Greening Higher Education qualification programmes with online learning

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ABSTRACT:

Digital infrastructure and devices and computer technology-based pedagogical applications are transforming the way higher education (HE) teaching, learning and assessment is delivered, and are having varied environmental, pedagogical and economic impacts. This chapter introduces the SusTEACH Modelling Tool following an investigation of the impact of computing technologies or Information and Communication Technologies (ICTs) on HE teaching models together with a carbon-based environmental assessment of 30 courses, offered by 15 UK-based HE institutions. This offers lecturers a tool for modelling UK-based course and qualification programmes, and estimating their energy consumption and CO_2 emissions, developed following an analysis of the relationship between various online and ICT-enhanced, face-to-face and print-based distance teaching models and the main sources of energy consumption in HE. Applied to the Open University's BSc Environmental Management and Technology programme, which uses various Online and ICT-enhanced Distance teaching models, the Tool shows that compared with a wholly face-to-face taught programme, carbon reductions of 84% are achieved. Discussion includes the role of online learning designs and pedagogical use of computer technologies for achieving carbon reduction in HE.

Introduction

This chapter is concerned with environmental sustainability and the question of whether online learning designs and the pedagogical use of computer technologies deliver better or worse environmental impacts than other teaching delivery designs. It describes the SusTEACH Modelling Tool, which was developed at the Open University (OU) following research investigations and analysis of findings from the SusTEACH project, which is an acronym that stands for **Sus**tainability **T**ools for **E**nvironmental **A**ppraisal of **C**arbon impacts of **H**igher education teaching models using ICTs (see http://www.open.ac.uk/blogs/susteach/?page_id=2) . It describes how this tool was applied to estimate the energy consumption and carbon impacts in a new case study of the OU's BSc (Honours) Environmental Management and Technology qualification programme.

In recent years, UK higher education (HE) has been transformed by the use of computer technologies or Information and Communication Technologies (ICTs) which refer to digital resources and technologies utilised for the preparation, administration, and provision of teaching, learning and assessment, and the infrastructure, such as Virtual Learning Environments (VLEs), networks and cloud computing services that supports this provision. The Open University (OU), as a leader in the provision of distance education and supported open learning, has been at the forefront of establishing ICT-based infrastructure, including the equipment and networks that support platforms housing educational content, tools and applications within learning systems. Developing this infrastructure has enabled a transition from print-based teaching delivery systems to new online or e-learning designs.

In the OU, as well as more widely in HE, ongoing experimentation seeks to address the challenges and opportunities offered by computer technologies and online multi-media to deliver high quality, large-scale, accessible, cost-effective and sustainable teaching and learning. Computer technologies allow institutions to offer online or e-learning experiences that address requirements for temporal and spatial flexibility in terms of when and where students learn, as well as individualised learning designs in terms of how they learn. Computer technologies also support online interactive learning experiences that involve collaborative working and the creation of 'collective intelligence' that is valued by employers, and is consequently also driving pedagogical innovation (Johnson et al. 2012, p8).

Experimental use of hardware and software within the HE infrastructure has supported technology-enhanced teaching and learning provision (see www.jisc.ac.uk). It has also favoured pedagogical innovation, such as the development of digital education resources. This includes both 'closed', fully copyrighted resources, and 'open' openly-licensed online open educational resources (OER) (such as found on OpenLearn www.open.edu/openlearn/ from the OU), and wholly online elearning courses and qualification programmes. This has led to radical new online learning designs, including the massification of education as a result of collaborative university partnerships to provide Massive Open Online Courses (MOOCs). These have widened access to global online learning communities. Examples include the Futurelearn platform led by the OU - www.futurelearn.com/, Coursera www.coursera.org/and Udacity www.udacity.com/ set up by Stanford University, and Edx set up by Harvard University and Massachusetts Institute of Technology (MIT), www.edx.org/about). Some of these initiatives have a role in encouraging students to become both producers and users of educational resources (Lane, 2010).

Pedagogical applications emerging from computer technologies are regularly reviewed in reports, such as the annual New Medium Consortium Horizon reports (Johnson et al. 2012), and the Open University (OU) reports on Innovating Pedagogy (Sharples et al. 2012; 2013). These reports highlight the challenge for HE institutions to radically rethink teaching and learning designs, and the way that these are delivered, supported and assessed (see Conole, 2013). They also raise the question of what is a sustainable HE teaching model, in terms of pedagogical, economic, and environmental criteria.

