits on content pages are likely to be the most interesting in terms of providing information about the ways that students use WebCT for learning Plant Diversity. 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 3 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 clearly indicated on Fig. 3, as are the times of both the practical and theory exams.

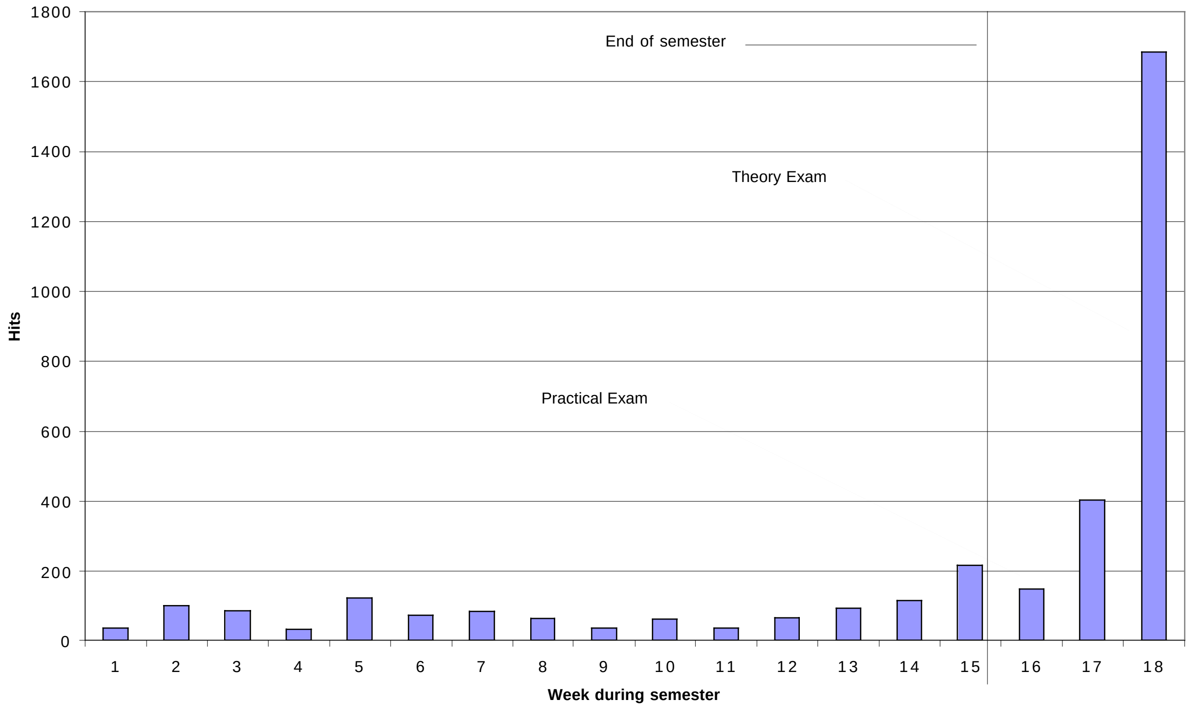


Figure 3. Distribution of hits on WebCT content pages in each week of the semester.

A striking feature of Fig. 3 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 smaller 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.

We identified earlier the close coupling between the practical and theoretical aspects of the course, so it is not surprising that students were able to use the online materials for this purpose.

Closer analysis of Fig. 3 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. Figure 3 may provide a misleading picture of actual usage, because many students will attempt to access all the content pages during the study break, whereas they only need to access one per week during the teaching period.

An alternative representation of student use of WebCT content pages is provided in Fig. 4. This graph displays the number of students who hit one or more content pages in each week. While 115 students accessed WebCT in the week before the exam, it is clear that significant numbers of students used WebCT during semester, with a peak of 53 in week 5. An average of over 27 students accessed WebCT in any one week of the teaching part of the semester.

While Figs. 3 and 4 provide an overview of the behaviour of the whole cohort of students, it provides no information about the behaviour of individuals, or groups of individuals. Observation of the data indicated that there was a great range of patterns of WebCT use (see Figure 5 for three representative cases). Some students used WebCT only during the study break. These students have been characterised as ‘crammers’. Other students used WebCT only during semester, and not during the study break. These students have been characterised as ‘revisers’. 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 pages. However, they *did* use the WebCT resources during the semester to revisit laboratory materials.

