Do engineers still move mountains? A "new world" appraisal in light of ethics, engineering, economics & the environment

John Buckeridge
School of Civil, Environmental & Chemical Engineering, RMIT University, Australia
john.buckeridge@rmit.edu.au

Abstract*: The preamble to the Washington Accord stipulates that engineering must be carried out responsibly and ethically, and be environmentally sound and sustainable. Without these criteria being met, engineering programmes will not be accredited. As a profession, engineers enjoy high social status and the privileges that flow from this; in turn engineers are expected to discharge their duties in a responsible, ethical fashion. That ethical behaviour is discussed on six separate sections in the 15-page document of the Accord's graduate attributes should give us cause to contemplate the importance that our profession places on ethical behaviour. This paper reviews why ethical awareness is so much a focus in the accreditation of undergraduate degrees in engineering; it then outlines a course on professional ethics that has been successfully taught for two decades in Australia, Germany and New Zealand. When initiated, this course was designed to serve the environmental engineering undergraduate but is now used in a plethora of programmes, including management and the humanities. It has also served a useful purpose in international benchmarking of the engineering curriculum. Over two decades, course handouts have evolved too - into texts, the latest of which,* 4 Es: Ethics, Engineering, Economics & Environment *is in its second edition. The paper then reflects upon how our profession has changed in the last few decades and whether we can, in light of environmental constraints, still contemplate the moving of mountains.*

Introduction

In 1989, the Washington Accord was ratified to ensure international equivalence of the engineering educational accreditation systems and education programmes offered by its signatories. Importantly, it allows graduates of accredited engineering programmes to practice engineering, at the entry level, in any of the signatory countries, which now include Australia, Canada, Chinese Taipei, Germany, Hong Kong, Ireland, Japan, Korea, Malaysia, New Zealand, Singapore, South Africa, United Kingdom and the United States of America. An interesting juxtaposition to the current accord is an earlier agreement, the Washington Accord (1946), which was directed at assessing human morality following World War II (Rubin, 1998). Washington Accords, it seems, deal with morality. This paper assesses the moral objectives of the 1989 accord, and notes that now, in a world where there is the greatest proportion citizens with tertiary education in history, that our profession is no worse than others; indeed, it may well be that it is one of the more moral.

Accreditation

Accreditation of engineering degrees is determined through an assessment of competencies, and the parent body of the Washington Accord, the International Engineering Alliance, has published competency profiles for professional engineers (IEA, 2009). The preamble in this document states the broad competencies of a professional engineer and not surprisingly, these include mastery of the appropriate engineering discipline, an ability to exercise judgement, a willingness to accept responsibility for one's actions and an ability to effectively communicate on complex engineering activities to other engineers and the community. Additionally, the document stipulates that engineering

must be carried out both "responsibly and ethically" and be "environmentally sound and sustainable". Without these criteria being met, programmes will not be accredited. An indication of the importance of the words "ethics" or "ethical" can be determined by the frequency with which they are referred in the document – 14 times in six separate sections or tables of a 15 page document.

The ethical standing of professions, especially engineering

The need for an ethics course:

High educational attainment, especially in Western societies, has led to closer inspection of the ethical framework of all professions. Professionals are accorded high status in society, but this comes with increasing accountability – and no moral failure of the professions is more poignant than in the recent hacking débâcle in R. Murdoch's *News of the World*, although A. Wakefield's flagrant abuse of consent procedures in medical research involving children is close behind (Buckeridge, 2011). The spotlight has been on engineering for longer, with an increased emphasis on ethics as an integral part of engineering curricula arising from a public perception, rightly or wrongly, that engineering and technology are destroying the environment (Carson, 1962; Buckeridge, 1995). This awareness led to the profession demanding that ethics be a mandatory component of the undergraduate engineering curriculum. Engineering schools generally responded to this in three ways: either they inculcated ethical practice throughout the curriculum; they developed a course on ethics, much like "communication skills" and had this taught by academics from outside the School; or they developed a course on ethical practice and had this taught by engineering faculty members. The last option was adopted by RMIT University as it provided the best opportunity to contextualize the subject.

