Exploring key sustainable development themes through learning activities

Heather Cruickshank
Richard Fenner

Centre for Sustainable Development, Department of Engineering
Cambridge University, U.K.

Abstract

The Masters programme in Engineering for Sustainable Development at Cambridge University explores a number of key themes, including dealing with: complexity, uncertainty, change, other disciplines, people, environmental limits, whole life costs, and trade-offs. This paper examines how these concepts are introduced and analyses the range of exercises and assignments which are designed to encourage students to test their own assumptions and abilities to develop competencies in these areas. Student performance against these tasks is discussed and student feedback is also presented, with a focus on how their awareness of the themes are met through a range of activities.

Introduction

Addressing sustainable development issues through postgraduate professional practice Masters programmes allows the freedom to move beyond both curriculum constraints and an emphasis on reductionist thinking often found in engineering courses at the undergraduate level. First degree programmes have tended to focus on conveying basic engineering science and general principles, whilst at the postgraduate level the application of those principles can be explored against the constraints and complexities represented by the wider issues relating to sustainability.

Fisk and Ahearn (2006) have suggested Masters level education provides two clear advantages. First, students bring with them a maturity and realism of outlook often based on their own experiences of working within engineering organizations. Secondly they are likely to take up positions of significant responsibility when leaving the course, being employed as leaders of engineering projects or recruited specifically to change management procedures towards more sustainable approaches. Fisk and Ahearn go on to suggest that such students "are able to challenge assumptions in the classroom rather than discover a disjunction with reality only when they try to apply acquired knowledge in the field"

The taught MPhil in "Engineering for Sustainable Development" at Cambridge University is such a professional practice Masters programme. It was set up in 2002 and in the last 8 years over 230 engineers from all of the major engineering disciplines have successfully graduated from the course. The philosophy behind the MPhil and its original development is described in an earlier paper by the authors (Fenner R.A. *et al*., 2005). The course has gone through several stages of evolution with a clear set of themes emerging with which the students are expected to engage. The mechanisms used for introducing and exploring these themes are the focus of this paper.

Student background and expectations

Many students enrolling on the course each year come with a number of years professional experience from working in the engineering industry. Whilst some students are new graduates, the age profile of participants at the start of the course has ranged from 21 to 64, with most being in their late twenties or early thirties. Each year group has had a strong international mix, with around 50 countries having been represented on the programme overall. Such a diversity of cultures and backgrounds leads to stimulating discussion in which different views are shared and challenged, with the result that students emerge seeing problems from a multiplicity of viewpoints and aspirations.

The participants' expectations vary, but these can be broadly summarised into two categories. For some younger fresh graduates there is a tendency to seek prescriptive solutions, with a desire to be told "how" to deliver a sustainable project or product, perhaps in the form of a rigorous Code of Practice or Design Manual. This is a reflection of their previous education where right and wrong answers are the norm, and everything is reduced or deconstructed into smaller tasks or models for which definitively "correct" solutions can be provided. This problem solving focus based on a reductionist or Newtonian model is appropriate in some circumstances but the emphasis on the MPhil programme is to concentrate more on the need for problem definition. Furthermore the students are confronted with a more holistic approach to measuring the performance of an engineering project which embraces both uncertainty and the need to achieve more than straightforward optimization around a single variable. Accepting that the engineer's first choice solution may not be acceptable in all parts of society can be uncomfortable for some who, if unchallenged, would perpetuate "a design and defend" attitude or a "predict and provide" solution, reflected in part by engineering educational structures and a largely conservative, risk-averse profession. Finding co-optimum solutions to satisfy a range of viewpoints and other constraints is challenging and requires an understanding and integration of issues which hitherto have not been within the domain of engineering professionals.

The more mature and experienced students fall into a second category, as coming from industry they often have direct experience of bad practice and want to understand why this occurs. They are also making a significant personal commitment to refocus their professional lives through seeking a change of direction through a formal educational route, often at some direct financial cost to themselves, and are therefore likely to be intolerant of fuzzy or vague ideas. This means they are usually strongly motivated and keen to learn new tools and methodologies for analyzing and measuring sustainable performance. One 51 year old former Highway Engineer articulated this well when she acknowledged that the course had: "provided the full 64 colour set of crayons rather than the 8 shades of grey pencil" with which she had been working for most of her professional life.

