ICT Sustainability from Day One.

Introducing new Computer Science students at a UK University to Sustainability.

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***Abstract*— As ICT impacts dramatically on the sustainability of the world and of individuals, both positive and negative, there is an urgent need to educate Computer Science students about Sustainability. This paper assesses the experience of a project to introduce new University students in a Computer Science department to concepts of sustainability. It describes the team project approach used during the first few weeks of a student's time at the University of the West of England and the standard template for sustainable technology proposals. It reviews the learning from five years of the programme and engagement of over 250 students.**

The programme has received positive student feedback and broadened the sustainability awareness of students. It has become an opportunity to introduce all new students in the department to the United Nations Sustainable Development Goals. The programme has shown reduced levels of student engagement in recent years and the paper explores some of the reasons for this. Overall, the programme makes a positive contribution to achievement of the University's sustainability policy and supports the requirements of the relevant professional body and the UK Quality Assurance Agency.*)*

***Index Terms*—ICT4S, Sustainability, Computer Science, Education for Sustainable Development, ESD, SDG**

I. Introduction

There is an urgent global problem with the unsustainable burden that our economies and lifestyles place upon the planet. This existential crisis is at its most threatening in the form of climate change where the difference between an average of 1.5 degree C warming and 2 degree C might increase "the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (medium confidence)" [1, p. 11]. There are other planetary limits where we have already exceeded safe thresholds and are at risk of exceeding others [2]. In addition to these environmental threats, society also faces social and economic pressures from unsustainable development. Whilst political and practical responses to these threats are frustratingly slow, there is some reason for hope in the form of the United Nations Sustainable Development Goals (SDGs), agreed by 193 countries in September 2015 [3]. These 17 goals set out a vision of the sustainable world we want by 2030.

Information and Communication Technologies (ICT) are a documented contributor to unsustainable development, for instance, responsible for roughly 2-4% of global Greenhouse Gas (GHG) emissions [4] [5]. However, ICT solutions also have the potential to enable GHG reductions in a variety of applications across the economy [6].

In the United Kingdom, many students arriving at University for their first year of undergraduate CS courses have a low awareness of the impacts of ICT on sustainability – negative or positive [7]. These are issues that they will face very directly in the course of their professional careers, so there is a responsibility on Computer Science (CS) departments to ensure these students have opportunities to engage with and learn about sustainability.

This paper explores the policy and curriculum context for sustainability in CS courses. It also describes the process and experience of introducing new CS students to sustainability in a project which has been running at the University of the West of England Bristol (UWE) for five years. UWE has a strong commitment to Education for Sustainable Development [8] [9] [10] and the Induction project is just one of a range of interventions to engage CS students with sustainability.

II. Policy and Curriculum Context

A. Definitions of Sustainability

1) Sustainability: a contested word in ICT

The very term 'sustainability' is a contested word in the ICT context. Some uses of 'sustainability' in computing journals refer to ICT providing a sustainable competitive advantage for an organisation. Sustainability is understood as relating to the provision of the required technology platforms and having the staff with the right skills to develop and maintain applications [11] [12].

Increasingly papers in this field are using the term 'sustainability' to refer to broader concepts of environmental, social and economic sustainability in the wider economy and ecosystem. There is a need for research of this change in usage This is consistent with the common usage of sustainability as a synonym for sustainable development. The most widely cited definition of sustainable development is development which "meets the needs of the present without compromising the ability of future generations to meet their own needs" [13, Sec. Summary para 27].

2) Sustainable Development

In September 2015, the 193 countries in the United Nations adopted the Sustainable Development Goals (SDGs) [3].

These 17 global goals are shown in figure 1. The goals consist of 169 specific targets to be achieved by 2030 or earlier. The 17 SDGs are quite generic and it is at the level of the targets that practical action can be mobilised and achievement measured.

Fig. 1. The United Nations Sustainable Development Goals [3]

An example of one of the goals is SDG4 "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" [3, p. 14] and an example of a target within this is SDG4.7 "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" [3, p. 17]. This places a clear responsibility on the education sector to deliver achievement of this target through Education for Sustainable Development (ESD).

