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EMBEDDING ETHICS INTO THE ENGINEERING AND PRODUCT DESIGN CURRICULA: A CASE STUDY FROM THE UK

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ABSTRACT
In recent years there has been a notable emphasis from professional bodies on embedding professionally relevant issues, such as sustainable development and ethics into academic courses for engineering and product design. For instance the Royal Academy of Engineering (RAEng) recently published its curriculum map for introducing ethics into the engineering curriculum for courses that do not explicitly cover this at present. The guidelines include a suggested three step approach, including an audit of current methods, a plan of action for the future and the implementation of the plan. The authors are attempting to begin the process of introducing ethics into its engineering and product design courses using these three stages. Currently, the team is about to enter the final and potentially most challenging stage of the process. This paper is presented as a case study, giving an overview and evaluation of the experiences of this team thus far, with reference to other case studies from overseas and our own experiences in the UK.

Keywords: Embedding ethics, engineering, product design, curriculum

1 INTRODUCTION

The idea of teaching ethics for many academics (engineers in particular) is an odd concept at first. In many cases, it is not just odd but not necessary at all. The interpretation of numbers is a clear cut process. If the calculation is done correctly, the answer is correct. If not, it is incorrect; right versus wrong. But dig a little deeper and the grey area and an ensuing discussion begins to emerge. What seemed to be a rather straight forward answer can quickly become debatable, flexible or even incorrect if the context of the problem is opened up. But how can academics teach this, and assess this if what they are used to is teaching and assessing problems with only right and wrong answers?

2 PROFESSIONAL BODIES AND OTHER RELEVANT RESOURCES FOR ETHICS

Much work has been done in recent years, in particular by the Royal Academy of Engineers (RAEng) to understand where and how ethics appears in the engineering curriculum and to implement their curriculum map into taught courses. Their guidelines include a suggested three step approach, including an audit of current methods, a plan of action for the future and the implementation of the plan. They indicate that when students are taught about ethics they will:

- **Understand** the nature of professional responsibility
- Be able to **identify** the ethical elements in decisions
- Be able to **address** and **resolve** problems arising from questionable practice
- Develop critical thinking skills and professional **judgement**
- **Understand** practical difficulties of bringing about change
- **Develop** a professional ethical identity to carry forward in their working life.

They then present their curriculum map, which neatly indicates the location, learning outcomes, content and process involved in implementing it as shown in Figure 1.

In the U.S. and in the U.K. there is a wealth of resources available for guidance, information and in some cases very detailed codes of ethics for Engineers through the RAEng, NSPE, ASME, ASCE, IEEE, IET, IMechE to name a few.

1. LOCATION			2. LEARNING OUTCOMES	3. CONTENT	4. PROCESS
Level	**Focus**	**Points of Delivery**	**Students should be able to:**	**Topics**	**Example Techniques**
1	Awareness of issues, obligations and responsibilities; sensitising students to ethical issues	Induction	1. give examples of ethical issues related to engineering; 2. recognise ethical responsibilities of engineers; 3. describe in outline an ethical framework for engineering.	Professionalism; codes of conduct; obligations to the public	Interactive small group sessions during student induction; developing case studies from newspaper or magazine articles.
		Modules		Duty of care; trust; introduction to applied ethics; ethical dimensions to engineering problem solving Introduction to a theoretical ethical framework based on deontology (duty), rights, utilitarianism, autonomy/consent and virtues (this topic could be introduced at Level 2)	Identify existing modules which can be modified to establish a clear ethical focus for the engineering programme. Each module will have illustrations, topics and exercises covering key ethical issues. Introductory modules to engineering would be ideal starting points.
2	Resolving practical problems; enabling students to identify ethical issues and to examine and weigh up opposing arguments	Modules	1. identify ethical issues related to an engineering situation; 2. suggest ways to deal with ethical issues in engineering; 3. illustrate the ethical dimension of practical engineering	Ethical cases in engineering; developed study of the ethical framework introduced at Level 1	Existing modules can be modified to include topics and exercises which address ethical issues from a practical standpoint. Give an ethical angle to traditional engineering exercises. Encourage group work and use familiar, non-specific engineering situations by way of introduction, such as plagiarism and negotiation.
		Placement preparation		Professional practice of oneself and others; differentiating between good and bad employers	Set up role-playing scenarios and debates between students; run intensive workshops for placement preparation.
3	Reflection and critique of ethical issues; consolidation of ethics skills and practice; specialist study	Design Project	1. undertake an ethical audit; 2. discuss ethical dilemmas in engineering; 3. justify an ethical stance.	Ethics audit of final year project	Self study and application to a student led project.
		Core Modules		Ethically ambiguous scenarios	Challenge students to defend their actions from an ethical standpoint by holding group debates.
		Ethics-specific optional modules		Philosophy of engineering; further ethical theory; engineering ethics and environmental ethics	Present case studies and dilemmas and give students practice in solving morally ambiguous scenarios. Encourage analysis, synthesis and report back of ethical issues.
4	Further reflection and critique of ethical issues; specialist study	Research-oriented module on ethics	1. articulate ethical problems in engineering; 2. reach an ethically justified or morally reasoned practical solution to an ethical problem with an appropriate plan of action; 3. propose policy relating to ethical questions in engineering	Research principles and ethics; risks and benefits of novel technologies; broader context of engineering; business ethics; corporate social responsibility	Present case studies and dilemmas and give students practice in solving morally ambiguous scenarios. Encourage written analysis and reports.

