The greening of computing and ICT curriculum: challenges and directions.

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Abstract

Higher Education Institutions have a responsibility to produce graduates who will contribute to the future workforce in a manner that extends knowledge and better practice. In the case of Information and Communications Technology, the next generation need to be more socially aware and have knowledge regarding the impact of their industry on the planet and society, to help address the shortcomings of many within the industry at present. However, given the focus of the majority of Computer Science and Information Systems curricula, examining issues of sustainability presents significant challenges to the curriculum. How might we best articulate these ‘social’ issues to technically focused undergraduates? Case-based approaches with final year students at the University of Plymouth considered sustainability in the curriculum, and qualitative analysis of coursework submissions enabled an assessment of the impact of these issues to help identify trends in perceptions and attitude. Conclusions drawn so far demonstrate the willingness of a subset of students to engage with sustainable issues, and allowed us to reflect on the appropriate models for delivery of such materials. Computing provision at University of Wales, Newport, is only just beginning to consider ‘Green IT’ within the curriculum, and comparisons are made with the work undertaken at the University of Plymouth.

Introduction

Modern organisations of different sizes across all sectors now face intense political and social pressures to be more environmentally responsible, but at the same time must remain competitive in order to maintain their profits or revenue streams (Cook, 2008). More recently recessionary influences have dramatically changed the global economic landscape, and it can be argued that they have helped place a greater emphasis on ‘green issues’ as a potential driver to help reduce costs and develop business sustainability. Information and Communication Technologies (ICT) are considered a significant contributor to operational costs, therefore when taken in parallel with consumer concerns about the environment have naturally led to greater awareness and need for response by mainstream ICT vendors, users and developers (Murphy, 2007). The IT industry contributes around 2% of global greenhouse gas emissions, equivalent to the aviation industry, but its emissions are actually growing at a much faster rate (Sparkes, 2008). The IT industry has therefore experienced justifiable criticism for its attitude towards sustainability and social responsibility given its significant carbon footprint and social impact. While the industry can be seen in some areas to be acknowledging the need for more accountable behaviour (for example
the corporate social responsibility outputs of BT, GSK, IBM) this is still in the minority. The main issues in the greening of ICT include the need to reduce energy consumption and use of natural resources, reduce travel and transportation, lower carbon emissions, and generate less waste. New legislation was introduced in the United Kingdom (UK) in 2007 to help minimise the impact that ICT and other technologies have on the environment, including the EC Directive on Waste Electrical and Electronic Equipment (WEEE) and the EU’s Energy Using Products (EUP) Directive. However, Boccaletti et al. (2008) argue that computing and ICT have the potential to reduce far more emissions than they generate, assuming that technology manufacturers and users fully understand how this can be facilitated and enabled.

Although the popularity of traditional computing courses in the UK has declined in recent years, globally there are still large numbers of students that are moving into the computing and ICT industry having first studied on relevant university undergraduate and postgraduate courses to give them the required knowledge, skills and understanding. These graduates will help to develop the digital economy and contribute to global economic and social productivity (Whetstone, 2009). The emergence of ‘green collar’ jobs as a phenomenon suggests that future graduates with environmental awareness and sustainable development capability will be much in demand, especially with the need to develop greener and cleaner technologies, and to build ICT applications to help tackle climate change and meet global targets on reducing carbon emissions (Ashford, 2008). It can however be argued that UK universities have been slow to consider revising their computing and ICT curriculum to accommodate these ‘green issues’, and it should be noted that professional bodies for computing and ICT such as the British Computer Society (BCS) have only recently launched a ‘Green Specialist Group’ as of March 2009.

This paper will consider the developing curriculum at University of Plymouth and at the University of Wales, Newport with a particular emphasis on the computing and ICT programmes in the departments where staff, students and resources relating to these programmes are located. The paper will look at current practice with respect to assessment (Plymouth), and at staff perceptions on the nature and location of the learning outcomes in the curriculum (Newport). Comparisons will be made with respect to the emerging approaches to tackling the issues of Education for Sustainable Development and Global Citizenship (ESDGC).

