Sustainable Development as a framework for ethics and skills in Higher Education Computing courses

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Abstract The impact of sustainable development on the curriculum remains variable, and in some disciplines the inclusion is considered by some to be inappropriate or not relevant. This paper considers the ways in which sustainable development can be embedded within the curriculum, with the dual aims of showing how it can be made both relevant to students within the context of their discipline, and how sustainable development can provide a framework for developing an appreciation of the legal, social, ethical and professional (LSEP) aspects of the discipline and to develop sustainability values in students.
The paper focusses on a case study in embedding sustainable development within Computer Science degree programmes, where the LSEP requirements are recognised by accrediting bodies and by many employers as essential characteristics and skills in graduates. The paper will describe how sustainable development provides an overarching framework within which to explore these issues. Moreover, the paper will include some examples of how this is successful in engaging students who may otherwise struggle to appreciate the LSEP topics. The success will be demonstrated through some objective data showing the impact of this approach to students understanding and acknowledgment of sustainability and how this may be applied to other disciplines and national contexts.

Introduction

The concept of Sustainable Development (SD) has become established as a concept (United Nations, 2010), and education is identified as a way to promote and support SD from an international strategic viewpoint. SD has been adopted and adapted by a variety of national government and government-related organisations. Considering the UK perspective, recent UK governments have developed the following key areas that underpin the international SD agenda, from a UK perspective, the UK SD guiding principles (DEFRA, 2011) are summarised as:

1. Living within Environmental Limits
2. Ensuring a Strong, Healthy and Just Society
3. Achieving a Sustainable Economy
4. Using Sound Science Responsibly
5. Promoting Good Governance

Within the educational context, SD is considered throughout the different stages, with Higher Education (tertiary education) being the final formal educational environment for SD skills and knowledge to be potentially promoted, as graduates move on to play their roles within society. This chapter considers some of the issues around delivering SD within the curriculum, and in particular within the context of Computer Science within the UK setting. However, the ideas and issues are transferrable to other educational levels, to other national settings and to different disciplines. The English funding council for HE (HEFCE, 2005) summarised the UN (2010) as

> "development which meets the needs of the present without compromising the ability of future generations to meet their own needs"

Many countries are increasingly focussing discussions and policy about the benefits to individuals and societies from Higher Education, and as part of this, there is an increasing recognition of the graduate attributes or skills that students develop, and can then apply within their later careers and other societal impact. Such graduate attributes (O'Connor et al, 2011) can show how such attributes are important to communities and link to wider civic, social and moral issues. Whilst government departments can promulgate SD within their policy contexts (DEFRA 2009 and 2013), the impact of this depends on a number of factors, from the nature of the policy – e.g. whether the requirement is must, should or simply advice) – as well as any link to enforcement i.e. how is the policy policed. Where such policy is left partly to choice, the impact is likely to be more limited and disparate.

Sustainable Development and Higher Education

In Higher Education in many countries, the autonomy of institutions is seen as paramount and provides the confidence in the type of skills and approaches developed in graduates. Within numerous countries, this means that curriculum and the outcomes for students are controlled by institutions, with loose oversight – possibly through quality review processes – by government organisations. In terms of SD, this can mean that the choice to engage with any part of the SD agenda is limited, or lacks cohesion. For example, national policies around carbon reduction, taxation and energy dependence can encourage or require that academic institutions – as large users of power and significant contributors to carbon pollution – adopt rigorous approaches to energy monitoring, management and reduction as a priority and thus engage with that facet of the SD agenda. However, the impetus for curriculum engagement with SD is typically much looser and lenient, which can mean that institutions lack the stimulus to deal with this part of the Education for SD program. In the UK context, elements of Higher Education policy is set by the individual states own funding councils, which adopt different approaches to expectations for SD (Gordon, 2009b).

A further dimension to potential engagement with SD in Higher Education stems from the differing nature of disciplines. In some, the expectation and requirement to include topics and issues that fall into the SD remit is clear; examples here include geography, biology environment and earth sciences. For other disciplines, the links can be made, though maybe less frequent – such as engineering and chemistry. Within the sciences, physics, mathematics and computer science can all be linked to SD, though the nature of the links and the motivation varies. Moving away from the Science, Technology, Engineering and Mathematical (STEM) disciplines, many others have clear potential motivating links to SD – including the social and governance issues (politics, social sciences), the economic drivers and consequences related to SD (business and logistics), as well as the wider civic and social concerns (education, politics and health). International aspects can motivate links to disciplines that focus on national concerns, such as nation based studies. Areas such as history, archaeology and drama can all be linked to SD, with considerations about change and the portrayal of change in societies, and how we can learn from past decisions and events. The UK Higher Education Academy provides support for education in universities, and includes resources for many subjects that demonstrate and provide case studies of how SD can be related to specific disciplines.

