TEACHING ETHICS TO ENGINEERS – REFLECTIONS ON AN INTERDISCIPLINARY APPROACH

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Abstract: This paper outlines an interdisciplinary approach to teaching Ethics to undergraduate Engineering students at Queen’s University Belfast. Focusing on the Royal Academy of Engineering’s ‘Statement of Ethical Principles’ we outline how from two different disciplinary perspectives (politics/philosophy and Engineering), over two years and with two cohorts of undergraduate Engineering students, we approached the teaching of Ethics to Engineers. Through the evaluation of student learning and staff reflection on the approach, we demonstrate the need for flexibility and adaptability in a) teaching Ethics to Engineers within a context where it is not often seen as ‘central’ or a ‘core’ competency and especially b) in relation to interdisciplinary approaches to teaching Ethics to Engineers.

Keywords: Ethics for Engineers. Royal Academy of Engineering’s Statement of Ethical Principles, interdisciplinary teaching, Engineering education, Engineering and Sustainability.

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1. BACKGROUND /MOTIVATION

The teaching of Engineering Ethics at Queen’s University Belfast (QUB) to Civil Engineering students, who have mostly passed through the Northern Irish School System, poses a number of problems for educators. Perhaps most prominent among these is the students’ reluctance to engage in what is perceived as ‘soft’ (non-numerical) subject matter, where answers are rarely clear cut. This contrasts with the students’ experience during the later part of their secondary education. Following completion of GCSE exams, students specialise in three to four technical subjects with a strong practical perspective and a significant numerical basis, where single correct answers are routinely encountered in the problems they confront; this continues into the first years of their university education. This is at odds with situations of ten confronting practicing Civil Engineers who are expected to make appropriate decisions based on largely qualitative information.

The problem with teaching Engineering Ethics is further compounded by an absence of expertise among academic staff, or reluctance of Engineering academics to specialise in the subject. Conversely, those routinely specialising in the study of Ethics rarely have the technical background to present topics in a format that may appear relevant to stimulate the interest of Engineering students. The requirement to address Engineering Ethics in degree courses in Civil Engineering as part of the accreditation process and the need to demonstrate the relevance of Ethics to Civil Engineers in their day-to-day activities has led staff at QUB to adopt a cross-disciplinary approach to teaching the subject to a class of 100+ Level II (second year) Civil Engineering Students. Prior to developing the aspect of the curriculum dealing with Engineering Ethics, preliminary discussion with final year undergraduate students suggested that many were unaware of the relevance and importance of Ethics in professional practice, despite being implicitly exposed to related issues, particularly in the latter part of their university education. Inquiries concerning student understanding of Ethics as a subject ranged from an approach for dealing with personal matters of conscience to an academic pursuit with little value in helping a professional to meet the needs of society. These findings suggested the need for a more explicit acknowledgement of the importance of Ethics within the Civil Engineering course curriculum.
2. PEDAGOGICAL AIMS

More explicit incorporation of Ethics in a Civil Engineering curriculum aimed to demonstrate the need and utility of an ethical code in professional practice in addressing dilemmas professionally, while meeting the greater needs of society. More specifically, the introduction of the topic aimed to demonstrate how current ethical guidelines are sufficiently flexible to “respond to moral exigencies and demands for efficiency and professional effectiveness” (Lozano, 2006)

While of course one can take (and is often tempted to take) a ‘tick box’ approach to the teaching of ethical issues within the Engineering curriculum, the key to the approach we took was to emphasise the importance of students having ‘learnt’, understood, and internalised the centrality and importance of ethical considerations in the professional practice of Engineering in general and, more specifically, the four fundamental principles outlined in the Royal Academy of Engineering’s (RAE) ‘Statement of Ethical Principles’ (SEP), namely:

- Accuracy and Rigour
- Respect for Life, Law and the Public Good
- Honesty and Integrity
- Responsible Leadership: Listening and Informing

(Royal Academy of Engineering, 2007)

We employed the RAE Engineering Ethics Curriculum Map as a basis for achieving these goals (Royal Academy of Engineering, 2008), with emphasis on developing a strong understanding of fundamental issues, obligations and responsibilities that require an Engineer to act ethically. Overall, presentation of subject matter focused on conveying the relevance of microethical issues, focusing on the individual and internal relations within the Civil Engineering profession (Herkert, 2005), before introducing macroethical topics and their importance to wider social context.

3. APPROACH

This paper offers an analysis and discussion from the ‘input’ or delivery aspect of the teaching of Ethics to undergraduate Engineers, focusing on discussion of the motivation, views and expectations we had as teachers. We explain how we approached the teaching process over two years and how the ‘output’ side (student feedback and our evaluation of how successfully intended learning outcomes had been achieved) influenced the modifications we made to course content during the latter part of this period.

