Ethics in an Engineering Curriculum

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Abstract: *Although Ethics and Engineering have existed as separate academic entities for a long time, it is only comparatively recently that the former formally became a part of the engineering profession and an accepted component of an engineering curriculum. This paper provides a comment as how this may have come about, and relates the author's experiences in two successive years of presenting Ethics to engineering undergraduates at his university. Furthermore, it suggests how this important part of engineering education can be introduced into an already overcrowded engineering curriculum.*

Keywords: *Ethics, engineering curriculum, teaching*

Introduction

Engineering has always been correctly perceived as a pragmatic profession, devoid of interesting speculations, and always focused toward a practical end. The essential element of the profession is an engineered precision in an imperfect and imprecise world that has created technological wonders of today. It is no surprise therefore, that philosophy and engineering have not always co-existed, at least not in an engineering curriculum. Those visionaries who saw benefits that humanities bestow upon its disciples have tried to broaden the horizons of practitioners of both by formally bringing them together. Traditionalist in either camp doubted widely prophesised merits of such a symbiosis which perhaps explains why many of these attempts in the past have not always endured.

Technology mushroomed and knowledge became paramount to wealth generation in the new millennium. The explosion of information displaced vestiges of non-specific subjects, overcrowding engineering curricula with a flood of new technical knowledge engendered by research. However, it soon became apparent that the technological progress came at a price of rapidly degrading eco-system and polluted environment. Sustainable development has become a by-word characterising attempts to minimse the unforgiving Second Law of Thermodynamics, which guarantees waste (except at the zero absolute temperature !) of all human endeavours, especially the technological.

Given the inevitability of waste generation, New Engineers are learning how to minimise it on one hand, and on the other, how to do it in a professionally acceptable manner (Beder, 1998; Johnston et al. 1999). To deal with the ensuing dilemma, ethics was taken from the body of philosophy and applied to the proverbial pragmatist, the engineer. Thus Engineering Ethics was born, to take its place alongside well established Legal Ethics, Medical Ethics and Business Ethics.

A Code of Ethics

In its simplest and the most effective format, Engineering Ethics is enshrined in a Code of Ethics that characterises a profession. While it provides guidelines for professional conduct to accredited members, it also offers assurance to the community at large, and potential clients, as to the professional and ethical credentials of otherwise perhaps unknown individuals. For example, all registered professional engineers in Australia are bound by the appropriate code of ethics given below (IEAust., 2003):

CODE OF ETHICS

In the following statement, "member" means a person enrolled on the Register of ENGINEERS AUSTRALIA pursuant to Bye-law 2 or any non-member of ENGINEERS AUSTRALIA who, for any purpose approved by Council, has signed an undertaking to be bound by the Code of Ethics and the Disciplinary Regulations that underpin it.

Members are committed to the Cardinal Principles of the Code:

- to respect the inherent dignity of the individual
- to act on the basis of a well informed conscience, and
- to act in the interest of the community and to uphold its Tenets.

The Tenets of the Code of Ethics are:

1. members shall at all times place their responsibility for the welfare, health and safety of the community before their responsibility to sectional or private interests, or to other members;

2. members shall act in order to merit the trust of the community and membership in the honour, integrity and dignity of the members and the profession;

3. members shall offer services, or advise on or undertake engineering assignments, only in areas of their competence and shall practise in a careful and diligent manner;

4. members shall act with fairness, honesty and in good faith towards all in the community, including clients, employers and colleagues;

5. members shall apply their skill and knowledge in the interest of their employer or client for whom they shall act as faithful agents or advisers, without compromising the welfare, health and safety of the community;

6. members shall take all reasonable steps to inform themselves, their clients and employers and the community of the social and environmental consequences of the actions and projects in which they are involved;

7. members shall express opinions, make statements or give evidence with fairness and honesty and on the basis of adequate knowledge;

8. members shall continue to develop relevant knowledge, skill and expertise throughout their careers and shall actively assist and encourage those under their direction to do likewise; and

9. members shall not assist, induce or be involved in a breach of these Tenets and shall support those who seek to uphold them.

Apart from other things, a Codes of Ethics, such as the one above, particularly require of professionals to be alert to the consequences of their actions on safety and wellbeing of the community. While all the professions do not share the same Code of Ethics, they all are nevertheless valid in that they provide a basis for an acceptable conduct amongst the professionals, and provide the community with appropriate expectations of conduct and performance from the professionals.

It comes as a surprise to most first year undergraduate engineers that there are other matters in addition to technical competence, which are imperative in the conduct of a professional engineer. This realisation early in their undergraduate training provides appropriate stimulus for sustained exposure to such matters, particularly ethics.

Teaching Ethics

Author's ongoing survey of practicing engineers of long standing who have not had Ethics included in their undergraduate syllabus, found that they express doubts not only about teaching of Ethics because of the nature of the subject, but also about the effectiveness of teaching it, e.g. Papi (2003). However, all agree that a practicing engineer ought to be ethical in his or her professional conduct, at the very least within the Tenets prescribed by their professional organization! While "practice is the best teacher", the manner of imparting knowledge has changed from teaching, to that of learning, while the role of the academic in charge is more that of a coordinator, mentor and facilitator, rather than a teacher only.