Few studies have examined the environmental impacts of HE systems of delivering teaching and learning. One exception, the Factor 10 Visions study 'Towards Sustainable Higher Education' examined the key sources of energy consumption and carbon emissions of campus-based versus

distance learning HE delivery systems (Roy *et al*. 2005). Building on this earlier work, the SusTEACH research and development project conducted a carbon-based environmental assessment of 30 UK HE courses in campus-based (19) and distance-based education systems (11) from 15 HE institutions. The institutions employed different pedagogical designs for delivering teaching, learning and assessment, including online, ICT-enhanced, and traditional face-to-face and print-based teaching methods for course provision (Caird et al. 2013). For clarity, 'course' or 'module' are terms used in HE to refer to the set of modular, standardised, independent, or interrelated teaching units that comprise an undergraduate or post-graduate qualification programme. Degree programmes may also be called 'courses' although to avoid confusion, the term course is used in the first sense to include component courses and modules, rather than qualifications.

The SusTEACH research findings have been reported elsewhere (Caird et al. 2013) and are summarised here to provide essential background information on the steps taken to develop the SusTEACH Toolkit, which followed the analysis of the relationship between teaching models used in different HE institutions and the energy consumption and CO_2 emissions of courses. The toolkit includes the online SusTEACH Planning Tool (http://www9.open.ac.uk/susteach) which is a quick tool for lecturers and academic designers to use to consider their proposed design for a new or existing course and to obtain feedback based on the likely carbon impacts associated with this plan. Whilst the Planning Tool is helpful to begin with, the SusTEACH Modelling Tool http://www9.open.ac.uk/susteach/background.htm#downloads offers lecturers and academic designers an Excel-based tool to allow detailed modelling of HE courses and qualification programmes, as discussed in this chapter.

Background to developing the SusTEACH Modelling Tool

To examine the energy consumption and carbon impacts of courses, an attempt was made to identify, classify and compare courses using different teaching models for the planned teaching, learning and assessment provision, and the associated involvement of computer technologies in pedagogical design and delivery. This led to the development of a Teaching Models Rating Tool which enabled lecturers to rate how they planned to use different teaching delivery methods for course provision. The methods included face-to-face teaching, print-based educational materials, and computer technologies and rich media to supplement or replace traditional methods (Caird and Lane, 2013). This tool was further developed online (for example http://www9.open.ac.uk/susteach).

Based on lecturers' ratings, this approach permitted the classification of each course based on its primary HE teaching model, using the following classification of HE Teaching Models:

- The Face-to-face Teaching Model uses mainly face-to-face teaching methods with no enhancement using computing technologies.
- The ICT–enhanced Face-to-face Teaching Model uses face-to-face teaching methods enhanced by the use of computer technologies, e.g. to provide online links to downloadable resources.
- The Distance Teaching Model uses mainly classic distance teaching methods such as using printed educational materials with supported learning and which has little or no enhancement using computing technologies.
- The ICT–enhanced Distance Teaching Model uses classic distance teaching methods, enhanced by some use of computer technologies e.g. to provide online links to downloadable resources or audio-visual digital resources.
- The Online Teaching Model provides mainly online teaching, learning and assessment, available via the course/module Virtual Learning Environment. The model may include minimal printed materials, and small amounts of face-to-face teaching e.g. to attend day schools.

This classification was used to support the SusTEACH research analysis following an environmental assessment of the 30 UK HE courses, noted above (Caird et al. 2013). The SusTEACH Modelling Tool rationalises and synthesises data associated with the various teaching model designs noted

above. This data includes the results of the analysis of the average energy consumption and CO_2 emissions associated with HE courses, which was based on data collected from students, lecturers and HE institutions, using online questionnaire surveys about course-related activities, and additional data gathered from databases, estates data and modelling software. These data sources included:

