**STEM Education and Digital Inclusion: E-Learning and GreenIT Initiatives for Sustainable Development**

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**Abstract**

The Internet has been globally accepted as a tool to assist with the sustainability issue. The awareness of Green IT is now considered in most schools, colleges and universities, particularly on STEM courses. Diverse organisations make major savings, in cost, use of paper and personnel, and in reducing their carbon footprint by utilising the Internet as a direct replacement for face-to-face meetings, publicity material. Advertisements for products or social services, now give the web address (URL) as the main source of further information. This is amidst the growing current need to increase the knowledge of the use of Internet and the benefit of computers to some sections of the population. Research has identified amongst others, two categories of learners, they include digital natives (the younger generation) and digital immigrants (the older generation). Between these two groups, there exist digital divide which tends to widen all the time as a result of the rapid rate of technological changes and advances. To address these changes, training needs to be provided to reach the non-digital natives. This paper examines some of the initiatives that have been developed and implemented. Actions to address the needs elderly have been undertaken by such organisations as Age Concern and such other charities as the Third Age Centre in Southampton where one of the authors is a trustee. Specialist short courses have been developed and delivered leading to qualifications such as the I/ECDL (International/European Computer Driving Licence). A range of some of these short courses are being offered at University of Ulster, designed to provide basic knowledge leading to qualifications, particularly for STEM students and employees. The paper presents some of these programmes and reports on some of the challenges in delivery and in particular how the use of technology is now widespread, facilitating innovative approaches. The increased use of e-learning addresses the need to reduce travelling, cost and carbon footprint and to provide learning opportunities to a wider range of potential students, both geographically dispersed and for students of a broad range of ages, hence providing lifelong learning.

The scenario at Southampton Solent University where e-learning courses have been run for many years is examined. These include programmes directed at preparing students for maritime qualifications enabling them to study at sea and those also aimed at preparing them for the BCS (British Computer Society) qualifications. Such initiatives attracted students from Europe, Africa, Asia, North and South America and New Zealand. Our current study shows that many of these students wished to add computing qualifications to their original STEM knowledge and qualifications in order to address the need for gaining computer skills in the engineering sector. Development of the use of e-learning, by teachers, trainers and managers across all sectors, has been supported by courses such as at University of Ulster on the MSc e-learning programme organised mainly through remote access and offered to students worldwide. These have not gone ahead without challenges. These are presented and discussed. The active promotion of e-learning is encouraged by the BCS and in particular through specialist groups such as the BCS e-learning group. Twenty-five percent (25%) of members of the BCS e-learning specialist group are based outside the UK, located across over 40 different countries. Very recently, the BCS GreenIT Specialist Group introduced two competitions aimed mainly at university students to encourage them to think more about sustainability. The first of the competition is aimed particularly at technology students involving asking them to identify a new re-use of old technology, while the second completion is aimed at producing, from parts of old IT equipment, artefacts such as collage, Interactive statues, interactive fashion accessories, directed at both engineering and design students. To encourage participation by universities, in addition to prizes for the winning groups of students, for both competitions, there are also green enhancing prizes for the universities of the winners. The paper calls for more innovative activities to be developed and implemented aimed at promoting STEM education and digital inclusion. Activities such as these, help to increase awareness both of sustainability, the effective use of technology to reduce Carbon footprints and to provide opportunities to enhance lifelong learning to a wider community.

**1. Introduction**

The Internet and the World Wide Web have become globally accessible tools for use at home and at work. This is intertwined with issues of sustainability, which is linked to Green IT, now considered in most schools, colleges and universities, particularly on STEM courses. It is now normal practice for students, regardless of age, to use the Internet as a source of information, as well as for social purposes [1]. They are encouraged to develop a sense of self-motivation for learning and problem solving, particularly for STEM students. This should lead to continuous lifelong learning, which is particular particularly relevant to the fast-changing STEM areas.