3) Sustainability and the Global ICT Industry

Significant sections of the ICT industry have recognised the responsibility of the industry for sustainability and the market opportunity for ICT solutions delivering sustainability benefits. The Global e-Sustainability Initiative (GeSI) [14] is a case in point. Formed in 2001 it is an industry funded body which has campaigned to promote the benefits the ICT industry can deliver towards sustainability. Their most high-profile reports have been Smart 2020 [15], Smarter 2020 [16] and Smarter 2030 [17] which describe and estimate the sustainability benefits from ICT implementation.

GeSI's website lists over 50 members and partners but the terms of membership make it clear that members are companies in the communication network industry. Whilst GeSI states that it is a source of impartial information, it is funded by ICT industry members with membership fees of 30,000 USD per year [18].

The Smarter 20nn series of reports have recognised the GHG impact of ICT use with estimates ranging initially from 2.7% of global emissions by 2020 [15] later reducing to 1.97% by 2030 [17]. However, the latest report claims that "ICT solutions can help cut 9.7 times more CO_2e than they emit" [17, p. 18]. This claim is based upon the impact modelling work carried out by Accenture for the report. Their model uses a rather basic approach to estimating the drivers and impacts, potentially with wide, but unspecified, uncertainty. More recently, Bieser and Hilty, published a systematic literature review of the methods used in studies estimating the indirect environmental effects of ICT systems e.g. reduction in transportation GHG emissions. They identify 15 different methods in 54 studies [19]. These vary in sophistication and focus. Most of the studies focus on changes to the processes of production and fail to account for potential changes in consumption arising from the ICT implementation. Hence these studies omit a potentially significant driver of environmental impact and only partially address the agenda of SDG12 - Responsible Consumption and Production.

Other global bodies have also highlighted the sustainability benefits that ICT can deliver [20]. Many global ICT industry companies have had long running campaigns on this theme with straplines such as IBM 'Smarter Planet', Philips 'Better Me, Better World ', Huawei 'Green World', SONY 'Road To Zero', O2 'Think Big' and CISCO 'EnergyWise'. These organisations see the story of ICT and sustainability as a business opportunity and source of positive corporate reputation. Globally, the Technology, Media and Telecommunications sector is amongst the top five sectors for rates of corporate responsibility (CR) reporting [21].

It has been left mostly to NGOs to point out the negative sustainability impacts of ICT including the dirty cloud campaign of Greenpeace [22] and the working conditions campaigns of China Labor Watch [23] and GoodElectronics [24]. There is also an emerging body of academic analysis of the impact of ICT systems on the SDGs in specific sectors e.g. Cancer Care Informatics [25].

The reality of ICT impacts on sustainability mean that industry employers are looking for staff with an understanding of sustainability. This is consistent with reports anticipating growth of 'Green Jobs' [26]. This is an industry pull factor shaping expectations of sustainability content in CS courses.

B. Teaching Sustainability

1) Sustainability in CS Curricula – United Kingdom.

In the United Kingdom, standards for Higher Education courses are set and monitored by the Quality Assurance Agency for Higher Education (QAA). The QAA publish Subject Benchmark statements for specific course domains which describe "what graduates might reasonably be expected to know, do and understand at the end of their studies" [27, p. 1]. So a key question when designing delivery of ESD in a CS course is what is required by the Computing Subject Benchmark Statement [28].

There is very little explicit content on sustainability in the 20 page QAA Computing Subject Benchmark Statement. It states that Computing graduates "create social and economic value by building secure, reliable and usable systems" [28, p. 7] completely omitting any reference to environmental value. The document groups the skills expected of Computing graduates under three headings: computing-related cognitive skills, computing-related practical skills, and generic skills for employability.

Computing-related cognitive skills include "recognise the professional, economic, social, environmental, moral and ethical issues involved in the sustainable exploitation of computer technology and be guided by the adoption of appropriate professional, ethical and legal practices" [28, p. 10]. 'Recognise' and 'be guided by' are surprisingly weak statements compared to the 'use', 'deploy' and 'analyse' written in some of the other cognitive skills statements.

