How green is your learning? Pedagogical options for environmentally sustainable education

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Abstract
This paper is based on a pilot project which looked at the impact of two different modes of learning, face to face and blended learning, on the environment. The results show that there is only a minor environmental advantage between the two different modes of learning. The paper puts forward pedagogical approaches that could lead to environmentally sustainable education.

1.0 Introduction

This paper is based on the "Greening of Elearning ChecK Out" (GeCKO) research which was carried out between November 2008 to January 2009 at the University of Leicester. The research looked at the impact of two different modes of learning, face to face and blended learning, on the environment. Over the past decade concerns have been expressed by governments and pressure groups about the environmental impact of education. In December 2002, the United Nations General Assembly adopted resolution 57/254 which was aimed at putting in place a United Nations Decade of Education for Sustainable Development (DESD). The DESD is aimed at changing current approaches to education by integrating the principles, values, and practices of sustainable development into all aspects of education and learning. Its primary goal is to: *"encourage Governments to consider the inclusion […] of measures to implement the Decade in their respective education systems […] and national development plans."* **(**United Nations General Assembly). DESD is also aimed at fostering greater quality of teaching and learning in education for sustainable development through the adoption of new behaviours and practices within existing educational programmes.

2.0 Environmentally sustainable education in the UK

In the UK, the passing of the Climate Change Act of 2008 (Department of Energy and Climate Change, 2008) was a significant move by government to address environmental challenges. Following the passing of the climate change law, various government agencies have adopted policies towards environmentally sustainable development. For example, in 2005 the Higher Education Funding Council for England (HEFCE) set out a 10 year vision and action plan to make sustainable development a central part of Higher Education. In June 2008 the HEFCE issued a policy development consultation as part of efforts to further contribute to the sustainable education development agenda (HEFCE, 2008). The document identifies four main roles by which environmentally sustainable education can be achieved as follows:

- Engaging with stakeholders to bring about policy synergies
- Building capacity of people to manage sustainable development
- Sharing good practice
- Rewarding more sustainable behaviour

The HEFCE further seeks to contribute to environmentally sustainable education through the skills and knowledge graduates acquire and also through teaching and research. Universities UK, has also adopted strategy which includes sustained research into environmental issues in collaboration with industry (Universities UK). The Learning and Skills Council (LSC) has made similar commitments (Learning and Skills Council – UK, 2005).

3.0 Institutional approaches towards environmentally friendly education

In 2007 the Times Higher Education published a UK wide Green league table aimed at pushing universities to adopt environmental policies and cut energy consumption. Although improvements have been made since in areas such as waste management, concern still remains in areas such as carbon emission, the use of renewable energy and changes in attitude (Times Higher Education. 2008). An examination of the literature reveals a combination of five broad strategies adopted by Higher Educational Institutions to address environmentally sustainable education.

3.1 Estate management strategies

The focus of estate management approaches is on buildings and improved management of physical infrastructure. The approach draws on the UK developed Building Research Establishment Environmental

Assessment Method (BREEAM) to incorporate environmental issues in all aspects of building i.e. energy, health, well-being, pollution, transport, land use, ecology and materials (James, 2004). Similar standards exist in the US (US Green Building Council) evident from the work of Rappaport (2008) and Wylie, (2008). The UK's Estate Management Statistics (EMS) provides information on performance in Higher Education estates directly connected to improvement in environmentally sustainable education.

3.2 Energy efficiency strategies
The emphasis of energy efficient approaches is on cost effective *low energy* buildings that have low impact on the environment. It is estimated that in England annual energy costs for the Further and Higher education sector total more than £200 million resulting in the release of at least 3 million tonnes of carbon dioxide (CO_2) into the atmosphere. Annual energy per institution ranges from under £200 000 to over £3 million and generally account for around 25% of building-related revenue expenditure (The Carbon Trust). A very significant step toward reducing fuel bills is the need to understand where energy is consumed, how occupants use buildings and the density and nature of occupied period.