Growing a Green ICT Sector

There are approximately one million people currently working in the IT industry and eSkills UK, the sector skills council for information technology (IT) and telecommunications in the UK, predicts that the industry is growing at such a rate that there will be a further 120,000 job opportunities created by 2012 (eSkills UK, 2008). According to the Society of IT Management (a professional body representing IT professionals in the public sector) expenditure in IT continues to grow (SOCIITM, 2009). There is now an interesting tension between an industry that is not perceived to be addressing its professional responsibility and is failing to demonstrate effective practice, yet one which will continue to grow and make an even more significant impact upon our world. Recent technical advances will move applications into “the cloud” (for a non-technical description, see Wikipedia, 2009), migrating functionality and data storage away from organisations and into massive, centralised data centres controlled by huge technology companies and accessed by their clients via high speed networks, which will generate even greater power consumption. Therefore, it is not surprising that there have been moves by some larger technology suppliers and consumers to start to embrace the ‘Green Agenda’. However, it can be cynically observed that those within the sector that are embracing ‘Green IT’ are doing so for primarily for cost savings, competitive advantage and brand image rather than for the benefits that
it can bring to the environment and global citizenship.

Until recently those recruited into the IT industry were recognised for their technical ability and logical thinking, and not for their environmental and social awareness. IT originally manifested itself as an entity that could hide deep inside an organisation, and there was little need for reflective practitioners to consider the broader societal implications of their newly developed systems. It should therefore be no surprise that we currently have a profession that is struggling to keep up with the impact of what they now do, in a highly inter-connected business and social world.

The beginnings of an ICT-related career will start in school, and will be developed through a computing or ICT-related degree at University into a job in the industry. However, when we examine the coverage of ICT education in schools, we see the age-old technical focus. Therefore those who wish to embark on an ICT career will apply to university with little grasp of the wider social implications of ICT. Certainly from the authors’ experiences, the “average” Computer Science\(^1\) undergraduate applicant will apply to such a degree because of an interest in computers and technology, but with little awareness of the wider industry. Last year the University of Plymouth surveyed all applicants at open and preview days to gain a snapshot of their understanding of the industry. The vast majority of the approximately 300 applicants were aware that the industry was a lucrative one, and that technical skills were important, yet had little grasp of the professional, legal or social skills required by the modern profession.

Therefore, we have to conclude that it is the responsibility of Higher Education Institutions (HEIs) to ensure that those graduating into the ICT industry are aware of the social implications of the technologies they develop and manage, with a clear appreciation of the wider impact of the systems they use. However, if we anecdotaly examine the majority of Computer Science degrees, we see they are still embedded in the technical aspects of the discipline, with much coverage of mathematical and algorithmic theory, architecture, communications, programming and data management. Coverage of social, environmental or legal aspects is very much in the minority.

There is now a growing awareness among ICT educators of the need to work towards understanding what is needed to produce a more socially and environmentally aware graduate. Whilst the mainstream ICT industry is still very much focused upon ‘technical’ training and education, there are pockets of emerging academic practice that attempt to integrate key issues and reflective learning into the Computer Science and ICT curriculum. This pedagogy aims to explore how curriculum and learning/teaching approaches need to be modified to facilitate a greater social awareness in learners who are typically keen to write code, develop games and websites, and create new technology. Research is needed to understand how such capability can be embedded in curriculum to ensure that graduates leave university appreciating the responsibility they will face in their professional careers. Two examples of evaluating academic practice at the University of Plymouth and at the University of Wales, Newport are discussed below.

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\(^1\) The term “Computer Science” is used here as a generic term to relate to all manner of computing related degrees in the UK.
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in the United States (US)\(^2\), so as to make students realise the potential impact of the technologies that are developed. The environmental impact of IT is also introduced at this stage by considering aspects such as the scale of power consumption in the industry by examining the scale of a large IT system (for example, the current University of Plymouth infrastructure consists of more than 100 servers and 5,500 desktop systems).