The discussions so far have shown how there are numerous drivers for SD within Higher Education. However, as noted this may well be purely framed as guidance and suggestions to practitioners. Echoing the autonomy of HE institutions, disciplines within HE are typified by their own communities of practice (Becher, 2001), who themselves have ownership of the nature of the content and practice of teaching within the Higher Education framework. With regards to SD, the examples in the previous paragraph reflect some of the views of how different disciplines relate to SD, and thus as to how practitioners may expect to demonstrate their own approaches. The decision of if and how to do such may be supported by disciplines – perhaps through subject expectations and requirements - and then these cascade down to the approach of distinct departments and the individual practitioners themselves. The viewpoint and approach of the individual can affect how much they do – or do not – engage with the SD subject and agenda, though in is still not uncommon for individual practitioners to have little exposure to or awareness of SD and how they could use it within their own teaching.

Considering the student perspective, recent surveys of student attitudes (for example, Drayson et al, 2013) shows that students expect and want the skills related to Sustainable Development. The following table summarises some results of students' expectations at the author's institution (based on data from the HEA 2013 review of SD attitudes, across campus, but with a majority of computing students).

% of students who agreed (very/somewhat)	With the following statements
24%	the importance of the environmental approach of the institution in selecting it originally
41%	the university approach to global development
19%	thought their course should improve their understanding of people's relationship to nature
51%	that they should have skills to consider medium/long term planning
46%	using resources efficiently
32%	whole system thinking

Table 1: Students' views on SD skills (HEA, 2013)

Professional Practice and Sustainable Development

Following on from the earlier consideration of graduate attributes, these can be further considered in terms of the professional development of students, as they become graduates and move into various roles in society. Supporting the focus on professional practice and employment, many disciplines have professional expectations and requirements, in particular where Higher Education (degree) courses are accredited and are expected to lead to direct professional practice. Such accreditation may require that degree programmes include content – and corresponding learning outcomes and assessment methods – that would ensure students have met and appreciate the professional aspects of their chosen discipline. This content typically complements the subject content itself, and includes the wider set of material about how the future graduate should act as a professional. They may include the legal framework within which they will be expected to operate. These topics may provide motivation and context in which to consider the ethical and moral issues and situations that the graduate will be expected to handle, and the wider social impact and social environment in which the student will later be living and working. The legislative and behavioural framework is sometimes referred to as the Legal, Social, Ethical and Professional (LSEP) features (see Figure 1).

Beyond accreditation, the demand for students with skills has been identified by a number of reports (e.g. Cade, 2008), where the need for graduates with skills related to environment and social responsibility was a key point. The idea of responsible employers

Figure 1: the LSEP themes

needing equally responsible employees can fit well into the SD remit, with SD potentially providing a basis within which to develop these particular attributes (Gordon, 2009a).

Having considered the wider context of SD and Higher Education, we now focus on the case study of SD within the Computer Science curriculum.

Computer Science and Sustainable Development

As a discipline, Computer Science has a strong ethos of professional development, with a focus on developing students as future practitioners. In common with many other professional disciplines – from health and nursing, through subjects such as law and engineering – the accrediting bodies for degree programmes require evidence that students are familiar with, and should abide by, the professional values for the subject. This is common across the range of sciences, where requirements for professional scientists are typically formalised through codes of practice or requirements for practitioners to follow. In computing, the various national professional and discipline bodies – including the British Computer Society (BCS) and Association for Computing Machinery (ACM) and IEEE Computer Society specify issues that a graduate should demonstrate. Whilst they come under a variety of acronyms and labels, one summary is the Legal, Social, Ethical and Professional (LSEP) values. These are values and concepts that students should be familiar with and able to demonstrate an understanding and appreciation of, especially the requirements of society and of the impact of their discipline and activities on society. These societal concerns are recognised by groups such as the Computer Professionals for Social Responsibility (2009), an organisation focussing on the impact of computing on society. The potential to build

In terms of curriculum issues, the ACM (2013) report on Computer Science curricula 2013 includes the social and professional practice expected of a computing student, with sustainability a core feature, developing from earlier expectations that students understand "cultural, social, legal and ethical issues inherent in the discipline of computing" (ibid). The

BCS course accreditation guidelines also identified the LSEP values as being core requirements, and now lists "environmental and sustainability aspects (BCS, 2012) as examples, within the wider LSEP topics. These requirements for course accreditation and approval also reflect the codes of practice for the respective organisations in terms of behaviours of graduates who work as computing professionals.