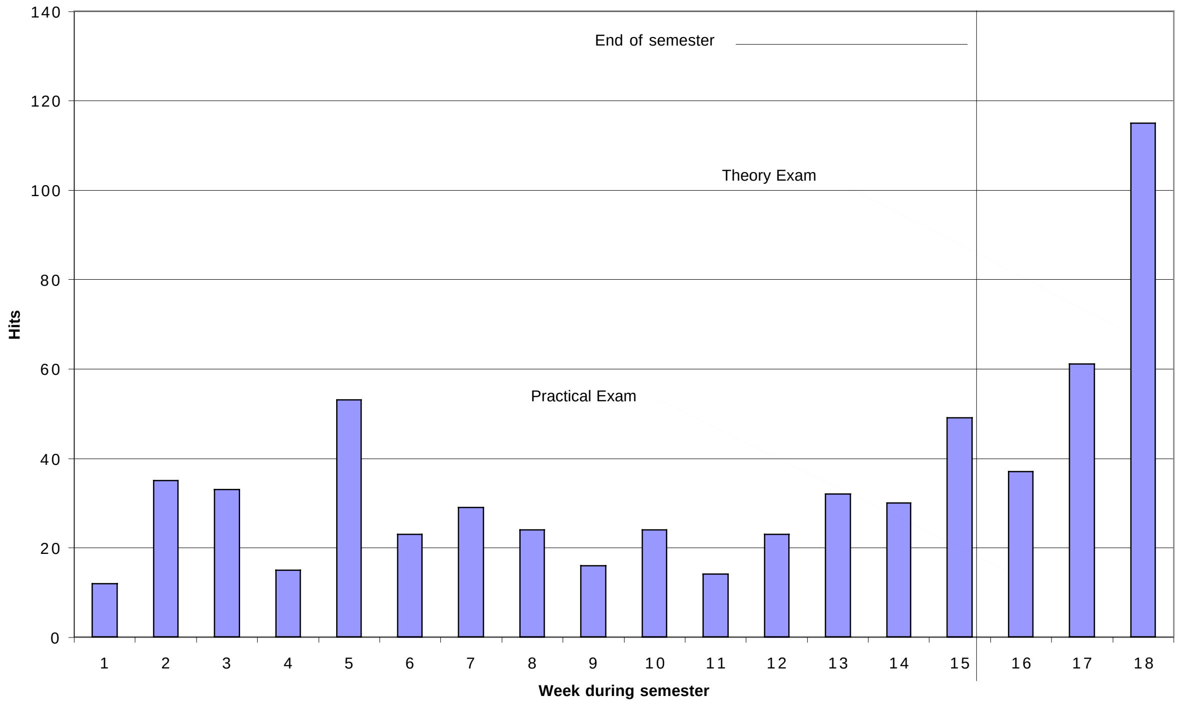


Figure 4. Numbers of students accessing one or more WebCT content pages in each week.

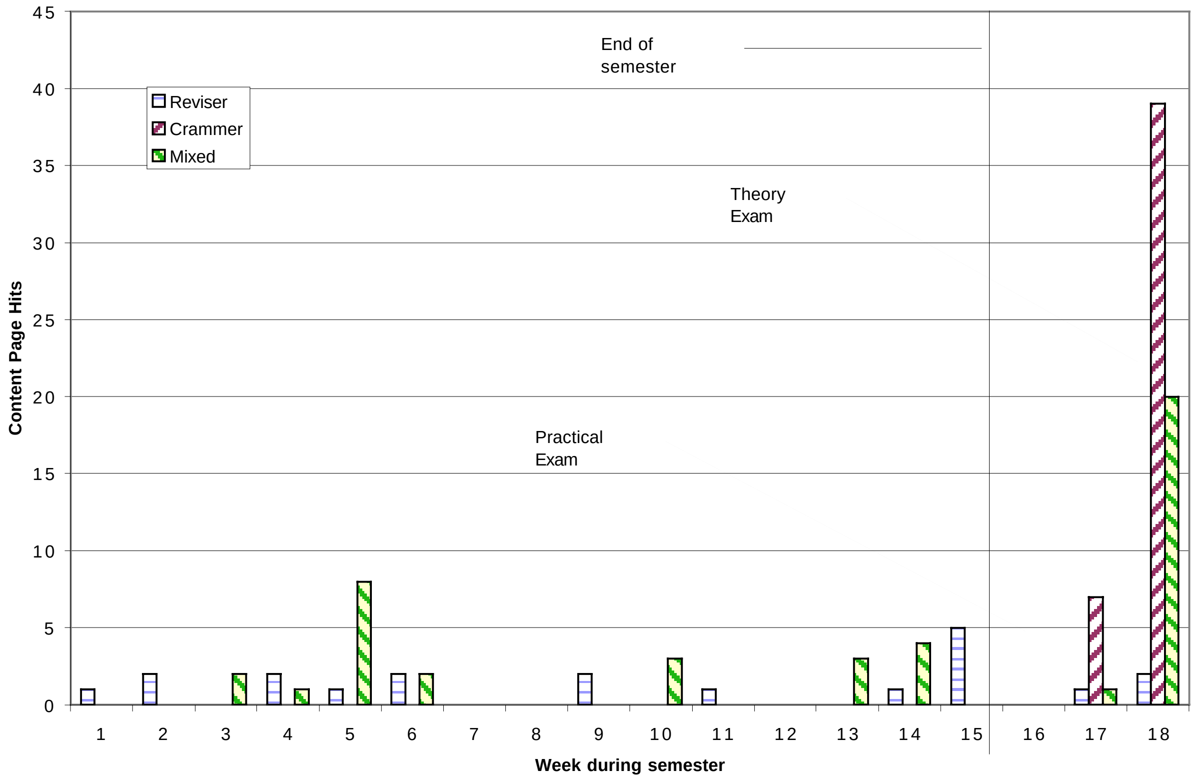


Figure 5. Individual usage patterns for students with three separate study patterns.

A third group of students ('mixed') used WebCT throughout the semester, displaying aspects of both revising and cramming behaviour.