Organisations need to reconsider the use of computers to minimise their power usage, carbon footprint and to maximise their efficiency. Organisations now realise the advantage of reducing printing, both for financial and environmental reasons. Large savings have been estimated by various organisations. The HM Revenue & Customs was reported to expect reductions of 12,000 tonnes of carbon dioxide and £2 million savings per year by enabling active power management on PCs and laptops. The UK Crown Prosecution Service was estimated to save £2.35 million by replacing computers every five years instead of every three years. Department of Work and Pensions estimated a savings of two million sheets of paper per year so reducing pressure on the environment (both trees and water to produce the paper) as well as Carbon Footprint and cost. A logistics provider, Wincanton plc, introduced a variety of low-cost actions that have already solved problems in addition to improving their carbon footprint considerably. Their employees were encouraged to car-share, by paying for the MoT of the driver, after it has been in use for three months, the carbon footprint saved by the passengers can be measured, in addition to easing potential car-parking problems. By purchasing six bicycles, which staff can borrow free for one month, their reduction of the carbon footprint can be measured. Many of the staff then realised the advantage in terms of personal fitness and financial savings of using a bicycle rather than a car. The re-use of printer cartridges, by reducing printing and switching off lights and equipment, at schools and colleges, has helped to make students more aware of sustainability issues in addition to reducing the costs for the educational establishments.

Organisations and academia now regularly consider the benefits of remote meetings, such as by using Skype, telephone or video-conferencing, so saving the time and cost (financial and environmental) of travel. These approaches are now being used in communication between lecturers and students in conjunction with the use of learning environments such as the open source Moodle software. The use of software simulators is particularly beneficial for experiments that could be dangerous or expensive for students to perform and that required equipment, or possibly expensive, in short supply or not easily available for students particularly if studying remotely [2]**.** Simulation software can be used to allowed students to understand the needs for sustainability, whether related to issues such as shortage of water, changes in climate and the effect on plants and wildlife. These environmental studies, by default, automatically provide links to STEM subjects, such as mathematics, geography, physics, chemistry and biology.

The majority of students of today can now be regarded as digital natives due to their confidence and ability to handle modern IT technology. Organisations, including Government departments and agencies now use Internet addresses in advertising, to provide, at very low cost, extended information about their products and services. This web address approach is now provided also on radio and television programmes to provide a source of further relevant information. This, although beneficial with respect to sustainability, provides sometimes major problems for non-digital natives. These could be referred to as Digital Immigrants, having become aware of the Internet as adults. The more mature Digital Immigrants, such as the Silver Surfers, have developed appropriate skills and confidence, but there are those that have not learnt to adapt to the world of the Internet. They are seriously disadvantaged, as much of the information needed to support those, particularly of the Third Age, having reached retirement, is most easily available via the Internet.

Charities such as Age Concern and the Southampton based Third Age Centre,

provide classes and help. The assistants who help the trainers, for these sessions are often STEM students, who volunteer to assist, so providing often a "helper" for every pair of course participants. These students benefit by gaining good communication skills and work experience that could be added to their CV to assist in future employability.

**2. Qualifications**

The growth of e-learning and e-examinations are particularly relevant in the computing sector. The ECDL (European Computer Driving Licence) and its counterpart, the ICDL (International Computing Driving Licence) is designed as a series of multi-choice questions that can be taken at various centres throughout the world. These qualifications are targeted at end users, teachers, students and computer hobbyists. There are a series of seven separate tests, which can be taken in any order. This confirmed the candidate's skills associated with creating and using files, word processing packages, spread sheets, databases, PowerPoint, e-mail and the Internet, together with general IT awareness. The BCS administers the ECDL in the UK. One of the authors, Ross, was responsible for setting up the first ECDL test centre based at Southampton Solent University. The first student that completed the ECDL in the UK was at Southampton Solent University. He then continued to successfully take the BCS examinations which resulted in changing his job from initially a stores clerk to becoming a computer professional. Another family of five comprised of the father, mother, and three sons, two of whom were just starting at Southampton Solent University and the youngest being about fifteen. The five members of the family attended an evening class regularly at the university and gradually took the seven tests so that all five members of the family completed the final test at the same time and were able to attend the award ceremony together. Some schools in the UK encouraged their teachers to take the ECDL qualifications, and allow some of their pupils also to take this qualification. Additional qualifications are also offered by the BCS for the more experienced end-users, such as the advanced version of some of the ECDL tests. These tests can be taken also by students.