The 2008 HEFCE report (HEFCE, 2008) on Sustainable Development in Higher Education in England noted how contrasting activity around Sustainable Development seemed, and empirical evidence from more recent reviews and projects reinforces this as something that remains an issue, with variable engagement with the SD agenda. Again, as noted in the HEFCE report, for some institutions and for individual practitioners, Sustainable Development is not considered important and lacks links to the curriculum.

Empirical evidence of staff perceptions identifies some of the typical barriers to including SD within local curricula, which can be summarised as

- Lack of relevance to the main subject – sometimes in spite of the accrediting bodies expectations;
- Overfull curricula – finding space for new material;
- Fear of indoctrination – recognising the balance between providing advice on what the issues are, distinct from forcing a view on what is the right answer;
- Attitudes – as noted earlier, SD engagement is potentially dependent on the individual practitioners own personal perspective and attitude;

The Quality Assurance Agency, responsible for standards in UK universities, provides content expectations through discipline specific benchmark statements. The QAA Computing Benchmark for undergraduate courses (QAA, 2007) and the more recent Master's degree benchmark (QAA, 2011) provide explicit links to these areas, with the 2007 guidance expecting students demonstrate cognitive skills

> "Professional considerations: 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"

whilst the 2011 report specifying under subject content that students should have

> "an understanding of professional, legal, social, cultural and ethical issues related to computing and an awareness of societal and environmental impact".

In the context of preparing students for work, the requirements by employers and by accrediting bodies is also a potential incentive: within computer science, a number professional certificates and practice encourage or require evidencing aspects around environmental awareness, or of cultural and societal impact, with

- concerns around data centres (European Commissions, 2009);
- utilising IT to support low carbon economies (Climate Group, 2008);
- dealing with the waste from IT (WEEE, 2006).

A Framework for LSEP

Developing from the discussion on the expectations amongst students, accrediting bodies and quality agencies of the inclusion of issues around legal, social, ethical and professional practice, we now consider how sustainability can provide an effective framework for this.

As already demonstrated, the practicing computer scientist will be expected to demonstrate an understanding of the impact of their work on society and the environment. Furthermore, depending on their specialism – be it data centres or commissioning new Information Systems, there is an expectation of both developing appropriate solutions and of potentially gaining evidence of continuing professional development related to this (e.g.

green IT certification (BCS, 2009). Power usage – the carbon footprint of IT – and the potential of computer science to address this, through efficient design or through improving the efficiency of other human activity - may provide case studies and examples around which to develop the impact of computing on the environment (Gordon, 2010b). This utilisation of computer science in addressing these types of problem can be considered as responsible use of science. Such professional aspects can be built into the curriculum, utilising sustainability related concepts in exploring the nature of being a professional. In a similar vein, the issues of waste and inefficiency can provide concrete examples through which to explore ethical and moral dimensions (Gordon, 2010a). The societal impact of technology – with concerns around the digital divide and the opportunities for computing to introduce new approaches to democracy and governance link directly to the SD topic of social issues, and can consider how social computing may – or may not – contribute to stronger societies. Legal topics around waste, data protection and information freedom can be related to these aspects too – with the hardware and information systems related to the first of those, and social aspects considered alongside the last two. Considering these overall topics, the motivation for LSEP can be clearly linked to the social, economic and environmental aspects of SD. Moreover, with the additional concerns of responsible science and good governance, we can identify the following framework for SD within the LSEP expectations for computer science.

Figure 2: a framework for LSEP and SD in Computing

Case study of the impact of embedding green issues within the computing curriculum

In order to demonstrate the potential gains from an educational perspective of embedding sustainable and green computing issues within computer science, we now consider some data arising from a first year undergraduate computer science module (circa 180 students over 5 years). This longitudinal study provides evidence of the positive impact of such material on motivating students generally, and extends an earlier study over 3 years (Gordon, 2011). Some of the material is available as reusable learning objects (see Gordon, 2010c for examples).