Computing-related practical skills include "the ability to recognise any risks and safety aspects that may be involved in the deployment of computing systems" and "The ability to evaluate systems in terms of quality attributes and possible trade-offs presented within the given problem" [28, p. 10]. If these are well-taught, they will encompass sustainability risks and trade-offs. However, the phrase 'within the given problem' is troubling as many sustainability impacts occur outside of the narrowly defined scope of an application.

The last item on the list of generic skills for employability does include the broader statement "Sustainability: recognising factors in environmental and societal contexts relating to the opportunities and challenges created by computing systems across a range of human activities" [28, p. 11]. Once again, this is a weak 'recognising' when other skills include 'construct', 'work unsupervised' or 'make best use of'.

There is a later blanket statement that student learning should be in "the context of social, ethical, legal, professional, environmental and economic factors relevant to Computing" [28, p. 12] but this is also a fairly nebulous requirement.

The Subject Benchmark Statement divides Computing into "Computer Science, Computer Engineering, Software Engineering, Information Technology, and Information Systems". In the page of definitions of these disciplines, only Information Systems contains the comment "including societal and environmental issues" [28, p. 8]. By implication societal and environmental issues are not included in the other four disciplines.

On balance the QAA requirements regarding sustainability are minor and weak in comparison to other content. However, the statement does note that for a prescriptive body of knowledge reference should be made to the Association of Computing Machinery (ACM) curricula. This ACM curricula will be reviewed for sustainability content in a subsequent section of this paper.

It is surprising that the Subject Benchmark Statement is weak on sustainability, given that the QAA together with the HEA had two years earlier published "Education for sustainable development: Guidance for UK higher education providers" [29]. The document is "intended to be relevant to educators in all disciplines wishing to embed or include learning about sustainable development within their curricula" [29, p. 2]. The guidance includes a set of 38 graduate outcomes expected from ESD (pages 10 -12). CS course designers should be encouraged to check that their programmes will give students the opportunities to achieve these outcomes.

In the United Kingdom, some CS courses are also accredited towards membership of the professional body known as BCS, the Chartered Institute for IT. The BCS publish a 43 page document of Guidelines on Course Accreditation [30]. It complements and refers to the QAA Computing Subject Benchmark Standard. The Guidelines are also weak on sustainability. There is a statement that "Programmes seeking accreditation must cover and assess the legal, social, ethical, and professional issues (LSEPIs) relating to computing" [30, p. 16]. "Environmental and sustainability aspects" only merit inclusion as one bullet point in a list of ten examples of LSEPIs. In the whole document, of six references to 'environment' only this one has the ecological meaning. The other references are to technical computing contexts. Somewhat more encouraging is that the guidance that LSEPIs "should be specifically detailed in the syllabus" [30, p. 17], not left to discretion or optional modules.

Academics in Higher Education cannot assume that students will come with an awareness of sustainability from primary or secondary schooling in the UK. UNESCO's report on ESD in the UK notes that "Since the election in 2010, the government emphasis on sustainable development has been reduced, and climate change is not the strong driver it was" [31, p. 17]. The Environmental Association of Universities and Colleges was amongst many signatories of a letter calling on the Secretary of State for Education to "keep sustainability in the National Curriculum objectives" [32] in response to a consultation questioning its status. A survey of first year undergraduate Computing students showed that 54% of the respondents did not believe that their subject had "any potential impact to any area of sustainable development - environmental, social or other" [7].

2) Sustainability in CS Curricula – Global.

The global statement of curricula for CS is published by a joint task force of the ACM and IEEE. The latest version is 518 pages [33] and once again is disappointingly light on sustainability. The body of knowledge does contain an attribute "SP/Sustainability" within the Knowledge Area "SP - Social Issues and Professional Practice" [33, p. 203]. This merits just one hour of Core-Tier 1 time and one hour of Core-Tier 2 time. Out of a combined total of 308 hours this demonstrates very little regard for sustainability.

