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# A Green Computing Professional Education Course Online

*Designing and delivering a course in ICT Sustainability Using Internet and eBooks*

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**Abstract**—Sustainable ICT Courses are being introduced at the vocational training level and more rarely at undergraduate and graduate levels. This paper reports on a graduate level Sustainable ICT Course run for the first time in 2009, as part of a global professional training program. The same course has been run at an Australian university and later adapted for North America by a Canadian university. The course had enrollments from industry based participants from both private and public sector organizations, as well as full time university students, with corporate Green ICT strategies being produced as course assignments. This paper discusses the student population and presents the course structure and assessment. An empirical evaluation of student responses, conducted at the end of the course, has yet to be completed, but some impressions of the differences in responses from graduate students and external participants is presented.

**Index Terms**—Sustainable ICT education, postgraduate studies, climate change, greenhouse gas emissions, e-learning, work integrated learning

## I. INTRODUCTION

A carbon emissions audit reported in 2007 that 1.52% of the total national emissions in Australia were attributable to computers and telecommunications equipment [1]. In response, the Australian Computer Society (ACS), commissioned an e-learning course in “Green ICT”, to train professionals in how to measure and reduce CO<sub>2</sub> emissions. The course was designed as part of an education program which uses a constructivist approach to education, derived from that of the UK Open University [2]. It was first run as part of the postgraduate masters level program in February 2009.

## II. ABOUT THE COURSE

### A. Rationale and Format

The ACS Computer Professional Education Program [3] consists of three core, compulsory subjects and one elective subject. Green ICT was added to the electives, using the same course format as other subjects: On-line content provided for 12 weeks of student work, with weekly text based discussion

forums and two assignments.

The course covers how to assess, and develop a strategies to reduce, the carbon footprint and materials use of the ICT operations of an organization. This is in the context where computers and telecommunications are threat to the environment through increased electricity consumption (leading to carbon emissions and global warming) and increased toxic waste from rapidly obsolete equipment. Students are expected to have a degree in ICT. Those completing the course are expected to be preparing carbon accounting reports for organizations, including those required under carbon accounting legislation.

The course objectives and assessment items are based on the skills definitions for “Sustainability Assessment” and “Sustainability Strategy” at level 5 of the Skills Framework for the information Age [4].

The course has been run by the ACS with students who are working in the ICT industry, by the Australian National University [5] for masters students of ICT/ Engineering and adapted for North America for Athabasca University Canada [6]. This paper concentrates on the course as offered by the ANU.

### B. Use of Open Access Material

The course notes used by ACS students were released under a Creative Commons open access license. This allowed the material to be revised for use at the Australian National University in July 2009. This version was then further revised and used for ACS students in the next semester. This approach allowed the more rapid revision of material than would be possible with a conventional textbook, and with more resources available than if the notes were just used by one institution.

As the notes evolved, it became clear that some of the administrative procedures would need to be separated from the subject content. As an example, different educational institutions use different assessment procedures, such as grading scales and proportion of marks for weekly work and assignments. The use of the Learning Management System (LMS) made it possible to remove the administrative detail from the course notes and rely on them being available from other

documents in the system. This also removes some burden from the student to have to read through the same standard material for each course they are undertaking: if the student can see it is the same link from the LMS for all courses, then they need read it only once.

While it may seem useful to have requirements for an assessment to be as detailed and specific as possible, this may not be the case. Courses which are part of an overall program should have consistent requirements. Thus it should not be necessary to restate the details common to all assessment in every assessment item or in every course. This is particularly the case where a LMS is used. The National Quality Council [7] include the details of how assessment is to be recorded in their "Ideal Characteristics of an Assessment Tool", which can be dealt standardised by the institution by using an LMS.

### C. BCS Certificate in Green IT Examination

Shortly after the ACS Green ICT course commenced, the British Computer Society (BCS) introduced the BCS Certificate in Green IT Examination [8]. The syllabus for the BCS certificate is largely consistent with that of the ACS course. However, the assessment and education methods for the BCS are very different.

The BCS certificate is designed to be delivered by accredited training providers in intensive mode, as 18 hours of lectures and practical work, over three days. This is followed by a one hour, closed book examination with 40 multiple choice questions. There are optional modules for region specific legislative requirements (European, UK or Australian), but this material is not assessed by the examination.