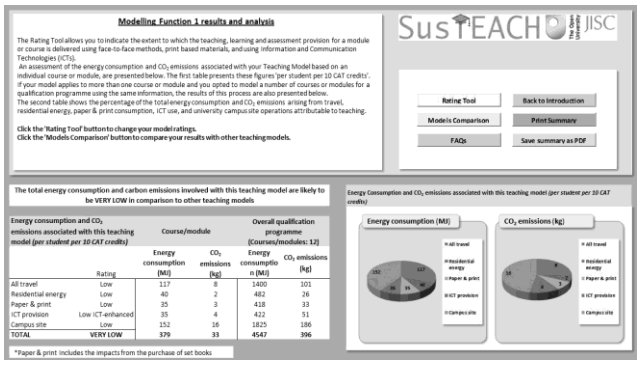
- Travel to and from places where teaching or learning takes place;
- Purchase and use of ICT devices;
- Purchase of books and publications, the provision of educational materials, and the use of paper for printing and photocopying;
- Residential energy use by students and lecturers;
- Campus site operations, including specific data collected for HE distance teaching systems on course production and presentation, and transportation of teaching materials.

The results of student and staff course-related activities were normalised using the standard UK Credit Accumulation and Transfer Scheme (CATS) system of HE institutional arrangements for measuring student progression towards defined learning outcomes and qualifications. This is a time-based measure for comparing the impacts of courses with defined study hours (www.qaa.ac.uk). This partly matches the European Credit Transfer Scheme within the European HE Area (ECTS, 2009). The CATS system identifies 1 CATS credit as equivalent to 10 hours total study. Study includes writing assignments, field work, etc. In summary, 120 CAT credits is equivalent to one student's full-time study per academic year; 360 CATS credits are required for an UK undergraduate Bachelor's degree; 180 credits for a post-graduate Master's degree.

The normalised course activity data was converted into energy consumption in megajoules (MJ) and CO_2 emissions in kilograms of carbon (Kg CO_2) using the latest carbon conversion factors available from the UK Departments for Environment, Food and Rural Affairs (Defra) and Energy and Climate Change (DECC). These provide conversion factors for all fuel sources, based on units of consumption and transportation, in a UK context (Defra/DECC, 2011). In addition, measures of embodied energy were gathered from environmental impact life-cycle studies to provide measures for paper, printed materials, and computer technology equipment (Caird et al. 2013). They include calculations of primary energy consumed over the life-cycle of a product or system associated with extraction, production, distribution, use and eventual disposal that gives rise to indirect emissions. These data were averaged per student, in order to derive the average energy consumption, and CO_2 emissions of a course, using a measure per student/ per 10 CATS credits (equivalent to 100 hours of study) (Caird et al. 2013).

In addition to modelling the impacts of different teaching model designs, the Modelling Tool includes an assessment of different energy impacts as a result of student travel behaviour and consumption of materials. For example, there may be considerable variation in transport impacts due to the impact of student air travel between the home and term-time residence of non-UK domiciled students. The tool accounts for these differences, and also allows the modelling of full qualification programmes that include a number of courses with similar or different delivery models.

Insert Plate 1: The SusTEACH Modelling Tool



Application of the SusTEACH Modelling Tool to the BSc qualification programme

This SusTEACH Tool was employed to estimate the likely energy impacts of the BSc (Honours) Environmental Management and Technology qualification which was offered by the OU in 2013 http://www3.open.ac.uk/study/undergraduate/qualification/q72.htm.

The BSc programme has 3 stages, equivalent to 3 years in a full-time, campus-based system, covering 120 study credits per year/stage. The delivery is flexible in order to allow students to study at varying paces to attain their degree over several years. Academic lecturers who were teaching on the component courses of the BSc programme were asked to identify the teaching methods used in their course(s). The BSc programme provision adopts a mixture of online, ICT-enhanced, print-based distance and face-to-face teaching methods to provide 8 courses equivalent to 360 CATs credits. Such blended or hybrid models that combine online and traditional teaching and learning are predicted to become the dominant scenario in HE (see Johnson et al. 2012). Table 1 presents an overview of this qualification programme in 2013 with a summary of teaching methods.

Course (Code)	Study credits (CATS)	Face-to face teaching	Provision of printed educational materials	ICT-enhancement and online teaching
Stage 1				
Environment: journeys through a changing world (U116)	60	Low	High	High
Exploring science (S104)	60	Low	Medium-High	Medium
Stage 2				
Energy and sustainability (T213)	30	Low	Medium-Low	High
Environmental management 1 (T219)	30	Low	Low	Online
Environmental science (S216) **OR**	60	Low	High	Medium
Environment: sharing a dynamic planet (DST206)		Low	High	Medium
Stage 3				
Renewable energy (T313)	30	Low	Medium-Low	High
Environmental management 2 (T319)	30	Low	Low	Online
Innovation: designing for a sustainable future (T307)	60	Low	Medium-High	Medium

Table 1: Overview of OU's BSc (Honours) Environmental Management and Technology qualification programme.