The challenge then is clear. How can numeracy-oriented postgraduate engineers be encouraged to embrace the wider social, economic, environmental and policy issues they must consider to ensure their engineering skills are properly focused in delivering the right technical solutions for the twenty-first century? The answer is to encourage them to begin by asking a broader set of questions, from which their own sustainable responses will emerge.

Sustainable Development Themes

There are many postgraduate programmes around the world which explore in technical detail a range of specialist issues such as the Economics of Climate Change or New and Renewable Energies. These are important and valuable programmes and train specialists in the growing number of technologies and policy issues urgently needed to transform how we deal with the pressures on the environment, manage the diminishing stock of natural resources, and develop low carbon systems.

Having recently looked at 108 institutions in the UK and 31 in North America the authors have been unable to find much evidence of programmes that actively attempt to change the mindset of general engineers who are still required to deliver the products and services demanded by a modern society, but in a more sustainable way and as part of an increasingly intricate socio-technical system. In a recent study of what engineering students learn on sustainability courses, Segalas, Ferrer-Balas and Mulder (2010) found that "most students after taking a course on SD, focus on the technological aspects of sustainability, regarding technology as offering solutions to environmental problems". They concluded there was much less emphasis from the students on the social / institutional aspects of

sustainability. Thus engineering for sustainable development can be reduced for some to just the level of the smart technical fix.

In part, this can be attributed to the notion that sustainable development is a vague, highly complex concept that is difficult to understand, and subject to endless definition and re-definition. Steiner and Posch (2006) argue that important concepts such as democracy, welfare and justice are not subject to an analytically precise definition and that similarly sustainable development is more dialectical than analytical. Despite this the ideas that lie behind the notion of sustainable development have to be translated into a series of key themes and these must be conveyed to students in effective learning environments. For example, Kamp (2006) describes how this has been achieved at Delft University of Technology recognising that sustainable development not only involves the environment, but also people and economics worldwide. This is summarized as requiring a transition towards non-polluting products that are made from renewable resources, as well as seeing the people part of sustainable development in a wide social context, so that organizations actively seek to make a long-term positive contribution to society, for which the company profit is the reward. It is important to encourage young engineers to think strategically about technology design and production and so understand processes of technological change. The overall objective has been clearly summarized by Bremer and Lopez-Franco (2006) when describing the graduate level programmes at ITESM in Mexico as creating students who leave the course as "agents of change, knowing how their everyday actions and choices have an impact on the environment, our society and the well being of future generations"

In the Cambridge University "Engineering for Sustainable Development" MPhil we have defined several themes, perhaps better conveyed as key challenges, in which engineers must respond to new societal expectation by:

Dealing with **complexity**	through adopting a systems approach.
Dealing with **uncertainty**	when decision making in the absence of complete information or evidence.
Dealing with **change**	by challenging orthodoxy and envisioning the future.
Dealing with **other disciplines**	through building multi-disciplinary teams.
Dealing with **environmental limits**	through resource efficiency, pollution control and maintaining ecosystem services.
Dealing with **people**	through consultation processes and negotiation to meet society's and individual's needs.
Dealing with **whole life costs**	by considering project externalities and life cycle management.
Dealing with **trade-offs**	by avoiding optimisation around a single variable to create solutions acceptable for all.

These themes are mapped onto the formal activities which all students undertake throughout the core MPhil programme. The following section will examine each of these core activities in detail and the students' responses to them. In addition to this (and not covered in detail here) there are over thirty elective modules available (studied by subsets of students) which provide specialist and more detailed teaching in topics such as Systems Dynamics, Complexity and Negotiation, and Development Engineering. Students also conduct a five–month individual Dissertation in which they must plan, execute and critically evaluate an original and investigative piece of work reflecting a broad spectrum of sustainability themes, and this is also not reported or analysed here.