An attempt was made to quantify the nature of student usage of WebCT through a Cramming Ratio and a Hit Frequency measure. Examples of these are shown in Table 8. 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. Extreme cramming behaviour would have all content hits during the study period, leading to a Cramming Ratio of 1. On the other hand, extreme reviser behaviour would have no content page hits during the study period, and hence a Cramming Ratio of 0. A mixed reviser/ crammer student would have a Cramming Ratio around 0.5.

Table 8. Examples of WebCT usage pattern measures for the three students displayed in Fig. 5.

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 page hits during the study period to the total number of content page hits.

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

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 less than ten times. 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 20 hits in one week.

A second measure was, therefore, introduced. That is the Hit Frequency, which is 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.

A hypothetical ideal student would use WebCT twice a week during semester:

- After the laboratory - hitting the one required page of content, plus others as needed for reinforcement of previous material;
- Before the next laboratory – previewing the material and preparing (although this could also be done using paper-based resources.

The same student would revisit each of the 13 pages at least once during the study period. Let us assume they access each page twice. This student would have a Cramming Ratio of 0.5 (26/52) and a Hit Frequency of 16 (13 weeks of semester plus three weeks of study).

These measures will be used in the next section to analyse the summative learning outcomes achieved by students.

4. Learning Outcomes

The grade distribution for N265 students in 2001 is shown in Figure 6 for both the terrestrial (main) and marine streams of students. It is visually apparent that marine 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 9).

In Figure 7, the distribution of grades is displayed for each of the four types of assessment in N265. The grade distribution is very similar for both streams for the Library assignment and for laboratory performance. However, it is clear that marine stream students performed significantly better in both of the examinations. While marine stream students had one different question to answer in the theory exam, this question was identified in §3.1.3 as being more difficult than the equivalent question for main stream students. Furthermore, the practical examination required all students to answer the same questions, so it is unlikely that any variation in grade is due to the type of examination question.

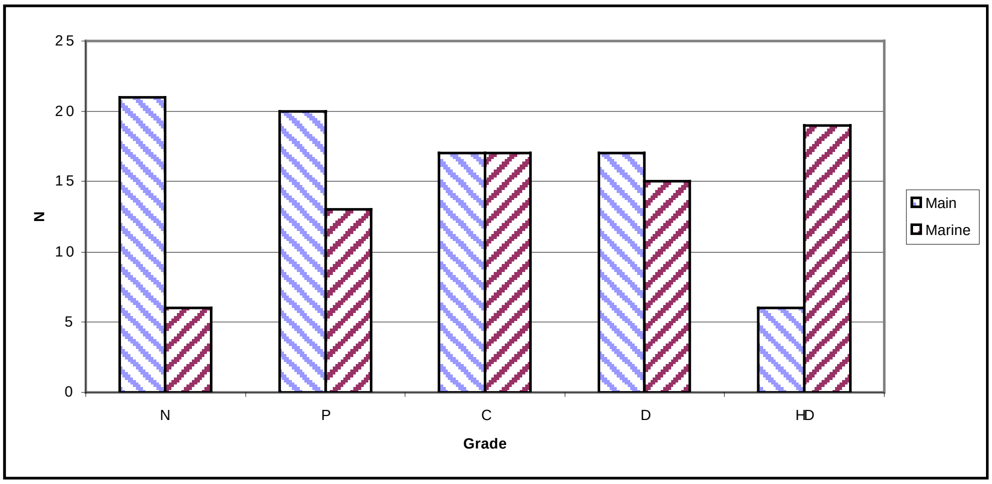
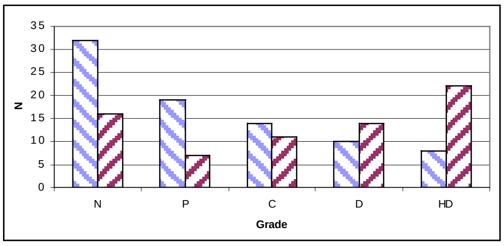
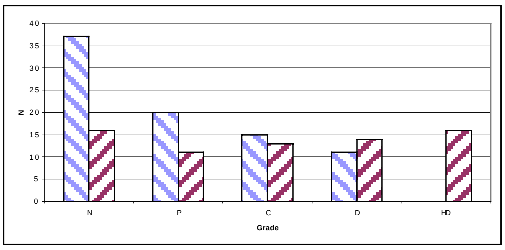


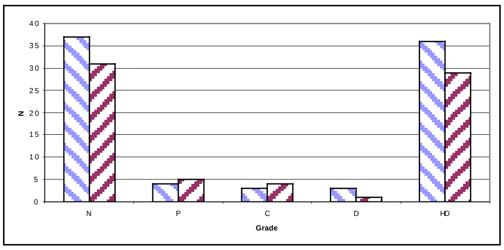
Figure 6. Distribution of final grades for the marine and main streams of N265 in 2001.



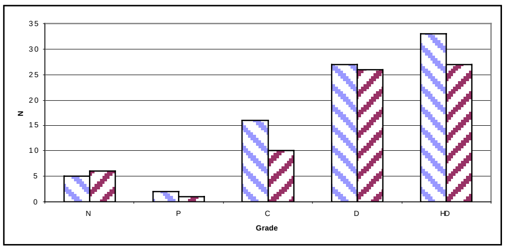
Theory Examination Grade Distribution



Practical Examination Grade Distribution



Library Assignment Grade Distribution



Laboratory Grade Distribution

Figure 7. Distribution of grades in each of the four assessment types in N265.