More advanced qualifications are provided by the BCS, the Institute of Chartered IT Professionals, via their ISEB (Information Systems Examination Board) Foundation examinations [3]. These include e-examinations related to topics such as computing analysis, designed and testing. One of the latest in the series of examinations is the Foundation Certificate in Green IT. This consists of forty multi-choice questions, relating to environmental good practice by end users of Green IT. This qualification is already particularly popular in India.

Other more advanced the examinations have been developed by the ISEB for the Diploma in Data Centres, which also consists of multi-choice questions, aimed at those working or managing data centres. The questions relate mainly to the EC Code of Good Practice for Data Centres and encompasses environmental good practice related to data centres.

**3. Courses at the University of Ulster**

A series of short practical courses have been developed at the University of Ulster aimed at those who wish to develop skills in the use of computers, from the effective use of multi-media and social networking to the use of graphics packages.

In addition to the traditional computer courses at the University of Ulster, there is an MSc in e-learning. The students study remotely, using virtual learning environments to develop skills in designing and using e-learning whether for schools, universities or organisations. This is a very practical course, providing the students with the opportunity to gain relevant practical skills and experience. Many more programmes are offered as part of continuing personal and professional development courses. There are those in the area of Fire Science and Hydrogen Safety, some in Entrepreneurship and Innovation technologies, and others in Life and Health Sciences to include occupational and health studies.

The modes of delivery consist of both fully online and blended, comprising both web supplemented and web dependent approaches. Some of these are offer qualifications that are accredited by professional bodies such as the British Computer Society, the Institution for Engineering and Technology (IET), the Institute of Mechanical Engineers (IMechE) etc.

**4. Courses at Southampton Solent University.**

The Southampton Solent University has been developing teaching material for remote study for many years. Material was initially developed to be sent to part-time students, to study while sailing the world, to obtain their maritime qualifications. Distance-learning courses were established by one of the authors, Ross, to prepare part-time students, already working in the computing industry, for the BCS Certificate, Diploma and Professional Graduate Diploma examinations [4], which are approximately at the level of the first year, second year, and final year of an undergraduate degree course. These involve only examinations, with no course work. It is possible to take courses to prepare students for these examinations or they could study alone. For a number of years, Ross was responsible for running distance learning courses [5] leading to all three levels of the BCS examinations The BCS Certificate in IT covered the three compulsory modules of Information Systems, Software Development, and Computer and Network Technology. Students were required to pass the compulsory Professional Issues in Information Systems Practice paper and three optional Diploma papers, from a range that included Database Systems, IT Project Management and IT Service Management. The BCS Professional Graduate Diploma in IT consisted of four modules, including topics such as Computer Service Management, Management Information Systems and Software Engineering. These BCS qualifications were particularly useful for students such as those in Africa, where suitable courses might not be available. For a computer professional working in the relevant area, it is not necessary for these qualifications to be taken in any order but eventually the student is required to undertake a project, which is normally work based. The students came from most parts of the world including North and South America, Europe, the Middle and Far East, Australia and New Zealand. In addition to the Internet based communications, students could talk directly, using telephone conferencing, with their tutors at pre-set times.

A mixture of a blended learning and distance-learning course was introduced leading to an MSc in Six Sigma. The unit material and assessment for two modules are made available to the students at the start of each 12 week set of two modules via the learning environment. The students attend for two weekends, after three and nine weeks from the start of the modules, and the unit assignment is submitted at the end of week twelve.

