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Ethics and the Professional: a Template for International Benchmarking in Engineering Education*

John Buckeridge
Faculty of Science and Engineering, Auckland University of Technology
Private Bag 92006, Auckland, New Zealand
Norbert Grünwald
Hochschule Wismar - University of Technology, Business and Design, PF 1210, Wismar, Germany

The globalisation of engineering education and the mobility of today's graduates have led to a need to correlate engineering qualifications in different educational systems. Some effective benchmarking is achieved at annual engineering educators' conferences, which provide invaluable fora for the sharing of pedagogic methodologies and ideas. This sharing may result in fine (or coarse) tuning of existing degree programmes and, where necessary, bring them in line with successful overseas programmes. However, in most situations, there are few opportunities to demonstrate the success of international benchmarking; this paper addresses this and provides an overview of a course on professional engineering ethics that is taught in three different countries, namely: New Zealand, Australia and Germany. The course has also been given exposure in China and has the potential to form the basis for a new programme there. The rationale for an ethics course in engineering is provided. Further, an outline of the way in which it is taught, including the use of a dedicated text, is discussed. Importantly (and unlike almost all other engineering courses), this course provides an opportunity for students to reach quite different, but nonetheless appropriate, conclusions about problem solving in engineering. Even more significant is the evaluation of *outcomes*, which, although potentially radically different, may not necessarily be *incorrect*.

INTRODUCTION

The current ease of international travel and the effectiveness of modern communication systems have resulted in graduates of professional qualifications adopting a global perspective as their *worldview*. Few will remain in the university towns in which they studied; most will leave the countries in which they graduated. If they can communicate well in the English language, their international opportunities are indeed great; this is particularly the case for graduates who possess intellectual and practical skills that are in high demand, such as engineering.

A prime rationale for the existence of organisations like the UNESCO International Centre for Engineering Education (UICEE) is the facilitation of cooperation between members (ie as participants at conferences and workshops). Not surprisingly, cooperation is most likely to be achieved when the parties involved possess common beliefs, systems and ethics, ie they have shared values [1]. However, before any *values consensus* can be attained, postulates, methodologies and concepts must be articulated and debated. It may be claimed that recent advances in information technology permit efficient and effective social and personal interaction, but they are nonetheless limited by the computer monitor. Humans are social animals and many of the more subtle nuances that are communicated in *live* inter-actions are lost in the electronic ether.

The authors contend that the most effective means of achieving the interaction so important in pedagogy is the live forum. Indeed, the lively interaction that this type of course engenders is fun for both student and teacher: the result is a seminal learning environment!

*A revised and expanded version of a keynote address presented at the *3rd Global Congress on Engineering Education*, held in Glasgow, Scotland, UK, from 30 June to 5 July 2002.

OPPORTUNITIES

Since the 1990s, there has been a strong move to inculcate more philosophy within the traditional (ie technology rich) engineering curriculum [2][3]. The elements considered most appropriate to be included in any revised curricula were ethics and systems thinking [4][5]. In part, the necessity for these subjects was clearly perceptible (ie a need to produce *balanced* graduates); this was reinforced by degradation of the natural environment and the perceived (negative) role that engineers may have had in this [6][7]. Yet it was also due to an increasing public awareness of the nature of professional practice from a public that was both well educated and had grown to expect and, indeed, *demand* the highest of professional standards of its engineers. In many respects, the engineering profession failed to provide what the public demanded, although the failure was not always due to lack of professionalism, rather it was due to *ineffective communication*. Engineers are traditionally poor communicators!

A prior lack of effective communication skills had been partly redressed in the 1980s by compulsory papers in which both writing and oral techniques were emphasised. However, these changes were not as successful as had been hoped because, in many instances, there was a failure to contextualise the communication skills in an engineering environment. This was undoubtedly a result of the background of some of the lecturers of *communication methods*, many of whom were from other faculties, especially humanities (ie *arts*). Pedagogic styles adopted by teachers from a traditional arts background are often foreign to engineering students and have led to a recognition that there are distinct and very different mindsets in arts and engineering [8]. There was a clear imperative then, to contextualise any revisions of an engineering curriculum.

Much has been published about the need to expose engineering students to ethical philosophy, especially ethics with a Western perspective [8]. However, the style and structure of the learning environment in which students are exposed to ethics is critical to the success of the course. Unfortunately, many intelligent people make the decision to become engineers on the basis of their self-perception as having a predominantly *left-brained* intellect, ie one in which numbers and logic, rather than literature, have ascendancy. This may result in some students having a rather negative perception about ethical studies (especially *philosophy*). Perhaps it is because of this that such students undertake engineering to deal with concrete issues, rather than embark upon aesthetic dreams. Indeed, they may feel disadvantaged, perhaps even destined for failure, in a *philosophy* course. For students, especially good engineering students, this is a most unfortunate attitude to possess about a course.