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).

The performance of the main- and marine stream students is shown statistically for a number of dimensions in Table 9.

The course Grade Point Average (GPA) provides a mechanism to compare the native talent of students across their whole university study to date. Marine stream students have a mean GPA of 2.26 compared to 2.06 for main stream students, but 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 9 show the three measures of online usage developed in §3.3.3 for both the main- and marine streams. Students with high motivation might be expected to show 'Reviser' characteristics, and have a high Hit Frequency. Table 9 indicates that there is no significant difference between the Hit Frequencies of the two streams. However, 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 made their extra hits largely during the study period.

Table 9. Performance indicators for the main- and marine stream students.

	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] $P < 0.05$

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.

This high number of hits on WebCT content pages during the study period, shown in Fig. 3, indicates that not only marine stream students exhibited cramming behaviour. To explore this hypothesis, the cramming ratio defined in Table 8 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 for the Cramming Ratio indicated a Non-crammer.

Table 10 shows the relationship between the average results for the two examinations for each cramming behaviour. It can be seen that Crammers performed better ($P<0.05$) in both the theory and practical examinations, regardless of which stream they were in.

Table 10. Relationship between examination performance and cramming behaviour for all students.

	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] $P < 0.05$

5. Comparison with N261 Animal Diversity

Another question of interest to the stakeholders was a comparison of performance in N265 Plant Diversity with its complementary unit, N261 Animal Diversity. Some staff and students felt that N261 was intrinsically more interesting and motivating.

> *They have a high proportion of students who would rather not be there. Now in that particular context it must be quite dispiriting in fact, for people who are in love with the discipline, and really enthused and excited by it, to have to be droving students who think basically it is dull, and wish to do little more than necessary to get through this requirement so they can race off and concentrate on the animals which is where they would rather be. That is a significant aspect of the context of*

teaching plant diversity and it is something I think one needs to be aware of when looking at student comments and evaluation. (Staff comment)

I don't really like it that much because plants don't really interest me in the slightest, I am very much into animals (student comment)

The Biology program has a steady proportion of students who want to become vets, and who have no interest in plants.

Table 11 summarises 2001 results from standard surveys of units for N261 and N265, together with the University-wide mean for seven questions relevant to this study. The scores for N261 and N265 were compared using a standard t-test. N265 scores below N261 in all seven cases. N265 is also below the University average for all questions, whereas N261 scores above the university average in five questions. In five cases, there is a statistically-significant discrepancy between N261 and N265. In the fourth and fifth questions (assessment and general organisation of the unit), the scores are relatively close. These two were also the only questions where N261 was below the University average.

It seems that the qualitative data quoted above are backed up by the survey results, and N261 is perceived by students as a better unit, except in assessment and general organization.

Table 11. Mean scores (standard deviations in parentheses) from relevant questions of the standard Murdoch student surveys of units, for both N261 and N265, compared to the University mean.

Question	**All Units** [a]	**N261**	**N265**
It was clear what I was expected to learn	3.03 (0.72)	3.11 [b] (0.56)	2.80 (0.67)
The assessed work was appropriate to the learning objectives	3.15 (0.62)	3.21 [b] (0.60)	2.91 (0.55)
Activities in the unit enhanced my knowledge and/or skills	3.18 (0.68)	3.39 [b] (0.54)	3.07 (0.52)
The assessment tasks tested my understanding rather than just memory	3.17 (0.67)	2.92 (0.79)	2.90 (0.68)
The unit resources were well-organised and easy to follow	3.04 (0.72)	3.00 (0.60)	2.91 (0.77)
Overall, I was satisfied with the quality of teaching	3.12 (0.74)	3.28 [b] (0.52)	2.81 (0.73)
Overall, I was satisfied with the quality of this unit	3.07 (0.75)	3.26 [b] (0.56)	2.83 (0.61)

[a] Responses from 10567 students in 296 units.
[b] $P < 0.01$

The relatively-poor rating of the unit N265 may be due to the nature of the teaching, the nature of the unit, or the interest and motivation of students in studying it.

Biology staff indicated that both N261 and N265 have similar structures and are taught similarly. While the analysis of N265 provided earlier in this report indicates shortcomings in the design of the unit, these are likely to also be present in N261.

The analysis reported earlier indicated weaknesses in the clarity of objectives and in the assessment of N265, and this is backed up by the survey results. However, N261 students also felt that assessment relied too heavily on memory, indicating a potential weakness in unit design.

The survey and other data presented here supports the view that student motivation is the major factor in the differences between N261 and N265. If students are not interested in a subject, it is harder for them to motivate themselves to study the topic. They may invest more time in studying an interesting subject, and have lower success rates in the uninteresting subject.

