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Journal of Cleaner Production 14 (2006) 906–915
Journal of Cleaner Production
www.elsevier.com/locate/jclepro

Meeting lifelong learning needs by distance teaching – Clean technology

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Received 1 August 2005; accepted 1 November 2005
Available online 9 March 2006

Abstract

The role of education and training is increasingly implicit, if not explicit, in environmental legislation and in management system standards. The consequence of these pressures is that organisations must develop their personnel for continuous improvement in environmental performance. Continuing professional development is a lifelong activity that can be supported by distance learning. Some approaches to this are described including various electronic resources, but all emphasise the broad range of issues that come into environmental decision making. The approaches also reflect the growth in corporate environmental reporting and the disclosure of environmental performance indicators. Performance measures of different media are outlined, while the efficiency, especially in relation to energy use, makes distance learning an application of cleaner production principles.

Keywords: Distance learning; Sustainable development; Environmental decision making; Environmental management; Energy efficiency

1. The need for environmental education and training

Most societies desire economic development to secure higher standards of living for current and future generations. They also seek to protect and to enhance their environment, the source of most resources. Cleaner production has an important part in the prevention of pollution. This is acknowledged in legislation such as the Integrated Pollution Prevention and Control (IPPC) Directive of 1996. Essentially, the IPPC Directive is about minimising pollution from various point sources throughout the European Union and human factors have an important role to play in implementing cleaner production. While jurisdictions outside Europe are not regulated under IPPC principles, the evolution of environmental legislation demanding cleaner production makes the need for such education universal.

All installations subject to IPPC are required to obtain permission from the appropriate regulatory bodies in the Member States. Unless they have a permit, they are not allowed to operate. Permits must be based on the concept of Best Available Techniques (BAT), for which the UK interpretation of techniques includes:

> **The Pollution Prevention and Control (England and Wales) Regulations 2000, Statutory Instrument 2000 No. 1973, ISBN 0 11 099621 6**
>
> … 'Techniques' include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

The human factor is clearly evident in this interpretation, and the regulations [1] emphasise this further through statements such as:

As with all aspects of pollution control, energy management requires specific skills and competencies in technical,

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doi:10.1016/j.jclepro.2005.11.050

financial and managerial fields. It is essential that staff have the appropriate skills in the areas of energy management for which they have responsibility, and that these skills are maintained and developed through training and continuing professional development.

The National Vocational Standards for Managing Energy are a statement of national best practice in managing energy and can be used as a Code of Good Practice. This can be useful especially where the energy management function is not carried out by a single person, as the standards can be used to align individual units with organisational roles to ensure that the entire organisation is being addressed.

Management and operator training are clear requirements for permits, but there are further demands for training. Guidance on Pollution Prevention and Control [2] indicates the regulator's view on the desirability of Environmental Management Systems.

> Under IPPC, some operators will apply environmental management systems at their installations, certified to either the EC's Eco-Management or Audit Scheme 'EMAS' or to ISO 14001. Regulators should encourage and take account of these standards, as both requires that the management system include safeguards for legal compliance and a commitment to continuous improvement in environmental performance which fits well with IPPC. The increased transparency of external certification required by EMAS and ISO 14001 should therefore help to establish and maintain the operator's competence and the adequacy of the installation's management.

Training forms an important element of recognised environmental management systems.

Other specific training needs are identified in examples such as [3]:

> 2.2. Education and training
>
> The organisation should acknowledge the need for continuous staff information and training on environmental issues. Basic information and training should be given to all employees. Training of management is also an essential part in managing changes.
>
> Employees who are more directly involved in the environmental management of the organisation through for example participation in joint working groups, should be given a more extensive upgrading of their qualifications. Such upgrading should consist of, but not be limited to, EMAS, environmental policies, best practices and communication.

It is clear that there is no escaping the need for education and training of people to meet these employment needs with 'best practices' often embracing both cleaner technologies and human factors. These education and training needs about environmental management and technology must be considered across the whole life cycle (from cradle to grave), and lifelong learning is essential to keep pace with developments. A question that remains is how can the transfer of knowledge and skills be done efficiently and effectively?

2. Producing competent environmental decision makers

In an examination of education and training in relation to environmental protection, the need was identified to help graduates evolve into 'leading problem solvers'. In this context, Porteous and Barratt [4] observed that too often the needs of employers were not always met in terms of the abilities of graduates of educational establishments. Why is this? Dominik et al. [5] suggest that most engineering has environmental aspects but the general education of engineers in natural environmental sciences and global environmental problems may be limited. Likewise, environmental education in technical universities often puts a focus on technological aspects and local impacts. They suggest that teaching focuses on finding solutions for immediate environmental problems (energy efficient technologies, waste management, clean-up) while neglecting a broader look at the global environment. Environmental curricula in other universities teach natural or socio-economic aspects of environmental science according to faculty. While specialisation is logical and desirable, students need to understand the more technical aspects of environmental protection and management including technical limitations and economical viability of projects. At the higher level, the Royal Commission on Environmental Pollution [6] recommended that environmental control specialists were best produced by conversion of graduates in science and engineering disciplines. In this way, graduates can build on a sound technical foundation by acquiring the socio-economic background. Practical experience is clearly essential, but much can be done for conversion by the distance-learning route as will be demonstrated shortly.