Review of core activities

It is not the intention in this paper to describe the syllabus content, lecture topics or teaching styles of the programme which develop and draw out the above themes. Instead we offer a review of the activities actively undertaken by the students themselves that help support the formal delivery of the material, and which attempt to provide an experiential engagement with these key issues.

Residential Field Courses

These are important for creating a group dynamic in which task sharing is important. The first two-day exercise takes place at the beginning of the programme and is an examination of three road schemes in southern England, loosely intended to explore the relationship of roads to landscape. Ostensibly students are asked to find a solution to the alignment of a new road past the World Heritage site at Stonehenge, but the reality is to expose them to how the complexity of constraints have led in practice to the inability to implement a solution to date, leaving the problem indefinitely unresolved. These road schemes (Twyford Down and Hindhead are also visited) are good examples of messy problems in which solutions must embrace non-technical as well as engineering features. *(Complexity)*

The second, longer field trip is towards the end of the programme and centres on issues relating to the post-mining regeneration of Cornwall. A number of diverse industries are visited including tourist sites such as the Eden Project, china clay workings, urban regeneration projects in Camborne-Pool-Redruth, new eco- town proposals at St Austell, and the development of renewable energy sources such as the Cornwall Wave Hub and one of the several wind farms in the area. This provides a real world context around which many of the concepts developed on the course can be synthesised and applied in seeking how development projects and the provision of improved infrastructure services can be implemented to meet sustainability principles, at a level of operational detail.
(Environmental limits, Change, Whole Life Costs, Other Disciplines)

Role Play

An important aspect to understanding the broader context in which engineering solutions must be delivered is to create an emotional attachment to the outcome of a decision. Experiencing something of the, perhaps irrational, passion displayed when decision stakes are high over an issue relating to a large infrastructure project can enable students to have more empathy towards stakeholders. Using role play based around cases of specific development projects can provide the circumstances to understand the behaviour of people within these contexts and to understand the linkages between certain problems, the behaviour and technologies within these contexts and the problems that result. Most importantly it can encourage contextual thinking (Dielman and Husingh, 2006).

An effective exercise is to use role plays such as Puerto Mauricio (van der Wansem, Dyke. and Susskind (2003)) based on a fictional coastal town in which a large and culturally significant parcel of land is about to be sold. Students take on the role of a variety of stakeholders and try to reach agreement on the development plans for the area. The exercise is designed to demonstrate the mutual gains approach to negotiation and consensus building in which mutually advantageous solutions are sought so that it isn't necessary that for one party to win, the other must lose. *(Tradeoffs, Uncertainty)*

Having experienced the emotional attachment associated with a stakeholder role students are then required to work in small groups and analyse a series of real development projects through interviewing current stakeholders such as developers, government officials and planning officers, objectors and end users. The issues which emerge are collated and discussed in a follow up two-day workshop and form the basis of a backcasting exercise (*People*, *Change*).

A second exercise is based around the enactment of a formal public enquiry, in front of a "planning inspector" played by a real professional expert in this area. Students prepare a Proof of Evidence statement and present this from their stakeholder perspective. The engineering projects which have been used are real cases of i) a solid waste incinerator, ii) a tidal barrage scheme, and iii) a large mixed development project in a regional city. A contrasting approach is taken on the second day in which a decision is reached through a less adversarial negotiation and consensus building approach. The final day provides a de-brief in which the students reflect, first in role, then out of role on the dynamics and outcomes of each process. *(Uncertainty, People, Tradeoffs).*

Another role play, run over the course of an afternoon, focuses on the process undertaken to determine EU regulation. It is led by a senior civil servant from DEFRA and is based on the negotiations around phasing out fluorochemicals. Groups of students negotiate from a number of perspectives representing governments, industries of various types, and pressure groups. The findings are surprisingly close to the real results that took around 18 months of high-level negotiation to achieve. This exercise helps students to appreciate the process of policy making but also the way in which apparently intractable differences can be negotiated. It also provides a practical lesson in ensuring that the perfect does not become the enemy of the good by being able to debrief and examine the places where concessions had to be made in order to arrive at consensus.
(Change, Environmental limits, People, Uncertainty)

