

Paper 83. Experiences of teaching sustainability, ethics, and innovation to engineering students using various pedagogic approaches.

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Abstract

Derby has one of the most highly skilled workforces in the UK, working in aerospace, rail and automotive engineering. Sustainability through innovation and ethical considerations are key parts of their work.

The University of Derby, within its School of Technology, embraced the concept of delivering sustainability and ethics explicitly into its mechanical engineering programmes from 2007 onwards following on from a drive by The Royal Academy of Engineering. Previously the subjects had been embedded in professional development parts of existing modules and may have been given only passing consideration. The School developed a broader module covering sustainability and the environment entitled “Ethics, Environment and Innovation” and delivers it to its final year multi-cultural mechanical engineering and civil engineering students. Other programmes at the University of Derby (in electrical engineering) and other universities tend to embed the subjects within modules, without explicit focus of sustainability and ethics within a discrete module.

This paper discusses the experiences of delivery of this subject over five years. Of particular interest are the teaching learning points in the way the module was delivered and also the nature of the assignments set. The person delivering the module had not formally studied the subject and there was a steep learning curve for him, discovering through doing what worked and what did not. The challenge of teaching sustainability and ethics to a class comprised of students from different cultural backgrounds should not be underestimated.

In 2012 The University started offering by distance learning a new course called MSc Professional Engineering. This innovative course is designed for engineers based in industry to study for a post-graduate degree to help them become professionally qualified. One of the modules, designed to be work-based learning and delivered on-line, is a negotiated module (Environmental and Ethical Responsibility). Negotiated means that students have freedom to choose the topic of their study in consultation with the module leader. An on-line resource has been developed for students studying this module. Experiences of the students from the first cohort studying the new master’s module have been gathered and analysed from the outset. Examples of the types of assignment that have been produced are given in this paper.

Conclusions are offered in this paper as to the type of delivery which works best for particular groups of students.

The way that the subject of this paper has helped shape a new Institute of Innovation in Sustainable Engineering (IISE) is also explored in terms of stand-alone professional development courses for local engineers.

1.0 Introduction

The University of Derby (UOD) has been educating engineers since the late 19th Century through its various incarnations from being a local science and technical college, to becoming a University in 1992. Traditionally, its main market for engineering students was part-time and it was supported by local industry, notably by organisations such as Rolls Royce plc. More recently the student body has become much more diverse and includes full-time students from the UK, Europe, the Middle East, India, Pakistan and Africa, as well as part-time local students. A new intake of students has been studying a Masters course in Professional Engineering by on-line distance learning since September 2012.

The University offers foundation programmes (pre degree level), Higher National qualifications, Foundation degrees (sub degree level), Honours degrees, postgraduate Masters degrees and PhDs. Currently there are over 1000 students in engineering and engineering-related disciplines (UOD, 2013).

The content of engineering courses in different disciplines is always the subject of much debate. On one hand, some parties want to broaden the base of engineering and make future engineers more aware of global issues (Bourne and Neal, 2008). Others however, like engineering institutions that accredit the courses, do not want dilution of the technical content. Perhaps one of the most significant statements about engineering in favour of the broadening approach was from Professor Julia King is quoted in (Bourne and Neal, 2008) in which she highlighted the importance of issues such as sustainability, energy, climate change, innovation, and its link to economic growth. She suggests that these topics should be included in an engineer's learning. So how can they be taught? Many think that they can be embedded into existing modules by simply getting the existing lecturer to put a section about it in an assignment or examination. The UOD took the approach six years ago that the content should be delivered as a stand alone core module for its degree courses in mechanical and civil engineering. The electrical engineers resisted the suggestion on the basis of dilution of technical content. It is interesting to note that all the mechanical and civil courses have achieved accreditation with the stand alone module.

2.0 Personal Experience

2.1 Undergraduate teaching

The undergraduate module is entitled Ethics, Environment and Innovation. It is currently a 20 credit module at level 6 and covers the three areas in the title, though not in isolation, and for assessment purposes the links between ethics and the environment, and innovation and the environment are usually made.