Modelling face-to-face teaching

All courses in this qualification programme had low levels of face-to-face teaching, although most included several contact classes (day schools) held in study centres (e.g. U116, S104, DST206 and T307). All the BSc courses require low amounts of travel during the course of study. Students typically live at home during the programme, and only travel to a study site (e.g. campus or study centre) a few times during the programme.

The SusTEACH Tool models the likely impacts of face-to-face teaching on energy consumption and carbon emissions by examining the impacts of course-related travel and accommodation. The impacts of term-time travel using guided rating options, and if applicable, travel between home and student accommodation and residential energy consumption are similarly assessed. Although not applicable in this case study, the SusTEACH Tool may also be used to model courses where students live in a university or temporary residence during their studies and need travel to and from home at the beginning and end of term or semester. Thus, the Tool captures this category of campus-based course which includes higher proportions of overseas students.

Modelling provision of printed educational materials

Although all the BSc courses provide printed educational materials, there were differences in the amount of printed materials used for the course provision. Some courses provide printed course books (e.g. U116, S216, S104, DST206), a set text (e.g. T213, T313), or pdf alternatives to print (e.g. T307), while others provide minimal print, with a course reference book, while being mainly online (e.g. T219, T319).

In this case study, the SusTEACH Tool identified two ratings for the use of printed educational materials. The HIGH RATING option applied when the majority of teaching was delivered using printed materials, in the form of paper, books, and other publications provided to students that were equivalent or greater than 250 sheets/pages per 10 CAT credits (e.g. U116, S104, S216, DST206, and T307). The LOW RATING option was found to apply when the main teaching method was not print-based, and any printed material provided to students was likely to be less than 250 sheets/pages per student per 10 CAT credits (e.g. T213, T219, T313, and T319). In addition to the materials provided, students may be required in some courses to purchase additional publications, which the SusTEACH Tool is capable of modelling, although this did not apply to any of the BSc courses under investigation.

Modelling ICT-enhanced and Online teaching, learning and assessment

All of the BSc courses were offered through the OU's VLE, although each course varied in the extent to which they were enhanced by computer technologies or online activities.

The SusTEACH Tool identified a HIGH RATING teaching option that applies when teaching, learning and assessment is provided mainly online, using computer technologies and digital resources available on the university websites and VLE. For example in this study, the BSc courses T219 and T319 are mainly online, although they have some minimal use of printed materials.

The ICT-enhanced teaching HIGH RATING option applies when the provision is strongly enhanced by computer technologies, for example via online links to downloadable resources, or offline using specially produced audio-visual digital resources (e.g. U116 offers DVDs and online activities. T213 and T313 have audio podcasts, online course materials, and some interactive computer-marked assessment (iCMA).

The ICT-enhanced teaching MEDIUM RATING option applies when there is some limited enhancement by computer technologies. (e.g. S216 offers virtual field trips, and three offline DVDs with interactive activities, although there are not many online links to resources and there is no need for students to use computer devices for parts of the course. S104 has some DVDs and some iCMA.

T307 offers downloadable resources, online tutorials and forums. DST206 offers a course website, online forums and some iCMA.)

The ICT-enhanced teaching LOW RATING option applies when the provision is mainly provided using face-to-face or print-based teaching materials and has little or no enhancement by computer technologies. This was not applicable to any of the BSc courses under investigation.

In summary, the SusTEACH Tool was used to estimate the energy impacts for the BSc courses, which were grouped together according to their teaching model design.

1. Courses with the ratings: Low face-to-face teaching; High printed materials; and Medium ICT-enhanced teaching [including S104 (60 CATS), T307 (60 CATS), S216/DST206 (60 CATS)] provide 180 CATS study credits equivalent.

2. Courses with the ratings: Low face-to-face teaching; High printed materials; and High ICT-enhanced teaching [including U116 (60 CATS)] provide 60 CATS study credits equivalent.

3. Courses with the ratings: Low face-to-face teaching; Low printed materials; and High ICT-enhanced teaching [including T213 (30 CATS), T313 (30 CATS)] provide 60 CATS study credits equivalent.