Change challenges and strategy

During the second term every student is required to identify and undertake a personal change challenge. The scale and impact of the challenge adopted is of less significance than the experience of undertaking the change and feeling the emotional aspects of success and frustration encountered. This then enhances students' ability to appreciate the ways in which to instigate a change and make it successful and this can then be demonstrated through a follow-on assignment to produce a strategy for organisation change. This is usually targeted at an organisation where students have worked previously or where they intend to work following completion of the course. As such, a number of these strategies have actually been implemented, thus bringing the theoretical aspects of the course clearly in line with the practical implementation that students will engage in after graduating.
(Change, People)

Games

Dielman and Huisingh (2006) describe in detail the benefits of playing games as a way of learning for Sustainable Development, as "they simulate mutually accepted rules, roles, conditions and assumptions". As well as a number of well known short games such as the nine dot game, stranded on the moon, and framing the problem, two more extensive games are used during the course typically each taking a 4 hour afternoon session

The first of these is a modified version of Fishbanks (Meadows 2004) in which fleets of boats of different sizes and owned by a range of operators from families to multinational corporations seek to optimize their fishing catches and profit whilst staying in business. A computer simulation provides information on the overall size of the diminishing fish stock but this is not revealed to the participants until the end, so decisions on how each fleet deploys its boats has to be made with imperfect information. The game is a good illustration of the tragedy of the commons and provides a rich opportunity to debrief on many of the core themes described earlier.

The modifications to the original game include descriptors of the various company profiles and different business motivations. This crossover with the role play aspects explored earlier in the course

allows students to take more of a vested interest in the results of the game. It is interesting to note that during the years of running this game with consecutive course cohorts the final state of the fish stocks is heading towards a more sustainable level than in the early trials. This is perhaps due to the timing of the game later in the course and the increasing emphasis on trade-offs and holistic rather than selfish viewpoints developed through the activities described above and in other aspects of the MPhil. (*Uncertainty, Environmental limits*)

The second game is a modified version of Building Futures *(RIBA/CABE 2008*) originally designed as a tool to help communities think about the future of their neighbourhood. The game is used to explore the issue of trade-offs in town planning where various options have designated 'points' associated with them and participants must allocate a 'spend' of those points against a planning timeline while also meeting some overarching objectives. Analysis of this game allows students to reflect on the need to balance early wins with long-term plans and to address the diverse needs and desires of different members of a community. The aim is to encourage students to look for non-technical as well as the more traditional engineering solutions. *(Change, People, Whole-life costs)*

A new Technology Uptake Game is also being developed by us for use on the course using a model of the uptake of household water treatment systems in India, in which the players take on the role of an NGO and have to allocate resources between various activities (such as expanding the system, promotion, education, production, subsidy and so on) with the objective of maximising the number of biosand water filters in continued use after a 20 year simulation period. Like the Building Futures Game players have finite resources to allocate and therefore need to make trade-offs between the ideals and as with the Fishbanks Game the model provides only partial feedback information to the players to influence their decision making. *(Tradeoffs, Uncertainty)*

Systems thinking

The need to approach problems systemically and to recognize the influence of non-linear dynamics and feedback loops is a vital theme through the whole programme. This is introduced on the very first morning when each student is given the book "The Hidden Connections" (Capra 2002) to read during the first month . This then forms the basis of discussions in which students critique Capra's ideas and begin to embrace the benefits of a systems approach to issues. Several simple and short exercises are used to introduce ideas relating to stocks and flows, and the impact of delays in a system response.

The Technology Uptake Game is based on a systems dynamics model which provides partial feedback information to the players with random natural and political events occurring at intervals through the game play. This game builds on the lessons from Capra's book and allows students to experience some of the complexity of applying technology or policy interventions in a simulated real situation.