In the late 1990s an intensive, one-week short course, *Ethics & the Professional* was trialed and delivered in RMIT's Bachelor of Environmental Engineering; it was scheduled in the fourth year, when the focus on project work minimized disruption to other courses. The course was also offered at Auckland University of Technology (New Zealand) and Wismar University of Applied Sciences, Technology, Business and Design (Germany), providing a useful vehicle to help benchmark the curricula of three members of the 1989 Washington Accord (Buckeridge & Grünwald, 2010).

The recent drop in ethical awareness: truth or fallacy?

Over the last few decades, there has been some debate as to the reasons for a perceived lack of a clear moral perspective in young engineers, with some surmising that it simply follows a secularization of society and a fragmentation of the traditional nuclear family (Buckeridge, 1995). In an attempt to evaluate this, a pilot survey of current fourth year students was undertaken to determine whether there was any religious education in a student's formative years, the premise being that this would now be low compared with earlier generations when religious education was the norm; and whether they lived with a solo parent, the premise here being that should the parent work, there would be less time available for discussion. A further question, regarding part-time employment, was added to gauge the amount of "free time" that students have – wherein they may pursue extracurricular interests (Table 1). As the ethnicity of the group surveyed was primarily Caucasian Australians, it was anticipated that the results would reflect the increasing secularity of Australian society (ABS, 2011).
However, from Table 1 we can infer that a lack of any exposure to religious doctrine is not a rationale

	yes	**no**
I live at home with both of my parents.	33.3%	66.6%
When young, I was exposed to religious education.	76.6%	23.3%
I have a job that lasts more than four hours per week.	76.6%	23.3%

Table 1. A student's formative environment. The results of a preliminary survey undertaken to assess possible influences on the development of a personal moral "world-view". n = 30.

for a weaker moral world-view (if indeed this exists). Most students no longer live with parents in their final year, and this is not unlike what I recall as an undergraduate in the 1960s; however it does differ from the 1960s as most then did not have to spend time during the semester in outside employment. The 2010 Gillard government's democratization of education has made tertiary

education close to ubiquitous, and almost certainly it has lowered entry levels, but it has also made it more expensive! The above conclusions are preliminary, but the hypothesis that the 21st Century engineering undergraduate is fundamentally secular is not proven.

Ethics in Practice

In the first case below, an ethical "conundrum within a conundrum" is discussed – where the model answers to a final year examination question are not quite what they seem, or perhaps should be. In the second case, an evaluation of RMIT University's short course *Ethics & the Professional* is provided; the offering of the course over one week, as opposed to a semester, is argued as the best way in which to immerse engineering students in assessing the morality of both personal and professional practice.

Evaluating an ethical conundrum

Not surprisingly, the short course *Ethics & the Professional* has a strong emphasis on learning through case studies, and these are introduced using a purpose-designed text (Buckeridge, 2011) supplemented by PowerPoint presentations. It begins with exemplars that involve everyday indiscretions, and then unfolds to examine the development of the professional engineer's code of ethics. It is in this latter section that the importance of membership of a professional society is extolled.

A professional body has a number of rôles, amongst which is mentorship and guidance of junior members. Indeed, under their section headed "Career Planning & Advice", Engineers Australia (EA) offers a range of career services for members – from helping you to find your first job, to workplace issues, giving notice and changing or ending your career. In light of this, I felt very confident including the following question (Table 2) in this year's examination; further, I was comfortable in assuming a response from EA along the lines that they would offer some mentorship and guidance to junior engineers if confronted with an ethical dilemma in their workplace. I had this verbally corroborated by a number of fellow members at a recent meeting at EA Melbourne Division.

