The role of case studies for the integration of sustainable development into the education of engineers

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ABSTRACT: In this article, the author discusses the function of case studies in educating engineering students for sustainable development. The author highlights the importance of introducing and effectively integrating case studies on sustainable development into the traditional engineering disciplines, how examples of both good and poor practice (of sustainability) can inform and assist students to better understand the concept of sustainability, and how students can apply these concepts to both their academic and practical engineering applications within employment. The benefit of case studies is that they allow students to visualise how sustainable development can be applied to all engineering decisions and also give them the capacity to understand the social, environmental and economic considerations associated with all projects, as well as in the application of their knowledge and skills to make informed engineering decisions.

INTRODUCTION

To date, there have been many variations on the definition of sustainable development, which has led for a call for a universal definition prior to the development of any educational programme. Understandably, this variation is due to the complexity of the issues, the dynamic environment and the various personal view points in addition to personal interpretation.

One of the most popular definitions is that contained within *Our Common Future*, the 1987 Report of the UN World Commission on Environment and Development, which reads as follows:

> *Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs* [1].

Several universities from around the world have made commitments to promote strategies for creating more sustainable universities, through their teaching, their campuses and their management. This has been accompanied by a series of international declarations, such as the Thessaloniki Declaration, which stated the following:

> *… all subject disciplines must address issues related to the environment and sustainable development and that university curricula must be reoriented towards a holistic approach to education* [2].

UK universities are now under pressure to demonstrate that they have met all their institutional missions, including those relating to social and environmental aspects, and are developing themselves sustainably.

One potentially important contribution to developing an auditing system to measure the non-financial missions is a new system that has become known as sustainability accounting. This is a new accounting discipline, emerging from a respected longer term body of work on environmental accounting, which strives to introduce methods of accounting for social and environmental impacts (positive and negative) that are normally not included in traditional financial accounting processes. The aim of sustainability accounting is to provide a realistic and complete picture of the costs and benefits arising from decisions about allocating resources (human and environmental).

Since the publication of the Department for Education and Skill's Sustainable Development Action Plan, and in light of the UK's universities draft statement of recommended practice on accounting in further and higher education, higher education will need to be seen to be responding to a wide range of stakeholders on its sustainability performance [3]. These stakeholders include staff and students.

The subject of sustainable development for engineers and engineering students is a key issue currently facing the higher education sector. The importance of sustainable development was clearly identified by the Engineering Council, UK, with its publication of the UK Standard for Professional Engineering Competence (UK-SPEC) [4]. This affirms that Chartered Engineers must *undertake engineering activities in a way which contributes to sustainable development.*

This commitment highlights the need for the increased use of appropriate technologies and practices, both in the developed and developing world, where resource consumption and environmental pollution have come to the forefront of scientific and public opinion.

Following the Engineering Council's publication, the Royal Academy of Engineering, UK, produced its own publication entitled *Engineering for Sustainable Development: Guiding Principles* [5]. The Guide is primarily aimed at academic teaching staff within engineering departments or schools within UK universities who need, or are considering how, to embed the principles of sustainable development into their curriculum. The guide is split into five distinct sections, one of which is dedicated to providing an illustration of sustainability issues in engineering through summaries of seven case studies. These case studies cover and complement the different engineering disciplines and demonstrate the crucial connections between engineering and sustainable development, highlighting the role of engineers in achieving sustainability.

Other studies have also highlighted the importance of case studies in the education of sustainable development, although not all have used the terminology *case study*, rather identifying good Education for Sustainable Development (ESD) practice through the *dissemination of creative and imaginative projects* [6]. They also draw on existing internal research on sustainable development and disseminate the key findings through academic courses [7].

THE EXISTING SUSTAINABLE DEVELOPMENT KNOWLEDGE OF ENGINEERING STUDENTS

There has been little previous research undertaken to determine the level of knowledge on sustainable development possessed by engineering students. One international study, which sought to evaluate student's knowledge on sustainable development, surveyed undergraduate engineers from 21 different universities in nine different countries [8]. The survey was carried out between October 2000 to June 2002 and involved a brief two-page, tick-box style questionnaire being delivered to a total of 3,134 engineering students across several disciplines and at different stages of their courses. The questionnaire was divided into four parts, starting with information about students, their level of knowledge and understanding of the environment and sustainable development, the perceived importance of sustainable development by the students and previous environmental/sustainability education.