When the author started delivering the undergraduate module it is reasonable to say that his experience of the subject, especially of ethics, was not detailed. He holds a first degree in materials and manufacturing and has post-graduate masters in both maintenance and management and has done research into manufacturing processes to doctoral level. None of his previous learning had been in the areas of ethics. Some background reading and Internet searching introduced him to some new concepts and terminology. It became clear that ethics was widely taught in other educational courses; such as law and medicine. The author learnt a great deal about the approach taken by these disciplines. The module was delivered in the order of topics covered in the title.

At the time the Royal Academy of Engineering (RAE) had produced materials about the importance of ethics to engineers and had some documentation in the way of meeting notes and guidelines (RAE, 2010). The author soon became aware of the Leeds University Ethics Centre (Leeds, 2008)

and subscribed to access their website. Conveniently they had produced a set of fairly generic resources and case studies specifically designed to introduce students to ethical thinking. The also produced a series of case studies specifically for engineering students. The latter were extensively used by the author – one experience of these is described later.

A starting point for delivering the module and ethical discussion was using an example from real life. For example a person had got his family airline tickets for a holiday but his credit card had not been debited. He had the tickets in his hand. What should he do? Ice breakers usually stimulated small group discussions, which would prove useful in later parts of the course by getting students to work in teams. At one stage the author had 150 students studying the module in one academic year. Even though they were split into 5 classes, it was a challenging to get small enough teams so that all students could contribute to discussions.

The teaching then moved more onto the engineering environment and why engineers should study ethics. The use of case studies soon became a valuable teaching tool. Most textbooks on engineering ethics e.g. Fleddermann, 2008 and Vesilind and Gunn, 2008 have many case studies but seem to concentrate mainly on disasters, finding out who was to blame and explaining changing legislation and not necessarily exploring day-to-day ethical issues and problems that engineers encounter in the workplace.

Typical examples cited in these texts were the space shuttle disaster (engineering design and the decision making processes to launch), working practices at Chernobyl or health and safety at Bhopal. These have been widely reported and students usually have heard of them (even though the instances reported are a quarter of a century old). It was possible to identify some concepts which would be later developed into a wider discussion on ethics. Words like ‘duty’, ‘health and safety’, ‘legislation’ started to appear.

The author learnt from other disciplines that most courses seemed to start out with the theoretical background to ethics first. He liked the idea of producing a roadmap for students. Initially he took a very academic approach by trying to give an overview of ethical concepts, ethical theories and their classification. This necessitated the use of unfamiliar words and the challenge of communicating moral concepts to a group of home and international students from different religious backgrounds could not be underestimated. In hindsight, it might have been the wrong approach. He questioned whether it was right to communicate Western concepts to students who have different beliefs. Nevertheless all religions teach the basics of right and wrong and good and bad and have an ethical foundation that can be shared.

Students were also given lectures on a framework for solving ethical dilemmas and taught how to make and present ethical arguments. In order to achieve a higher grade they were encouraged to include ethical theories in their work.

An important feature of the preparation of students for the real world involved investigating what the engineering institutions and associated bodies said about ethics. In the author’s view some institutions are better than others in this respect. The Royal Academy of Engineering in collaboration with Engineering Council UK in 2004 (RAE, 2004) produced “A statement of Ethical Principles”. In the main these have been adapted by engineering institutions with perhaps the best, in the author’s opinion, being that from the Institution of Civil Engineers (ICE) (ICE, 2013). It is instructive to look at their guidelines having studied the basics of ethical theories: the word ‘duty’ appears very often in the writing.

The most successful case study, from the author's perspective, involved an investigation into advising the government of a fictitious sub-Saharan African country as to the best suppliers of its future energy needs (Howard, 2007). The case study worked well as either an individual or a class group exercise. Students were given a scenario where a government had been given a choice of six energy solutions (2 nuclear options, gas, oil, wind, and bio-mass) and they had to act as consultants advising on the optimum choice. Initially students tended to concentrate on the technical solution (supply of 1GW energy now with expansion in the future). Many thought that wind was the best solution but the practical reality of 1000 wind turbines on a ridge made them change their minds. However with the tutor's intervention soon this was expanded to cover the environment, employability, the argument of crops for food vs. crops for fuel, sustainability, health and safety, human rights, employment and future sources of supply. Students who could then incorporate the ethical concepts above into their arguments produced the more sophisticated solutions and were given the most credit. The word 'incorporate' was crucial as some students kept the concepts separate from their arguments but with practice were able to improve.