In the second year, a more detailed ethical and legislative examination of the social and environmental aspects of the industry is carried out, considering the “carrot” of ethical practice against the “stick” of legislation. Within this context, the growing body of environmental guidelines and legislation is explored (for example, the UK Government’s aim to make the public sector IT carbon neutral by 2012\(^3\)). The assessment requires students to evaluate the social and ethical implications of a proposed software system they develop within another part of their second year. The final year embarks on a more detailed examination of students’ perceptions and attitudes towards the environmental aspects of the profession into which they are about to enter. In the final term of their degree, students take on a module that gets them to reflect upon their own position within the industry and their career aspirations against the topics of Globalisation, Green IT, and Social Responsibility. Each topic is supported by lectures in the topic area. In the case of Green IT, the context is put in place by a more general lecture about the global implications of sustainability (delivered by staff from the University’s Centre for Sustainable Futures\(^4\)), prior to examining key issues faced by the industry, such as power and waste material management. In each area, the students are asked to pick a recent news story and to write an essay on why they selected the specific article, and whether they believe the issues raised in the story are important for the industry as a whole and, more importantly, for their own career aspirations. It should be stressed that as the cohort in this study would not have had detailed coverage in the first two years of their degree around aspects of sustainability in the IT curriculum, for the majority this subject material was effectively new to them.

For the Green IT assessment, this was evaluated by an analysis of 55 coursework submissions. The objectives of the evaluation were:

- To examine the choice of story – topic, focus and “bias” (i.e. for or against the green agenda)
- To identify key themes that are drawn from the personal reflection

A sample of the essays was randomly selected to develop a coding scheme of terms that was then used to code up all of the submissions. Analysis of the coding responses allowed us to identify key themes to address the evaluation objectives. The findings from this analysis are presented below, with anonymised quotes from some of the submissions to support these.

1. A lack of awareness of green issues in the IT sector

“I must admit that all of these issues surrounding ‘Green IT’ and sustainability never occurred to me as relevant or something that I should consider within my career”

The most significant finding from this analysis was that green IT issues were not familiar to the students. Many stated that the lectures delivered and articles they researched were the first time they had reflected upon the environmental implications of the IT industry in detail. Some had come across these issues on placement, but none stated a familiarity with the issues from previous University work.

2. Students are environmentally aware and can relate green IT to their wider beliefs

“The article makes me think about the type of company that I would like to work for. I did not know that IT companies were such a big factor

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\(^2\) For example, see http://www.georgia-sex-offenders.com/maps/offenders.php

\(^3\) http://www.cabinetoffice.gov.uk/media/66177/greening_government_ict.pdf

\(^4\) http://csf.plymouth.ac.uk/
in the poor health of the environment. I would not like to be part of a company that did nothing to try and lessen their environmental impact.”

However, what is also apparent is that an awareness of sustainability within the IT industry causes a strong reaction to the theme. Many students reflected on their awareness of green issues in their social lives, but had not really considered its relevance to IT. Having learned about these issues in lectures, and then developed their understanding through subsequent research, the fact that they could relate their career to their social beliefs formed strong opinions regarding their choice of company. In some cases, as in the case highlighted above, students stated they would not work for a company without a green IT policy.

3. Green IT is a hardware problem

“I plan to go into web development, there is no way you can make software greener, it is the hardware that needs to be improved to run the software more efficiently”

Interestingly, among some of the more technically minded students who had stated they wished to enter into software development careers, there was a feeling that they could not do anything in their jobs to address energy efficiency, therefore it was not their problem. Given that any IT professional will use hardware as part of their daily operational functions, and their awareness and choice of such could have serious implications for the company. More importantly, efficient software development, that which will be able to be effectively scaled, can result in a significant reduction in the amount of hardware required to run them.

4. Green IT is good PR!

“While I feel there isn’t anything major that I can do to improve my carbon footprint as a self employed web designer I do feel that if I was to try and keep my business green I could possibly increase my clientele”

The PR perspective of green IT was reflected upon both personally and in the sector as a whole. It was interesting to see many comments related to the positive “spin” that companies were receiving from having green strategies, as well as comments such as the one above, where students were considering being perceived as “environmentally friendly” might be a good thing personally as well as professionally!