Issues within computing education

The stereotypes of a typical computing student does have some resonance with experience, especially in the UK where the gender imbalance (Scragg, 1988) in computing courses is recognised as a weakness and risk to the discipline. The figure below shows intake proportions for the author's own department, they are reflective of the typical (approximately 90% domination of male students in computing disciplines). Moreover, beyond the gender bias within the discipline, the technical focus for many students can seem at odds to the topics that fall within the LSEP and SD remit. Social aspects may be considered by many students as peripheral, when their main interest is to work on their latest assignment or programming project by themselves. Ethics – being a more philosophical concept – can be considered by some students as of only limited interest and relevance. The notion of professionalism itself – bringing together the other topics, may well be considered by some as extraneous. The study summarised below provides some data on the positive impact of motivating LSEP material through SD topics.

When including new material within teaching, there is an issue about whether to integrate it within existing modules and courses, or to include specialist modules that focus on the content. The benefit of the explicit stand-alone approach can be that students and accrediting bodies can clearly identify the relevant material. However, such approaches can also cause barriers – where students do not see the relevance of the material, or colleagues are reluctant to take on the teaching of the content. The benefits of integrating ethics and social responsibility into the core curriculum (Martin and Weltz, 1999) are that teaching staff and students will meet it, and it offers the opportunity to place the material in context.

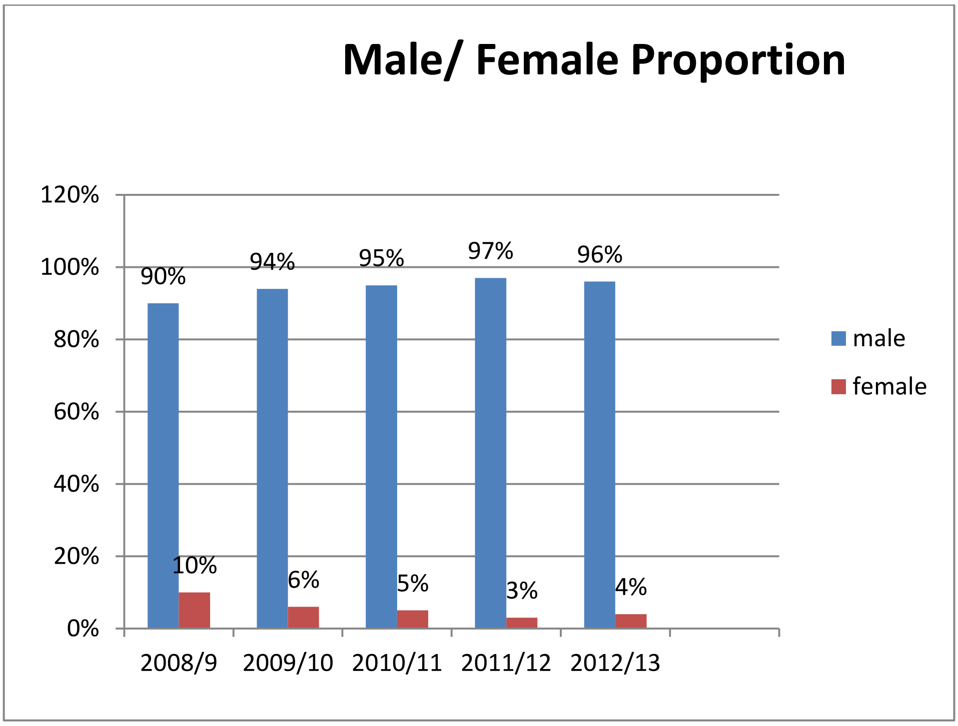

Figure 3: Proportion of male/female students

Evidence of impact

This case study considers an embedding approach, with LSEP and SD material embedded within existing core computing content, related to professional and IT skills. Considering the 5 years of the study, student engagement with the module has generally improved. There is some indication from assessment that students have greater recognition of the relevance of the LSEP material – motivated by examples and links to SD. It also appears that this material has in general improved the engagement – at least as measured through attainment - of the students based on their end of section assessments. The results for the female students is more varied – whilst it was postulated that they may respond to the social aspects more strongly than their male counterparts, the overall results are not markedly better as illustrated in the figures below.