Figure 1. The thorough and detailed engineering ethics curriculum map from the RAEng.

Similarly, a trip to the campus library throws up a wide range of titles. These typically can be categorised into either general engineering ethics [1-4], catastrophy and failure [5, 6], and sustainable development [7,8]. So there is plenty of information, good information, available to all educators which relates engineering theory and practice with ethical issues and considerations. But how does that translate to teaching on the ground? How are these issues actually embedded into the curriculum?

As far back as 1984, soon after the field of engineering ethics emerged in the mid 1970's it was identified that the potential for progress was good. However, the implementation of engineering ethics in the engineering curriculum was shown to proceed "very slowly" [9]. Today, 26 years later, this trend continues, some progress has been made, albeit very slowly. A survey of UK University Engineering departments carried out by the RAEng Teaching of Engineering Ethics Working Group highlighted that of the 263 Heads of Departments approached, only 56 responded. The Working Group does point out that: "this is a relatively high response rate for surveys of this kind, and the many detailed comments provided, indicated a substantial level of interest in the topic". Looking at the results that were presented in this survey, this does not appear to be the case at all. Of those department heads surveyed (and remember only 21% actually responded), when asked if they planned to increase the delivery of the learning outcomes (set out in the RAEng curriculum map):

- 20% indicated "not at all"
- 18% indicated "incrementally"
- 24% indicated "over 5 years"
- 38% indicated "over the next 1-2 years"

As a result of this survey, the key messages published this survey indicated that:

- "parts of the curriculum need redesigning to identify opportunities and teaching methods to deliver the learning outcomes"
- "there is an overwhelming need for new case study material that engages the students, particularly stemming from UK experience"
- "there is a strong requirement for the training of staff in the appropriate teaching skills".

These key messages may indicate a strong "interest in the topic" but how will this translate into academics actually taking ethics seriously and more importantly teaching it to their students wherever this may be appropriate? The RAEng, other professional bodies and even the Engineering Subject Centre here in the U.K. clearly do take this issue seriously. They provide enormous amounts of resources available and have hinted that ethics should and eventually will be a mandatory part of the engineering curriculum. But how does this work on the ground, with academics teaching engineering? And what about Product Design? How does this fit with the engineering model?

3 AN INSTITUTIONAL AUDIT

For this paper the authors wanted to (informally) investigate how and where ethics was being taught in our institution in the Product Design and Mechanical Engineering degrees. Three different approaches were taken: informal chats with various colleagues over a coffee (the light touch), a blanket email requesting any examples, case studies or information that might be relevant (the probing approach), and a forum for staff to discuss titled: 'Tell us about it': Ensuring good ethical practice across the Faculty (centrally organised by the office of the Faculty of Science and Engineering).
Several observations were noted from all three of these approaches:

- That ethics underpins almost every topic related to engineering and product design
- Only a small number of staff were actively engaging with the topic of ethics in engineering and product design
- Many staff who teach engineering were not interested in engaging with the topic of ethics
- Staff teaching product design were more likely to engage with the topic of ethics in their teaching
- Many staff were unaware that there was potential to engage the topic of ethics in their subject area when the authors discussed this with them.

There were some examples where ethics was being covered in the curricula in both engineering and product design courses. These include using briefs for projects around inclusive design (driven by students' social awareness and underpinned by their empathy for the user of their product), working with consumers and the responsibilities in delivering to real world expectations, corporate laws and certification, and quite a few instances of sustainable development projects related to energy usage and working with the community. However, these examples were sporadic and delivered by only a few members of staff and were typically confined to those modules where discussion and dialogue with students was an integral part of the delivery.
It is recognised that the topic of ethics may not be of interest to all educators in this area, and the timing of the approaches may have been ill-timed. However, despite the interest at the professional institution level, the general perception on the ground from teaching academics was clear: there is little interest in embedding ethics into *their* curriculum at our institution.
It is hypothesized that one reason underpinning these observations is the professional experience levels of the staff. Some staff have little or no experience of working in an industrial environment, for others their experience is out of date and of little relevance in the professional scene today. The product design teaching staff were perhaps more engaged with this topic because they tended to also have links with the professional world outside of the University environment. Another reason for the lack of interest could be associated with the reluctance of some staff to engage with improving their teaching and learning skills; instead engaging with and perusing only their research interests. The final suggested reason for the reluctance to engage in this issue is the lethargy associated with overloaded timetables and the idea of cramming this topic into an already busy schedule, not to mention the idea of added bureaucratic layers or jumping through hoops.