The overriding factor in an accomplishment is mission orientation and the extent and scope of operating parameters, all else being equal. Starting with such a precept, a technical objective is bounded by non-technical considerations often leading to an acceptable solution via a multiplicity of paths. It is this element of choice that frequently evokes a dilemma. Ethics is seen as being essential in facilitating the most appropriate answer.

In the University of Western Sydney, Engineering Ethics is only a small part of a comprehensive *Introduction to Professional Practice* which aims at providing all first year students in the School of Engineering and Industrial Design with elements of interdisciplinary interaction and understanding as well as an introduction to professionally ethical conduct.

Engineering Ethics was introduced as Professional Ethics to accommodate the presence in class of a group of Industrial Design students. Following the last year's experience, described in Ilic (2002), the subject was introduced by providing the definition of ethics (Martin & Schinzinger, (1996):

- *the study of moral issues and decisions confronting individuals and organizations, and*
- *the study of related questions about the moral ideals, character, policies and relationships of people and corporations involved in technological activity.*

The definition was immediately followed by several examples, which were discussed at length, including the merits of a suggested resolution of a dilemma. The examples used were non analytical in nature and essentially involved, either sloppy organisational practices, disguised bribes or manager – employee confrontation involving undermining of professional judgement with adverse safety implications. While considerable time was spent in discussing merits of each case, it led seamlessly to segments dealing with professional responsibility for safety and responsibility to employers. Subsequent tutorials (Grodzicki, 2003) focused on a different set of practical cases (including "whistle-blowing") as well as an exposed and publicised case of company price fixing reported in the local press.

The only definitive outcome of such a short exposure to a formal discussion of Ethics is awakening of students' awareness of non-technical issues confronting them in practice of their future professions. In particular, it drew their attention to the often evolutionary nature preceding unethical outcomes. While such an approach did not provide analytical answers, it alerted them to the principles involved in their solution and further references for more information.

Students' response was cautious and in some cases seemed to indicate that loyalty to employer was paramount. This was a moot point resolved by reference to the professional code of ethics. Another interesting point made by a student was the ethics of manufacturing weapons of war. This was "resolved" by reference to their application – is it for defence or attack; preservation of a society or its demise?

Because of their predisposition to analytical approaches to problem solving, students of engineering as well as many engineering academics, are more comfortable with numbers. Hence, effective learning of Engineering Ethics is often beset with difficulties at the very outset, calling for appropriate augmentation when students' future professional skills become more developed, towards the end, rather at the outset, of their respective undergraduate studies. Studies of Engineering Ethics based on cases involving numerical problems have proved popular and pedagogically effective in introducing the subject to engineering undergraduates. In her plan for undergraduate teaching of ethics, Whitbeck (2003) also advocates "hands on," "practice-oriented," "experiential," or "active" approach. Specifically, she asserts that:

The active learning exercises should be chosen so that over the course of their undergraduate career students engage in developing a full range of ethical skills. These include not only making judgments about whether some action is ethical, or which of a set of multiple choices is the best (or least bad), but skills such as the ability to:

- *Find statements of ethical standards by reputable bodies and evaluate the legitimacy of those standards*
- *Conduct an ongoing assessment of a problem in a way that does not cause unnecessary harm (e.g., destroy a person's reputation)*
- *Recognize explanations other than the one that appears most likely*
- *Fashion responses that will be robust in the sense that they will be wise, even if the situation turns out to be other than the one that seemed most plausible*
- *Recognize when the moral territory is unfamiliar and locate good advice about how to proceed and the likely effects of doing so*

Experiential learning of Ethics is also promoted at the Texas A&M University (2003) which provides, by way of case studies, interesting numerical problems of varying degrees of technical complexity. This approach proved extremely popular, such that a separate course in Engineering Ethics was introduced, helped by significant project funding from the National Science Foundation. The reason for the popularity of ethics was seen as the consequence of students' perception of it as value adding to their professional studies. Unless Professional Ethics is followed up in senior years, the UWS approach, by contrast, will have a more limited impact.

Conclusions and recommendations

Although not yet widely introduced into engineering curriculum, Engineering Ethics has a definitive role to play in the life of a professional engineer. By eventually becoming a full member of a Professional Society, an engineer tacitly accepts a concomitant code of professional behaviour and standards of performance, including responsibility for the quality of environment and community at large. To be ethical, his or her technical performance has to be executed within such bounds. Universities therefore have an additional role to play, and prepare the future professionals effectively to deal with such demands of their chosen

profession. The major implementation problem appears to be an already overcrowded curriculum. This may easily be overcome by having in the introduction to each subject, usually the first lecture, a segment devoted to social implications (ethics and sustainability) of practicing the material to be studied, especially by way of an example involving the subject material, or from the academic's own professional experience.

On the other hand, frequent rationalising and updating engineering curricula, especially in terms of market needs, would be one way to enable ethics to be introduced as a formal subject.

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