So there is the challenge: to teach (or provide) a positive learning environment in which students can gain an appreciation of the place of ethics in professional engineering practice. This challenge is, of course, an opportunity that may have ramifications in the manner in which other courses are provided.

COURSE STRUCTURE

In most universities, engineering courses are taught on a semester basis. Generally, semesters span some 14 or so weeks, with a formal examination at the conclusion. Engineering ethics courses that conform to this standard semester structure offer the following advantages:

- They fit nicely in the existing timetable system.
- They conform to the general structure of other courses (and as such are familiar to students).
- They permit gradual learning (or *drip feeding*) of students over an extended period.
- They permit cross-referencing to other courses running concurrently.

A quick analysis of these advantages may lead one to conclude that the best way in which an ethics course should be taught is over a full semester. However, a closer analysis is warranted: the first two of the above *advantages* are primarily administrative, ie they permit a homogenous semester of uniform class/workshop duration to be planned in which physical and human resource use is maximised. Although a purist may complain that this is not sound reasoning from a pedagogic perspective, the structure must be considered in light of the tight fiscal framework in which universities must now function. However, any plan to increase efficiency by having uniform class sizes is flawed, particularly in engineering, where laboratories and workshop periods will certainly be of longer duration (and with smaller numbers of students) than traditional lectures.

Nevertheless, a structured learning programme over an extended period of time has some advantages. It provides an opportunity for the delivery of a more sedate (and less threatening) progression of ideas (many of which may be unfamiliar to the student), along with regular extended feedback and assessment. Students can afford to miss the occasional lecture

(and often do so) without severe consequences. The learning environment, especially in large lecture theatres, is likely to be more impersonal, offering less interaction between participants. These aspects may appeal to some students. In addition, the assessment (ie outcomes) of this type of course structure will naturally drift towards a *marks*-oriented pedagogic paradigm.

An effective way in which to get students' interest in a topic is to demonstrate that it has wide relevance outside the particular course in which it is offered. Cross-referencing between courses can be an invaluable pedagogic tool through which to pursue and demonstrate this, especially when courses are offered concurrently. However, to accomplish this requires a high level of liaison between lecturers, not only with respect to the order and nature of course *delivery*, but also in the understanding of the philosophy and content of other courses taught in the programme. This is not easily achieved.

An alternative to a full semester course is the short duration block course. Block courses are well suited to place participants in a *full subject immersion* environment, where all the topics studied pertain to the same general topic, ie students think about little else during the course. Block courses lend well to highly interactive teaching and where group projects are programmed. The very nature of block courses ensures that they are not *marks*-oriented; rather they are *learning*-oriented (ie student comprehension driven). The authors conclude that to enhance the learning outcomes most effectively, courses of this nature are best taught in full immersion mode.

Typically, block courses:

- Are of short duration.
- Have an *intense* learning environment.
- Demand a high level of group interaction.
- Have a restriction on the number of students enrolled for any one course. For example, in the block course titled *Engineering Ethics*, the upper limit is about 50 students. Beyond this, interaction between the facilitating professor and individual students becomes increasingly difficult to achieve.

In addition, they also require both flexibility of students/staff and more physical resources, although these are generally only for short periods of time. In particular, the following are required:

- Timetabling to release students (and staff) for an extended block.
- A high degree of organisation: the facilitating professor (or teacher) is appearing before the students for up to eight hours a day.
- Good support material (ie course manual, and background literature and materials for presentation).

One of the most effective ways to ensure success has been to provide a detailed, interactive course manual and to have numerous copies of key papers/ texts available during the course.

THE CURRENT BLOCK COURSE: *ETHICS FOR ENGINEERS*

The course is divided up into four parts; the first focuses on definitions of moral theory – often from outside a direct engineering perspective. This part gives an overview of moral theory and provides an opportunity for students in groups to get to know each other, ie it breaks the ice. The second part looks at placing ethical issues within an engineering context, and involves decision making as *engineers*. The third part looks at the development of codes of ethics.

A specially designed text, *Ethics and the Professional*, has been developed as a companion to this course [9]. It incorporates all the components of the course manual used previously over a 12-year development period. Importantly, the text is available at *cost price* to students. It is structured to complement the course progression beginning with an overview of moral theory, focusing on key Western philosophical perspectives such as virtue ethics, utlitarianism, deontology and existentialism. It then analyses the role of the professional, and investigates the criteria and/or rules under which professionals can be expected to function. A final section deals with ethics in research. There is an index, and an appendix (in German), that includes the code of ethics for professional engineers.

