Reflection of UCL Civil and Environmental Engineering experience in integrating ethics in engineering education

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Abstract

Discussions on ethical aspects of engineering and the development of ethical codes of practices are now common practice in many countries. These discussions stem from the 20th century experience that engineering decisions can have profound implications for the wellbeing of the public and the environment, although different societies have followed specific paths in their development of codes of engineering ethics (Downey et al. 2007). Engineers need to act within their professional code of conduct and be able to make ethically sound decisions and therefore engineering ethics cannot be separated from technical competence.

Yet, despite these developments, the integration of ethical aspects into the education of future engineers remains patchy. At UCL, the Department of Civil, Environmental and Geomatic Engineering (CEGE) have adapted the ethics curriculum map written by the Royal Academy of Engineering working group on teaching engineering ethics, which was released in 2008. The process included the development of an internal discussion document that proposed ethics learning outcomes and identified opportunities for integrating them in the curriculum, including suggestions for teaching activities and assessment. In addition, an outline for an ethics teaching toolkit and a proposal for evaluating and reviewing ethics teaching in the department was developed.

While the integration of ethics into the departmental curriculum started in earnest only in the current academic year, we have decided to evaluate the reception of the programme by the lecturers in the department. This was carried out through questionnaires and interviews. The response of those that were interviewed is generally positive.

Time, logistics and teaching formats seem to be main concerns. Few are keen on the idea of lectures that specifically focus on ethics. Most stress ideas of interactive, reflective and group-based learning which are widely used in the department. Case-studies seem especially popular as they can be used in tutorial groups and during scenario based learning.

While a toolkit with information about ethics was provided to all lecturers, only a few have gone onto integrating parts of it into their own teaching.

The interview also included questions about personal ethics. Most staff reported that they had not faced any significant ethical dilemmas in their own work to date. It is possible to identify academics who have clear opinions and people who have more tacit or less articulated views on engineering ethics and related issues. Staff showed either a more flexible, situational approach to ethics, or principled stances. Sustainability is often an important driver for those with more normative ethical positions.

Introduction

International and national background

The technological choices engineers make throughout their professional lives can have long lasting consequences on the environment and other people. A growing awareness of this fact has led engineering professional institutions to extend their codes of conduct from rules mainly centred on professional integrity and peer respect to more general concerns about the wider impact of the projects engineers are involved in. This growing professional concern has been accompanied by a drive by professional accreditation bodies to include some form of engineering or professional ethics in university engineering curricula. For instance, the much discussed "Engineering Criteria" (Shuman et al 2005) first published in 2001 by the US Accreditation Board for Engineering and Technology (ABET) stipulates that Engineers should possess "an understanding of professional and ethical responsibility", "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context" (ABET-Criteria). Similar requirements have emerged in most western speaking countries. In the UK, the major engineering institutions have also updated their codes of conduct to include similar prescripts. For instance in 2004, the Institution of Civil Engineers, one of the most prominent British engineering institutions published a revised Code of Conduct that explicitly states a duty to behave ethically. This may not in itself appears particularly new but the institution concomitantly published a document entitled "Advice on ethical conduct" giving further detail as to what the authors of the code of conduct had in mind regarding professional ethics (ICE WEB REF). The Advice document touches upon a wide range of aspects, including responsibility towards risk taking, sustainability, the environment and disaster reduction. Another British organisation, the Royal Academy of Engineering has also been very actively promoting wider ethic considerations within the UK engineering profession. Not strictly an institution offering chartership or degree accreditation, the role of the Academy is to "enhance the UK's engineering capabilities; to celebrate excellence and inspire the next generation; and to lead debate by guiding informed thinking and influencing public policy." (RAEng-About Us) The Royal Academy of Engineering's activities in engineering ethics are divided into two strands: (1) ethics and engineering practice and (2) teaching engineering ethics. As part of the latter, the academy published a 'curriculum map' (RAEng-Curriculum Map) designed to help Engineering Schools teach engineering ethics.