2.1. Standards for environmental management training

In the UK, vocational standards for energy management were developed by the Management Charter Initiative as noted earlier. Similar standards for environmental management included the principles of good practice set out below. These standards were defined by examining what practitioners actually do in their places of work, and were produced after consultation with people in several hundred organisations ranging from major manufacturing companies to organisations in the public sector. The common denominator was that all organisations operate in the environment and have activities with an environmental impact. The standards covered the full range of activities which those responsible for environmental management were expected to carry out.

Cleaner production is implicit in these principles. In addition, the vocational standards identified a number of personal competencies for environmental management, including:

- Acting strategically
- Behaving ethically

- Communicating
- Influencing others
- Searching for information
- Thinking and taking decisions

These principles take further the points raised earlier that all individuals have a responsibility to identify problems and to participate in solving those problems. All are useful components that any course aiming to train people for careers in environmental performance management should recognise. They may be translated into relevant criteria for managerial and operator training and highlight the continual process of professional development that mirrors the continual cycle of improvement required in environmental management systems (Table 1).

3. Translating training needs into action by distance learning

Distance learning offers one route to education and training in relation to cleaner production. Pretorius [7] cites various references placing distance education in the context of a teaching and learning process in which the educator and learner are removed from each other in time and space and which typically involves a combination of different media. He points out that this form of education is no longer viewed as a 'second class' option.

Burt [8] made a detailed assessment of the relative merits of face-to-face against distance teaching. He observed that a minimalist definition of distance education identifies it as education that occurs at a distance, with a relative absence of face-to-face communication. Modern information technology makes distance education less distant. More meaningful debate centres on whether the medium has a certain form, involves technology and includes interaction, independence, openness and critical reflection. All are enabled by distance teaching and increasingly conventional universities embrace elements of distance media.

Table 1
Examples of training requirements of environmental management systems standards

ISO 14000 Environmental management systems	Eco-management & audit system [Council regulation (EEC) No 1836/93]
Identify training needs	Identify training needs
Provide appropriate training to employees related to significant impacts	Provide appropriate training for all personnel whose work may have significant effect upon the environment
Raise environmental awareness of employees at all relevant levels of: • conformance with policy; • impact of their work; • benefits of improved personal performance; • consequences of poor performance.	Ensure employees are aware of importance of • compliance with environmental policy; • environmental benefits of effective job performance; • potential consequences of inadequate job performance.
Ensure personnel performing specific tasks are competent	Maintain records of training.
Ensure contractors have requisite training	Ensure contractors are made aware of requirements and provisions

Building on this definition we can identify that distance learning as an approach to teaching has distinct advantages.

- It contributes to the professional and career development of individuals while allowing them to remain in full-time employment.
- Students study at their own pace, integrating and balancing learning with their job.
- Employers gain from the increased knowledge and skills of staff without releasing them for long periods.
- Distance learning can be integrated within an organisation's own training programme or with other options.
- Distance learning is more cost-effective than conventional teaching, and offers high quality educational experiences drawn from many experts and reflecting international best practice.
- Company training using open learning can be 40% cheaper than conventional training [9].
- Access barriers to conventional training can be removed.
- Location presents few barriers.

In addition, and in the context of cleaner production, a recent study [10] found that, on average, the production and provision of distance-learning courses consumed nearly 90% less energy, and produced 85% fewer climate changing carbon dioxide emissions than conventional full-time campus-based university courses. The much lower environmental impacts of distance learning compared to campus-based courses is mainly due to a major reduction in the amount of student travel, economies of scale in utilisation of the campus site, and the elimination of much of the energy consumption of student housing. The study also compared e-learning courses to print-based distance-learning courses and found that e-learning courses offer only a relatively small reduction in energy consumption (on average 20%) and CO_2 emissions (12%) over print-based distance-learning courses. This was attributed to high student use of networked computing, consumption of paper for printing of web-based material, and additional home heating for night-time Internet access. This study challenged claims about the 'dematerialisation' effects and environmental benefits of using ICT to provide services such as higher education. The environmental impacts of a service depend mainly on its requirements for travel and a dedicated infrastructure of buildings and equipment. The use of ICT or other methods will only benefit the environment if they reduce the service's requirements for energy-intensive transport, dedicated equipment and heating and lighting of buildings. Distance education can do this and is, therefore, an approach that offers many opportunities and efficiencies. It can help avoid some of the seemingly 'wasteful' aspects associated with conventional approaches to education and training.