The following figures show the results of assessments at the end of a semester's teaching Students performance within the module was split between the IT content, explicit LSEP content, and combined material taught under the auspices of SD, that is motivating the IT and LSEP themes through the context of SD related examples.

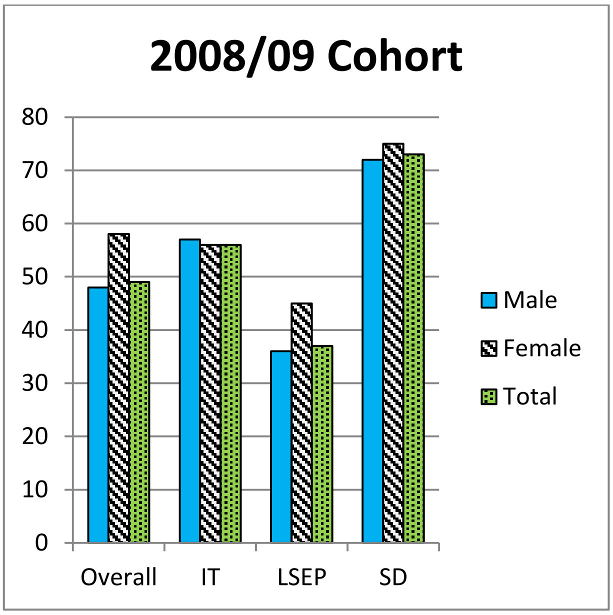

Figure 4: Assessment results 2008/09

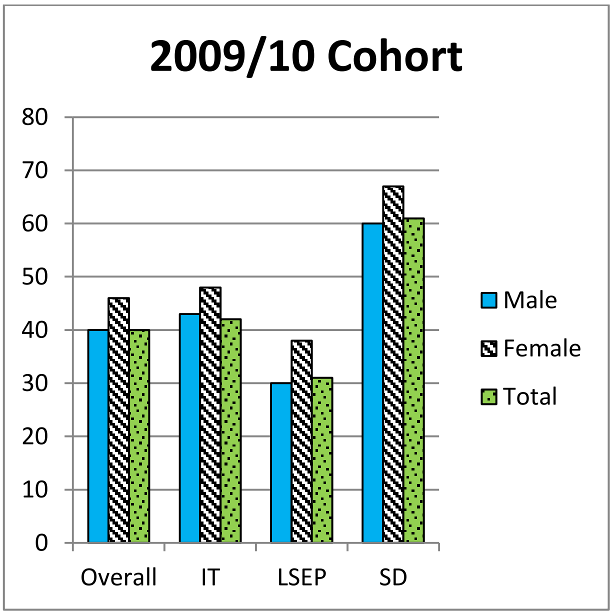

Figure 5: Assessment results 2009/10

As can be seen from the figures, the achievement in IT material was generally higher than the LSEP content, for all categories of students – apart from the most recent cohort where the figures were similar. There was no pattern between attainment in IT versus LSEP when considered by gender. However, the marks for the SD motivated material are consistently and substantially higher than that for the separate IT and LSEP streams.

Overall, this demonstrates that the students appear to connect with the material most effectively when the material was combined, exceeding the performance in the separate material by a significant margin.