3.3 Space management strategies
Closely related to the above is space management which is believed to provide measurable environmental benefits. The table below shows the broad range and mix of space and building types found in colleges and universities and annual consumption for representative space types.

Table 1   Space use in Higher Education

Space	% of average higher education campus	Electrical target (kWh/m2)	Fossil target (kWh/m2)
Teaching	25	22	151
Research	20	105	150
Lecture Hall	5	108	412
Office	30	36	95
Library	10	50	150
Catering	25	650	1100
Recreation	7.5	150	360
Total academic	**100% of academic (75% of total)**	**75**	**185**
Total residential	**100% of residential (25% of total)**	**85**	**240**

Source: Energy efficiency in further and higher education – Carbon Trust

The Space Management Group (SMG) of UK Higher Education has put forward a model which combines cost factors with space drivers for accessing the design and use of spaces to reduce energy consumption (The Space Management Group). Among the strategies suggested are computerised centralised timetabling, data collection on space utilisation, space charging and observance of space norms. A study commissioned by The UK Joint Information Systems Council (JISC) into "Open plan technology rich learning and teaching spaces", has shown how different institutions utilise some of the above strategies put forward by SMG to improve energy efficient space management (Watson, Anderson, Strachan, 2007).

3.4 Information technology strategies
The carbon emissions associated with ICT usage is yet another approach by many Higher Educational institutions aimed at greening of learning. It is estimated that UK universities and colleges as a whole:
- utilise around 1,458,000 computers, 249,000 printers, 240,000 servers
- have ICT-related electricity bills of about £121 million in 2009
- indirectly emit 528,000 tonnes of carbon dioxide from electrical use (James, and Hopkinson, 2008).

A study at the University of Sheffield discovered that ICT accounts for 18% of the university's total electricity consumption, with desktop computing accounting for half of this (Cartledge, 2008). At a workshop organised by the JISC-funded SusteIT project in September 2008 on "sustainable desktops" a number of good practices were put forward to deal with the problems associated with ICT emissions such as powering down PCs when not in use, harvesting ideal CPUs through grid computing techniques, purchasing devices with low power consumptions, substituting thin client devices for PCs and changing practices with regards to replacement and disposal of ICT equipments (JISC and SusteIT, 2008). The SusteIT project also produced a tool to help estimate

the in-use energy and carbon footprint of non-residential ICT usage in Further and Higher Education (Hopkinson and James, 2008)

3.5 Mobility strategies
Closely related to ICT use is travel. The conventional wisdom is that avoiding car travel for learning purposes can help the environment and cut carbon emissions. "Green Meter" produced by iLinc Communication has been designed to measure such impact. Attached to web-conferencing software, the meter measures the amount of carbon that would have been emitted had users opted to travel to meeting and learning sites as opposed to using conferencing tools. The "Green Meter" detects the location of the people who are attending a Web meeting using their IP address which helps to calculate the distance between participants attending the web meeting and the meeting leader to give a measure of the exact amount of eliminated travel and generates a CO_2 emissions savings (Hickley, 2008).

4.0 Greening of Elearning ChecK Out (GeCKO) project background
Undoubtedly very little attention has been given to pedagogical strategies as an option within Higher Education for tackling the impact of education on the environment. As is evident from the above, operational measures focused on buildings, space management, energy consumption and choice of technology have featured, to the disadvantage of pedagogical strategies. GeCKO was born out of a concern to improve the environmental impact of education through teaching and learning strategies. The project was funded by the University of Leicester's 'Teaching Enhancement Fund' (TEF) as a pilot project following publication of the 2008 Times Higher Education Green league table which ranked the University of Leicester 96th. GECKO compares two different modes of learning and teaching delivery with the aim to inform institutional policy on the environmental sustainability of learning and teaching at the university.

5.0 Methodology
Data was gathered through a survey over a three week period. Sixteen students from two programmes - Integrated Science (5) and Physics (11) voluntarily participated in the research. The Integrated Science programme is a blended learning programme delivered online and face to face. Students on the programme are issued with laptops at the beginning of their programme. The physics programme is delivered through the traditional face to face on campus method.