3.1. Course choice

The Open University offers many environmental courses that may be taken in isolation to satisfy specific professional development needs. Several courses from the undergraduate

programme from the Faculty of Technology may be combined leading to a Diploma in Pollution Control as well as to a BSc degree. Fig. 1 indicates some of the courses, each of which is identified by a characteristic code number for brevity. Features of the first year undergraduate course are described elsewhere [11].

The postgraduate programme in Environmental Decision Making is also indicated in Fig. 1. This programme is aimed directly at the needs of environmental professionals.

One course in this programme, *Enterprise and the Environment* (T862, former version T830), is based very much at the level of businesses and has a focus on pollution prevention and clean technologies through resource efficiency, but in the context of socio-economic and management systems frameworks. The course assessment often uses current literature to develop and assess skills in critical reading of the technical literature and some of the issues it raises link directly to the course materials.

For example, a recent paper from this journal [12] provided an excellent focus for tutor marked assignments (TMA) as indicated in Table 2.

Such papers place course materials in a practical context and reflect the complexities of real problems. For example, the authors of the cited paper suggest that environmental and economic trade-offs that are difficult to assess objectively are sometimes needed. Students have to discuss this view in the context of the course and other relevant issues in the paper dealing with value judgements. They also need to take the discussion further by concentrating on the subjectivity inherent in

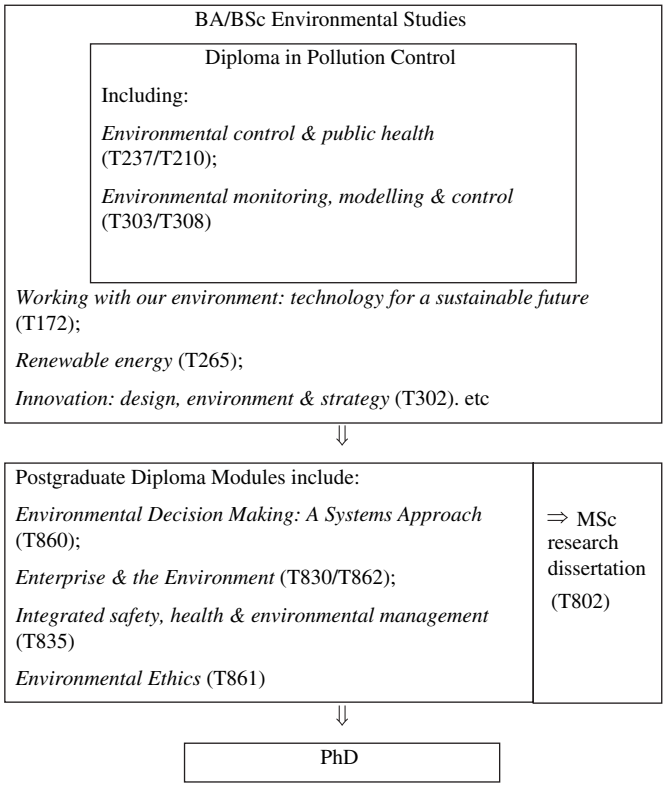

Fig. 1. Some contributions from the Technology Faculty to an environmental curriculum (course code shown in parentheses).

Table 2
Linking the *Journal of Cleaner Production* paper to course content and assessment

Themes from the paper [12]	Course context
• 'Sustainability is a concept that is better suited to poetic, rather than specific, interpretation'	Assignment 1 questions relating to issues in Block 1 – WHY are environmental issues important to organisations?
• Environmental and economic trade-offs • Industrial ecology • Environmental effects • The application of economic metrics for environmental decision making	
• System boundaries and limitations of thermodynamic metrics	Assignment 2 questions relating to issues in Block 2 – WHAT can be done technically to ensure that energy and raw materials are used efficiently?
• Whether energy efficiency can be a measure of sustainability • Product 'dematerialisation' • 'Material efficiency' • Designers may optimise for any number of criteria and that different objective criteria will likely result in different designs.	
• Difficulties of integrating indices in life cycle assessment is clearly demonstrated in the paper by Seager and Theis	Assignment 3 questions relating to issues in Block 3 – HOW to make it happen by appropriate risk assessment and management and the use of environmental management systems, life cycle assessment and corporate environmental reporting.
• Taxonomy of metrics • Climate forcing impacts	

many environmental problems, and the balancing in environmental decisions.

Later in their paper, the authors use the term 'material efficiency' without qualification. Students are asked to define this term and discuss the difficulties in using this as a metric to promote recycling.