4. Courses with the ratings: Low face-to-face teaching; Low printed materials; and High Online teaching [including T219 (30 CATS), T319 (30 CATS)] provide 60 CATS study credits equivalent.

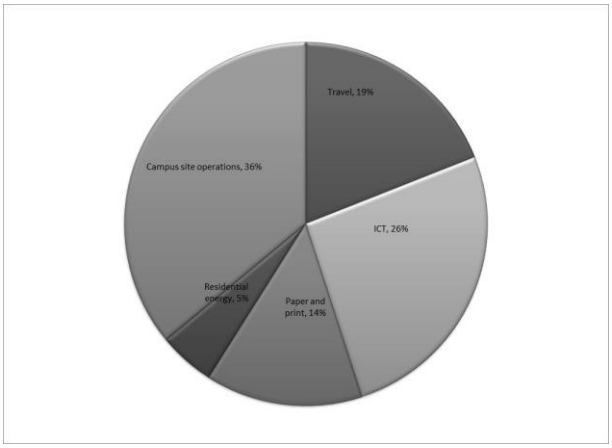
The results of using the SusTEACH's Tool's Function 1 to estimate the impacts of each group of courses are presented in Table 2.

Teaching Models Designs		Teaching Model impacts per student per 10 CATS		Total BSc impacts per student per 360 CATS	
	CATS	energy consumption (MJ)	carbon emission (kg CO_2)	energy consumption (MJ)	carbon emission (kg CO_2)
Low Face-to-Face, High print, Medium ICT-enhanced	180	476	42	8568	749
Low Face-to-Face, High print, High ICT-enhanced	60	536	50	3215	298
Low Face-to-Face, Low print, High ICT-enhanced	60	471	45	2829	269
Low Face-to-Face, Low print, High Online	60	451	42	2707	250
Total qualification impacts	360			17319	1566

Table 2: Average energy and carbon impacts of OU's BSc programme

The overall impacts for the BSc qualification programme were estimated to be 17319 MJ and 1566Kg CO_2 per student per 3600 study hours/360 CATS credits. The main sources of energy consumption and emissions for this programme were found to be attributable to campus site operations and the purchase and use of computer technologies for course activities (Figure 1).

Insert Figure 1: Percentage sources of CO_2 in the BSc programme



The SusTEACH Tool may also be used to predict the effect of changing the design of a course, such as the OU's plans to replace most of the print-based delivery component of two of the BSc programme courses (S216 and T307 in Table 1) with an online learning design, blended with some minimal face-to-face teaching. In doing so, it should be noted that the main driver for change is pedagogical, and to provide individualised, flexible, interactive, synchronous and collaborative learning experiences, using computer technologies and online media, rather than primarily to reduce carbon emissions.

Within the next few years, the design of the delivery of these courses (S206 in place of S216 and T317 in place of T307) will change them from High to Low print, Medium ICT-enhanced to Online and continue to have a Low Face-to-face teaching component with minor contact delivery (a few day schools) as offered to students. Analysis using this Tool shows that this new design is estimated to reduce the carbon impacts of paper and printed materials from 8 to 3 kg CO_2 per 10 CATS credits, whilst increasing the ICT-related impacts from 8 to 13kg CO_2 per 10 CATS credits. This suggests a trade-off between the in-course ICT-related energy impacts, and the impacts of paper and printed materials.

Using the Qualification Programme Teaching Models panel

Whilst the new planned course designs may not lead to carbon reductions, the overall carbon impacts associated with the various teaching models are low relative to campus-based, face-to-face teaching models. This was demonstrated by using the second function of SusTEACH Tool to compare different teaching models using the Qualification Programme Teaching Models panel. The BSc programme presents two courses (T219 and T319) using Online Teaching Models (60 CATS credits) and the remaining six courses are taught with various ICT-enhanced Distance Teaching Models (300 CATS credits). Using this information, SusTEACH's Qualification Programme Teaching Models panel allowed for a ready calculation of the likely impacts using different teaching models for presenting the BSc programme.