Working in the department of Civil, Environmental and Geomatic Engineering Department (CEGE) at University College London (UCL), we are small group of staff particularly interested in the subjects of engineering philosophy and ethics. Keen to push Engineering Ethics forward in the teaching, we used the Royal Academy of Engineering Curriculum Map as the basis for our endeavour and proposed to our department the introduction of some ethics-related learning outcomes in our programmes during the summer 2009. To identify the level of interest and engagement from other academic staff on the subject, we decided to conduct staff interviews to all academic staff willing to be interviewed during the spring 2010. This paper reports on the outcome from these interviews.

Departmental Context

The recent introduction of engineering ethics in the departmental programmes is the latest chapter in a years-long attempt to broaden the curriculum beyond strictly technical subjects. In 2006 CEGE instigated a radical restructuring of its undergraduate degree programmes in Civil and

Environmental Engineering. Prior to 2006 UCL undergraduate programmes in civil and environmental engineering consisted of a lecture and laboratory based programme in structural mechanics, soil mechanics, fluid mechanics, materials, pollution control, society, mathematics and computing; a project-based design curriculum; a research project; and advanced modules in specialist topics. Student learning was assessed by coursework and exams in individual subject areas. For students on a three year BEng programme there was no explicit opportunity for integration of learning across the different subjects, with the exception of design projects. The fourth year of the MEng programme was dominated by an integrated design project which aimed at bringing together knowledge from different subjects, but there were limited opportunities to integrate learning in the first three years of the programme.

The new degree programmes implemented in 2006 are a hybrid of conventional lecture and laboratory learning with Problem Based Learning (PBL). The most radical changes to the programmes have occurred in the first two years. The first and second year curriculum is divided into four clusters – tools, mechanisms, context and change – which are taught in four week blocks of lecture and laboratory classes each followed by one week intensive group projects called scenarios. The tools cluster includes mathematics, computing and communication skills. The mechanisms cluster covers essential civil and environmental engineering sciences. The context cluster addresses sustainable development, professional practice, public engagement, history, economics, statistics and geology. The change cluster includes design exercises, systems engineering and the week-long scenarios.

Although ethics has not featured explicitly as a learning outcome in our teaching up until September 2009, some of the material taught in the Context Cluster is intended to make students aware of the potential tensions between technical and social considerations (planning exercise, transport and society, environmental impact). Some ethical deliberation is also necessary in many of the design decisions taken during the scenarios. Scenarios aim to present the students with real world problems and many involve data and expertise provided by industrial collaborators. Scenario topics include: analysing traffic congestion problems in a medium sized town; designing solutions to the traffic congestion problems in the town; designing a low impact shrimp farm; designing a pedestrian footbridge to meet community needs; managing the development of a community centre; performing a feasibility study of transport links to an airport; undertaking site assessment and designing a wind farm; and analysing water supply options and designing a reservoir.

Keen to make ethics-related learning outcomes feature more prominently in the curriculum, we decided to adapt slightly the Royal Academy of Engineering Map aforementioned to suits out own yearly structure. As far as teaching delivery is concerned, there seems to be a growing consensus among academics already teaching ethics to engineers that this is best done through interactive sessions such as workshops, role plays or discussion centred around case studies (e.g. Cruz et al 2003, Prince 2006, Børsen 2008). Aware of this and anxious not to load further an already overcrowded timetable, it was recommended that a small number of ethics-related learning outcomes be integrated into existing teaching activities (context lectures and scenarios) while the rest of the ethics curriculum would be discussed in Tutorial Groups. These groups are a long standing departmental tradition. Each year, first and second-year undergraduates, grouped in 5 or 6 are assigned a member of academic staff who then becomes their personal tutor for that year. Each group meets their personal tutor once a week for up to an hour to discuss issues and progress. These meetings are not intended to be heavily technical (as would be solving a specific problem sheet in

fluid mechanics for example). Academics are free to use this slot as they see fit. As a way of introducing engineering ethics to undergraduates, we proposed that these tutorials might be used on a voluntary basis. In order to provide some support, we collected a range of material (possible activities, case studies to discuss, web resources available etc) under the name of Engineering Ethics Toolkit. We then made the ethics curriculum and toolkit available to all academic staff with enough information that they knew what they were expected to do with it should they wish to. The teaching delivery was therefore made on a purely voluntary basis. To monitor the level of interest and engagement from other academic staff on the subject, we decided to conduct staff interviews with all academic staff willing to be interviewed.