3.2. The scientific method vs environmental problem solving

Recalling the need for environmental professionals to be practical problem solvers, it is appropriate to consider some implications for what this involves. The scientific method is a fundamental technique for practising science and involves collecting facts, but this is merely accounting. The science comes in the systematic examination and ordering of the facts, from which we may see patterns, and be able to explain what is happening. We may then test the hypothesis by further experiments and ultimately produce a scientific law that explains what will always happen. The process is essentially organised common sense. This approach extends beyond the realms of

pure science, and applies, in part, to many problems of the environment and its management, but there is a fundamental difference. The scientific method produces an exact solution to a problem, but the environmental problem solving solution is not exact, and many other solutions could be equally effective. A clear expression of this is recognised in the interpretation of 'best available techniques', which may often involve clean technologies, but there is not necessarily a single 'best'. This example also demonstrates the essential difference between problem solving and decision making, which some regard as the same process. It is not unusual for several apparently equal solutions to be possible for an environmental problem, and this creates the need for decision making. Even where only one solution is apparent, there remains a decision of whether to apply or to reject the solution.

Practical pollution problem solving covers a wide range of situations, and with the advent of environmental management systems, this aspect is essentially anticipatory. It forms part of the corporate risk management strategy and involves identifying where improvements can be made to avoid future pollution problems. This approach is evident in the trend towards environmental auditing. This concept implies identifying potential problems before they occur, and so environmental decision-making education must deal with this anticipatory aspect as well as solving pollution problems already in existence. In terms of solving the problem, many may be able to suggest viable options, but this approach can be inefficient and expensive. The ideal is to have sufficient insight to the problems that make up a situation, and then to match against practicable solutions and often these solutions involve clean technologies. Both practitioners and educators face great challenges in meeting these demands, and project work based on real-life issues can be useful here. However, a central problem with environmental auditing is its inability to quantify compound externalities (the problem of sub-optimization). It is therefore appropriate for Seager and Theis [12] to compare the process leading to sustainability as 'poetic' as opposed to scientific and for students to be exposed to such views.

Several of the courses shown in Fig. 1 include practical projects. Fig. 2 links the range of project options with resource provision and has the Technology courses placed within it, although their locations are not absolute.

Bearing in mind the absence of a single best answer to many practical problems, open-ended challenges are appropriate at higher levels. The scope of these, ideally real-life, problems should be sufficiently broad to give a variety of options for approaching them, and for potential solutions. They should also be of interest and relevance to ensure motivation, but not be so demanding that the best students cannot make reasonable progress within a prescribed time period.

The strong skills orientation of T862 and T835 serve to illustrate the fit within the overall curriculum. Students need to have gained practice in independent learning, which they can do through studying a range of courses, and some familiarity with computer use, which is adequately provided by level 1 courses in Maths and Computing or Technology although this is far from essential. In distance teaching we are often dealing with adults with considerable and varied experience and knowledge. Students on these courses are required to 'audit' an organisation of their own choice using appropriate skills from the teaching material. However, some students do not work in organisations that readily lend themselves to such activities within the course timescale. Moreover, practical problem solving is often a multi-disciplinary activity and

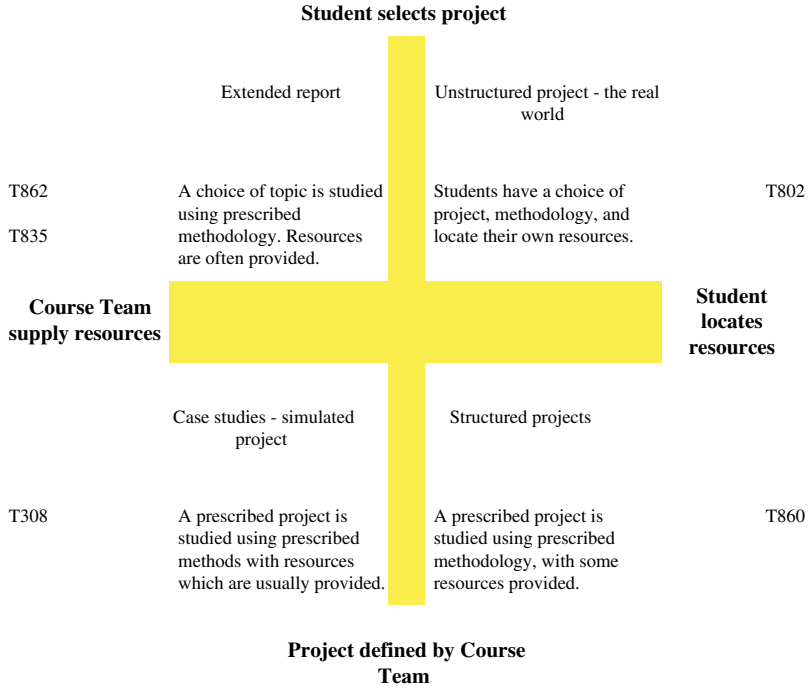

Fig. 2. A taxonomy of project options.

this cooperation can be developed through the medium of computer conferencing.