During this twelve week period, regular contact is maintained between the tutors and the students at pre-agreed times (usually in the evenings or at the weekends, via video-conferencing. This is in addition to the one-to-one communications via e-mail, telephone and video conferencing between a student and the tutor. This mode of study has been very successful and has attracted students from all parts of the UK and Europe

**5. BCS Activities**

The BCS, the Chartered Institute of IT, actively supports the concept of e-learning and of promoting sustainability. It established an Academy, (Uhomoibhi is a member of this Academy for learning) which is particularly associated with raising the profile of ICT in schools, for potential undergraduates and future ICT professionals. Full description of the purpose of this Academy was explained by the BCS Vice-President BCS, Professor Bacon [6] in her opening keynote speech of the BCS INSPIRE conference in 2010.

Careers working parties had previously been set up (Ross was a member) that developed a series of A3 and A4 posters to raise the awareness of ICT at careers conventions and to be given to schools, so that the careers teachers could interchange the different posters on a regular basis, to raise awareness of ICT with the pupils. The texts on these were:

Do you have:

A gift for communicating with people?

* And inquiring mind?
* An eye for detail?
* The ability to see the wider picture?
* A logical approach

Have you thought about IT?

Do you like:

* Working with others?
* Solving problems?
* Helping people?
* Learning new skills?
* Effecting change?

Have you thought about IT?

Do you want to work with:

* Film makers?
* Fashion designers?
* Bankers?
* Hospitals?
* Manufacturers?
* Education?

Have you thought about IT?

Did you want to work as a:

* Games designer?
* Web designer?
* Business analyst?
* Network manager?
* Hardware designer?
* Support analyst?

Have you thought about IT?

On each of these was a smiling under-graduate student holding the banner that said "Have you thought about IT? "

The BCS careers panel also produced the series of e-leaflets, indicating the different skills and qualifications necessary for the different ICT roles, together with explanations of various ICT jobs, such as on the Entry Skills e-leaflet [7]. An example of one of these is the Typical Career Paths leaflet [8], which provided a simple flow chart explaining that if a pupil had specialist skills ranging from communication skills that could lead forward to systems analysis roles then on to project management and eventually to the Head of the ICT Department. Alternatively, if a pupil had technical skills which could lead to the role of programmer, then systems designer and then again leading to the top job of Head of the ICT Department. This particular leaflet was the most popular at careers conventions and with the ICT and careers teachers. The range of BCS Career Leaflets [9] cover a range of roles, but more are needed, as the variation of ICT roles constantly change and new roles develop.

The leaflets could consider possible entry points into the computer industry such as

16 year-old with and without qualifications

18 year-old with qualifications

20 year-old with HND or Foundation degrees

21 year-old with computing/Network/BIT/non IT related degrees

Various types of training could be identified, as follows: full-time, part-time, remote learning and the ability to continue education at a later date, should also be considered.

The types of jobs could be:

Games development from a technical perspective and from the perspective of designing games and marketing them

Web design

Help-desk

Systems Analysis (stressing the use of communication skills)

Programming

Network Management

Operations

Also mentioning opportunities in the future for teleworking [10]**,** which could be attractive when the ICT professional has a young family. Today, teleworking has a potentially key role in the green agenda. Final points stress that the computer professional normally works in teams to address problems, and that computing is essential now to all industries and is used to address real problems that help people and the environment. In addition for material aimed at schools, school teachers and careers advisers, there is a need for guidance material aimed at undergraduates, to guide students on various types of jobs, the requirements of potential employers and possible routes to obtain particular types of employment in the computing industry. This material could include case histories and quotes from successful BCS Young Professional Group members.

in addition, the BCS has produced a series of mini films (ExcITing careers, 2010) [11], which are freely available on the Internet. In each of these, a typical student interviews a professional in their first few years within the IT industry. There are questions about his or her background, what type of course was taken and particularly what their job involves. These include roles such as in the games industry, networking and web designing. Today, each of the roles should include awareness of sustainability, both for financial and environmental reasons.