To gather data for the project, students were issued with booklets for self entry of data, which was base on their weekly estimation of consumption under four key variables directly linked to teaching and learning related CO_2 emission. The variables were:
- ICT use covering computers, laptops, photocopiers and scanners
- Paper use covering printing and photocopy
- Energy use covering electricity and heating
- Mode of travel for example car, bus, walking, etc.

To work out the elements of CO_2 emission within each variable we took the number of hours spent using the device, material or services multiplied by a conversion factor to arrive at the CO_2 emitted per device per hour. For example to measure the CO_2 associated with energy use we multiplied the amount of gas used in kWh by a conversion factor for energy units – 0.185 kg CO_2 - for the number of hours the gas was in use (The Carbon Trust, 2008). The same was done for elements for the rest of the variables. To measure the weekly average of carbon emission used, the total amount of CO_2 emission per individual elements was divided by the number of participant on each programme. The cumulative average for the overall experiment was calculated by adding the total CO_2 generated for each variable by the population size of each study cohort.

An induction programme was organised at the beginning of the research to explain the objectives of the research to participants and to also seek individual consent. Each student received a £20 voucher as an incentive for participating in the research.

6.0 Findings
The results from each mode of study linked to each of the four variables – ICT, Paper, Energy and Travel - are presented below.

6.1 Use of ICT
The results show that overall I-Science students generated less carbon associated with ICT usage compared to their physics counterparts. This may appear rather strange considering that students on the online programme are likely to be more dependent on ICT than their face to face counterparts. This could perhaps be attributed to the fact that, laptops are more environmentally friendly despite their use over longer periods of time.

Table 2   ICT related CO2 emission

Period	I – Science (online)		Physics (face-to-face)	
	Usage per student per wk (kg)	Average per student (kg)	Usage per student per wk (kg)	Average per student (kg)
wk1	1.341		3.831	
wk2	0.804	0.891	2.378	2.907
wk3	0.528		2.513	

6.2 Use of paper
Compared to their counterparts on the physics programme, I-Science students were found to use less paper. The results may be understandable considering that the I-Science study cohort depended more on their laptops to access and download materials whereas their Physics counterparts are given handouts and more likely to print course and other materials from the internet. This notwithstanding the evidence shows that no matter the delivery method paper use is typical for both modes of learning.

Table 3 CO2 emission for paper usage

Period	I – Science (online)		Physics (face-to-face)	
	Usage per student per wk (kg)	Average per student (kg)	Usage per student per wk (kg)	Average per student (kg)
wk1	0		0.173	
wk2	0.039	0.055	0.361	0.275
wk3	0.126		0.290	

6.3 Use of energy
Consumption of energy was found to be high amongst students on the I-Science programme compared to their Physics counterparts on the face to face programme. This finding may be linked to energy use associated with heating and electricity in bedrooms over long periods of time. The data shows that I-Science students did more private study in their accommodation. It is however worth pointing out that the average energy consumption per student for the face-to-face programme is likely to increase or decrease depending on the number of students per lecture.

Table 4 CO2 emission associated with energy use

Period	I – Science (online)		Physics (face-to-face)	
	Usage per student per wk (kg)	Average per student (kg)	Usage per student per wk (kg)	Average per student (kg)
wk1	6.282		5.714	
wk2	8.369	7.219	4.533	4.987
wk3	7.008		4.715	

6.4 Travel to and from university
The findings on travel were rather surprising. It was expected that students on the online programme would make the occasional journey to the university to meet informally with other students and to use materials in the library. We found striking differences in carbon emission associated with travel to and from university between the I-Science and Physics students. One reason for this is that one student on the I-Science programme used their car for travelling to the university in the first week of the research. It is also understood that most students on the I-Science programme are mature students and are therefore more likely to use a car to university.