This addresses the pedagogical concept in the social constructivist approach that learning involves an active social process, students constructing and validating newly acquired skills and knowledge by engaging in dialogue with fellow learners, tutors and experts raised in studies such as that by Timms et al. [13]. They note that simply delivering course materials over the Web involves student experience that may be 'little more than (sophisticated) page turning'. By contrast, conferencing offers the potential for feedback from several people, each with their own expertise. In addition to general course conferences, T862 seeks to develop such group activity through the analysis of corporate environmental reports, and students can readily gain access to such documents. Students select their own organisation for study and compare their findings with those of their peers using the conference facilities. This can provide opportunities for different interpretations from content analysis of the same report as well as allowing comparisons in and between industry sectors. It also provides an appropriate alternative to the conventional business-based project.

An indispensable facet of environmental management is the ability to form, work within, and maintain productive relationships, within and outside organisations. Understanding how to work with Government, various environmental and social NGOs, and most importantly, within the organisation is a prerequisite to any effective environmental management strategy. While distance learning can offer an economic incentive to educational institutions, and can be effective in many fields of study, it cannot replace the complex, subtle and indispensable interactions between people. However, it can provide a powerful tool to augment any environmental management study and can be made accessible through many programmes, internationally.

4. Quality in content and delivery

The Open University approach involves supported distance teaching methods, with emphasis on the support element provided by tutors during the presentation of a course. Communication channels are provided by mechanisms such as tutorials, telephone, and an e-desktop, with access to electronic resources, library facilities and so on (Fig. 3). Quality during presentation is maintained by systematic monitoring of the work of tutors to ensure accuracy in assessment and appropriate distance teaching techniques. The course approval and development systems at the Open University are rigorous, and all proposals are closely examined in relation to educational objectives and the means of achieving them. The course team approach to course development involves constructive criticism of draft materials before professional editing. All courses are assessed externally before presentation, and have an external examiner during presentation.

5. Other environmental training resources

The Open University has also developed several packs on environmental issues. Packs do not usually include an element of assessment to measure student performance.

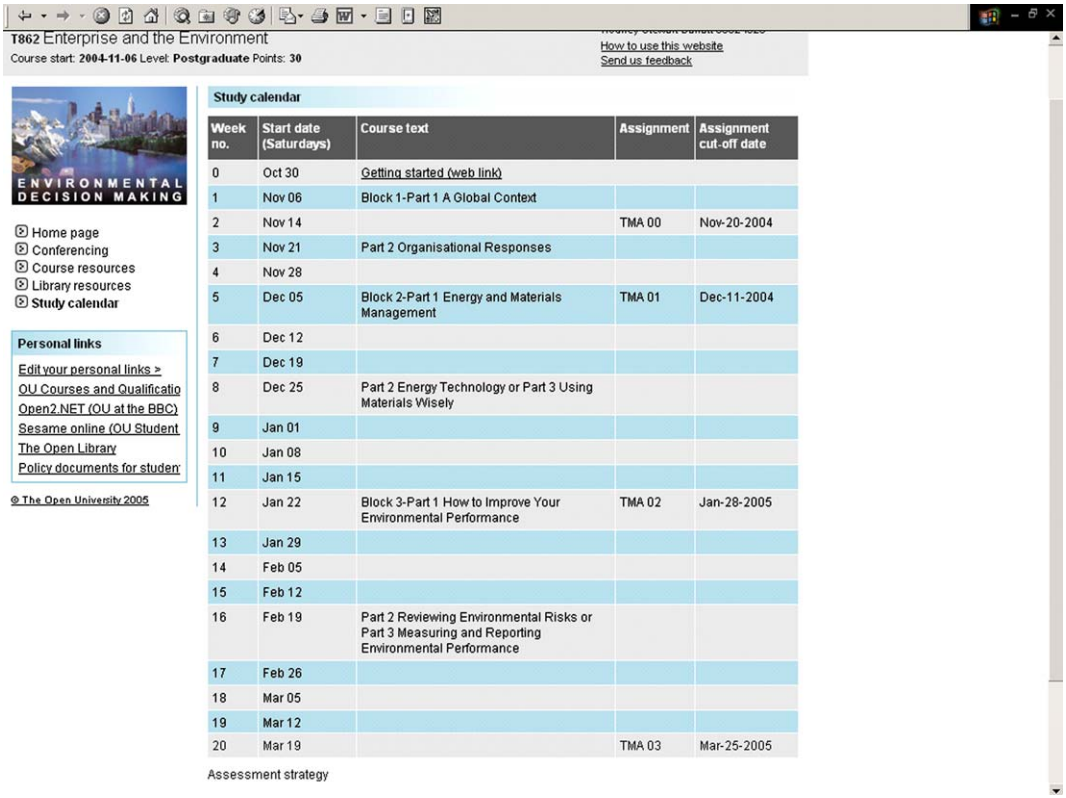

Fig. 3. The e-desktop for enterprise and the environment.