## III. ASSESSMENT IN THE COURSE

Assessment is by contribution to weekly forums and two written assignments: mid semester and at the end of the course. The weekly forum questions are at the end of each week in the course book. The assessment scheme, assignment questions and rubrics are in the assessment appendix of the book.

The tutor is key to this form of e-learning. In the introductory posting for the course, the tutor is required to point out where the assessment items are and explain that the rubric are based on the generic one of the institution: weekly forum assessment is a limited fail, pass, credit scale and the assignments the full scale. Each week the tutor should post each question for that week as a forum topic, so the students can post their answers in that thread of discussion.

In the weekly forum posting for the course, the tutor should provide an example of a good posting, suggest areas for general improvement. The tutor should also remind students how many weeks there are to the next assignment being due and that the weekly forum questions are designed to be used in the assignments.

In the weekly individual feedback to students (via the Dialogue tool of the LMS, not email), the tutor must provide a

mark for that week and at least one example of a good posting by the student and one suggestion for an improvement to a posting. If there are no postings from a student for a week, they should be reminded by the tutor that participation is compulsory and after two weeks, the program supervisor should be advised.

For at least the first two weeks of the course, formal referencing of sources should be required for all forum postings. Those students who do not correctly reference, or who copy material without attribution, should be given a mark of zero. After two weeks the tutor can use their judgment as to if it is necessary to continue this practice.

Two weeks before the assignments, students should be reminded that sample past papers are available from the "Assessment Exemplar" link on the LMS. Students should be reminded that they can submit an official document from their workplace as their assessment item, provided they undertook the work and have approval from their workplace (any national security or commercially sensitive details should be removed from the document before submission). For the first assignment students who do achieve a Pass mark due to poor referencing should be referred to the student support centre, for individual assistance and offered a resubmit after two weeks.

The assignments should be marked with reference to the rubric, first determining what grade is warranted and then the mark within the grade. Marks are not allocated to individual aspects of the work and no summation is carried out. The examiner can use a copy of the rubric as feedback to the student, with relevant comments indicated by highlighting phases in the rubric (this can be done with an electronic document returned via the LMS).

### A. Making Students Pay Attention to Formative Feedback by Combining it with Assessment

Conventional educational theory suggests that formative feedback should be provided to students to help them improve. This should be in addition to summative assessment for the final grading for a course. However, students pay far closer attention to marks than they do to tutor feedback. The practice experience of this course is that a weekly mark of 2% accompanying the feedback is sufficient to have the students pay attention to what they are being told by the tutor.

### B. Authentic Assessment Tasks

Gulikers, Bastians and Kirschner [9] define an authentic assessment as:

"... one which appropriately reflects the competency that needs to be assessed and that it represents real-life problems of the knowledge domain being assessed and that the thinking processes that experts use to solve the problem in real life are also required by the assessment task."

The course requires students to prepare reports typical of a workplace setting. This contrasts with the multiple choice test used by the British Computer Society for their “Foundation Certificate in Green IT” [8]. An IT practitioner is unlikely to be asked multiple choice questions as part of their daily job.

Students are encouraged to answer all assessment items from the point of view of their workplace (or one they are familiar with), making them more authentic to the student. The assessment items are based on official international skills definitions from the professional body, and so are similar to real tasks. The student as are required to make real calculations based on a real world situation, requiring the students to demonstrate mastery. As both the course content and assignments are based closely on skills definitions and practice standards, there is a clear alignment between learning outcomes, course content, assessment and professional knowledge. Workplace skills are integrated by the student being encouraged to submit a real report from their workplace, in consultation with their supervisor. The weekly questions and feedback are intended to show how the assessment helps with learning.

The assessment methods are not without problems. The emphasis on written reports can be difficult for computer science students, particularly international students with English as a second language. Students may be used to only writing computer code and mathematical equations and be assessed by multiple choice questions. This may be the first time the student has to have write a 2,000 word assignment. This may be considered biased against international students. However, these students will be required to undertake such tasks in the workplace. The amount of assessment proposed is consistent with the 5000 words of assignment set by University of Melbourne [10]. The use of short weekly tasks and two major assignments provides a balance of tasks. The weekly feedback provides timely advice to students to help them before the assignments.