**5.1 The BCS e-learning Specialist Group**

When the BCS e-learning Specialist Group of which both authors, Uhomoibhi and Ross are Chair and Vice Chair respectively, was established to promote and assist with the use of e-learning and foster the safe use of the Internet for learning [12], it was a goal to address issues of sustainability and engage in promoting education for all by reaching out to all learners globally.. This Specialist Group has organised a series of physical meetings in various locations, from Southampton to Belfast, and has also utilised meetings, partially held in Second Life. The use of the virtual environment and video-conferencing, will such as the proposed events to be held in the UAE, are an excellent way to enable those members of the Specialist Group situated outside the UK. The approach can be viewed as promoting sustainability [13].

Physical meetings are also arranged outside the UK, such as when the Chair, Uhomoibhi, visited South Africa and Poland so arrangements were made for such on-site events. This Specialist Group has approximately 25% of its membership in countries outside the UK, located across over 40 different countries, including from USA, Canada, Africa, the Middle and the Far East, and mainland Europe. In addition to these activities, the e-learning Specialist Group, in conjunction with the BCS Quality Specialist Group, arranges the annual INSPIRE (International Software Process Improvement through Research and Education) conferences, INSPIRE 2011 [14]. These have been held in various locations from Loughborough (the year) and previously in various locations including Belfast, London, in Spain and in Finland.

**5.2 The BCS Greene IT Specialist Group**

The BCS GreenIT Specialist Group was formed to promote sustainability, particularly related to end users. There is a separate BCS Specialist Group that is concerned with green issues relating to managing and operating Data Centres. The Green IT Specialist Group provides free e-guidance briefing papers, arranges physical meetings in various locations, and produces conference and journal papers together with articles , such those as by Ross in Government Technology. In addition, this Specialist Group produces filmed events and recorded audio discussions that are made freely available on their BCS website.

**6. BCS Competitions to Raise Student Awareness**

A series of global competitions have been arranged by the BCS to generate interest in sustainability and e-learning among students at Universities, Higher and Further Educational establishments. These provide opportunities for students to enhance their CVs, by receiving a Certificate confirming they are winners or runners up in these international competitions. Entries are invited from individuals or groups of students at all levels of study, from postgraduate, undergraduate or in other education, whether in full-time or part-time study; and is open to BCS and non-BCS members. Entries are made on the competition page on the appropriate Specialist Group’s web site, via a nominated single point of contact, normally a lecturer, for each competition. Each establishment could submit up to ten entries for each competition; and it is left to the points of contact to sift down to this limit, if more than ten entries were submitted to them

For each of the competitions, the language is in English. A BCS panel assesses all submitted entries and select those for further consideration. All shortlisted entries have an opportunity to present their proposal, utilising technology where appropriate. The owners of the proposal retain IP and copyright over the proposal but provide BCS with media rights and all other rights appropriate for the competition.

**6.1 The BCS e-Learning Specialist Group’s Competition**

The BCS e-Learning Specialist Group has been running a competition, submitted by the point of contact to the BCS. The theme is the “Benefit of e-learning”. Entries consist of a five hundred word description of the application, which could be actual or a proposed application of any form of e-learning, including an educational game, together with a single screen picture, as an e-poster, describing, via limited text and illustrations the application. Examples could relate to gaining skills, professional qualifications or ensuring children’s safety with the Internet. The email addresses for questions, from the points of contact, being elearningcomp@bcs.org

**6.2 The BCS GreenIT Specialist Group’s Competition**

The BCS GreenIT Specialist Group introduced two competitions aimed mainly at university students to encourage them to think more about sustainability. The competition theme is the “innovative use of redundant IT equipment for promoting the Green IT agenda and messages”. The first of the competition is aimed particularly at technology students involving asking them to identify a new re-use of old technology, while the second completion is aimed at producing, from parts of old IT equipment, artefacts such as collage, Interactive statues, interactive fashion accessories, directed at both engineering and design students.