Fig. 2. Programme SDG map [36, p36]

Another global guide to which CS course designers may refer is the Skills Framework for the Information Age (SFIA) which is now in version 7 [34]. This does have a skill SUST defined as "The provision of advice, assistance and leadership to enable the organisation to minimise negative environmental impact" [34, p. 46]. Note that this is defined entirely in negative terms. There is no mention of the positive environmental impacts and the statement is also weak on social aspects of sustainability. The SUST skills are only prescribed at levels 4, 5 and 6 so are not expected of lower level staff. The word 'sustainability' is used 25 times in the 134 page document but most uses imply the meaning of maintainability of systems.

Overall, the United Kingdom and Global curricula for Computing offer little support or weight to coverage of sustainability in courses offered by CS departments. This is surprising given the emphasis placed on sustainability by ICT industry bodies and employers.

3) Education for Sustainable Development – Institution Context

Although the National and Global CS curricula offer little encouragement to the Department of Computer Science and Creative Technologies, there is strong encouragement towards ESD at an Institution level from UWE Bristol. This includes a dedicated staff lead, a cross university knowledge exchange group, published ESD policies, annual reports and a parallel commitment from the Students' Union [8]. The institutional context is more fully described in Longhurst et al (2015) and Gough and Longhurst (2018). UWE Bristol has a stated vision for ESD that "By 2020, all staff and students will be familiar with the UN SDGs and have an awareness of their relevance to the individual's own discipline." [35, p. 8]. As part of this commitment, all departments are mapping their programmes of study to identify their coverage of the UN SDGs. An SDG map for one of the programmes in the Department of Computer Science and Creative Technologies is shown in figure 2 [36, p. 36]. UWE Bristol's five stated Graduate Attributes [37], collectively describe a sustainability literate graduate. Therefore there is an emphasis on activities for students to develop these attributes, whether in formal teaching or extra-curricular opportunities.

4) Teaching Approaches for ESD in CS

Given the strong Institutional encouragement for ESD but weak subject curricula, it is useful to review the literature on ESD teaching approaches for CS. Searches were carried out using the terms (sustainability AND computer science AND Teaching) and separately (ESD AND computer science) using the SUMMON library search. The terms were narrow to maximize relevance. SUMMON was used because it offers wide literature coverage and fewer spurious results than Google Scholar [25].

Recognition of employability as a key driver for teaching sustainability to CS students was reported by Gordon et al [38] with a key choice whether to embed the topic across the CS programme or segregate it to a separate taught component.

The segregated approach was described in the design of a Green Computing module at RMIT University [39] and University of Coventry [40]. Hamilton discusses the design of a teaching module specifically covering Green Computing in her brief paper on "Learning and Teaching Computing Sustainability". This includes students using single board computers to gather data on 'Green Variables" such as "power usage for lighting and computers, air quality, actual paper usage" [39, p.

338]. Payne describes a group-work activity for second year Computing students to recommend sustainability tips for a fictional IT organisation. The approach adopted by Coventry University at that stage was to include sustainability as a separate work package rather than embedded throughout the Computing curriculum. It was noted that this approach experienced poor student engagement.

The embedded strategy is discussed in approaches to incorporate Sustainable ICT topics in the Innovation and Technology Management MSc at Bath University [41]. In this paper, Cayzer emphasizes an approach which focusses on students responding to the constraints which sustainability will place on their future projects such as legislative drivers and energy efficiency targets, rather than debating the science of climate change.