When it came to discussions about the environment, the course material became much more accessible. News bulletins rarely avoid the notions of global warming, environmental disasters, and climate change. There were many resources available for this topic. For instance the International Panel on Climate Change (IPCC) website (IPCC, 2012) has many resources as did the UK Government websites. Renewable energies are an interesting topic for further exploration and there is much material available. Alternative fuelled vehicles and passive houses are other areas which proved interesting to students. An investigation of the environmental and sustainable impact of the proposed High Speed 2 rail project was a relevant topic for final year civil engineers. It was felt by the author that several of the students could defend its building using ethical concepts at public enquiries which may be part of their future roles in working life.

Innovation theories were introduced with the intention of students incorporating ideas into coursework. An important topic centred around what made companies 'innovative', how they were structured and how the ideas were channeled to ensure commercial success. A typical assignment would be to research an environmentally friendly product and the company that produced it. Many students chose to investigate innovative organisations such as Arup. The author played one clip about this organization that was particularly inspiring for students entitled "Engineers are cool" (Arup, 2009). It described both visually and with music the differences engineers could make to the lives of others through the applications of innovative technologies especially concerning the impact on sustainability and the environment.

2.2 Post-graduate Teaching

The new negotiated module Environmental and Ethical Responsibility is part of an MSc Professional Engineering. The programme is designed for working engineers who want to obtain chartered status. It has been developed by the UOD as part of the Engineering Gateways project (Engineering Gateways, 2012), and has been recognised by various engineering institutions that play a vital part in its operation. It was designed to be work-based utilising distance learning resources. It was intended that students would be able to measure the impact of their work on their organization. The first thing to note is that learning outcomes are business orientated. Secondly, the course was not taught face to face so the students needed access to resources on-line. An initial list of largely Internet resources was compiled as part of a research project and these were indicated to the students at the start of the module.

The real challenge with this module has been its work-based nature, the fact that it was not formally taught, and the fact that interaction between learners through classes and case studies was absent.

The group (four students only) did however have a weekly tutorial session with the module leader. The author in this case was the module moderator so did not have ongoing direct contact with the students. The author could see the students' development on the module with time through the online learning system to which he had access to as a moderator.

The titles of topics decided by the students through negotiation were:

- Environmental Impact Assessment on GSM-Railway Installation Design;
- The Oil Industry and Environmental Pollution : A case study of the Niger-Delta region;
- Project Sustainability Appraisal Tool for the UK Rail Sector : Validation and Testing;
- Life Cycle of Electronics in Manufacturing Industry.

The author sought the views of the students on nearing completion of the module. They thought they had benefitted from doing the module. When they were asked as to how they tackled the ethical aspect of their work the students were at a loss. It became clear that they could not really identify what was meant. Some students said they would have benefitted from more on-line notes and lectures on ethics. The students did not use the on-line resource effectively.

In general though, the students produced industry relevant reports which covered environmental aspects contained in various directives appropriate to the industry they were interested in. The author felt that they would not be in a position to ethically argue their cases in front of a public enquiry which might be the case for several of them in the future. There is more work to be done.

The possibilities of linking up learners and tutors through social networking platforms offers potential for this interaction and will be explored in time. The University of Derby on-line platform will also allow this interaction, provided the students are willing to be involved, although it is not a requirement of the module currently.

2.3 Short Course Development

The UOD is about to launch a new Institute of Innovation in Sustainable Engineering (IISE). It will provide a focus for the next step in the development of the suite of engineering programmes and will provide a strong signal of alignment between the UOD and the City of Derby. It is intended that IISE will:

- Provide a focus for development of distinctive programmes at post-graduate level and the development of post-graduate research;
- Enrich the general undergraduate curriculum with specific modules linked to the work of the IISE;
- Provide additional support to enable the full suite of engineering programmes to achieve chartered accreditation;
- Support the on-going engagement with industrial partners at all levels, as well as provide a resource for bid activities with regional and national agencies.