The reader is continuously challenged in the text by being asked to derive solutions to moral dilemmas that range in focus from the social to the professional. However, the text gives no *correct* answers to moral questions, nor should it, as after over 3,000 years of Western moral philosophical deliberation, we have yet to reach a consensus over what is a meet and proper response to many moral dilemmas.

Absenteeism

One problem that specifically pertains to the tight block course structure arises when a student is absent (eg due to illness). Surprisingly, the first author

experienced this only once in 15 years of teaching the subject, but this is clearly more a case of good luck than good management. If students do miss a block course (or a significant part of one), they have the option to carry forward an incomplete coursework mark and resit the examination at the end of the next semester, or to re-enrol in the course at the next available opportunity.

However, even with full semester courses, the student can miss a *finals* examination. There are well-established methods, like aegrotat assessment, for dealing with this.

Group Presentations

At the beginning of the block course, students are assigned to study in groups of about four. These groups are fixed for the duration of the course and report back, with consensus views, on case studies given throughout the course.

The groups are also given a topic for a *presentation* at the outset. Each group formally gives their presentation on the last session of the course. It must involve all members of the group, and both peers and faculty grade the effectiveness of their performance. The grade given is used in the final course assessment. The presentations involve ethical dilemmas in engineering and/or technology. Students are asked to appraise the scenario from a number of ethical perspectives and conclude with a solution that provides the best possible way in which to deal with the situation. Presentations are generally a very enjoyable part of the overall programme, as they give lecturers an opportunity to evaluate the effectiveness of the learning environment.

PEDAGOGY

At this point, it is perhaps, useful to reflect upon the teaching environment.

The substance of which *good teachers* are made is particularly elusive. Unfortunately, some of the best teachers are not in the university realm (there are probably many more good teachers, as a percentage of staff, in polytechnics). Indeed, the university environment is often portrayed as a degree factory, where performance outcomes are measured primarily from a fiscal perspective (or perhaps from the number of research papers generated). In many faculties, this may relate directly to student enrolment numbers.

Nonetheless, a successful *marks*-driven course outcome may be one in which the following (singly or in combination) are achieved:

- Excellent students are motivated to achieve outstanding results.
- Excellent students pass, despite poor teaching.
- Average students are motivated to achieve good grades.
- Poor students are enthused sufficiently by teacher/lecturers to pass.

Of these, the first may be achieved with relative ease, the second is undesirable, whilst the third and fourth are a measure of a good learning environment.

In the university sector, a teacher can clearly anticipate a degree of student motivation that is absent in pre-tertiary learning environments. A teacher may also expect a more considered approach to the assessment style than with young children. At the university level, it is all too easy to recognise assessment patterns; this provides excellent opportunities for students to memorise answers and this is especially the case with the more philosophical courses, eg a student may well conclude the following:

> *I learnt this about Kant and even though the question in the examination is really not about Kant, it does provide an opportunity for me to demonstrate to the assessor just how clever and erudite I am.*

Those of us who mark summative assessments at the end of each semester know how common this is.

As discussed, a full-immersion teaching environment - one that is only truly achievable in a block course - places students in a situation where they are constantly required to provide (and justify) their own views on topics, both to peers and to the *facilitator*. Further, through contextualising and providing constant feedback, it is hoped that the learning environment will be more successful in providing a lasting impression on students.

Assessment

Formative assessment is adopted during the active phase of the programme through active feedback and the group presentations (this method permits both individuals and groups to interact with the facilitator). Subsequent to this, students are required to complete a comprehensive assignment (due some four weeks after the block course) and present themselves for a final examination.

The current weighting of the assessment is 50:50 (coursework: examination), although this can be altered to suit. Students are always asked to grade

the presentation of groups other than their own, but are surprisingly reluctant to be the sole judge of their peers. In one particular year, after students were advised that they would be carrying out 100% of the group presentation assessment, a formal approach was made by them to have the professor (or professors) provide at least 50% of the grade for group presentation. In almost all situations to date, students have been found to grade their peers more aggressively than the academic staff.

TEACHING ETHICS

> *Train up a child in the way he should go: and when he is old, he will not depart from it.*
>
> Proverbs 22:6.

The above quotation, from the Book of Proverbs, has been part of the underlying educational philosophy of many doctrines. In some, such as the Jesuits, the critical age is seven, beyond which morality is supposedly more-or-less *fixed*. It specifically pertains to the moral advancement (or enlightenment) of an individual and is perceived as being different from all other types of intellectual enhancement, where accumulation of knowledge and ideas can extend throughout a lifetime.