Table 2: A case study *Ethics in the Workplace*. A question from the 2011 BE examination.

A young engineering graduate is employed in the Melbourne branch of a large international plastics company. Through her manager, a registered engineer, instructions are received from Head Office in Los Angeles to undertake a development project. The project is a large task that will take three years to complete. The work is especially welcome because the branch has been under threat of closure as a result of cost cutting and its failure to attract sufficient work. *When going through the correspondence and briefing material, the graduate finds a confidential file that has been enclosed by accident. It shows that the work to be undertaken is a waste of shareholder's money, but that this is being covered up to protect the senior engineer at the branch and a local politician, whose seat is marginal. Reference is made in the file to a restricted report from a highly respected consultant who advises strongly against the proposed project on environmental grounds.* *The engineer decides to photocopy the file and tell her manager. After having handed over the original file, the engineer and manager are told by the senior engineer to "forget you ever saw it!" There is also a threat that should this become public, some employees could lose their jobs. Closure of the branch office is a possibility, at a time when other work opportunities are unlikely.* *After a lot of thought, the engineer "goes public" and sends the photocopied material to the press.*

Candidates were asked to discuss the moral issues that are raised, and to explain these in terms of utilitarian and deontological perspectives. In particular, they were asked to consider the morality of the following activities:

- Reading a sensitive file to which one is not intended to have access,
- Photocopying a confidential file and giving it to the media,
- The senior professional engineer telling a junior staff member and her manager to *forget it!*
- Making a moral decision, knowing that in doing so, some staff could lose their jobs.

Students were then asked *what should the young employee have done as a professional engineer?*

In marking the exam scripts, I found that many students supported going to the media, but only four (out of 70) suggested going to EA. To close the loop, I had taken the unprecedented step of seeking confirmation of exactly what EA would recommend in this situation, so it came as a considerable surprise when the following written response to my query arrived from EA's Head Office:

> *First, it is important to note that it is not standard practice for Engineers Australia to provide advice in the terms you have described.*
>
> *The advice to such a query would usually be that any decision to disclose should be preceded by a process of consultation through appropriate channels. In most instances we would suggest that the person seeks independent legal advice*.

Whilst this response may well contravene the current EA Code of Ethics under Category 3: "Exercise Leadership"; additionally it begs the question: "apart from upholding the profession, what is the purpose of professional membership if it does not provide members (especially juniors) with ethical mentorship and advice?" It is argued here that to simply *seek legal advice* is inappropriate guidance and/or advice. A rationale is not clear… perhaps the profession is simply avoiding legal entanglement?

Evaluating the short course *Ethics & the Professional*

The short course *Ethics & the Professional* has been run in the Environmental Engineering degree for 13 years – both at RMIT and Wismar. It has consistently achieved a very positive student evaluation or good teaching score (GTS), with much of this success due to the manner of delivery – which involves both a high level of interaction between participants and a focus on group projects (Table 3). Additionally students have, from the outset, been involved in peer assessment, giving them a very real interest in their learning environment (Buckeridge & Grünwald, 2010). Table 3 also includes the GTS results for a much broader focussed course on professional practice that is run for Chemical Engineering students. The results for the latter course demonstrate that even with the same delivery, by the same people, we can anticipate a natural fluctuation in student assessment.

Table 3. Good Teaching Scale results 2006-2011

Year	GTS in Environmental Engineering	GTS in Chemical Engineering
2006	88.2%	-
2007	-	-
2008	90.6%	60.8%
2009	85.4%	82.5%
2010	83.2%	92.9%
2011	82.5%	78.1%

Results for the short course *Ethics & the Professional.* A GTS is assessed for all courses at RMIT; the scale is out of 100, with scores exceeding 85% considered exemplary. Missing data is due to a transitional period between earlier assessment and the current system. Note: The Chemical Engineering course (RHS) is delivered by three faculty members, and content is not restricted to "ethics".