A formal coursework assignment also reinforces the need to see problems in a non-linear way by requiring students to prepare a cognitive map of a short piece of text, and to use this to comment on the position of each stakeholder. This is followed with an introduction to Vensim software (http://www.vensim.com/software.html) and a task to draw a causal loop diagram of the key components and inter-relationships for one of the following: Water supply for rural communities in a developing country; transport policy for a UK city; siting of an onshore wind farm; manufacture of a mobile phone; or production of biodiesel from agricultural feedstock. Students are asked to comment on appropriate location of the system boundary, feedback mechanisms, key stakeholders and their positions, and possible intervention points. *(Complexity)*

Multi criteria decision making

An exercise in constructing a decision using the Analytical Hierarchy Process (AHP) is based around choosing a sustainable retrofit option to reduce the carbon footprint in a domestic home. Criteria to be considered include cost, reduction in GHG emissions and ease of installation and four alternative options are evaluated: sealing the building envelope, on-site energy generation, installation of energy efficient appliances, and home monitoring with smart performance meters. Students are encouraged to make their own informed judgement to determine the relative pair-wise comparison of the criteria, (e.g. x is twice as important as y, y is five times more important than z etc.) with a brief comment on the rationale used. A single preferred alternative is identified, and the exercise repeated to understand how sensitive the outcome is to the choice of weightings. *(Complexity, Other disciplines)*

Awareness of literature and viewpoints from other disciplines

A popular activity, especially for students from a traditional engineering background, is to ask them to review a book of their choice drawn from classic texts on Sustainable Development. These include: *Silent Spring* (Carson 1962*), Limits to Growth- the 30 year Update* (Meadows et al 2004), *Gaia* (Lovelock 1979), *Development as Freedom* (Sen, 1999), *Ecological Economics* (Daly and Farley 2003), *Cradle to Cradle* (McDonough and Braungart, 2002). The reviews have been highly creative and presented in a range of different styles, even including in one instance the transcript of an imaginary radio interview. Importantly the review then forms the basis for a commentary on how the text addresses one or more of the themes laid out earlier in this paper. (*Other disciplines*)

Management of Technology Innovation Consultancy Project

This is carried out in teams over an eight-week period with each group working for a real external industrial Client on some business aspect of their operation. The terms of reference of each project are agreed at the outset and can vary considerably but must address the problem from a sustainability perspective and take a whole life cost approach in any analysis. This is an opportunity for local companies to harness the technical and management skills of the MPhil students to focus on a specific management problem. *(Whole life costs).*

Reflections on student feedback and performance

Student Performance

Students generally perform well against these tasks with a significant feature being the mutual support they give to each other in their learning. There has been a clear sharing ethos in every cohort which reflects the self-selecting nature of the participants around a desire to change the world for the better. This is in stark contrast to other programmes which focus more on enterprise and entrepreneurial activity and as such produce an inherently more competitive group dynamic.

However, students' initial understanding of the issues discussed above is often limited or weak when they commence the course. For example, in the bathtub exercise to test understanding of stocks and flows (described by Sterman, 2002) students are asked to draw the behaviour of the quantity of water in a bathtub given that outflow is constant but inflow is varying. Over the last three years only 28% of students have correctly responded, (compared with 36% which Sterman reports from MIT graduates). Many of the attempts reveal the expected pattern matching responses which can represent completely spurious understanding of system behaviour, and is a way of starting to challenge participants about their assumptions.

Student Feedback

Two ways of identifying student perceptions of their own learning have been used. The first has been to use an axial coding approach to the analysis of routine feedback questionnaires drawn from recent years. For every course module these ask students to indicate performance ranging from Very Good, Good, Satisfactory, Poor and Unacceptable in the following domains: Usefulness of content, interest stimulated, pace of lectures, teaching quality, use of handouts and supporting information, use of visual aids and relevance to expectations. In addition the difficulty of the assignments is rated (from 1 = low/hard/poor to 5 = high/ easy/good) against the following criteria: interest, difficulty, usefulness and the number of hours taken for completion . Qualitative comments are then also added as desired by the respondent. Whilst this exercise is essentially aimed at quality control it can also reveal some interesting aspects about the students' perceptions of the programme.