Table 5 CO2 emission associated with travel

Period	I – Science (online)		Physics (face-to-face)	
	Usage per student per wk (kg)	Average per student (kg)	Usage per student per wk (kg)	Average per student (kg)
wk1	7.008		0.093	
wk2	0	2.336	0	0.052
wk3	0		0.063	

When the overall average carbon emission associated with each mode of study was further aggregated across the four key variables i.e. ICT, paper, energy and travel, the cumulative average carbon emission per student was 8.221173kg and 8.24689kg for I-Science and Physics students respectively, a difference of 0.026kg. Thus there was no striking difference in carbon emissions between the two modes of study.

7.0 Conclusion and implications
We began this paper by noting that in the UK; very little attention has been paid to pedagogical strategies as an option for tackling environmental problems associated with Higher Education. We pointed out that policy makers in Higher Education have favoured interventions focused on cost reduction rather than policies that impact on the wider educational environment. Operational measures focused on buildings, space management, energy consumption and choice of technology have featured highly to the disadvantage of pedagogical choices of learning design and delivery that impact positively on the environment.

Environmentally sustainable learning design
Our study has shown that energy use associated with carbon emission is higher for the I-Science (blended learning) programme compared to their face to face Physics counterparts. On the other hand we also found that paper and ICT use associated with carbon emission is higher for the face to face physics students compared to their I-Science counterparts who are given laptops at the beginning of their programme. On the whole, we conclude, based on the cumulative average carbon emission per students in this project that, there is only a minor environmental advantage between blended and face to face modes of learning - a difference of merely 0.026kg in favour of the blended learning programme. Thus the argument that blended is *more* environmentally friendly cannot be sustained on the evidence of this study. This findings support similar observations made by Roy and Potter (2008) in a study of 20 UK courses – 13 campus-based, seven print and online distance learning in which they concluded that E-learning appears to offer only relatively small energy emissions reduction when compared with other modes of learning. Over the years for economic, social and other reason policy makers in higher education have opted for one mode of study over the other. It is our contention that instead of opting for one mode of learning design and delivery over another, policy makers in Higher Education should carefully consider balancing specific elements of the learning process within different modes of study in a manner that would produce eco-friendly results. The disparate offerings should be integrated in a manner that responds to individual learning preferences but also leads to positive environmental gains. This calls for instructional design methods that are environmentally sustainable.

Greening "travel"
The finding on travel is this study is rather surprising. It was expected that students on the blended learning programme would make the occasional journey to the university and hence produce less carbon emission associated with travel. On the contrary we found a relatively higher carbon emission associated with travel on the I-Science blended learning programme. This was as a result of one participant travelling by car to the university in the first week of the research data gathering. Whilst acknowledging the value of occasional face to face meetings with tutors on campus by blended learning students, consideration need to be given to promoting synchronous interaction using web-conferencing tools. The "Green Meter" produced by iLinc Communication (Hickley,2008), designed to measure the amount of carbon that could have been emitted had users opted to travel to meeting sites is one example of how positive environmental gains associated with learning related travel can be assessed. We need to point out that most students who participated in this research live within a short distance of campus and thus a different cohort may provide different outcomes for travel related carbon emission.

Promoting "green" behaviour

Lastly this study has shown that, no matter the teaching method, paper use is typical for both modes of learning. This may be a direct consequence of the difficulty of reading from a computer screen. Compared with paper computer screens are seen as less readable. We also found that home energy use by I-Science students was higher compared with the physics students with one student on the I-Science programme reporting that he forgot and left his laptop on for twenty four hours. Undoubtedly this raises behavioural questions in terms of change in attitudes and learning lifestyles of students.. Students need to be made aware of the environmental implications of learning related behaviours and the efficient use of ICT equipments both at home and in the university. One way of achieving this will be to incorporate environmentally sustainable programmes into Higher Education curriculum irrespective of the programme being pursued. Instituting environmental awards should also go a long way to encourage environmentally responsible behaviour.