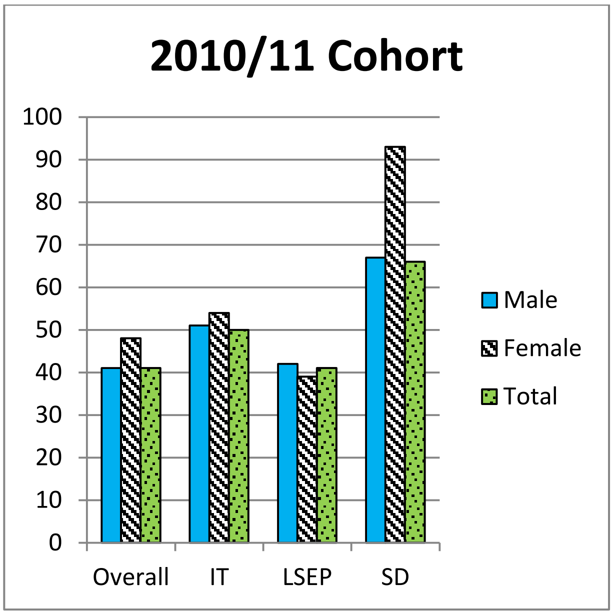

Figure 6: Assessment results 2010/11

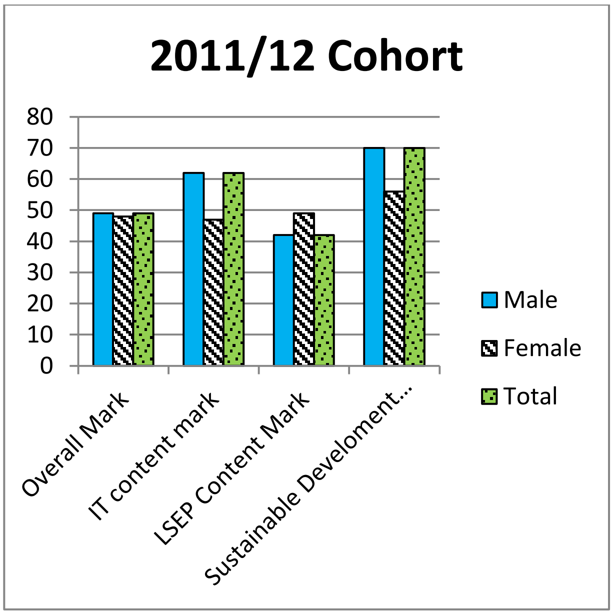

Figure 7: Assessment results 2011/12

The overall profiles for the material taught to 5 different cohorts demonstrate an consistent pattern, with generally a higher mark in IT material than LSEP, and with a significantly higher mark in Sustainable Development than the other two. From the data considered in the figures, there is some evidence that providing a strong and coherent context for the delivery of LSEP material linked to IT, situated within the framework of Sustainable Development can improve students' engagement with material, and their performance as measured through assessment. The data provided indicates that this can have a greater effect for female students in computing – for 4 of the 5 years considered.

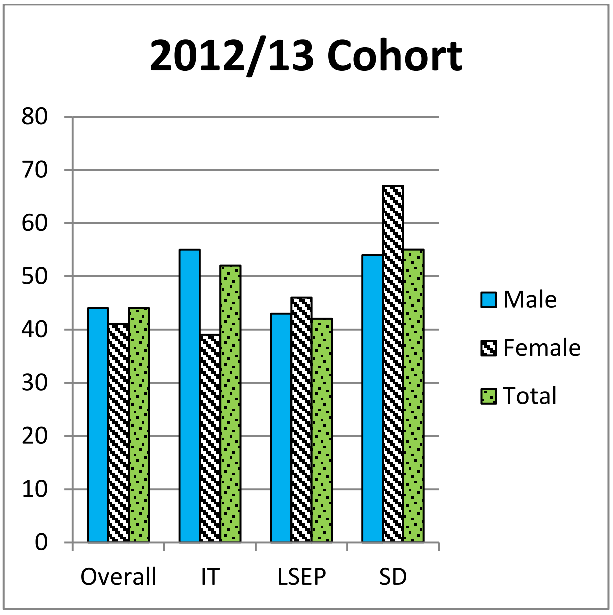

Figure 8: Assessment results 2012/13

Conclusions

As we have considered in this chapter, SD is both expected and required to be included within the computing curriculum at universities, at least to some extent. As noted in the wider context, the impact of SD on the curriculum is variable. The discussion of how SD can be used to motivate LSEP and related topics within computer science discussed ways that could be applied to other disciplines. A key element of this approach to embedding SD within a course – whether as a stand-alone module or placed within other modules (Pattinson et al, 2011), (Gordon et al, 2011) – is that it demonstrates how SD can be made both relevant to students within the context of their discipline, and how sustainable development can provide a framework for developing an appreciation of the legal, social, ethical and professional aspects of their discipline. The framework described and illustrated in the chapter is transferrable to other disciplines – where the underpinning ideas of professional behaviours are key elements of the graduate attributes expected from students successfully completing recognised courses.

The success of this approach has been illustrated through a longitudinal study (approximate 1000 students over 5 years) where the positive impact of motivating LSEP concepts, by linking them to core discipline content (in this case IT) within the context of SD examples led to improved attainment. Such motivation through examples is relevant to other

Whilst the embedding of SD was shown to be successful in terms of improving performance in LSEP and IT learning, the material was not explicitly labelled as SD, and end of module surveys of students indicated that many students were not aware they had met Sustainable Development in spite of demonstrating the skills and attributes related to it.

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