The questionnaire results indicated that although the engineering students were knowledgeable about high profile environmental issues, such as, acid rain and global warming, the level of knowledge relating to 15 particular aspects including ISO 14001, the Kyoto Protocol and the Rio Declaration, industrial ecology, components and approaches to sustainable development, and inter- and intra-generational equity was very poor, with some students acknowledging that they had not even heard of these concepts before. The questionnaire also highlighted differences between countries, with students from Sweden, Germany and Vietnam having the highest knowledge and understanding of sustainable development. More encouragingly, despite a relatively low understanding of sustainable development by engineering students overall, most students recognised sustainable development to be either *important* or *very important*.

The authors of this research acknowledged their perceived difficulties when teaching sustainable development to engineers, as engineering students *needed to see an immediate and direct relevance between the theory of sustainable development and engineering practice* [8]. One reason for this is the perception by engineering students that sustainability is often perceived as a *soft science*, rather than the *hard science* of engineering [9].

ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT USING CASE STUDIES

It is necessary to determine the *definition* or purpose of any teaching programme or case study prior to delivery. There is a clear distinction between education about sustainable development and education *for* sustainable development. The former simply implies an awareness of the issues and the ability to discuss them in context, while education for sustainable development implies not simply an understanding of the issues, but an ability to apply, design and operate systems that are sustainable.

In order to achieve education for sustainable development, it is necessary to give individuals/students more than simply the knowledge and skills for recognising sustainable development, but the capacity to develop sustainable development practices in their *own world*. The scale of the focus of the education must also be considered. The key to sustainable development for many is the use of localised solutions for local problems, while others immediately consider global issues, such as ozone depletion, habitat destruction and resource consumption.

An additional issue is the perceived format that sustainable development education should take. For example, should it be taught as an independent subject or in the context of *traditional* engineering subjects as case studies. The type of approach is dependent on what the individual lecturer or institution feels is most applicable to the teaching and curriculum, and will also be influenced by any existing materials. For either option, the lecturer/tutor needs to be, at least, familiar with the principles of sustainable development, ensuring that the taught skills base is sufficient to fulfil the educational requirements of the course and the UK SPEC.

The University of Surrey, Surrey, England, UK, developed a three-tier approach to teaching sustainability [9]. This consisted of dedicated teaching and tutorials, specific case studies and the integration of sustainability into the overall curriculum. The use of practical case studies at Surrey enables students to apply sustainability concepts and identify sustainable solutions and, as a result, a series of practical case studies have been developed by staff [10]. This is an identical approach to that used at Bristol University, Bristol, England, UK.

It is essential that any case studies include how the subject can be integrated into teaching practice. The Engineering Subject Centre, (EngSC) UK, commissioned a series of *briefing papers in education for sustainable development* [11], two of which were compiled within engineering management at Bristol. Each EngSC case study can be disseminated as a teaching resource in its own right, or as a briefing paper that introduces the individual topic to the academic, through its comprehensive bibliography/references listing. The academic can then develop that material to their chosen level. Together, the papers form a collated series of case studies on topics in sustainable development in order to facilitate the introduction of sustainability issues into the curriculum by academics with a responsibility for ESD. The series of papers are, therefore, a building block for use, as appropriate, by the individual academic in their teaching of sustainable development. They can also perform as a template for academics looking to formulate their own case studies.

Each of these case studies has several mandatory fields that are essential for the understanding and delivery of the topic, including an *adoption section*, which notes how it was taught by the author, the implementation of the topic (actual/ predicted), accompanied with real-life examples to illustrate and inform the reader of its adoption into teaching. The only missing component from the case studies is an evaluation factor, which it was anticipated the various universities would implement themselves, based on their existing evaluation structures.

This approach provides tutors with the flexibility to adopt the *off-the-peg* resources that best fit their teaching strategies and learning outcomes, and require no additional or only limited additional resources to customise.

Although case studies are a useful teaching tool for the understanding of sustainable development, some case studies are timely and their subject matter will become out of date or superseded by a superior example. Therefore, they require regular review and revision to remain current and to furnish students with the latest knowledge. However, it is acknowledged that this process is resource consuming, as is the initial development of any case study. The resource requirement, in particular that of time, is one of the prominent barriers to the adoption of more case studies within the engineering curriculum.

The use of *localised* case studies can provide students with good resource material. For example, linking the course to the university's own Environmental Management System (EMS), not only demonstrates the university's commitment to sustainability, but also provides current data within a practical industry-led model.

Such a philosophy has already been adopted by other UK universities. One such university is Bradford, which is currently creating a sustainable campus at its city centre site [12]. The ecoversity project will transform the campus environment, while also aiding community engagement, supporting business generation and educating students, staff and the community about sustainability. The University's aim is to deliver a student experience incorporating learning and participation in sustainability, through *engaging students and propagating the skills and knowledge needed in the pursuit of sustainable development*. Demonstration areas will include space for teaching and conducting research, in addition to showcasing environmental technologies.