In their study of 80 ICT program students at the University of Zurich (UZH) and KTH Stockholm (KTH) who covered a sustainable development topic in their dissertation, Hilty and Huber found a set of five teaching themes which most motivated the students

- "A conceptual framework of positive and negative impacts of ICT on SD.
- Real-life reports on the recycling of ICT hardware, with a focus on informal recycling in developing countries.
- Real-life reports on using ICT to reduce greenhouse gas emissions, for example, by videoconferencing.
- Statistical data on the total material demand of modern economies.
- Historical evidence for rebound effects" [42, p. 651]

Extra-mural approaches can also make a significant contribution to students' appreciation of sustainability. This is reported within the context of Bristol's year as European Green Capital, during which the two Universities in Bristol supported engagement of students with the city community through volunteering, placements / internships and projects [43]

C. Sustainable Technology Proposal Induction Project

The Department of Computer Science and Creative Technologies (CSCT) at UWE Bristol has included sustainability content in its programmes for many years. Most notably in the Community Action and Knowledge Exchange (CAKE) projects where final year undergraduate students work in teams to deliver digital technology projects for community organisations [44]. There are good examples of embedding sustainability throughout the curriculum such as using local air quality datasets in coursework for data handling topics. The department has mapped one of its programmes, BSc Information Technology Management for Business, towards the SDGs and shown good levels of coverage across the programme [36, p. 36] as shown in Appendix 2.

However, there was not a taught component which explicitly introduced concepts of sustainability. So in 2013 CSCT made a decision to add sustainability content to the Induction week in order to raise the sustainability awareness amongst the whole cohort of new students. A Sustainable Technology Proposal Induction Project was designed for its first run in September 2013. It was led and delivered by Ian Brooks who was employed by UWE Bristol on an Environmental Innovation support programme. He had previously worked on Green IT for IBM including as IBM's Sustainability Leader on their IT outsourcing programme at Defra (UK Department for Environment, Food and Rural Affairs). Martin Serpell, an established Senior Lecturer in CSCT jointly authored and delivered the talks.

The project included a one hour talk on the sustainability impacts and benefits of ICT [45] for new CS students in Induction week (w/c 16 Sep 2013) and a 20 minute version for Games Technology and Music Technology students. This talk introduced the optional team competition and the process for participating. It was made clear that the competition was voluntary, did not have a prize and did not contribute any marks towards the student's course. There were follow up sessions with individual degree programmes to encourage teams to participate and to answer questions about the competition.

The competition was a team project for groups of four students to identify a sustainability problem and propose a technology solution to deliver sustainability benefits. A simple five slide PowerPoint template for submission of the team proposal was provided [46] as shown in Appendix 1. Deadline for submission was 30 Sep 2013 using online submission through the Blackboard VLE. The submissions were scored by three sustainability professionals including the chair of the BCS Green IT Specialist Group. The winning team were offered support time for development of their idea.

This content and contact time met the Sustainability requirements of the QAA Computing Subject Benchmark Statement, the ACM Computing Curricula and the Skills Framework for the Information Age 7. The content partially met the requirements of the BCS Accreditation Guidelines though not the requirement of the LSEPIs to be explicit in the syllabus as there is no module specification for this induction activity.

36 teams submitted proposals with a combined total of 129 students participating. The winning team proposed a booking app for students to share taxis returning from the city centre to campus, with anticipated reductions in GHG and monetary savings for students.

The winning student team were provided mentoring time over the course of the year and enrolled in the UWE Bristol Entrepreneurship support programme. They later won a small start-up support grant from UWE Bristol to further develop their proposal.

Given the high level of student engagement on this optional project and the positive informal feedback, CSCT decided to repeat the Sustainable Technology Proposal Induction Project in subsequent years.

In 2014 and 2015 the same process was followed with the addition of a £100 prize of Amazon vouchers to be shared amongst the winning team. Assessment was completed by one member of staff. In 2014, 22 teams with a combined total of 70 students participated. In 2015, 13 teams with 46 students.

In 2016 session delivery was by one member of staff only and with no follow up sessions taken up by individual programmes. Content on the SDGs was added to the presentation and the students asked to identify the SDGs which benefitted from their proposal. 3 teams with 11 students submitted proposals. There was some student feedback that the deadline for submission was too short.

In 2017 in response to feedback, the submission deadline was set as 20th October. 3 teams with a total of 8 students submitted proposals.

A core set of data about the content and nature of each submission in each of the years was kept by the project leader and analysed as the basis for this research.