Methodology

An email was sent to all academic staff in the department in January 2010 explaining we would like to interview as many of them as possible to find out what they thought of engineering ethics in general and the proposed departmental curriculum and toolkit in particular. Out of a total of 36 academic staff 13 agreed to be interviewed after a single email invitation. It was stipulated that the interviews would be carried out by a researcher in psychology (Chrisitan Solberg, co-author of this paper) not otherwise directly involved in the department. The interviews were recorded then transcribed by a third party and finally anonymised as far as possible by Christian.

The semi-structured interviews began by asking for a short history of the staff members' backgrounds. They were asked for their general views on engineering ethics and if they have any experience of ethical issues or dilemmas in their careers. They were also asked about their views on the best way to teach engineering ethics and finally their engagement with the ethics toolkit which had been circulated in the department.

The results presented in this paper are the outcome of analysis of the 13 interview transcripts, with further interviews and transcription currently underway. The process of analysing the transcript followed common protocols in qualitative data analysis. The process started by reading the transcripts for the first time, and highlighting statements and discussions that are relevant to understanding the perceptions and positions of members of staff towards ethical issues and the teaching of ethics to students. These paragraphs and statements were then copied to a new document, and thereby increasing their anonymity. Once the text was separated, descriptive keywords were attached to each section and then the text was reorganised according to major headings and sub-headings. This provided a complete document with both codes and transcript extracts that express these codes.

Analysis of the Results

The main themes that emerged from the analysis were: the nature of engineering ethics; personal ethics; the importance of teaching ethics; and how to teach ethics.

The nature of engineering ethics

> the engineering profession needs to sort of stand up for non-financial values, you know, on honesty, health and safety, fairness

Engineering ethics are closely related to the purpose of the profession in ensuring public safety, improving social conditions, protecting the environment and promoting sustainability. Engineers are important actors in highlighting alternative values and issues in contrast to the perceived dominance of the profit motive in major developments and projects. Engineering ethics involves working within the specific social and environmental contexts rather than imposing inappropriate technical solutions. Engineering ethics are associated with risk management and perception, in relation to human safety and the environment.

Fairness is also considered an important element of engineering ethics, in the sense of fair dealings with other engineers, clients and the public, and in relation to trade, employment and broader issues of social equity. Dealing with bribery and corruption, particularly in developing countries, was highlighted as a particular ethical issue which engineers have to deal with directly through their own practice and indirectly through their knowledge of the corrupt practices of other engineers and professionals.

Codes of conduct are seen as a baseline or safety net for professional conduct and ethical practice rather than all encompassing or sufficient to ensure ethical practice and decisions. Such codes included research ethics protocols and plagiarism policies for students, as well as professional codes of conduct for engineers. The importance of engineers acting within the limits of their competence was raised as an ethical consideration, aligned with concern about people working as engineers without sufficient training and qualifications. Ethics are seen to cover a broad range of issues from personal interactions with students or research participants through to global issues such as the provision of clean water and sanitation to poor communities, requiring different ethical competences for staff, students and professional engineers.

Personal ethics

The academics interviewed consider themselves to be ethical people, although some express uncertainty and uneasiness with some of their career experiences or the nature or the work that they are engaged in as researchers. Most of the academics' discussions about personal ethics focussed on their work as researchers. About half those interviewed could not describe a particular ethical dilemma or ethically contentious situation that they had experienced in their career, though most explained ethical reasoning that either underpinned their career choices or specific decisions to become involved with particular industries or research partners. Research relating to military technologies is seen as ethically contentious. Some staff said that they would not engage in military related research, others felt that it was important for ethically sound academics to be involved in such contentious fields, particularly to promote useful civilian outcomes. Some of those who were not directly involved in contentious research topics were concerned about working with companies who were involved in such field, even if it did not relate directly to their particular work or project.