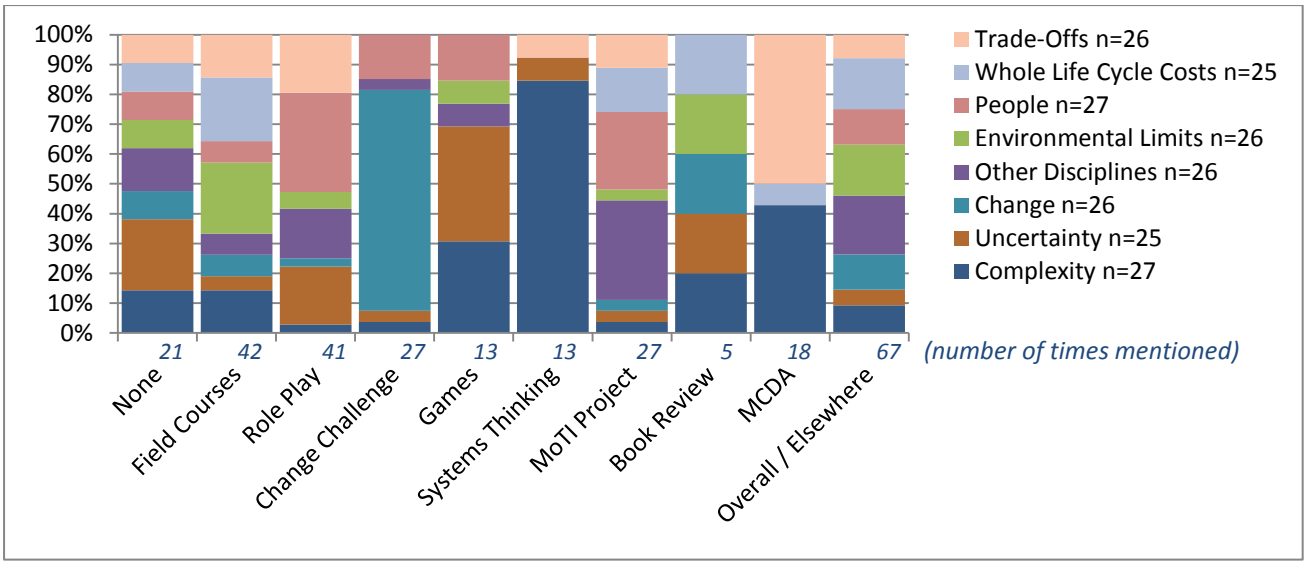
Positive comments specifically mentioning the role plays noted them as the best aspect of the module due to it encouraging engagement whereas negative comments referred to time management and organizational issues: Fishbanks being too long and Regulation too short. The experience regarding the three-day planning inquiry role play was generally positive but even though the activity forms the major part of the module and its assessment, almost one-third of 2008-9 respondents did not mention it in their feedback. Over two cohorts, one-fifth of students don't mention the role play experience in their responses. Where it was mentioned positive comments about the role play include the representation of "real life context" and "what it is really like". Students appear to relish the "tangible", "extremely hands on" approach and see the value towards "excellent learning" making it "worthwhile", "valuable", "enlightening", "excellent", "extremely interesting", "inspiring" and a "very good experience". Again, negative comments referred to organizational issues associated with the event. Similarly 42% of two cohorts were positive about the book review being a new and stimulating experience for those with a traditional engineering educational background, whilst 8% found it difficult and hard to see its value (50% did not mention the exercise).

A second exercise has been carried out in which the 2009/10 cohort of 36 students were asked to complete a survey asking them which activities, if any, on the MPhil course reflected the eight key themes listed earlier. 28 students in the group responded. As the activities themselves were not explicitly linked to these themes during the teaching and course delivery, this is a test of the students' perceptions about whether or not the course is providing learning environments to develop awareness and skills in these areas.

Students' responses illustrate that rather than matching a specific activity with a particular key theme, instead there are a range of lessons to be taken from participation in each of the various activities (Figure 1). The activities most associated with each theme are highlighted in the table. Different students take away different messages from the activities but they consider all aspects of the key themes are covered somewhere. Beyond identifying the specific activities described in this paper which they associated with each theme, they also pointed to many other areas of the course, including lectures, seminar discussions and specific elective modules, where they recognised these ideas were developed (shown as "elsewhere" in Figure 1). In contrast some responses explicitly noted that the individual couldn't identify a specific activity with a theme, (shown as "none" in Figure 1). In many cases students also made particular reference to: "the interaction with multi-cultural and multi-background classmates through the year was the best part", with opportunities to learn from each other's experiences being highly valued.