One aspect of Green (Sustainable) IT is the disposal of redundant equipment. The BCS Green IT Specialist Group support the mantra of reuse, renew, recycle but far too often redundant IT equipment is either stored permanently, or scrapped and the components removed and the raw materials recycled. We think that redundant IT equipment can be used for other computing or non-computing purposes and are holding this competition to determine the most innovative artistic, Public Relations (PR) or design use of redundant IT equipment.

Most corporate or educational IT is replaced on a 3 year rolling refresh cycle, this is due to warranty cover and the vicious circle of hardware/software upgrades or new releases, but the items themselves are designed to last a lot longer. The GreenIT Specialist Group recognise that most computers are over specified for their current use: internet access, email and office applications do not require state of the art computing platforms except for advanced applications such as GIS, media and graphics. The GreenIT Specialist Group also recognises that some bodies will already be operating a robust recycling plan, such as selling equipment to staff, donations to charitable organisations or disposal to WEEE operators or specialist computer recycling companies but we want to see radical and innovative alternative solutions. The GreenIT Specialist Group stresses the need to see redundant equipment being used for other things- the scope is wide - anything that is imaginative, and promotes if possible the messages around sustainability and re-use. The only constraints are that the competitors record exactly what they have done or are planning to do for judging purposes, and that their proposal meets their institution’s ethical and legal requirements.

For the innovative IT recycling – Art and Design Competition, typical examples might be of visual artworks such as sculptures, installations, collages, fashion accessories, furniture or any type of product design. The entry consists of five hundred word description, in Arial font 11 Point in English, of the artefact or design, , incorporating the theme of the innovative use of redundant IT equipment for promoting the Green IT agenda and messages, together with URL(s) to wherever photo(s) or other supporting media reside. The entries are marked on Innovation, Impact and Quality, with all these criteria equally weighted. For the Innovative IT Recycling –Technical Innovation Competition, examples could be the use of redundant equipment with environmental sensors to provide real or stored data for monitoring functions such as connected to web cams, thermometers; these as part of local environmental control systems, such as domestic lighting and central heating; networking with others to provide a linking of dispersed IT resource for significant computations.

The entry, a maximum of one thousand words, in Arial font 11 Point in English, should include if possible the project overview (executive summary), the equipment specification prior to project, the equipment specification post project, the project description (detailed), the intended outcomes and the proposed future work to develop the proposal, the entries are marked on Innovation, quality of submission, commercial potential, social potential and environmental potential. All criteria are equally weighted, To encourage participation by universities, in addition to prizes for the winning groups of students, for both competitions, there are also green enhancing prizes for the universities of the winners, sponsored by Carbon3IT Ltd. The email addresses for questions from the points of contact are available at GreenITArtcomp@bcs.org for the Art and Design competition and for GreenITTechInnovcomp@bcs.org for the Technical Innovation Competition.

**7. Conclusions**

The trend for new or replaced mobile-phones and laptops, in different coloured cases, has promoted a potential non-green culture. Possibly there needs to be a new status symbol of vintage technology which has already been achieved for vintage clothes, jewellery, furniture and cars (although the latter are not often very green!). The paper calls for more innovative activities to be developed and implemented aimed at promoting STEM education and digital inclusion.

New programmes are being developed all the time to enhance learning, widening participation in higher education by diversity of learners at universities. However, there is the recognition of the dwindling number of students entering higher education to study STEM subjects. This spells the need for digital inclusion and for professional organisation to become actively involved in sustainable development education process.

Activities such as those described above, help to increase awareness both of sustainability, the effective use of technology to reduce Carbon footprints and to provide opportunities to enhance lifelong learning to a wider community.

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