Therefore, student performance in N261 and N265 was investigated over seven years, with results shown in Figures 8-11. Figure 8 displays the enrolment trend in both units, from 1995 to 2001. Although enrolment numbers are very similar from year to year, in 2001, only 80 students of the cohort of 153 in N265 were also

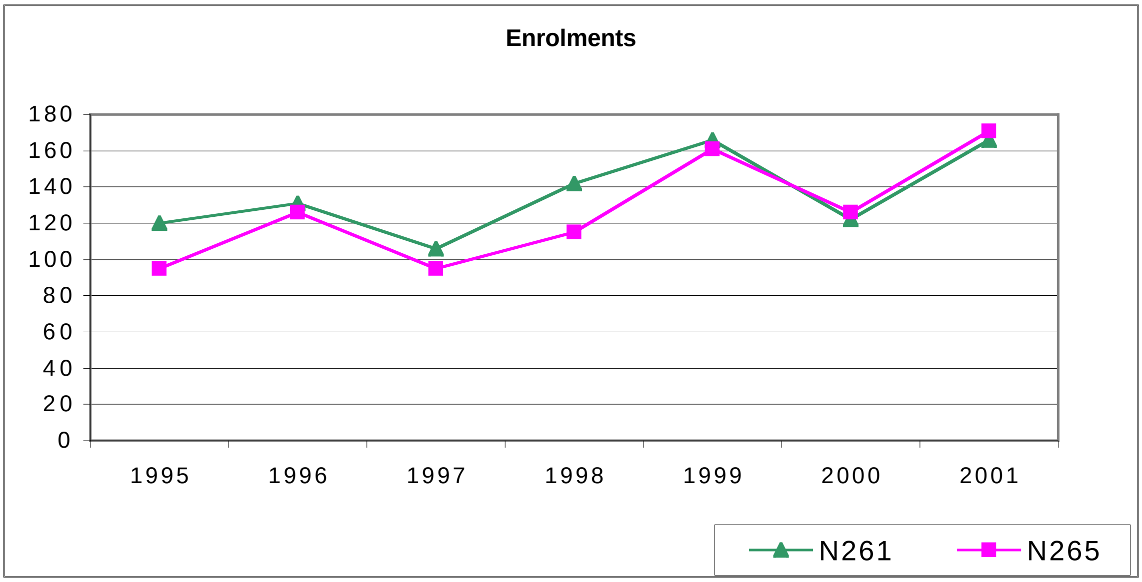


Figure 8. Enrolments for N261 and N265, from 1995 to 2001, inclusive.

enrolled in N261. The withdrawal rates for each unit also followed similar trends from year to year.

Figure 9 shows the overall pass rate for both N261 and N265 over the entire period. Over most years (1995 and 2001 excepted), N261 had, clearly, a higher pass rate, in the mid- to high 90% range, while N265 had a pass rate in the mid- to low 80% range. Given the similarities in the nature of both units discussed earlier, it appears that motivation is the factor behind the low pas rates in N265. However, in 2001, the pass rate for N261 fell sharply. No data is available to explain this decrease.

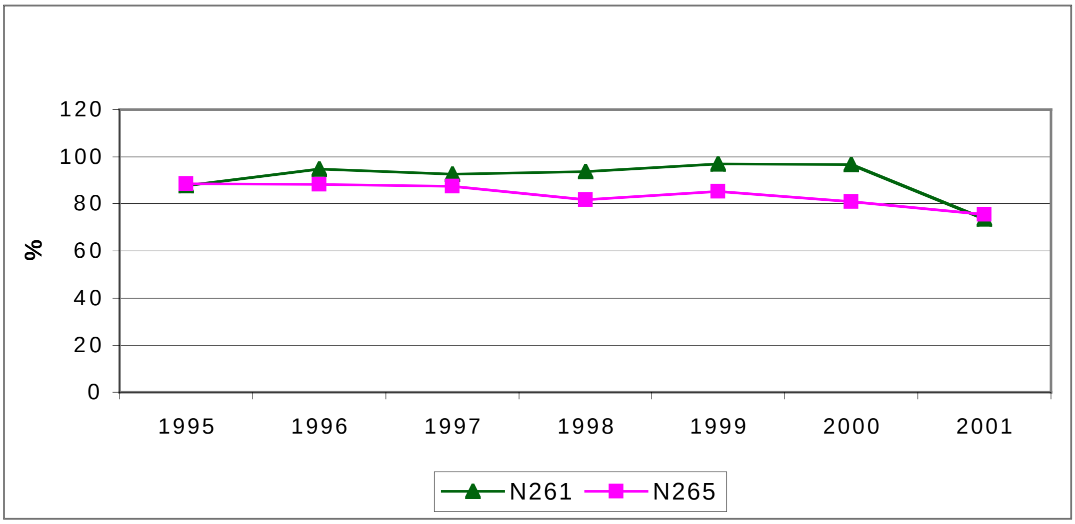


Figure 9. Overall pass rates for N261 and N265, from 1995 to 2001, inclusive.

The lower overall pass rates (and consequently higher failure rates) in N265, shown in Fig. 9, indicated that N261 students should have higher scores than N265 students, on average. To confirm this, we calculated a unit grade point average (GPA) for each unit for each year. The formula $GPA = \sum_{i=1}^{5} N_i * G_i$ was used, where N_i = the number of students with grade G_i, and G_i = the value associated with each grade. Following Murdoch University's convention for assigning grade point averages to students, G_i values of 4,3,2,1,0 correspond to 'high distinction', ' distinction ', 'credit', 'pass' and 'fail', respectively.

The unit grade point average for both units over seven years is displayed in both Fig. 10 and statistically analysed in Table 12. It can be seen that N261 students achieved a higher unit GPA in all years. Table 12 compares the unit GPA's for each year using a standard t-test. The N261 GPA is significantly higher (at the P=0.05 level) than that for N265 in four of the seven years.