There are a number of potential barriers to embedding sustainable development into the engineering curriculum, including the perception of some tutors/lecturers and course designers that sustainable development is beyond the remit of engineers. This barrier has now been overcome in part by the UK SPEC stating that Chartered Engineers must *undertake engineering activities in a way which contributes to sustainable development* [4]. The use of case studies can clearly demonstrate both to academics and students the direct synergies and applications of sustainable development to their specific engineering discipline.

CONCLUSIONS

In order to achieve education for sustainable development, it is necessary to give individuals/students more than simply the knowledge and skills for recognising sustainable development, but also the capacity to develop sustainable development practices in their *own world*. The scale of the focus of the education must also be considered – local or global? The key to sustainable development for many is the use of localised solutions for local problems, while others immediately consider global issues like ozone depletion, habitat destruction and resource consumption.

In order for engineering students to be able to apply sustainable development to their practice, engineers require more than simply knowledge, but an additional set of skills. These skills must furnish engineers with the capacity to develop sustainability practices and empower them through different methodologies and strategies for implementation. Many of these skills can be acquired through the practice of their knowledge in addition to the practical application of various taught techniques. Business skills, such as effective communication and change management, are powerful tools for integrating sustainable development into the business place and the professional careers of engineers.

Sustainable development is truly an interdisciplinary subject, requiring a minimum of educational awareness in the social, environmental and economic disciplines, as well as the ability to develop holistic thinking approaches within and between the disciplines. Although these skills exist within universities as a whole, they may not yet be developed within a single department or faculty. The interdepartmental transfer of skills, knowledge, and even learning and teaching materials, are essential if sustainable development is to be successfully integrated into engineering curriculum. However, the current allocation of academics and disciplines between the various schools, faculties and departments actually undermines this philosophy, helping to create rivalries, and the perceived prestige of certain disciplines over others. Independent financial accounting systems also act as a barrier for students wishing to undertake courses and modules from different departments.

The interaction and communication between departments is the first step in producing an interdisciplinary teaching course that will seek to ensure that work will neither be duplicated nor missed, and that valuable opportunities created within one department do not go unrealised. However, the distribution of academics to specific departments often sees the individuals being assigned to different buildings and often different campuses, thereby creating a geographical barrier to interdisciplinary teaching and research. Joined up thinking and joined up action is urgently required.

Increases in the quantity and quality of environmental education need to be realised at higher education levels. Although there has been a rise in the number of environmentally related subjects available at a university, environmental issues do not seem to have been accepted into the syllabuses of other *non-environmental* courses. We are living in an age where every process and decision has some effect on the environment, and it is imperative that those people who control the processes and making these decisions are aware of the consequences. It is all too easy, with the advent of climate controlled buildings, e-mail, phone and fax to separate oneself from the environment outside the office window, the air conditioned car and the double glazed house. Part of the challenge is to re-connect individuals with their environment, be it through real-life case studies, hands-on education and learning, or even contact with, the local community.

There is an increasing demand for engineering graduates who have experienced joined-up learning experiences and have developed interdisciplinary skills essential for modern forward-thinking organisations. Thus, it is essential that universities provide students with the best opportunities for success in the job market and furnish them with enough understanding to make decisions that assist, rather than hinder, the advancement towards sustainable development.

The empowerment of students to make sustainable development decisions is essential if they are to truly believe that they, as individuals *at home*, and as individuals within their organisation, can really make a difference towards sustainable development.

Universities who fail to deliver high quality education for sustainable development will find that their courses do not meet the requirements of the accrediting institutes and the Engineering Council, resulting in their students being unable to demonstrate their ability to *undertake engineering activities in a way which contributes to sustainable development*, and ultimately unable to gain Chartered status without further study. Engineering courses that do not furnish students with the ability of becoming Chartered will invariably be unpopular and, in the increasingly competitive higher education sector, will become obsolete, while potentially harming the reputation of the institution.

However, teaching is not the only area of activity where sustainable development is becoming increasingly important. Research within many universities is playing an increasingly important role, both in terms of financial support and academically. One example is the UK's Research Assessment Exercise, RAE, which *grades* university departments on the quality of their research.

As early as 2001, the UK Government introduced funding for a *Sustainable Technologies Initiative*, and some of the funding councils have introduced a multidisciplinary research agenda to any research conducted in sustainability. As the research in sustainable development increases, so does the potential for this research to be incorporated into teaching.

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