4 THE REAL WORLD: STUDENT PERSPECTIVES

In contrast to the limited, drawn out information that came from some staff members, an in class discussion with students on the product design course resulted in a lively discussion on ethics issues in their education. One interesting discursive point that seemed to emerge was that leaders of society, especially recently, with politicians, bankers and decision makers were seemingly not ethical in their approaches to their professions. It was seen that those such tightly defined and well informed ethical guidelines proposed by the professional bodies were in contrast to those being exercised in the real world. In their eyes, who was upholding these ethical standards? Students were bringing to the table

their own case studies and examples, of companies they would or wouldn't work for, of companies who were basing their ethical standards (and as a result their decisions) on potential for lower financial losses (e.g. for a product recall), of companies who were recalling dangerous products in one country but not another simply because of the lack of public knowledge of the products deficiencies.
Students overwhelmingly (in this group only) indicated that ethics were not being covered sufficiently on their course up until that point. Outcomes that the students agreed would be an appropriate way forward to begin embedding ethics further into their curriculum included:

- Provision of resources, case studies, examples etc (clearly this is available currently)
- Guidance and access to receiving ethical approval for projects or research (previously accessible mostly to research staff and students)
- An opportunity for reflection on personal ethics and how these relate to professional attitudes or particular projects.

On the whole, the discussions with the students were only matched with those of a few other staff members. Most staff did not (perhaps were not able to?) discuss such issues with such passion or detail.

5 A PLAN OF ACTION: ORDER FROM CHAOS

In response to the Faculty based workshop, discussions and other prompts from the Faculty Ethics Committee each school in our faculty has an ethics officer assigned to each division (in this instance the Division of Engineering and Product Design). All undergraduate, postgraduate and research students (and staff) have access to guidance, resources and ethical approval documentation/processes through our online institutional gateway. These include a 'light touch' checklist, shown in Figure 2, which we hope is an approachable entry point for students and staff who are interested in evaluating the ethical issues associated with their projects or research. From here, items that are flagged up needing further attention require a more detailed ethical approval request form to be completed in order to progress. Information and guidance on, for example consent forms is also provided online.
So all the systems seem to be in place for students when they carry out their own work, including projects and research. But how do we embed the ethics into the curriculum? Into their day to day lessons? Into their assessments and exams? In the authors' opinion, this will only happen when:

- Teaching staff are educated as educators, not simply researchers
- Teaching staff engage with up to date industrial projects
- Teaching staff move away from using only lecture-exam based teaching and learning methods.

This will clearly be a challenge for educational institutions in the areas of engineering and product design. It will involve altering the balance of staff, their skill sets and backgrounds and how they spend their time teaching, researching and engaging professionally, socially and industrially.

6 CONCLUSIONS

There is a substantial amount of information, guidance and resource available to support the embedding of ethics into the engineering and product design curricula. Despite this, institutions have been "very slow" in taking up ethics into the formal curricula. Engineering education needs a real shake up. In particular it must move away from the formal lecture-exam based methods with only technical content that dominate the curricula. Perhaps these methods have their place, but they should not dwarf other teaching and learning methods like they currently do. Staff need not only to engage with industry to understand what is happening with the real world of engineering, but also to work on their ability to teach in up to date and appropriate ways so that students learn about the relevant topics in a context that will help them to be professionals after they graduate. It is recognized that this will be a long and difficult process, taking possibly another 26 years or even longer.

Please tick the appropriate box	Yes	No
1. Is this research likely to have significant negative impacts on the environment? (*For example, the release of dangerous substances or damaging intrusions into protected habitats.)*		
2. Does the study involve participants who might be considered vulnerable due to age or to a social, psychological or medical condition? (*Examples include children, people with learning disabilities or mental health problems, but participants who may be considered vulnerable are not confined to these groups.)*		
3. Does the study require the co-operation of an individual to gain access to the participants? (*e.g. a teacher at a school or a manager of sheltered housing)*		
4. Will the participants be asked to discuss what might be perceived as sensitive topics? (*e.g. sexual behaviour, drug use, religious belief, detailed financial matters)*		
5. Will individual participants be involved in repetitive or prolonged testing?		
6. Could participants experience psychological stress, anxiety or other negative consequences (beyond what would be expected to be encountered in normal life)?		
7. Will any participants be likely to undergo vigorous physical activity, pain, or exposure to dangerous situations, environments or materials as part of the research?		
8. Will photographic or video recordings of research participants be collected as part of the research?		
9. Will any participants receive financial reimbursement for their time? (*excluding reasonable expenses to cover travel and other costs*)		
10. Will members of the public be indirectly involved in the research without their knowledge at the time? (*e.g. covert observation of people in non-public places, the use of methods that will affect privacy)*		
11. Does this research include secondary data that may carry personal or sensitive organisational information? (S*econdary data refers to any data you plan to use that you did not collect yourself. Examples of sensitive secondary data include datasets held by organisations, patient records, confidential minutes of meetings, personal diary entries. These are only examples and not an exhaustive list).*		
12. Are there any other ethical concerns associated with the research that are not covered in the questions above?		

Figure 2. Questions on our 'light touch' undergraduate ethics checklist. Note: If students have answered 'yes' to any of the questions they will need to complete an ethics approval form prior to the commencement of research.

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