However, whether or not it is true is fundamental to the teaching of ethics in an engineering degree. Teachers are thus faced with the vexing question of whether ethics can be taught to 20 year olds. Then if this is answered in the affirmative, there is the next question of *how?*

There are probably few who would strongly disagree with the aforementioned quote from Proverbs. Most *balanced* children do seem to have a good understanding of right and wrong by the time they are seven. Further, they may well have defined the boundaries of any spiritual framework that they are to possess as an adult by this time. What they almost certainly do not possess as children is an understanding of how their personal ethical construct should function in a professional context. A child's ethical framework is limited by a limited worldview. As adults, and with the spiritual and secular experiences that adulthood brings, individuals expand their worldview immensely.

However, the world, especially the West, has become increasingly secular over the last quarter century. In its urgency to demonstrate political correctness, Western educational revisionists (in New Zealand for example) have reformed State School curricula to significantly curtail any moral/ethical and/or religious studies component within the curriculum (although in Germany religious and/or philosophical studies are still part of the compulsory component of a child's education between ages six and nine). In New Zealand, what compounds the situation is what has replaced the moral/ethical content: so-called *real-life* subjects such as collage making, media studies and photography, that apparently *enrich* young minds and allow opportunity for true self expression.

The secularisation of New Zealand schools has now existed for sufficient time for the first cohort of politically correct children to become parents; further, many families have parents working full-time, or – even worse – have a solo parent in full-time employment. We are reaping the harvest of this: today's children are very aware of their *rights*, but have little or no understanding of their social obligations and *responsibilities*. In short, many lack a cogent values framework.

At engineering school, an unawareness of ethical constructs is likely to severely obstruct a student's (and ultimately a graduate's) ability to act in a professional manner. Of course, one can hope (and anticipate?) that many students will have had real exposure to moral and value issues in the home environment. But present surveys indicate that this is not happening to an increasing percentage of students: again we conclude that a primary cause is likely to be a dysfunctional home environment where the expected contact between parent(s) and child in formative years is limited, especially when the parent(s) works long hours.

The university can provide an environment in which to provide healthy debate about moral issues and how these impact on one's ability to practice as a professional. The course that we currently run in New Zealand, Australia and Germany aims to do this: to provide young engineers with an appreciation of some of the issues (and problems) that they may be exposed to in the workforce.

In addition, some tertiary institutions in China have expressed interest in the course, and in 2001, the first author was invited to give lectures on Western Philosophy (especially ethics and sustainability) in Nanjing. This invitation was extended in 2002, when a further series of lectures were given in Xi'an. The Chinese appear to see a course of this nature as accomplishing cultural exchange in both language and values. The increasing number of Chinese students undertaking studies in Western universities certainly makes courses of this nature doubly appealing, as does the language of delivery: English.

CONCLUDING REMARKS

However, the teaching of moral theory is a delicate one; over the more than 15 years that the first author has been facilitating this type of course, it has been found necessary always to expect the *unexpected*, to have one's hand on the intellectual *reverse gear.* It is easy to misinterpret different cultures and values (eg one of the first studies undertaken in the course is to define whether a *universal* truth exists). It is interesting to gently provide the students with examples of cultures where exceptions to their perceived rule or norm exist [10]. This course aims to provide an awareness of these difficulties in a supportive, interactive and non-threatening environment.

Over the last 16 years, the course has been evaluated at its conclusion by an anonymous student survey. Feedback from this has been used to finely tune delivery. There has always been very positive feedback. The positive attitude of students is based upon the *enjoyment* they had during the course – through interaction with their peers and facilitator. In exploring ideas and concepts that had generally been not within their normal gamut of conversation, students have indicated that they have developed new perspectives on life, the engineering profession and society, which, it is hoped, will carry them through to being proficient, competent and resourceful global engineers.

The knowledge that other students, in distant parts of the world, are undertaking the same course is a comfort to students. It is also a comfort to those of us who offer and facilitate the course!

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BIOGRAPHIES

Professor John Buckeridge is currently Deputy Dean (Research), Head of School of Engineering, and Director of the Earth and Oceanic Science Research Centre (EOS) at the Auckland University of Technology (AUT), Auckland, New Zealand. His published research exceeds 150 papers, reports and books, with areas ranging through civil and environmental engineering, geotechnical engineering, environmental impact assessment, modelling of environmental effects, biogeography, palaeobiology, engineering education and philosophy (professional ethics).