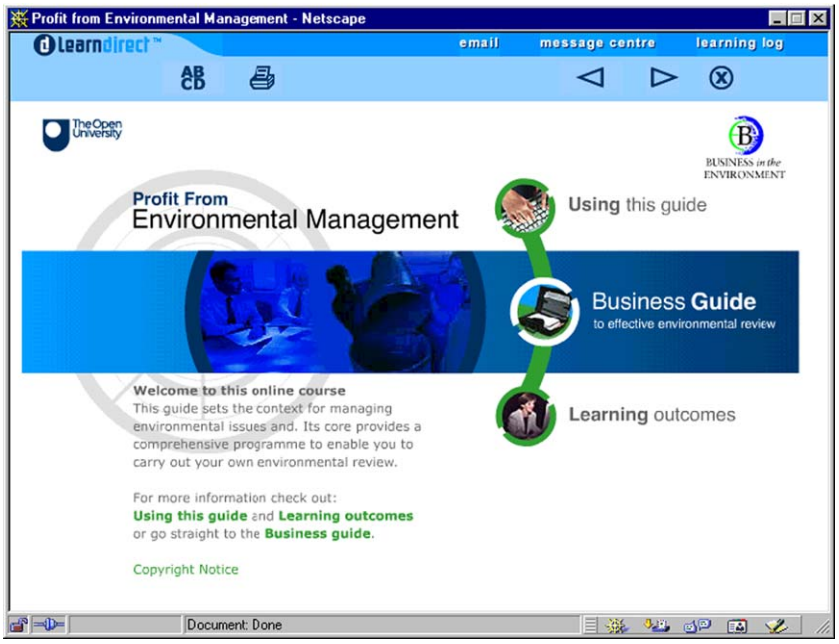

Fig. 4. Learndirect commissioned an online version of 'Profit from Environmental Management'.

A pack on *Renewable Energy* was developed as a resource for higher education, and received awards for its innovative approach. It evolved to form T265 identified in Fig. 1. Another pack on *Waste management* was supported by landfill tax funding, demonstrating the role of economic instruments in environmental protection and the recycling of such taxes into environmental education.

Profit from Environmental Management was a pack released in May 1995 as a training resource to enable small and medium enterprises to carry out an environmental review as they work towards developing environmental management systems. Developed in association with Business in the Environment, the production of this pack was supported by funds from a consortium of large businesses, including IBM, Glaxo-Wellcome and Lloyds Bank, as well as by the Department of Trade and Industry and several Training and Enterprise Councils. *Profit from Environmental Management* subsequently formed the basis of another approach to distance teaching through the University for Industry. This UK government initiative for lifelong learning uses online media offered through the service known as Learndirect. The original pack was updated and converted to a Web-based training resource (Fig. 4) linked to the vocational qualifications.

For completeness and in full recognition of lifelong learning, it is also appropriate to mention another landfill tax funded initiative to develop '*Wicked waste*', a teaching resource for schools that emphasised the importance of efficient resource use (Fig. 5). Environmental awareness often involves changing the culture in organisations. Developing this awareness at an early age is important. Through this pack, issues about resource utilisation, recycling and waste are linked to literacy and numeracy modules in the school curriculum.

These examples illustrate the growth of electronic resources in environmental education and training. They also reflect the growth of 'green' information technology through the growth in corporate environmental reporting on the Internet and the disclosure of environmental performance indicators. The level of staff training will be increasingly visible, and is one environmental performance indicator that cannot be ignored.

5.1. So how successful is distance teaching?

The Institute of Educational Technology at the Open University regularly evaluates the performance of courses and carries out research on student experiences as adult distance learners. A survey of several courses in the environment curriculum depicted in Fig. 1 was carried out [14] by seeking student responses using a four point scale with a range from

Fig. 5. Opening screen from the *Wicked waste* CD-ROM for schools.

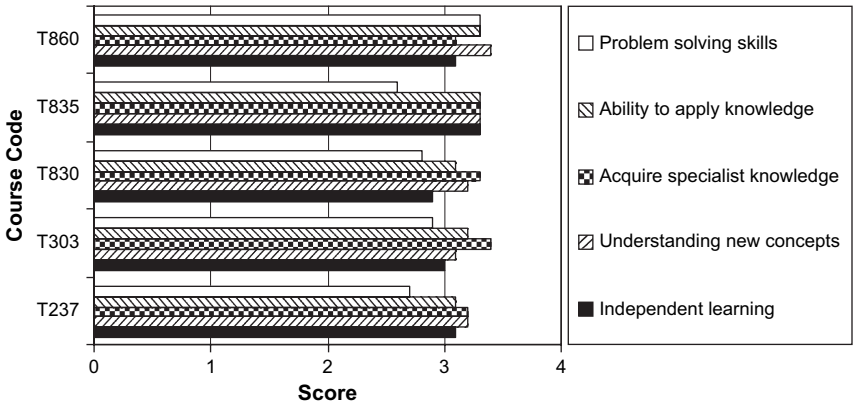

Fig. 6. Self-assessment of student achievement of learning objectives.

'1 = not at all' to '4 = very' in terms of how well each issue was addressed. Some of the findings will now be illustrated.