Academics demonstrated good understanding and practice in relation to research ethics. This included specific reflections about the role of research ethics protocols and committees relating to vulnerable populations and animals. Issues such as acknowledging the source of funding for research projects and maintaining transparency in research were also raised as part of personal ethical frameworks and conduct.

Although cumulatively, the main areas relevant to engineering ethics were mentioned throughout all the interviews, most individual interviews revealed a rather partial view of the subject, often limited to the specific area to which the particular individual has had to grapple with in the past.

Teaching ethics

> it's probably more reprehensible to send out an engineer without ethical thinking than it is without mathematical thinking

All the academics interviewed agree that it is very important to teach ethics to engineering students. It is important to develop students' capacity for ethical reasoning and to understand the ethical issues that engineers face. Ethics are seen as integral to good decision making, not only in the immediate context of the graduate but in more senior positions later in life. Teaching ethics has additional benefits of developing students' capacity for critical reasoning and to see their work in a broader context. Some staff understood ethics as stemming from family and social backgrounds, which students bring with them to engineering. Ethical thinking is a generic skill which can be developed by application to engineering problems, as well as a set of specific issues for the engineering profession to deal with.

A strong theme was the importance of teaching ethics by example. Several staff raised the importance of behaving ethically in their own research and teaching as a means of demonstrating ethics to students. This included dealing fairly with students in cases of plagiarism or late coursework, being ethical in their research and in all their interactions with colleagues and students.

Many of the participants thought that teaching ethics was difficult. They saw tensions between teaching ethics as a process of thinking through issues and potentially constraining students' freedom to develop their own ideas and solutions. It is also difficult to teach students about ethics if they are unable to see the immediate implications of the concepts or issues being discussed. Some staff feel uneasy moving beyond merely discussing ethical issues with students into more formal teaching methods.

Integrating ethics into the curriculum

> what you need to do is make the staff conscious of ethical issues. I think it's more important to make the staff aware so they can then incorporate it in their teaching where appropriate

The academics generally agree on the need to integrate engineering ethics into the core curriculum, but some are conscious that the curriculum is already heavily loaded. One participant is in favour of a separate module on engineering ethics, having experience of such a format from another university. Most feel that lectures may be necessary to deal with specific topics but are unlikely to succeed in achieving ethics learning outcomes. It is important to introduce ethical issues in specific contexts using examples, case studies, projects and seminars. Students need to be allowed to discuss the issues and develop their own positions.

A number of respondents felt that although it may not have been explicitly called ethics, what we proposed in the ethics curriculum, was already being covered at least in part. Against this argument, another respondent pointed out that if a topic does not feature prominently in the curriculum (clear timetabled contact time, assessment etc) then students are unlikely to take the subject seriously.

The engineering toolkit provided to all staff by the co-authors at the start of the academic year has not been widely utilised. Many participants admitted that they had not read the document, although they see the value in case studies and other material which the tool kit provides. One participant had used the case study materials to discuss issues surrounding bribery with a tutorial group. The reasons for not engaging with the material were generally ascribed to high workload or lack of interest.

Elements of discussion – Ethics and the academic position

Throughout the interviews, a fairly consistent picture of the worldview of the academics interviewed emerged. This conception to some extent reproduces the stereotypes contrasting universities to the non-university world. This mental picture is represented diagrammatically in Figure 1. The point here is not to discuss the accuracy of this mental picture from an empirical point of view but rather to use it to understand better how engineering academics do and do not conceptualise ethics.