Some activities planned are to encourage and support the research agenda for the School and University through developments in sustainable design and innovation in products and manufacturing processes and also sustainable rail transport infrastructure.

The complete operational plan for the IISE is still being formulated and at the time of writing a Director has been appointed. It is likely that short courses on the theme of sustainability will be written and delivered by staff at the IISE. Some of these may also be accessible for undergraduate

and post-graduate students as well as employees from local industries. The experience of delivering face to face and distance learning approaches will no doubt be combined to produce a stimulating experience for participants.

3.0 Discussion

The UOD has a track record in successfully delivering a module covering many aspects of sustainable engineering and ethics at undergraduate level and has recently begun to do the same at post-graduate level. The experiences of delivery of the modules have now been recorded for others to learn from. The success of the approach has been demonstrated through student achievement and recognised externally by accrediting bodies who did not see its inclusion in the curriculum as a dilution of technical content. The then president of the Institution of Civil Engineers on a visit to the University in 2009 saw the benefit of the module and commented on its innovative nature.

From the author's perspective, the aspects that worked well in the undergraduate module were:

- The use of case studies – especially when the author talked through them and made them the basis for a lecture;
- Linking work with the Engineering Institution requirements (very clear with Civil Engineers);
- Using the environment as the basis of the module and linking it with both ethics and innovation.

Things that did not go well:

- Group work (especially when non-native English speakers had difficulty understanding some of the cases);
- Going too deeply into theoretical aspects (e.g. ethics).

The new post-graduate module has only had one instance of an offering so far and it has allowed opportunity for an individual engineer to have a significant impact on his/her working practices and that of their employer.

An initial list of internet resources has been compiled and split into three categories: general, ethics, and sustainability, in line with the module specification. These are being used on the Blackboard version of the new module as resources.

Aspects that worked well for the new post-graduate module

- The students were employed and had the opportunity to apply the content in a work-based scenario in the real world.
- The postgraduate student had the services of an on-line tutor and could attend weekly face to face tutorials

Things that did not go well

- From the current observations students needed to be made more ethically aware. Perhaps some face to face on ethics would have benefited them.
- It was noted that simply providing students with a list of resources did not seem to help them in developing an understanding of ethical concepts that could be applied in workplace scenarios.

This paper was a reflective view based on personal experience. It is recognised by the author that the current work needs to be put into context with previous work carried out in the field and this would be the subject of a more extensive article.

4.0 Conclusions

A stand-alone final year undergraduate module explicitly covering sustainability, ethics and innovation has been delivered successfully for 6 years and the courses it has been part of have achieved accreditation by professional bodies.

Case studies in engineering ethics were a valuable resource in the delivery of taught modules.

Students studying by distance learning need to be guided in the use of resources, and blended learning appears to be a better route for understanding ethical concepts.

5.0 References

Arup and Partners. 2009. <http://www.youtube.com/watch?v=DGmIkYw19gg>

Bourne D and Neal I, 2008 *The Global Engineer*, incorporating global skills within UK higher Education of engineers.

Engineering Gateways 2012 www.engineeringgateways.co.uk/

Fleddermann C B, 2008 *Engineering Ethics (Third Edition)*, Pearson Prentice Hall

Howard I., 2007 'Energy Consultancy', *Inter-Disciplinary Ethics Resources Database*, Leeds: IDEA CETL University of Leeds

Institution of Civil Engineers 2013 www.ice.org.uk

IPPC 2012 <http://www.ipcc.ch/>

Leeds 2008 www.idea.leeds.ac.uk/

RAE 2004

www.raeng.org.uk/societygov/engineeringethics/pdf/Statement_of_Ethical_Principles.pdf

RAE 2008

http://www.raeng.org.uk/societygov/engineeringethics/pdf/Teaching_Engineering_Ethics.pdf

Vesilind PA and Gunn AS, 2008 *Engineering Ethics and the Environment*, Cambridge University Press

UOD 2013 www.derby.ac.uk

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