5.2. Achieving learning outcomes

Measures of the achievement of learning outcomes from the student perspective may be questionable, but their views provide one measure of course performance. Fig. 6 summarises the results of several of the learning outcomes. It is evident that there is broad satisfaction across the spectrum, but higher-level courses score well in specific areas. So, for example, the third level course T303 and the postgraduate course T830/T862 deliver specialist knowledge that the students regard highly. It is also apparent that T860 is ahead of the other courses in the delivery of problem solving skills and understanding new concepts these are key learning outcomes that link to environmental decision making.

5.3. Meeting career aspirations

The survey also revealed that the courses were strongly linked to professional needs. However, the distinction between undergraduates and postgraduates was readily apparent, with the latter rating job relationships highly, as indicated in Fig. 7. Continual professional development is clearly supported by these courses. Some benefits for learners and outcomes for communities and organisations are indicated by student comments on the electronic conferences. Some of these address real world issues facing the students, as the following examples reflect.

'Has anyone else seen the wonderful job advertised this week … doing just the stuff we've just done for Question 3?'

'By studying this course I can now confidently begin an audit for the company and suggest improvements. Without the course I would not even know where to start.'

'The T830 course has given me lots of ideas for saving money on materials and energy…I think the amount we have spent so far will be paid back within 6 months.'

'It still amazes me how useful T835 is proving to be. I've just landed a contract in which T835 techniques are the answer.'

A subsequent Courses Survey in 2001 asked students to rate how helpful they had found the various components they had used on their course [15]. The survey included T237, T303, T265 from the scheme in Fig. 1. The report emphasised that comparisons of the various use of media components are limited by various characteristics of the survey. The first of these concerns the actual use of any particular media component by an individual course. There is a large variety of aims and objectives that different courses are looking to achieve through their use of a particular media component that the bluntness of the survey is unable to resolve. Any comparison is unlikely to be a 'like-for-like' comparison. Focussing on the media used, as this report does, puts the emphasis on 'how' teaching is conveyed to learners to a greater extent than 'what' that teaching is doing.

In Fig. 8, the dark line at 0.0% shows the baseline, the overall rating for all OU courses – the black dots show by how much the response relating to each medium differs from this standard. Looking at the traditional medium of printed text, it is evident that, like the 'numbers-based' hard sciences and the Business School, this medium is rated lower than by students in the more discursive, literary areas. Rae suggested

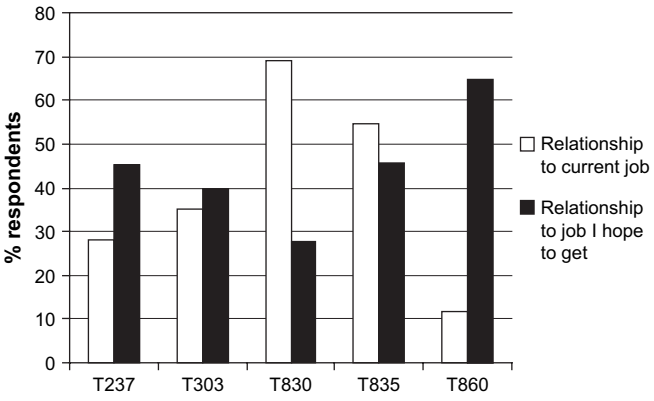

Fig. 7. Relevance of courses to environmental careers.

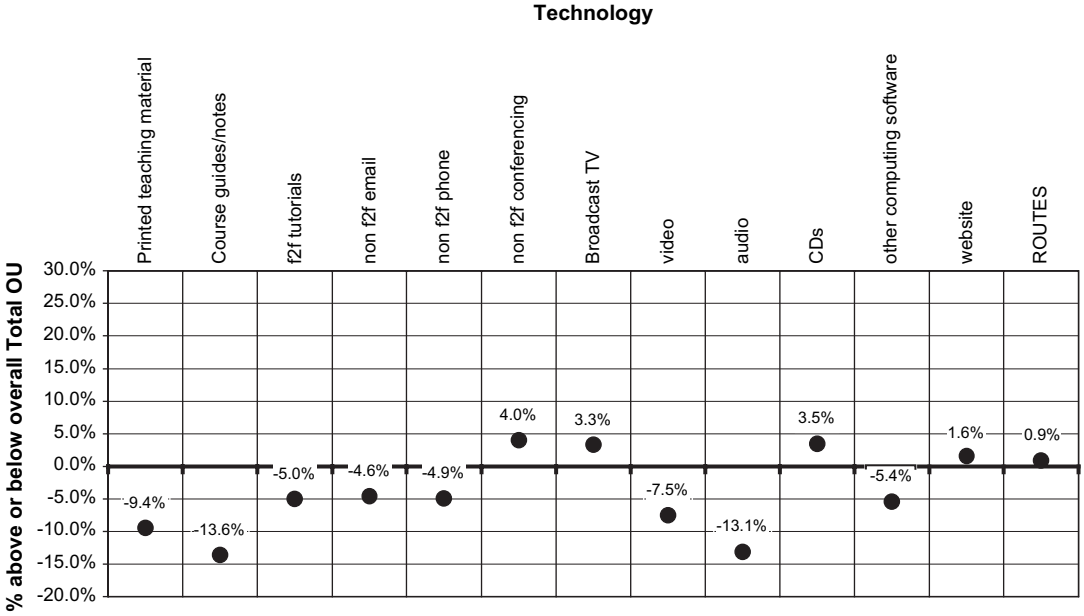

Fig. 8. Student perceptions of media for distance teaching.