The Royal Academy of Engineering’s Engineering Ethics Curriculum Map states that “The study of Ethics helps students to develop widely applicable skills in communication, reasoning and reflection. These skills enhance students’ abilities and help them engage with other aspects of the Engineering programme such as group work and work placements” (Royal Academy of Engineering, 2008). In this way the RAE makes it clear that the teaching of Ethics ought not be seen as a ‘bolt on’ or ‘tick box’ exercise that has to be gone through in order to get to the ‘real’ or ‘core’ skills, training and experience that constitute Engineering. In approaching the design, delivery, assessment and evaluation of teaching Ethics to Engineers, we explicitly sought to build in not simply the students’ exposure to ethical issues and the RAE Statement of Ethical Principles, but to encourage them to recognise the need, in accordance with the spirit of the RAE curriculum map, the benefits of understanding and internalising ethical considerations as professional Engineers, and the responsibilities attendant upon being a member of the Engineering profession; this included standards, codes of conduct and behaviour to which they must adhere. Moreover, we aimed to demonstrate that the approach not only had implications at the personal, company and community level, but also contributed to the well being of society in general.

From a teaching perspective, simply obliging or requiring students to listen passively and discuss ethical issues was a necessary but not sufficient condition for the type of learning we wanted them to
experience. Indeed the use of alternative methods to this approach has been acknowledged as a superior means of improving student learning and understanding in third level education (Race, 2001). While mindful of the limited time and resources allotted to this section of the curriculum, our approach was informed by our view of students. We viewed students as active learners and, following a review of case studies (e.g. Stern & Pimmel, 2002; Prince, 2006), endeavoured to apply a subset of the educational techniques recommended in the RAE Engineering Ethics curriculum map, which we considered most appropriate to the students’ background and physical constraints on teaching (class size, location, time allocation).

In view of the considerable logistical and pedagogical problems associated with the development of a separate module dealing with Engineering Ethics, for pragmatic reasons we elected to integrate an Ethics programme into an existing Communications module, where many related and relevant topics were already being presented, e.g. plagiarism/collusion, responsibility of Engineers in/for disasters. To ensure a more widespread appreciation of the relevance of Ethics, a broad range of teaching formats were incorporated into the programme, accounting for a range of learning styles. Previous anonymous student evaluations of the Communications module suggested that the class responded more favourably to active/interactive teaching techniques, as have been noted elsewhere (Stern & Pimmel 2002). Furthermore, Ethics-related course content was aligned with other activities within the Communications module to ensure that students could avail of the opportunity to integrate skills from other parts of their training, e.g. the use of graphics to help meet the principle of listening and informing.

4. Programme Details

Initial course presentation involved an introduction to Ethics in the form of a lecture, which focused on the individual’s responsibility for behaving and thinking ethically. Specifically in the lecture, (but also in subsequent group work,) the benefits of “being ethical” (in the sense of this being a constitutive as opposed to a contingent aspect of the practice of being ‘good’ and ‘professional’ Engineer) were outlined. The topic was initially couched in terms of personal mores, which was then developed to demonstrate how these could be transferred to professional practice, e.g. the everyday respect for the life and dignity of members of the public must also be considered at a professional level. Critically, the lecture highlighted the point that not all issues in the Engineering profession are addressed by the law, and Engineers must often make value judgements that may have wider implications, but not necessarily be of legal significance; in this sense following appropriate ethical guidelines can have considerable long-term practical benefits. We underscored the argument made by Robinson (2005) that contrary to a widely held perception, working ethically has considerable practical benefits and increases employability. In the lecture we outlined ‘practical benefits’ as including:

- Not being sued
- Not being struck off
- Having a good reputation
- Not having to remember falsehoods
- Being able to sleep easy at night and not worrying…
- Permitting learning from mistakes more openly and honestly
- Taking pride in having high ethical and professional standards
- Helping resist temptation of taking short cuts.