D. Discussion of Five Years' Experience

The most striking feature in the data from the five years' experience is the notable drop in the number of students participating in later years as shown in figure 3. There is no definitive data as to the reason for this reduction and further research is needed to explain it. Contributory factors are likely to include: no program-specific follow up sessions in 2016 which had supported the development of teams and expectation of participation; student perceptions of 17 SDGs as complex; and Introduction of a prize in 2014 altering the student motivation.

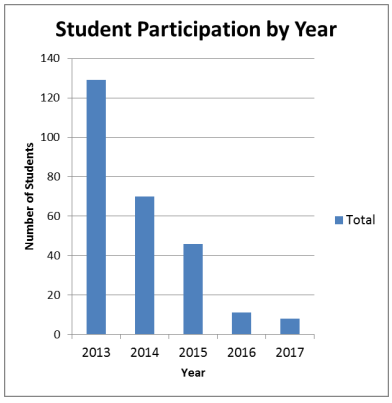

Fig. 3. Student Participation by Year

The student proposals were categorised as to whether they were an improvement to the sustainability of IT, e.g. Data Centre efficiency, or improvement to sustainability delivered by IT, e.g. transport GHG reduction. The analysis is shown in fig. 4.

The proposals were also categorised by the SDG which was the primary beneficiary of the technology proposal. For 2016 and 2017 this was identified by the student team. For previous years the author has reviewed the proposal in the light of the SDGs which were agreed in September 2015. The analysis is shown in figure 5. 47% of the proposals delivered benefits primarily relating to SDG 7 "Ensure access to affordable, reliable, sustainable and modern energy for all" [3]. SDG target 7.3 relates to energy efficiency improvement and most of the improvements proposed to the sustainability of IT are energy efficiency improvements.

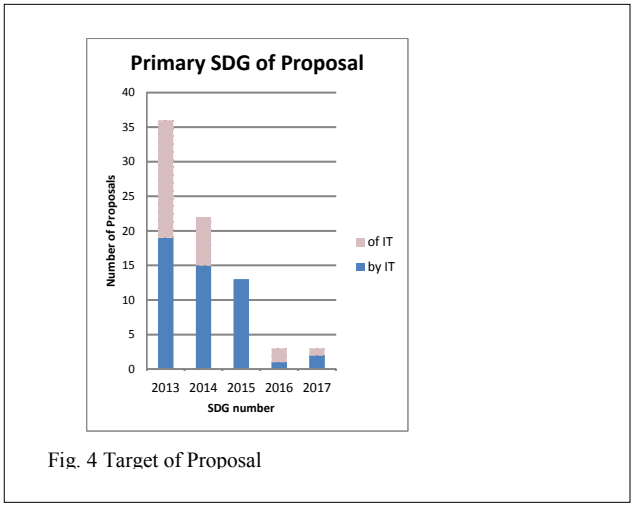

Fig. 4 Target of Proposal

In 2018, students from each year group were asked to provide written feedback on their experience of the Sustainable Technology Proposal Induction Project. The following themes emerged from their responses.

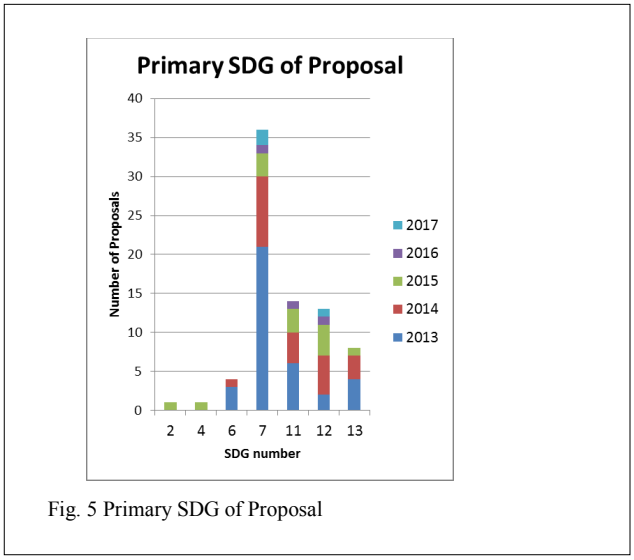

Fig. 5 Primary SDG of Proposal

Knowledge of Sustainability and Technology. Students valued the opportunity to learn and to research the topic of sustainability and technology. One student observed that the project "highlighted just how bad the current situation is in some areas, something which I feel all IT students and practitioners need to be aware of" [47]