The role play exercises (specifically citing the 3-day public enquiry) and Field Courses have clearly had the most impact. Other activities are seen as focussing around a single theme (such as Systems Thinking reflecting complexity, and the change challenge being a vehicle for exploring change), and

exercises such as the book review are not strongly associated with any of the 8 SD themes. Games are recognised as drawing out a number of ideas but are less frequently cited than some of the other activities. Looking from the other direction the themes recognised most strongly by the students in relation to the activities are *complexity* and *people*. It is the other parts of the course which are seen to address more strongly issues relating to *other disciplines* and *environmental limits*.



	None	Field Courses	Role Play	Change Challenge	Games	Systems Thinking	MoTI Project	Book Review	MCDA	Mentioned elsewhere
Complexity n=27	11%	**22%**	**4%**	**4%**	**15%**	**41%**	**4%**	**4%**	**22%**	26%
Uncertainty n=25	20%	**8%**	**28%**	**4%**	**20%**	**4%**	**4%**	**4%**	**16%**	16%
Change n=26	8%	**12%**	**4%**	**77%**	**0%**	**0%**	**4%**	**4%**	**0%**	35%
Other Disciplines n=26	12%	**12%**	**23%**	**4%**	**4%**	**0%**	**35%**	**0%**	**0%**	58%
Environmental Limits n=26	8%	**38%**	**8%**	**0%**	**4%**	**0%**	**4%**	**4%**	**0%**	50%
People n=27	7%	**11%**	**63%**	**15%**	**7%**	**0%**	**26%**	**0%**	**0%**	33%
Whole Life Cycle Costs n=25	8%	**36%**	**0%**	**0%**	**0%**	**0%**	**16%**	**4%**	**4%**	52%
Trade-Offs n=26	8%	**23%**	**27%**	**0%**	**0%**	**4%**	**12%**	**0%**	**27%**	23%

Figure 1: Student perceptions of key themes covered by various course activities

Several students often express some bemusement at the activities and assignments which they are asked to do. However, after completion of the task they can often appreciate the wider benefits of the exercise. For example, one student in the 2009-10 cohort said of the book review and an essay based on their assessment of a place and an engineering project (in the style of Jared Diamond's vulnerability analysis from his book "Collapse: How Societies Choose to Fail or Survive" (Diamond 2005)): "The two assignments were excellently chosen. I couldn't understand initially why we had to do a book review but as I progressed with it, it helped me understand the underlying issues of the story". They recognise that the tasks are: "New and different from the norm", provide a "new and useful skill to develop", and can be "fun and useful" while also being "really interesting", "exciting and challenging". Several students reported that they had "loved the assignments", "loved the book and review", really learned a lot", "enjoyed the read" that they "may not otherwise have made time for" and that "reading book and review hardly counted as work". Others commented that the "Collapse assignment was extremely interesting".

Encouraging students to take on the role of stakeholders through role plays of various scales, as one student says "gave a real sense of how to approach conflict scenarios within stakeholder engagement process". This is an experience many students may not previously have had. Similarly, the experience enacting a real change, no matter how large or small, gives a tangible lesson of the theoretical grounding. The feedback from one student reported that the practical application of the change theories through the assignments was "surprisingly the best bit" of the module.

Conclusion

During the evolution of the MPhil course in Engineering for Sustainable Development over the eight years it has been running, a number of key themes have emerged. These have been in response to experiences of delivering the MPhil to a series of student groups or due to strategic restructuring of the course material to meet a better reflection of the issues embodied in the concepts of sustainability. Similarly, a range of activities undertaken on the course have been developed to address the key issues identified. In some cases the relationship between the activities and the themes they address is clear and direct, in others it is more subtle. However, overall the course is delivering a balance of non-technical transferrable skills through the core module taught components or through facilitation of access to lessons elsewhere.

An overarching conclusion is that for students from an engineering background it is an holistic approach to delivering a new way of thinking through a combination of lectures, class activities, assignments, interactions between class members, and access to material elsewhere in the University that enables participants to develop their skills towards delivery of sustainable development in their future careers.

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