It is also notable that, since the practical examination and web resources were introduced for N265 in 1999, the GPA for N265 has trended upward, and towards N261 values. In previous years, with the exception of 1998, the trends were very similar for both units.

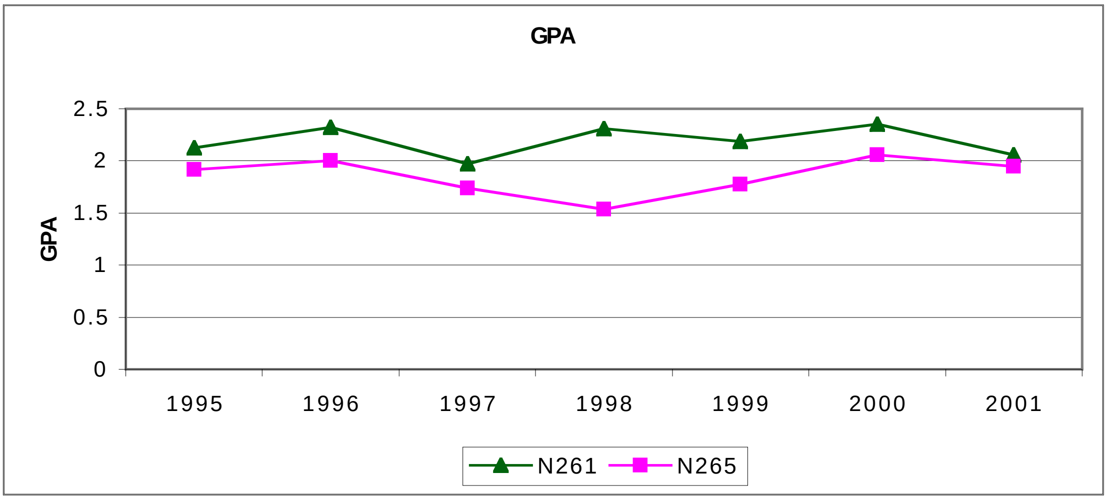


Figure 10. Grade point average for N261 and N265, from 1995 to 2001, inclusive.

Table 12. Comparison of grade point averages for N261 and N265, from 1995 to 2001, inclusive.

Unit	**N261**	**N265**
1995	2.13	1.91
1996	2.32 [a]	2.00
1997	1.97	1.74
1998	2.31 [a]	1.54
1999	2.19 [a]	1.78
2000	2.35 [b]	2.06
2001	2.06	1.95

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

Consistently with Fig. 10, N265 tended to have a greater percentage of students with grades of N (Fail) and P (Pass) than N261. Similarly, N261 students consistently scored more C's (Credits) and D's (Distinctions).

However, as shown in Fig. 11, the number of HD's in N265 increased markedly from 1999, outstripping N261. 1999 corresponds to the introduction of online resources in N265, providing improved opportunities for motivated students to perform well in the type of assessment used in that unit. The year 2000 corresponded to the introduction of the marine stream in N265. In Section 4, we identified that Marine stream students, in 2001, were more motivated towards Cramming, and scored more HD's than their Main stream counterparts, and used the online materials extensively for this purpose.

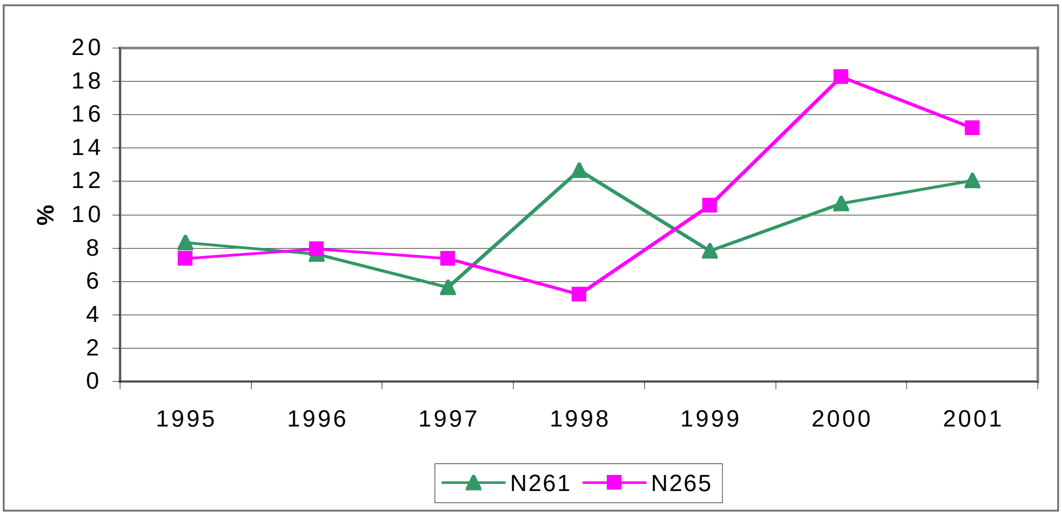


Figure 11. Percentage of students graded as HD in N261 and N265, from 1995 to 2001, inclusive.

The evidence indicates that the online materials contributed to the increased number of HD's in N265, shown in Fig. 11.