This modelling function shows that if the full BSc qualification programme was provided using the Face-to-face Teaching Model, then the overall impacts would substantially increase in terms of energy consumption, by 89% to 154559 MJ and carbon emissions by 84% to 10005Kg CO_2 per student per 360 CATS credits. This was primarily a result of the impacts associated with the typical requirements for campus-based students to travel to university sites, establish additional residential accommodation, and use campus buildings and facilities. By comparison, a fully online qualification programme would decrease the BSc programme's estimated energy consumption by 24%, to 13069 MJ and carbon emissions by 18% to 1285Kg CO_2 per student per 360 CATS credits.

Conclusions

Further advice on using the SusTEACH Modelling Tool can be freely downloaded, together with the user guide, via a new online teaching unit entitled 'The environmental impact of teaching and learning' for the Open University's free Open Learn website http://www.open.edu/openlearn/nature-environment/the-environment/the-environmental-impact-teaching-and-learning/content-section-0. With the increased availability of computer technologies and online media, and adoption of innovative pedagogical designs in HE, the SusTEACH toolkit should have value for helping to assess how these impact on the environmental sustainability of the teaching and learning practices of the institutions offering them.

The primary value of the SusTEACH project is its novelty in determining the likely carbon-based environmental impacts of HE courses using online, ICT-enhanced and other teaching delivery models. From the analysis of the main sources of energy consumption and carbon emissions based on the SusTEACH findings in this and other studies, a Toolkit has been developed to include the SusTEACH Modelling Tool (http://www9.open.ac.uk/susteach/background.htm#downloads. This aims to help HE lecturers and senior managers to plan for future sustainable teaching and learning initiatives in courses and qualification programmes.

As pedagogical use of computer technologies continues to transform HE, together with future changes expected in campus building and technology energy efficiency and carbon impacts, as well as potential changes in student and staff lifestyle behaviours, there is a need for future longitudinal research to extend data collection to a larger HE sample both within and beyond the UK. The Modelling Tool is a useful tool, albeit limited in terms of the datasets available at present, and consequently open to further development and trialling.

In summary, this chapter presents a case study of using the SusTEACH Modelling Tool to estimate the likely energy impacts of a degree programme at the OU. It shows that the use of Online and ICT-enhanced Distance teaching models in this degree programme can produce carbon reductions of 84% in comparison with a wholly face-to-face taught BSc programme. Whilst the impact of using digital infrastructures and computer technologies are higher when ICT-enhanced distance and online learning designs are adopted, the overall carbon impacts of HE courses are lower as a result of reducing the main sources of energy consumption associated with teaching and learning. Moving to a fully online qualification programme would reduce carbon emissions by a further 18%, mainly by reducing the use of printed materials and travel associated with face-to-face teaching in the BSc programme.

Environmental benefits and energy savings need to be balanced against pedagogical objectives and student satisfaction. For example, a major UK survey found that student satisfaction with university programmes is associated with face-to-face contact time with academic staff (Which?/HEPI, 2013). In addition, many students enjoy receiving print-based materials, and their behaviour suggests a preference to read materials notwithstanding their coincident availability as online-only readings (Caird et. al. 2013). Various explanations for this preference have been offered (see e.g. Jabr, 2013).

Overall, however, there is little doubt that the use of computer technologies and online media to provide online and blended ICT-enhanced teaching models can achieve significant carbon reductions in the delivery of educational programmes. Benefits are not simply achieved from pedagogical use of computer technologies, but as a result of new course designs that reduce the main sources of HE energy consumption associated with travel, residential energy consumption and campus site operations. ICT-enhanced, online and distance teaching methods can result in significant carbon reductions in courses, by reducing or replacing the requirements for students to travel to classrooms, live away from home, and use campus facilities. Consequently, notwithstanding the tensions noted above, addressing the challenges of achieving the transition to sustainable, low carbon HE systems could be supported by greater attention to new pedagogical designs that aim to reduce the energy impacts associated with HE teaching and learning provision.

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Bionotes

Sally Caird is a Research Fellow in Design and Innovation, Andy Lane is Professor of Environmental Systems, and Ed Swithenby is the SusTEACH Research Assistant all in the Faculty of Maths, Computing and Technology at the Open University. Caird's research incorporates the design and innovation processes involved with the adoption and use of low carbon technologies, and environmental assessment methodologies for complex systems. Lane was the founding director of the Open University's OpenLearn platform for open education resources http://openlearn.open.ac.uk/ and has research interests in systems of open education and the management of complex environmental systems. Swithenby has researched higher education courses and their carbon impacts.