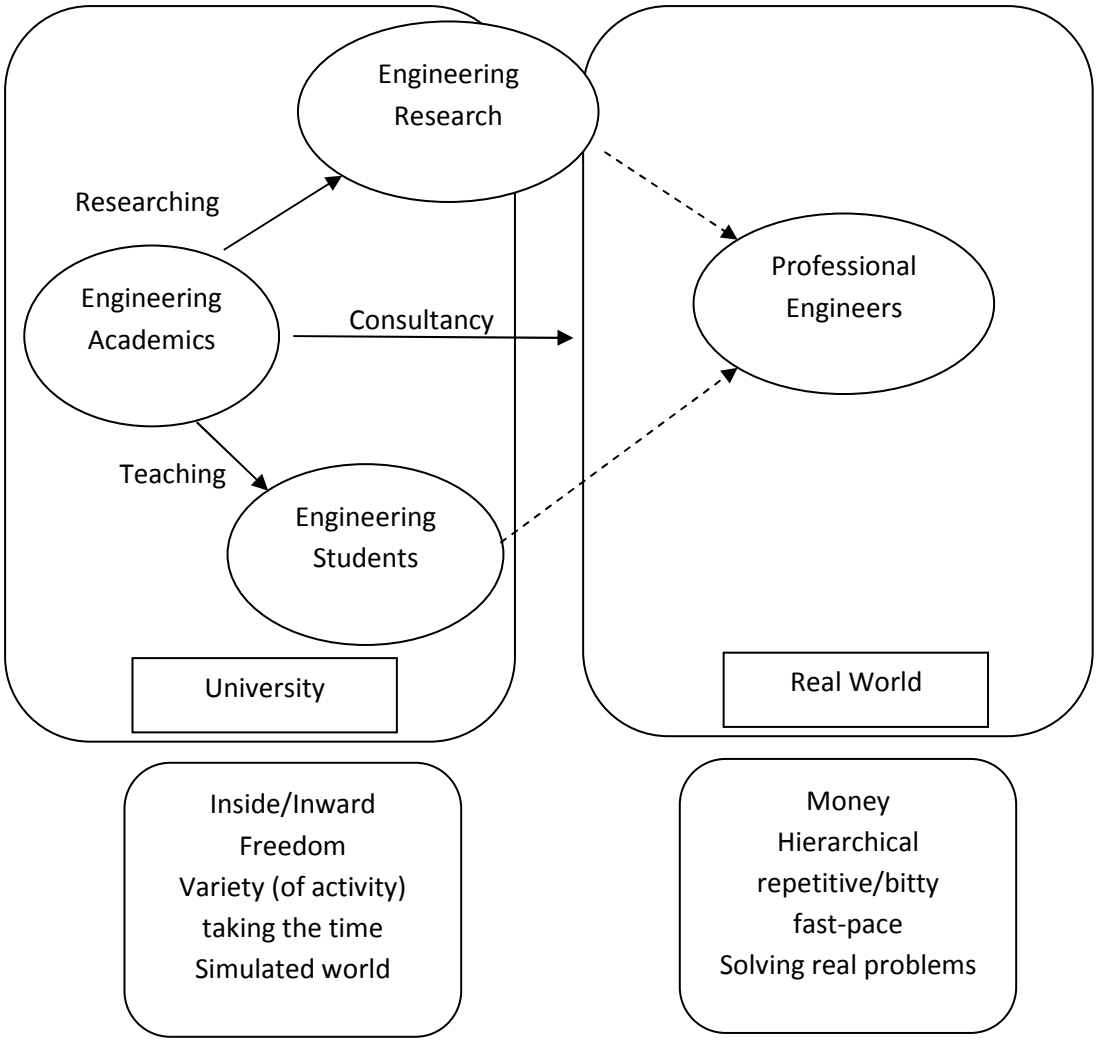

Figure 1 – Mental picture of the world

The academic world is almost always contrasted to the 'real world'. This presumably means first the professional engineers and secondly the rest of society at large. The list of keywords used to describe both worlds (figure 1) is a clear set of binary oppositions. According to this worldview, apart

from the occasional consultancy work, there is no direct link between academia and 'the real world'. Teaching students has long-term and often intangible effects onto the 'real world' (though it has demonstrable effects on students in the short term). Similarly, academic research – though it may be carried out in close collaboration with industry – is also often characterised by long lead times in terms of impact.

If one accepts that ethics is associated with making decisions and taking practical actions, this worldview suggests that academics can mostly demonstrate ethical practice professionally through those three areas (research, consultancy and teaching). As many respondents pointed out, this implies that if academics are to lead by example in terms of teaching for example, they should make sure that they deal with students with fairness etc. The implicit teaching model for this is some kind of mimesis whereby the students 'pick it up' by contact as it were.