While outlining the ‘practical benefits’ of being ethical could be constructed as appealing to more ‘self-centred/self-interested’ reasons for ‘doing the right thing’, we presented the view that:

a) these personal practical benefits were balanced against other aspects of teaching Ethics in which ‘doing the right’ thing was suggested to sometimes require the personal courage (especially in relation to being a junior member of a team within a strict hierarchical work management context) to challenge established cultures or decision-making processes and therefore potentially result in depriving the individual of short term benefit;
b) the inclusion of the above long term practical benefits were important to communicate the agency and action required to ‘act ethically’, that is, being ethical was not something that could safely remain as an internal ethical monologue, such that students would think that ‘being ethical’ was a matter of ‘being aware’ of the SEP for example, but not implementing and acting on them. In short, we were conscious of the need that students did not regard ethical issues as ‘abstract’, stand alone matters divorced from professional action. As indicated below, we feel that the first year we taught this element of the course the approach adopted added to, rather than challenged, this misperception.

c) ethical actions have benefits beyond those awarded to the individual or employer. Engineering decisions will impact on society and an Engineer’s professional responsibility is ultimately to the general public.

In the rest of this paper we reflect on our experience of teaching Ethics to undergraduate Engineers. What follows needs to be qualified by the fact that we did not originally construe this teaching as a ‘research project’ and did not monitor or evaluate the student learning over the two years in a manner which would provide empirical data or enable us to definitively draw causal relations. However, based on our own observations of student learning, student assessments and our own evaluation of the teaching, what we provide in the rest of the paper are grounded judgements as to the design, delivery and student learning.

5 IMPERDIICIPAL TEACHING

This paper is based both on our experience of teaching Ethics to undergraduate Civil Engineering students, coming from two different disciplinary backgrounds (Engineering – Flynn and Politics/Philosophy – Barry), and also from other published research on interdisciplinary approaches to Engineering Ethics teaching (Graber and Pionke, 2007).

A criticism that could perhaps be levelled at the RAE and other professional Engineering bodies, e.g. Institution for Engineering and Technology, Engineers Ireland, and some existing research and publications on teaching Ethics to Engineers, is that not enough emphasis is placed on adopting an interdisciplinary approach, meaning bringing in colleagues from other disciplines to teach this aspect of the Engineering curriculum. The need for such an approach has also been highlighted elsewhere (Herkert, 2005). As well as sharing the load and exposing students to a different but related disciplinary approach to their subject (hence bringing some variety to the delivery of the curriculum) such interdisciplinary, cross-department teaching helps develop both teaching and research synergies and builds collaborative networks as well as interpersonal connections.

In the case study presented here, emphasis on ‘Sustainability/sustainable development’, one of the areas of specialism of one of the authors (Barry), given its intrinsic interdisciplinary character, was extremely useful as a focus through which to explore ethical aspects of Engineering issues and their wider impacts on the quality of life in society. While not exhausting the range of potential Engineering issues/case studies through which Engineering Ethics could be explored, there is much to be said in favour of focusing on topics which highlight the overlap between Sustainability and Engineering in terms of the contribution of Engineering to achieving sustainability across economic, social and environmental ‘bottom lines’ (Barry and Farrell, 2010).

A focus on Sustainability can provide an extremely useful ‘bridge’ to integrate and link the harder technical/material dimensions of Engineering and the softer human/social dimensions in a robust, coherent and easily understandable manner. Thus a focus on Sustainability and Engineering within the context of sustainable development, automatically moves teaching and research in an explicitly interdisciplinary manner in which it is hard not to engage with social and ethical aspects of Engineering. Moreover, unlike other aspects of the Social Sciences, all course participants will have been exposed to the topic in previous courses, albeit from a more technical perspective. Sustainability thus provides a useful frame of reference for relating the potential of Engineering decisions to impact on wider society.
6. Module Presentation and Outcomes

Year 1:
In the first year of teaching this section of the module, the lecture on ‘Ethics for Engineers’ was presented by Barry where generic philosophical concepts that underpin the study of Ethics were presented to students. This included utilitarian concepts (benefits for the greatest good), and Kantian concepts (relating actions to duty) and legalistic concepts (following established procedure). Subsequent facilitated workshops, where students were divided into small groups and asked to discuss / apply different ethical approaches to specific problems, aimed to both deepen student understanding of subject matter and provide the course instructors with formative feedback. Intended learning outcomes corresponded broadly to those suited to Level I and Level II on the RAE Engineering Ethics Curriculum Map, namely to be able to outline the general principles of the ethical framework in Engineering, including the Engineer’s responsibility and to be able to identify ethical issues relating to Engineering situations through examples.

To achieve these outcomes all groups were given a hypothetical case study of an Engineering situation in class, which raised ethical issues. Participants were then invited to discuss each approach in their assigned groups, to show how the three ethical approaches were applicable, and how the SEP could be used to determine appropriate course/s of action. The approach adopted aimed to engage all class members. An open discussion between groups was initiated by the class facilitator by asking spokespersons from each group to present an issue using one of the three ethical concepts. Following the class, a summative assessment where students needed to source a case study, relating to a specific aspect of the Statement of Ethic Principles, aimed to consolidate student learning and provide a means by which participants could integrate their knowledge of Ethics with technical and communication skills in a final written report and oral presentation. To further facilitate participation the summative assessment marking scheme aimed to provide the opportunity to cross-examine presenting groups and for groups asking and responding to obtain further marks from a fixed pool of marks based on the quality of questioning and responses, i.e. one group could steal marks from another based on the quality and relevance of the dialogue.