Norbert Grünwald was born in Rostock, Germany, on 5 October 1953. He studied mathematics at the University of Rostock, receiving the degree of Bachelor of Mathematics in 1979, and was awarded a doctorate, specialising in discrete mathematics, in 1984. Between 1984 and 1986, he was on the scientific staff of Deutsche Seereederei Rostock, a shipping line, before working as a scientific assistant in the Institute of Mathematics of the Warnemünde/ Wustrow Maritime Academy.

In 1991, he took up a scientific assistant position in the Department of Mathematics of the University of Rostock, and since 1992, he has been Professor of Mathematics and Operations Research in the Department of Mechanical Engineering at Hochschule Wismar - University of Technology, Business and Design, Wismar, Germany, where he is actively involved in the self-government of the institution. From 1998 until 2002, he was the Dean of Mechanical Engineering/Process and Environmental Engineering and was elected Rector of Hochschule Wismar in September 2002.

Professor Dr Grünwald has published several works and has been involved in a number of research projects and expert reports. He is a coordinator and jury member of the German Mathematical Olympiad, and is a member of Deutscher Mathematiker-Vereinigung e.V. and Mathematikolympiaden e.V. Prof. Grünwald is also a member of the Accreditation Commission of the Accreditation Agency for Study Courses in Engineering, Informatics and Natural Sciences (ASIIN).

On the international front, he is a member of the International Liaison Group for Engineering Education (ILG-EE) and of the UICEE Academic Advisory Committee, of which he is a Deputy Chairman. He is also a Co-Director of the Gottlob Frege Centre for Engineering Science and Design, a satellite centre of the UICEE.

He was awarded the UICEE Silver Badge of Honour for Distinguished Contributions to Engineering Education in 1998, and the UICEE Gold Badge of Honour was conferred upon him during the *2nd Global Congress on Engineering Eduation*, held in Wismar in 2000.

World Transactions on Engineering and Technology Education

A Call for Papers

Current events have impacted upon the arena of international conferences and academic travel, impinging on the freedom of intellectual movement to conferences and the like that are so important for the advancement of engineering education internationally and regionally and, indeed, the development of humankind now and into the future. Wars, threats and diseases affect the physical presentation of ideas at conferences, fora and seminars; however, the liberty of thought and the exchange of educational ideas cannot be bordered, blasted and subdued. To this end, the UNESCO International Centre for Engineering Education (UICEE) has established the *World Transactions on Engineering and Technology Education*, which is open to everyone around the world who is interested in the progression of engineering education. Current unfortunate circumstances have meant that the *World Transactions* offers a safer and cost-effective alternative to conference participation.

The first volume of the UICEE s *World Transactions* presented a range of papers from across the spectrum of engineering education and from around the world, including over 50 very interesting and insightful representations from many countries worldwide. From this, it can be seen that the *World Transactions* contribute strongly to the publication of engineering and technology education papers globally, which is essential for academic life and the continued growth and evolution in humanity s store of knowledge and understanding across nations, cultures and continents.

A call for papers is made for the next issue of the *World Transactions on Engineering and Technology Education*, **Vol.2, No.2**. The very nature of the *World Transactions* is open to every facet of engineering and technology education and is not confined to traditional views about science, engineering and technology. As such, there are no overriding engineering or technology themes, but rather the overarching principle of the globalised expansion of engineering and technology education that is not confined to borders or regions; instead the *World Transactions* seeks to benefit all those involved in the engineering and technology through the wider dissemination of knowledge.

The deadline for this issue is **30 June 2003**. Authors should indicate their interest as soon as possible. Additional information can be found at the UICEE s homepage under *UICEE s World Transactions* at http://www.eng.monash.edu.au/uicee/

Interested persons should submit their original, previously unpublished papers to the UICEE for consideration to be included in the *World Transactions.* Authors should be aware of the standard formatting structure, which will essentially be the same as for other UICEE publications. Papers are to be submitted in MS Word format in 10pt font, single-spaced, double column, and a **maximum of 4 pages** in total, including abstract and figures (additional fees will apply for extra pages). Fees are based on cost recovery for editorial and publishing work, and every submitted paper will cost $A450. Also, within the cost structure is the delivery of one copy of the *World Transactions* per paper submission by airmail postage to anywhere in the world.

The electronic kit for authors, incorporating standard formatting details and submission forms, covering copyright, will be supplied on request. Potential authors should notify their intention of submitting a paper at their earliest convenience and earlier submissions than **30 June 2003** will be particularly welcome. Further correspondence via e-mail should be directed to Mr Marc Riemer on marc.riemer@eng.monash.edu.au