6. Cost-benefit Analysis

An important part of this evaluation study was to determine the cost effectiveness of the online enhancements to N265.

6.1 Cost Modelling

Cost analysis was done using an activity-based costing approach proposed by Ehrmann & Milam (1999), as part of the Flashlight Project. The Flashlight costing model has seven steps:

1. Identify resource concerns and questions
2. Identify outputs
3. Identify activities to produce the outputs
4. Identify the academic support units
5. Identify the resources consumed by the academic units
6. Determine the costs of the activities
7. Tally the costs of the activities to give the output costs.

The model can be used to calculate costs for teaching with, and without, online resources for comparison. Initially, in this case, only the components of N265 that were impacted by the introduction of online laboratory resources were considered. The Flashlight methodology was translated into a spreadsheet model, with separate sheets for people costs, other direct costs, equipment costs, space costs and a summary calculation sheet. Within each sheet, the costs were calculated by identifying activities and tasks for each output.

The following sections work through each of the steps of the costing model.

6.1.1 Resource Concerns and Questions

The resource questions are concerned with correctly capturing the costs of providing the on-line resources, both development costs and ongoing costs.

6.1.2 Identify Outputs

In addition to the outputs of the traditional unit, the online enhancements provided two additional outputs: the web-based laboratory manual and the materials for the library assignment. These resources were additional to any existing resources. Students were still required to attend all the laboratories and lectures, and purchase all of the traditional notes and manuals. All the traditional teaching activities were still undertaken and the teaching staff and teaching time and resources were not reduced.

The additional online outputs were:

- The online laboratory manual;
- The online library manual;
- Other resources provided in WebCT (discussion group, glossaries, library assignment, access to student marks).

The laboratory manual included photographs of demonstration microscope slides and plant specimens, and digital videos of algae.

6.1.3 Identify Activities Required to Produce the Outputs

The outputs described in the previous section can be broken down into activities, and these can be characterised as initial *development* activities, and ongoing *maintenance* activities, as shown in Table 13.

Table 13. Development and maintenance activities identified in the costing model.

Output	Development Activities	Maintenance Activities
Laboratory manual	• Photograph material for manual • HTML Coding for web page	• Update manual each week • Annual review and maintenance
Library manual	• Convert manual to on-line format	• Annual review and maintenance
Other resources	• Add resources to web page	• Weekly monitoring • Annual review and maintenance

6.1.4 Identify Academic Support Units that Participate in these Activities

One person, employed at associate lecturer level, did all the work associated with developing and supporting the online teaching resources for N265.

6.1.5 Identify Resources that these Units Consume in their Activities

The development and support of the online material for N265 did not require any consumable resources, but there was significant investment in equipment to photograph and digitise the laboratory specimens, including:

- Electronic camera
- Microscope video mounts
- Video digitising unit
- Television monitor
- Personal Computer

6.1.6 Calculate and Tally the Costs for each Activity

The costs for developing the online materials in N265 had two components: people costs and equipment costs. These are summarised in Table 14.

The staff member dong the development work estimated the number of hours he spent on each of the activities listed in Table 13. These were multiplied by an average hourly rate, including on-costs, of $26 per hour. The people costs for developing the online materials are shown in the third column of Table 14, while equipment costs are shown in the fourth column.

Ongoing maintenance costs had a negligible equipment component, but are predominantly people-related.

Table 14. Estimated cost of each activity.

Output	Development Cost			Maintenance Cost[1]
	Total	People	Equipment	
Laboratory manual	$4,705	$3,380	$1,325	$962
Library manual	$321	$312	$9	$267
Other resources	$267	$260	$7	$348
Total	$5,293	$3,952	$1341	$1,577

[1]Almost entirely people costs

After an initial, grant-supported setup cost of $5,293, the annual maintenance cost of supporting the on-line material for N265 was estimated as $1,577.

6.2 Estimating Total Unit Costs

It is helpful to consider the costs of teaching the traditional components of the unit, to act as a baseline against which to compare the additional costs of the online enhancements to the unit. Table 15 identifies a number of areas requiring funding for the current teaching, including estimated costs for these. These costs were estimated according to the following assumptions:

- Lectures: 4 lectures a week for 13 weeks at an average Level C salary, including on-costs, of $43 per hour, as well as 4 hours preparation a week, at the same rate.
- Laboratories: 11 demonstrators 4 hours a week, plus 1 hour preparation time per class for 11 weeks, at an average Level B salary, including on-costs, of $36 per hour. 26.25 hours per week of technical staff preparation time was also needed.
- Marking time: 89.25 hours (40 minutes per student) at an average Level B salary, including on-costs, of $36 per hour
- Space rental: calculated according to figures provided by the Office of Facilities Management;
- WebCT: central support of WebCT system, calculated at a full cost-recovery rate of $12.50 per student, plus $100 setup costs;
- Unit consumables: amount budgetted for by Division for running costs not centrally funded.

Table 15 makes no estimates of costs for: pre-semester preparation for teaching the unit; school and university administrative overheads; provision for holidays and sick leave; personal and central computing equipment, consultations with students, etc.

Table 15. Estimated ongoing teaching costs for N265.