Outcome:
Student feedback during the workshops identified from an early stage that the students experienced considerable difficulty in relating the concepts presented in the lecture to the case study; this was in part reflected in their reluctance to engage with the instructor and the rest of the class. This finding was further corroborated by the nature of the student-selected case studies presented at the end of the module, where small groups reported on the relevance of particular principle from the SEP and its relevance to the case study, without viewing the problem in its wider context, i.e. in terms of responsibility to society.

An overall review of student performance in the small-group work and written submitted assignments demonstrated that, while some students had developed a basic understanding of the subject matter and had a grasp of the main issues, the teaching approach fell short in terms of deeper student learning. This dissatisfaction with the shallow level of student understanding and lack of appreciation of the applicability of ethical issues to Engineering practice appeared to be due in large part to the fact that the teaching strategy chosen i.e. using terms, concepts and approaches that were simply not part of the students previous learning experience. It led to a complete review and a decision to try a different strategy in the second year.

Year 2
Poor performance in achieving the module intended learning outcomes in Year 1 prompted an overhaul of module structure and presentation. Consultation between both instructors led to a consensus that abstract philosophical concepts should be more firmly related to concrete examples. A restructured introductory lecture focused more on the perspective that different parties in a hypothetical Engineering problem may have on the same issue, e.g. how would a problem be viewed
by a regulator, financier or client? Presentation of divisive topics in class provided a background for emphasising the contrasting views that individuals may take of appropriate action to be undertaken in tackling problems, including raising the issue of to whom the Engineer is ultimately accountable. This approach provided a basis for introducing the RAE SEP as a guideline by which Engineers should practice, and further underscoring to the class that the Civil Engineer’s ultimate responsibility is to society. Following this approach prompted greater discussion and appeared to provide a more stimulating means of introducing the SEP.

Associated restructuring of group work classes, linked to the lecture, led to an increased and more structured emphasis on case studies sourced from Texas AMU (Prichard, 1992). These studies contrasted with high profile cases routinely encountered in the literature (and presented the previous year) in that they emphasised the importance of acting ethically throughout one’s professional career. The initial case study involved an Engineering student, who needed to question standard practices in a factory. The final study implicated personnel at management level in a conflict of interest case. The case studies also served to underscore the implications of ethical decisions not only at the personal level, but also to society.

Previous poor student engagement suggested that general discussion, based on collective opinions of the potential issues from different philosophical perspectives was ineffective. Reappraisal of educational methods in the literature suggested that role playing may be an appropriate means of deepening understanding of unfamiliar subject matter (Prince, 2006). Moreover, class participants were already familiar with this method and had responded favourably to it previously in the Communications module. The exercise completed as small group work required separate groups to assess different case studies. Different members of each group advocated different perspectives on a problem, e.g. a client, an environmental regulator, or a member of the public. Presentation of the different perspectives in each case study to the rest of the class was followed by feedback, in which other small groups judged the effectiveness of individual arguments. Finally, the class evaluated how the SEP applied to the overall issue, and how the Engineer should act most responsibly.

Case study evaluation deliberately began with those topics most relevant to students/recent graduates and progressed to issues that may be confronted senior professionals. This approach aimed to underscore the point that Ethics remains a crucial issue throughout an Engineer’s career. Formative feedback provided during the class demonstrated an improved student understanding of potentially significant issues and the relevance of the entire SEP (rather than individual concepts) to the topic solicited from other groups.

As in Year 1 the Introduction to Ethics lecture and role playing exercise provided a basis for a summative small group activity, which required students to source a case study with relevance to Engineering Ethics. The case studies chosen ranged from the Titanic disaster and the Heathrow Tunnel Collapse, to the Kansas City Hyatt Regency Walkway Collapse, although issues of local relevance were marked preferentially. Each group presented its case to the rest of the class as an oral presentation, and to the module co-ordinator as a written group report. Groups received bonus marks where they demonstrated the ability to integrate more than one point from the SEP into their arguments and responses.