This may be reasonably unproblematic if all engineering students were to become academics. This is however not the case as most of them go on to work in the private sector after their university degree. Moreover about half the interviewees had no significant industrial experience. This raises two issues: (1) 'mimetic teaching' of ethics may not prepare engineering students to the difficult situations they may encounter in the private sector, (2) academics with no industrial experience may find it difficult to teach ethics in a way which is relevant to future practicing engineers. In the worst case scenario, one could imagine an academic preaching from a moral high ground about decisions or situations which they may never have encountered themselves.

This suggests that if engineering ethics is to be taught in a distributed manner, by integration throughout the existing curriculum, relying on academics personal ideas of ethics may not be sufficient. A more pro-active training may be necessary for the teaching to be effective – possibly involving sympathetic industrial collaborators to share their experiences.

Conclusions

At University College London, a small group of academics proposed the introduction of some ethics related learning outcomes into the curriculum of the Department of Civil, Environmental and Geomatic Engineering department. This ethics teaching was suggested to other academics but was not imposed. Six months later we carried out staff interviews to monitor the level of engagement with our proposal. This paper reports on the finding from these interviews.

From the responses obtained, the main conclusions are that

- ⇨ Academics recognise the importance of teaching ethics
- ⇨ Academics are mostly capable of ethical reasoning, demonstrated by their own ethical conduct in research and teaching and in some cases through their specific career choices
- ⇨ Academics think that teaching ethics is difficult – conceptually and practically.
- ⇨ They have mixed views on how to teach ethics – most support integration into the core curriculum but others think it should be left to more discursive situations such as tutorials.
- ⇨ The ethics tool kit we prepared has had limited impact – although staff recognise the importance of teaching ethics they have not engaged with the toolkit. This is likely to be related to priorities in the curriculum and workload, and because some staff feel more comfortable taking an informal approach to engineering ethics.

References

ABET, Criteria for Accrediting Engineering Programs, Baltimore, Md.: Engineering Accreditation Commission, Nov. 11, 2003.

http://www.abet.org/Linked%20Documents-UPDATE/Criteria%20and%20PP/E001%2009-10%20EAC%20Criteria%2012-01-08.pdf .
Last accessed August 2010

Børsen, T. "Developing ethics competencies among science students at the University of Copenhagen" European Journal of Engineering Education 33(2) (2008). 13 Apr. 2010

Cruz, J. A. and Frey, W. J. An Effective Strategy for Integrating Ethics Across the Curriculum in Engineering: An ABET 2000 Challenge *Science and Engineering Ethics (2003)* ***9,*** *543-568*

Downey, G. L., Lucena, J. C. and Mitcham, C. (2007) Engineering Ethics and Identity: Emerging Initiatives in Comparative Perspective Science and Engineering Ethics 13 pp.463-487.

ICE Code of Professional Conduct
http://www.ice.org.uk/getattachment/1ebe1f7e-7b36-43a2-a4eb-520901cc01cc/Code-of-professional-conduct-for-members.aspx
Last accessed August 2010

ICE Advice on Ethical Conduct
http://www.ice.org.uk/Information-resources/Document-Library/Advice-on-ethical-conduct-%281%29
Last accessed August 2010

Prince, R. H. Teaching Engineering Ethics using Role-Playing in a Culturally Diverse Student Group. *Science and Engineering Ethics, Volume 12, Issue 2, 2006*

Royal Academy of Engineering. About us (Online)
http://www.raeng.org.uk/about/default.htm
Last accessed August 2010

Royal Academy of Engineering. An Engineering Ethics Curriculum Map.
http://www.raeng.org.uk/news/releases/pdf/Ethics_Curriculum_Map.pdf
Last accessed August 2010

Shuman, L., Besterfield-Sacre, M., and McGourty, J., "The ABET "Professional Skills-Can they be Taught? Can they be Assessed?" Journal of Engineering Education, Vo. 94, No. 1, January 2005, pp. 41-55