Component	Cost	% of whole
Lectures	$4,476	9.6%
Laboratory	$28,739	61.4%
Marking	$3,202	6.8%
Space rental	$4,798	10.3%
WebCT central costs	$2,013	4.3%
Online Maintenance	$1,577	3.4%
Unit consumables	$2,000	4.3%
Total	**$46,806**	

When the larger financial circumstances are considered, the costs of maintaining the online enhancements to N265 are approximately 3.4% of the total cost of running the unit. As currently conceived, the online materials are added onto the structure of the unit, and hence add, marginally, to the cost of running it. At the same time, however, evidence has been presented that the learning environment for students has been enhanced by the introduction of these materials.

Anecdotal evidence suggests that student consultations for N265 are now substantially less than for N261.

7. Discussion

The results reported in this report 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 study examined the nature and structure of Plant Diversity. Some valid, but relatively unimportant findings were:

- A close relationship was found between theory and practice in the unit.
- Although overall unit objectives were not explicitly stated, these were, somehow, understood by students.
- Some laboratory sessions were found to be too long, while others were too short.
- A tension existed between the terrestrial and marine streams. This has been addressed in 2002 by offering two separate units with some common lectures.

However, a further finding is fundamental to the success of the unit. The 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.

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" (1992, p164).

Independently of this research evidence, academic staff associated with the unit saw an opportunity to comprehensively redesign the unit, by introducing a common theme to the unit, reducing the number and nature of lectures, and giving students activities to do in the rest of their study time. 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.

A range of areas of improvement were identified:

- The introduction of the online materials made it possible to introduce an experimental, or manipulative, component to the practicals.

- WebCT usage was seen as appropriate, but could be expanded and enhanced, by adding self-tests for students, by using existing materials in the lecture component of the unit, and by increasing the use of video resources.
- CFL materials were not used in lectures, because appropriate technology was not consistently available in lecture theatres.
- Students are looking for more use of the discussion forum, and this could be built into the structure of the unit.

Learning Outcomes

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.

Students clearly prefer studying N261 Animal Diversity to N265, and an analysis of their performance over several years indicates that N261 has significantly higher pass rates and grade point averages. The survey and other data presented here supports the view that student motivation is the major factor in the differences between N261 and N265. If students are not interested in a subject, it is harder for them to motivate themselves to study the topic. They may invest more time in studying an interesting subject, and have lower success rates in the uninteresting subject.

However, since the introduction of online materials in N265 in 1999, N265 grades have trended towards those in N261. This has been caused by an increase in the number of high distinctions in N265.

Cost-benefit Analysis

A cost benefit analysis was carried out. The initial setup cost of $5,293 was funded by a grant. Annual, ongoing maintenance cost of supporting the on-line material in N265 are estimated at $1,577. However, the total cost of running the unit was estimated at $46,806. Maintaining the online materials is only 3.4% of the total cost of the unit, and the previous analysis has indicated its benefits. It could be argued that the largely intangible benefits of improved student motivation and performance outweigh the costs of providing the online materials.

Evidence has been presented that the learning environment for students (and staff) could be enhanced by re-engineering the unit to become more student-centred, and less content-oriented. As part of this re-engineering, there is the potential to replace content transmission through lectures with seminar sessions, and to support problem-solving with online resources. In such a case, the online materials would become integral, rather than supplementary, and cost savings can be made by reducing other aspects of the financial equation.

This study 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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10. Appendices

Appendix A. Human Research Ethics Approval Form (Form A).

Appendix B Student Questionnaire

Student Survey Questions

1. What are your main reasons for studying this unit?
   Required course
   Interest
   Relevant content
   Useful skills
   Other

   If you chose Other please elaborate

2. What do you expect to gain from this unit?

3. How do you feel N265 relates to your whole degree/program of study?

4. What do you think you are expected to learn in this unit?

5. How closely linked do you think the practical and theoretical components of Plant Diversity are?

   Very closely linked
   Closely linked
   Not closely linked
   Not linked at all
   Don't know

   Please comment on your answer, ie, How are they linked?

6. What do you like most about Plant Diversity?

7. Are there any areas of the course which you think could be improved?
   Yes No

   If you answered yes, please suggest how the course could be improved

8. Do the lecturers use any of the WebCT material in classes?
   Yes No Don't know

9. Do you use WebCT for Plant Diversity?
   Yes No

   If No, why not?
   Not accessible
   No computer
   Do not know how to use WebCT
   Not useful
   Other

   If you chose Other please elaborate

10. Why do you use the online material? (Please select as many as apply)
Revision
Preparation
Confidence
Interest
Nice graphics
Help writing up lab reports
Convenient
Other
Did not use it

If you chose Other please elaborate

11. Did you find the online material useful?
Yes No

12. Does the online material help you to understand the course?
Yes No

Please comment on your answer.

13. Do you feel that, because of the online content, you have less need to attend lectures?
Yes Perhaps No

14. Do you feel that, because of the online content, you have less need to attend laboratory classes?
Yes Perhaps No

15. Do you feel that, because of the online content, your lab time is used more effectively?
Yes Perhaps No

16. Do you feel that, because of the online content, your confidence with the lab material is greater?
Yes Perhaps No

17. Do you feel that, because of the online content, the unit is easier?
Yes Perhaps No

18. Do you feel that, because of the online content, you are learning more effectively?
Yes Perhaps No