5. Power management is the most visible aspect of green IT

“I do consider power efficiency and controlling costs to be an important issue”

The vast majority of articles selected by students focused upon the issues of power management to achieve cost savings, therefore achieving a green IT strategy. There was very little discussion around other aspects of sustainable IT such as waste management and this would suggest (given that students were given free reign to select any article they felt appropriate) that power management is currently the most visible aspect of green IT.

Evaluating Current Practice at the University of Wales, Newport

At the University of Wales, Newport in the Department of Business & Computing, all staff members were asked to respond briefly to three questions. Only the responses from seven staff (out of nine) in the Division of Computing are considered here, and the questions with a summary of responses are given below:

1. Do you cover sustainability, environmental or global citizenship issues in any of the modules you teach, and if so where?

Interestingly, the answer to this question was almost entirely ‘No’ except for one respondent who covered battery technologies and their environmental implications in a postgraduate Mobile Computing module, and another respondent who covered sustainability issues in the first year Professional Skills module. However, it was argued that there
was not enough space to cover skills-related curriculum in the module, and so some important sustainability content and discussion was unfortunately omitted to focus on the development of transferable skills.

2. Are any of these issues articulated in the learning outcomes for your modules, or in the indicative content?

Again the answer to this question was almost entirely ‘No’ except for one respondent who stated that ethical rather than sustainability issues were articulated in the learning outcomes. Another respondent suggested there was scope to include such issues in Software Engineering implications when considering more general engineering.

3. Do you think these issues are important in the modules that you teach, or should be better covered by other modules or at a programme level (such as in PDP activity or skills development sessions)?

Most staff stated that the issues are important and should be embedded and integrated into the modules. However one respondent was of the opinion that sustainability was a PDP issue and not for the modules, but acknowledged that s/he could be wrong. This is in contrast to another respondent who said:

“I think these issues would be better addressed within the modules rather than as a separate module in itself. I found a lot of students do not wish to fully engage in modules that they do not feel fit with their core study area (despite the efforts of lecturing staff to explain the importance of such a module)”

Conclusions

Inferences drawn so far at Plymouth demonstrate the willingness of a subset of students to engage with sustainable issues, and allowed reflection on the appropriate models for delivery of such material. It is clear that these issues need to be integrated into the assessments if they are to be fully developed, and this is contingent on them having been articulated in the learning outcomes which has been facilitated systematically at Plymouth at all of the levels of study, with the support of the Centre for Sustainable Futures. Computing provision at Newport is only just beginning to consider ‘Green IT’ within the curriculum, and the main finding to date is that staff believe that there should be an embedding of the issues in each of the modules rather than as ‘peripheral’ to their studies in a dedicated module, which some staff believe is counter-productive. This would suggest that it needs to be explicit in learning outcomes in the core modules, but clearly this needs to be tested out from research on students (and there is an ongoing ESDGC project funded by Newport’s Centre for Excellence in Learning and Teaching to consider this), and necessitates further discussions within the Division of Computing in terms of what are the core modules, what are the key issues, and how best to achieve this.

Some computing lecturers at Newport are still unable to see the relevance to their ‘technical’ module area, so these issues are not considered at all, thus there is already a potential conflict in terms of developing approaches to ESDGC in this area. At postgraduate level, sustainability is considered in a module called Strategic Planning for Technology Management which is taught by one of the authors of this paper, and during assessment students each choose a different organisation and evaluate their strategic directions to include sustainability issues, in a similar way to the Plymouth approach. However, there is limited personal and career reflection, and much scope for further enhancement which can only be facilitated through incremental change processes to modify the intended learning outcomes that are linked to the assessments. There is opportunity for further work at Plymouth to evaluate the perceptions of staff teaching the computing and ICT modules and to consider how this relates to better assessment practice and outcomes for ESDGC.

In conclusion, one useful student quote from a Plymouth essay poignantly demonstrates the bigger challenge facing all institutions that teach computing and ICT:
“How are we supposed to develop skills to address the needs of Green IT when we are being taught current, not future, practice at University? The solution is to teach sustainable IT at University along with the rest of the course to incorporate new skills and ideals that are necessary to make a beneficial change in corporate IT”.

REFERENCES