Sustainability content in the rest of the course. Students from 2013-16 noted that they did not identify much sustainability content elsewhere in their course. However, this has clearly been an area of improvement as a student from 2016 stated that sustainability was "something that was later covered in multiple modules (as it is a growing area of both interest and concern)" [47]

The student feedback also highlighted a number of significant co-benefits of the project.

- Career development. The skills and experience developed in the proposal process served them well for establishing their early career
- Lasting relationships. Many students observed that the team work and friendships built continued through their university time and beyond.
- Mentoring and opportunities. The process of research and talking to staff about their ideas created confidence and developed opportunities for the students.
- Project development. Understanding how an idea moves from being an idea into something "students could work together to lead […] by themselves" [48]

From a staff perspective, the process of the proposal project helped students become familiar with the University systems in the first weeks of their course and in a context where marks were not at stake.

III. Recommendations

For CS courses which have not yet embedded Sustainability content throughout their programme, an induction activity along the lines described above can be a strong contribution to achieving the Sustainability requirements of the UK and Global curricula.

Whilst the one hour talk on ICT sustainability will provide a baseline awareness for new students, it is engagement with the team proposal project which provides the maximum benefit for the student. To ensure the highest levels of participation, it is essential that staff engage with students in smaller cohort groups to provide a realistic opportunity for team formation. This inevitably requires supporting time commitment from the staff delivering the project.

CS departments designing ICT Sustainability content and activities for their programmes should consider the UK and Global curricula as an absolute minimum. They should be encouraged to follow the QAA & HEA ESD guidance document [29]. They should map their programmes against the SDGs to ensure that they are giving their students an employability advantage. The global ICT industry needs new employees who are equipped for responsible professional careers in a time of sustainability constraints as climate change impacts become increasingly damaging.

IV. Conclusion

The global ICT industry shows high awareness of the significance of ICT for delivering sustainability benefits along with an acknowledgement of the contribution of ICT to climate change. This is in part a market opportunity for this sector but does also mean that sustainability awareness enhances employability for students entering the ICT sector.

Given this industry context, the UK and Global curricula for CS cover surprisingly little Sustainability both in terms of few references to the concepts and weakly worded requirements.

Universities which have a strong commitment to Education for Sustainable Development, have choices to make about embedding Sustainability throughout the CS syllabus or providing a standalone component.

An ICT Sustainability project as described in this paper can make a valuable standalone contribution to raising the awareness of each new CS cohort, and allow time to embed Sustainability systematically throughout the course.

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Appendix 1: Sustainable Tech Project Proposal format

Anon University

Computer Science

Sustainable Tech Project Proposal

Team members names

Version 1.0 nn September 2013

Problem description

Brief description of the problem identified by the team

Sources:

2

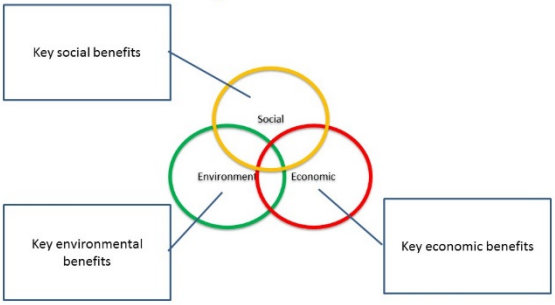
Proposed solution

Brief description of the solution proposed by the team

Sources:

3

Sustainability benefits



Sources:

4

Proposed technology

Brief description of the technological solution proposed by the team and sustainability impacts of the technology

Sources:

5

References

Information sources used in the project

6

BSc (Hons) Information Technology Management for Business (ITMB)