**Outcome and Follow-up**

Of the 21 groups of 5-6 students, 10 received grades of over 70%, with the lowest grade being 58%. Overall average mark was 67%, which lay within the expected range for the module marks, as outlined by School grading policy. While of course one must be cautious in interpreting student grades, we feel the student group work did give us confidence that the majority of students demonstrated a good grasp of the Statement of Ethical Principles and were able to demonstrate how they could be applied to ‘real life’ Engineering situations.

Following case study presentation, each group of students was required to ‘map’ the four principles in the Statement of Ethical Principles onto their case study and then answer the following question ‘How
does the statement of ethical principles relate to the principles of Sustainability in Engineering? The question aimed to provide further opportunity for groups to reflect on the impact of microethical Engineering decisions on Society, and how these decisions may in fact have a macroethical component. The outcome of the post-presentation evaluation suggested significant improvement in student understanding of the topic. All but three groups recognised the ethical responsibility of Engineers to society, and the importance of developing designs with the longer term needs of society in mind. Twelve groups explicitly related the SEP to the principles of Sustainability; with a further four groups acknowledging potentially wider implications for society. The ‘Post-presentation evaluation’ returns from each student sub-group thus suggest that the requirement to ‘map’ the group case study to each of the four RAE Ethical Principles provided an improved approach to learning and testing/verifying student understanding of the applicability of these ethical principles.

7. CONCLUSIONS AND RECOMMENDATIONS

a) The use of small group work (both in terms of small group discussion and group projects) indicates that the gap identified between the staff-centred concerns on teaching a curriculum and the student-centred experience of ‘learning’ can be overcome within facilitated and guided experiences. Within the small group discussion or project context, students can learn from each other, thus both facilitating and encouraging more independent learning and also providing opportunities for deeper learning.

b) An important part of this process is honest and frank staff evaluation of the teaching and learning. In terms of interdisciplinary team teaching this is vital since it is most often the case that colleagues from different disciplinary backgrounds, different research and pedagogic cultures need to get to know one another, understand each other’s intellectual frames of reference, concepts and so on.

c) Within the context of having limited space for integrating ethical considerations within the Engineering curriculum, all core modules should have some ethical component, rather than the provision of a stand-alone ethical module which is semi-detached from other modules. The stand alone approach can lead to the danger of a ‘tick box’ approach, feeding into student (and perhaps staff) perception that Ethics is not a core aspect of the Engineering curriculum but an ‘externally’ imposed requirement (from the RAE or other accrediting professional body). Additionally, consideration should be given to integrating Engineering and non-Engineering students within the Ethics component of the curriculum, as suggested by Graber and Pionke (2007), perhaps, as indicated above, using ‘Sustainability’ as the focus for a dialogue between Engineering and non-Engineering (social science and humanities) students and courses.

d) The RAE Guiding Principles for Sustainable Development provide a useful frame of reference for Civil Engineering students to understand the implications of professional decisions on wider society and how microethical issues may have a larger macroethical aspect. Student familiarity with the guiding principles provided a useful means for embedding technical issues into a social context and subject matter with which students were otherwise unfamiliar.

When teaching Engineering students Ethics, one needs to bear in mind that the language and concepts used need to be appropriate to their level of ethical understanding. It is critical to avoid abstractions outside of their domain of interest. We firmly believe that everyone is and ought to be ‘ethical’ – in the sense that there is a basic, intuitive perception of ‘right and wrong’ and that one does not need ethical training to discern ethical from unethical behaviour. That said, within the formal university setting against the backdrop of a professionally accredited degree course and most importantly with a full understanding of what it means to view Engineering as a ‘profession’ (like the medical, or legal profession), it is imperative that students understand the privileged position they will have once they qualify. With the power, authority and public respect of being a professional Engineer comes responsibility; to understand oneself as a ‘Professional Engineer’ must mean thinking of oneself as a type of person who does not do certain things. Here we come closest to the notion that perhaps has motivated our approach to teaching Ethics to Engineers, that is about character, the active reflection upon and creation of a sense of oneself as a professional Engineer who cultivates the ‘habit’ of being ethical, of working with the letter and spirit of codes such as the RAE’s Statement of Ethical
Principles, such that one’s professional practice becomes a matter of who you are and aspire to be, rather than thinking ‘being ethical’ always is a matter of having ‘external’ rules ‘imposed’.

The findings of this study have indicated that Engineering students, when presented with appropriate subject matter – in this case placing Engineering within the wider context of Sustainability and the interdisciplinary challenge of the transition towards Sustainability - can learn and apply ethical concepts to problems relevant to their day to day professional practice. Nonetheless, there remains room for improvement. This study forms part of a longer term iterative approach in which the most appropriate means and techniques for teaching Engineering Ethics will be further developed and adapted in teaching Civil Engineering students.

8. References