The assessment for the course is integrated into a fixed weekly curriculum, as a result there is limited scope for negotiation of the format and timing of assessment. Institutional rules normally allow for special consideration of students with special needs and that will be required. However, in the workplace, missing a deadline is not acceptable and so it is argued that late assessment submission should not normally be accepted.

No self, peer or client assessment has been included in the course. The ACS is currently considering client assessment, with students asked to have their supervisor sign off on assignments. However this could cause bias for some students.

The course is interdisciplinary, as it requires some aspects of climate science, business management and procurement policy. However, a wide range of topic can be difficult for an IT specialist to master in one course. Buckley and Exton [11] point out that IT professionals programmers tend to focus on knowledge for a particular task (at the Application level of Bloom's cogitative levels) and may need prompting to operate at the higher levels of Analysis, Evaluation and Synthesis.

#### IV. EVALUATION OF THE COURSE

The ANU conducts standard student evaluations of each course run. The “Student Experience of Learning Support” [12] has a set of eight questions asked about each course. For e-learning, there is a set of six “Student Experience of Teaching: Blended/Online teaching” questions.

##### A. Standard Questions

These are questions for each student, to assess the student's view of the course content, materials and delivery means:

TABLE I. STANDARD STUDENT FEEDBACK QUESTIONS

Question Number	Question	Answer Type (Multiple Choice or Free Text)
1	I had a clear idea of what was expected of me in this course.	Multiple Choice
2	The teaching and learning activities (eg. lectures, tutorials, field trips) supported my learning	Multiple Choice
3	I had ready access to the learning opportunities provided in this course (eg. course notes, online materials, library resources, field trips)	Multiple Choice
4	The assessment seemed appropriate given the goals of the course	Multiple Choice
5	The feedback I received during the course supported my learning	Multiple Choice
6	Overall, I was satisfied with my learning experience in this course	Multiple Choice
7	What are the most notable strengths of the course?	Free Text
8	What suggestions for improvement would you like to make?	Free Text

a. Multiple choice answers: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree, Not Applicable

##### B. Blended/Online teaching questions

These are questions are to assess the teaching method, where on-line teaching (or a blended mode of on-line and classroom teaching) is used:

TABLE II. STUDENT FEEDBACK BLENDED/ONLINE TEACHING QUESTIONS

Question Number	Question
1	The facilitator/lecturer taught in a way which supported my learning.
2	The facilitator/lecturer taught in a way that challenged me intellectually.
3	The facilitator/lecturer incorporated an appropriate level of flexibility in the course
4	The facilitator/lecturer used educational technologies in ways which supported my learning
5	I had sufficient feedback to be able to assess my progress during the course
6	1.The facilitator/lecturer actively encouraged student participation (such as questions and discussions)

## ISSUES WITH THE COURSE

### *Localization of Content*

An issue for the course is if it should be tailored to each country's requirements, or can be one international syllabus. The BCS include supplementary material for different countries in their green ICT program, but do not test this in the examination. Athabasca University have included North American content in their version of the ACS course. The views of the industry panel would be sought on this issue along with the responses of the students.

### *English Language Requirement*

An English Language Competency score [13] of at least IELTS 7 for Academic Reading and Academic Writing is required. Computer use proficiency equivalent to the ECDL / ICDL certification program modules: 2 "Using the Computer and Managing Files", 3 "Word Processing" and 7 "Web Browsing and Communication", are required.

### *Published Formats*

The course was originally prepared using the web based course authoring tools in the Moodle Learning Management System (MLS). The ACS, ANU and Athabasca University all use the same LMS, allowing simple transfer of the courseware between systems, via the Moodle backup and restore function.

The first version of the course used a separate web document for each of the twelve weekly topics in the course. However, this created a maintenance burden and was confusing for the student. The materials were therefore all consolidated into one web based eBook, using the Moodle "book module" function, with one chapter per topic in the book.

The course content was exported from Moodle in HTML format and converted to Amazon Kindle and ePub eBook formats, as well as PDF, a standalone web site and a print-on-demand paperback book [14]. However, provision of the notes within the LMS has proved more popular with students and simpler to maintain.

## V. CONCLUSION

A sustainable ICT course can be provided on-line at the graduate level. Such a course can be provided internationally

both to industry participants and full time university students. Work integrated learning can be used, with students producing , green ICT strategies for their workplace as part of a course. However, further work is needed to provide an empirical evaluation of student responses to such courses.

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