That *Ethics & the Professional* has consistently received very positive student feedback is all the more pertinent as engineers traditionally have a strong "left brained" mental capacity, i.e. amongst other skills, they tend to be good at understanding or applying mathematical concepts. Engineering undergraduates are, not surprisingly, cautiously hesitant prior to a course where "right-brained, artistic" thinking is explored, but written responses from some identify it as one of the most rewarding subjects that they have studied. In particular, the delivery, which involves full immersion in the topic for a week, has been strongly endorsed. An earlier trial, where the topic was drip-fed over a full semester did not allow students to fully engage in the case studies – indeed, student involvement was superficial, generally restricted to a quick read over the previous lecture, five minutes prior to class.

Testament to the on-going success of *Ethics & the Professional* has been its utility beyond engineering, e.g. in postgraduate programmes in Human Rights at RMIT's College of Design & Social Context, and as a core paper in Wismar University's new *Master of Energie- und Ressourceneffiziente*

Technologien und Verfahren (Master of Energy & Resource Efficient Technologies & Practice). As noted, wider proliferation of the course is supported by a text rich in case studies – *4 Es: Ethics, Engineering, Economics & Environment*, and this is now in its second edition (Buckeridge, 2011).

Tertiary study in the Twenty-first Century

An expansion of knowledge:

At a research methods seminar held at RMIT earlier this year, there was heated discussion about changes that have occurred in the teaching and learning environment over the last four decades – in particular the effects of information technology. Whilst a small number of participants lamented technological advances, most were appreciative of the advantages of having unlimited access to much of human knowledge; indeed, Weller (2011) notes that we produce more knowledge in two days than was created by human history until 2003. However, many students have difficulty in determining veracity in web pages, and many are overwhelmed by the opportunity that the service provides. Too often students are simply seduced by repetition, e.g. the current mantra pervading the web "that carbon dioxide is a pollutant" is now endorsed by many without deep thought. Weller (2011) believes that we cannot redress this knowledge abundance, and I suspect, few would seriously want too. What is important to recognise is the increased time required for students to effectively assess this unlimited knowledge. Not surprisingly, students often disappoint in their assignments by citing far too few references, i.e. their research skills are either poorly developed, or poorly utilised**.**

Another linked observation made is that few current students demonstrate competence in simple (but accurate) sketching. The act of drawing traditionally provides one with useful insight into an object's form, function and place in the world. But digital photography, and the rapidity with which images can be downloaded, manipulated and inserted into documents has made the *art of drawing* somewhat superfluous for undergraduates. A result is a reduced ability to observe… to truly observe what it is that one is studying.

Perhaps this simply reflects the nature of our current students – their aptitude and the time that they have available for education. The opportunity to undertake tertiary education is now very much greater than in the latter half of the 20th Century, and a degree is now aggressively promoted as the passport to future happiness and security. Business opportunities arise from this of course, and it can be argued that tertiary education has now evolved to become a commodity rather than a service; certainly this is reflected by the place of education in Victoria's revenue stream – education is now our biggest industry, and the third biggest in Australia (Collins, 2011).

Networking:

Concurrent with the increase in knowledge abundance has been the evolution of social networking. This provides wonderful opportunities in the learning and teaching environment, especially in student projects that involve teamwork: up to now, membership of study groups has been local, but the opportunity exists to expand this to include international members, e.g. students from Germany and Australia, working via the web, in the same group. A trial using a virtual, interactive classroom has been undertaken with *Ethics & the Professional,* and this incorporated live peer-assessment of group presentations from Norwegian and German students. Technological difficulties aside, this gave the opportunity for real-time, two-way networking. It was fun, and it certainly enhanced the learning environment. Nonetheless, there are areas where caution must be exercised, particularly regarding privacy. Students are more than enthusiastic about utilising the web, but surprisingly, many seem unaware of the longevity of any seemingly innocuous statement that they post on the web.