It is acknowledged that this study is very small and our findings are not representative of the wider I-Science and Physics programmes in the University of Leicester. It is envisaged that the findings of this project would lead to a more large scale project in a wider context to establish the validity or otherwise of the findings of this pilot project. The outcomes which emerge should inform the adoption of pedagogical strategies that are environmental friendly and sustainable within UK Higher Education.

References

1. THE CARBON TRUST. Energy efficiency in further and higher education: cost effective low energy buildings. (Energy consumption guide 54). www.thecarbontrust.co.uk/energy)

2. THE CARBON TRUST (2008). Conversion factors. Found at: http://www.carbontrust.co.uk/resource/conversion_factors/default.htm

3. CARTLEDGE, C.; (2008). Energy impacts of ICT at the University of Sheffield: A study of the SusteIT project. Found at http://www.susteit.org.uk/news/info.php?refnum=36&startnum= *[accessed 5-8 January 2009]*

4. DEPARTMENT OF ENERGY AND CLIMATE CHANGE " Climate change Act 2008" http://www.defra.gov.uk/environment/climatechange/uk/legislation/ *[accessed 7 January 2009]*

5. ESTATES MANAGEMENT STATISTICS-UK. http://www.opdems.ac.uk/ *[accessed 6 January 2009]*

6. FEARN, H. (2008). "Green Shoots". Times Higher Education July 2008. http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=402566

7. HOPKINSON, L., & JAMES P., (2008). Energy and carbon impacts of ICT: user guide for the SusteIT Foot printing tool. http://www.susteit.org.uk/news/info.php?refnum=36&startnum= *[accessed 5-8 January 2009]*

8. HICKLEY, A. R., (2008) ChannelWeB: *"Web conferencing tool measures carbon savings".* http://www.crn.com/networking/205602919?queryText=green+meter)

9. HIGHER EDUCATION FUNDING COUNCIL FOR ENGLAND (2008). "Sustainable development in higher education Consultation on 2008 update to strategic statement and action plan" http://www.hefce.ac.uk/pubs/hefce/2008/08_18/ *[accessed 7 January 2008]*

10. JAMES, P. (2004). Assessing the Environmental Performance of Buildings in Higher Education – HEEPI Workshop University of Leicester 2004. www.heepi.org.uk

11. JAMES, P.; AND HOPKINSON L., (2008) Sustainable ICT in Further and Higher Education. http://www.susteit.org.uk/news/info.php?refnum=36&startnum= *[accessed 5-8 January 2009]*

12. JOINT INFORMATION SYSTEMS COMMITTEE. (2008) SusteIT project. "Sustainable desktop" workshop. September 2008 http://www.susteit.org.uk/news/index.php *[accessed 5-8 January 2009]*

13. THE LEARNING AND SKILLS COUNCIL. "From Here to Sustainability: The Learning and Skills Council's Strategy for Sustainable Development". http://readingroom.lsc.gov.uk/lsc/2005/ourbusiness/strategy

14. Space Management Group (2008). UK Higher Education Space Management Project. http://www.smg.ac.uk/

15. UNITED NATIONS GENERAL ASSEMBLY. Education for Sustainable Development http://portal.unesco.org/education/en/ev.php *[accessed 7 January 2009]*

16. UNIVERSITIES UK. "Greening spires: universities and the green agenda", (http://www.universitiesuk.ac.uk/Publications/Bookshop/Documents/green_spires.pdf) *[accessed 7 January 2009]*

17. US GREEN BUILDING COUNCIL. http://www.usgbc.org/ *[accessed January 2009]*

18. WATSON, L.; ANDERSON, H.; DAVIS, K.S., (2007). The Design and Management of Open Plan Technology Rich Learning and Teaching Spaces in Further and Higher Education in the UK. Case Studies. October 2007. http://www.jisc.ac.uk/whatwedo/projects/managinglearningspaces.aspx

19. WYLIE W., (2008) "Ave Maria University in Florida builds a new campus that integrates IT and facilities management systems. http://www.edtechmag.com/higher/march-april-2008/ready-for-delivery-2.html.