that this reflects C.P. Snow's (1959) polemic 'Two Cultures' divide [16] between the quantitative and literary disciplines.

Course Websites tend to be based on the so-called Promises e-desktop initiative as illustrated in Fig. 3, and these tend to be viewed as helpful, although course CDs, and electronic conferencing seemed to rank higher. Summaries of the usage of the T862 and T835 e-Desktop for the 6-month course presentation starting November 2004 revealed that for each course, the busiest month saw around 160 unique visitors accessing the site visiting it 285 times. This was encouraging, given the course populations of around 50 students. For both courses, the busiest day of the week was Monday and the busiest hour of the day was from 12 to 1 pm and from 11 to 12 am. The most commonly viewed part of the e-desktop was the Conferencing area, supporting a view noted previously that interactions between people are highly regarded by students. In Fig. 3, ROUTES provides access to electronic resources via the web and is also well regarded. Perhaps surprising is the low rating of face-to-face tutorials.

Another IET survey included several postgraduate courses from Technology in the sample [17]. These courses included T862, T835 and T801 from the scheme in Fig. 1. The Technology Faculty and the Business School had the 'youngest' student cohorts, with over 60% of Technology students and over 56% of OUBS students under the age of 40. Age may also be a factor in access to and use of C&IT; e-MORI studies [18] suggest that people below age 44 account for almost two-thirds of Internet usage. Technology courses scored highly in the usefulness of e-mail contact with tutors and in e-conferencing.

Overall perceptions are summarised in Fig. 9, from which it may be seen that there is general satisfaction in the distance

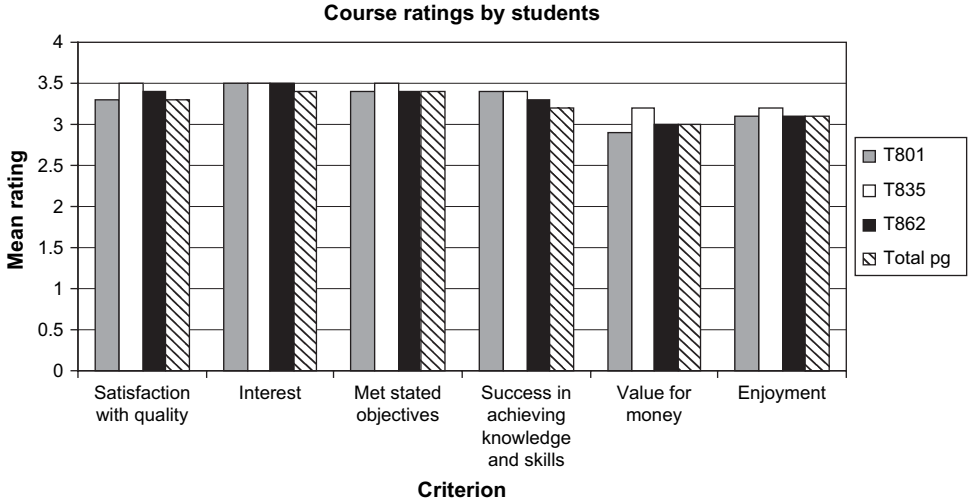

Fig. 9. Student ratings of courses as a whole.

teaching from various perspectives. However, a recent comment on a course conference speaks for itself.

The course material is meticulous and written really well. I actually looked forward to reading the next page!!

6. Conclusion

Education and training about environmental management and technology can be achieved effectively and efficiently by distance teaching. In common with the wider Open University innovations in distance teaching media, the courses described here are always evolving. Increasing use of the Internet offers new opportunities to reduce distances, to share knowledge and experience and to provide access to educational resources. Like environmental problems and many aspects of cleaner production, environmental education by distance teaching has no boundaries and can operate internationally and throughout the lifelong learning spectrum.

At the professional level in the cycle of learning, we are often dealing with adults with considerable and varied experience and knowledge. Distance teaching can tap this vast resource and develop it to the benefit of students and the organisations in which they work. It can be effective in many fields of study, but replacing the complex, subtle and indispensable interactions between people is more challenging. However, it can provide many advantages, not the least being greater economic and energy efficiency, and as such may be viewed as 'cleaner production'.

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