Issues of relevance
Place in the ITMB programme

1 NO POVERTY

IT enabling access to resources e.g. financial services, land registries and supporting resilience.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP6-30-3 and 6 other modules

2 ZERO HUNGER

Role of logistics systems in food distribution. Productivity improvement through Smart agriculture.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP6-30-3 and 6 other modules

3 GOOD HEALTH AND WELL-BEING

Use of telehealth to widen healthcare coverage and App-supported healthy behaviour change
Modules: UFCF6X-30-2, UFCFP6-30-3, UMSD7T-15-3 and 7 other modules

4 QUALITY EDUCATION

ITMB students have extensive learning in Entrepreneurship. Importance of lifelong learning in information systems. Changing nature of skills. Broadening access to education through online learning.
Modules: UMSD87-15-3, UFCF6X-30-2, UFCFP6-30-3 and 10 other modules

5 GENDER EQUALITY

Learning about leadership, gender and diversity. Role of IT in enabling work opportunities which improve gender equality e.g. working from home
Modules: UFCF6X-30-2, UFCFP6-30-3, UMSD7T-15-3, UMOD6F-15-3 and 7 other modules

6 CLEAN WATER AND SANITATION

Role of IT in Integrated Water Resource Management. IT systems for running Water companies.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP6-30-3 and 6 other modules

7 AFFORDABLE AND CLEAN ENERGY

Carbon footprint arising from IT use of electricity (about 3% of global GHG emissions). Imperative to decarbonise IT. Smart Grids.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP6-30-3 and 6 other modules

UWE Bristol — University of the West of England

8 DECENT WORK AND ECONOMIC GROWTH

Impact of technology on work. Role of entrepreneurship in creating work and growth.
Modules: UMSD87-15-3, UFCFA5-15-3, UFCFE6-15-3 and 15 other modules

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Guru lectures on areas of IT driven innovation. Role of IT in disrupting old business models and creating new value. Importance of IT infrastructure in enabling innovation.
Modules: UFCFP3-30-1, UMSD7T-15-3, UFCF6X-30-2 and 13 other modules

10 REDUCED INEQUALITIES

Key Issues raised by ICTs that give rise to ethical concerns. Impact of disruptive technologies on wealth distribution. Precarious work. Use of IT to widen equality of opportunity.
Modules: UFCFP6-30-3, UMSD7T-15-3, UFCFB5-15-3 and 7 other modules

11 SUSTAINABLE CITIES AND COMMUNITIES

Smart City systems. IT in management of city traffic. Role of IT in supporting citizen engagement in urban planning.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UMODDP-15-1 and 8 other modules

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Role of IT in supply chain. Guru lectures on areas of IT driven innovation. Food waste reduction. IT in business sustainability reporting.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP3-30-1, UFCFP6-30-3 and 9 other modules

13 CLIMATE ACTION

Key role of IT in carbon reduction (required for 20% of GHG reductions by 2030). Reducing the carbon footprint arising from IT use of electricity (about 3% of global GHG emissions).
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP6-30-3 and 7 other modules

14 LIFE BELOW WATER

Responsible management of eWaste to reduce water pollution. Use of remote sensing for fisheries management / protection.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP6-30-3 and 6 other modules

15 LIFE ON LAND

IT in sharing benefits of genetic resources. Remote sensing for conservation.
Modules: Induction Sustainable Technology team project, UFCF6X-30-2, UFCFP6-30-3 and 6 other modules

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

Social consequences of technological innovation. Issues of surveillance and cybercrime. Socio-technical hybrid nature of information practice.
Modules: UFCFA5-15-3, UFCFB5-15-3, UMODDP-15-1 and 12 other modules

17 PARTNERSHIPS FOR THE GOALS

Ability to adapt to different academic and cultural settings. Technology sharing and cooperation. Role of the Technology Bank.
Modules: UFCFWJ-15-3, UFCF6X-30-2, UFCFP6-30-3 and 9 other modules

Appendix 2: Course SDG Map