Conclusions

The short course *Ethics & the Professional* has consistently received very positive student feedback. Engineering undergraduates like its delivery style and structure. Nonetheless, it is clear that there remains a great need to extend the ethical imperative in engineering: our ongoing failure in conserving our world is shown no more clearly than in the following statement, through which engineers are challenged to lift their moral gaze above their own immediate world:

> *the ethical role of the engineer* (is) *in assessing the good and bad impacts of technology, and wondering who defines these attributes*. (Ramaswami, 2010).

Not surprisingly, many of us now extol the value of the engineer as a politician, hopefully achieving an even greater impact on a sustainable shaping of our world. In a recent essay on globalization, Gerhardt (2010) reflected upon what makes a good engineer; he viewed the values *trust, respect and confidence* as the basis of a rewarding future. More than two thousand years ago, Aristotle saw this too – and he embodied these values as *virtues*, which in turn lead to growth of good character (Buckeridge, 2011).

Analysis of the current code of ethics for EA shows us that most things have not changed – our goal as good engineers, to lead a good life, remains much as in Aristotle's Greece. What has changed is our ability to disrupt nature, irreversibly, and this has placed even greater pressure on our young, especially our young engineers, to ensure a sustainable and rewarding future for all.

In reflecting upon the above, we should be mindful that in the past, engineers truly have moved mountains – the motorways, harbours and grand hydro-schemes in our world are testament to this. But massive changes to the environment are now not so widely accepted as they once were. The mountains we must now move are more likely to be virtual, and in striving to move these, our new graduates must have the mental tools to gauge the true, long-term outcomes of their actions… i.e. to determine the ethical, engineering, economic and environmental implications.

References

Australian Bureau of Statistics (2008). Cultural Diversity: Religion. Accessed at http://www.abs.gov.au/ausstats/abs@.nsf/ on 8 July, 2011.

Buckeridge, J. S. (1995). Introducing philosophy and ethics to the engineering curriculum. *Transactions of the Institution of Professional Engineers New Zealand* July 1994. 21(1), 1-4. (Published April 1995).

Buckeridge, J.S. (2011). *4 Es: Ethics, Engineering, Economics & Environment* 2nd Edition, Sydney: Federation Press.

Buckeridge, J. S. & Grünwald, N. (2010). Professions and Public Credibility: In D.M. Edralin & G.R. Barbajera (Eds.), An assessment of a course to evaluate ethics, environment, economics and engineering. *Proceedings of the 3rd International Conference on Innovation & Entrepreneurship and the 3rd International Conference on Engineering & Business Education* (pp. 96-105). Manila, Philippines.

Carson, R. (1962). *Silent Spring*. Boston: Houghton Mifflin.

Collins, S. (2011). University chiefs earning top dollar. *The Age*. 9 May, 2011, p. 2.

Engineers Australia (2011). *Professional Development: Career Planning & Advice*. Accessed at http://www.engineersaustralia.org.au/professional-development/career-planning-and-advice/career-planning-and-advice_home.cfm on 30 June, 2011.

Gerhardt, L.A. (2010). A lifetime of touches of an elusive "Virtual Elephant": Global Engineering Education. In G. Downey & K. Beddoes (Eds.), *What is Global Engineering Education for?* (pp. 198-216). Morgan & Claypool.

International Engineering Alliance (2009). *Graduate Attributes and Professional Competencies*. Accessed at http://www.ieagreements.org/GradProfiles.cfm on 30 June, 2011.

Ramaswamai, A. (2010). Finding and educating self across multiple domains. In G. Downey & K. Beddoes (Eds.), *What is Global Engineering Education for?* (pp. 151-174). Morgan & Claypool.

Rubin, S.J. (1998). The Washington Accord fifty years later: neutrality, morality, and international law. *American University International Law Review* 14(6): 61-82.

Weller, M. (2011). A pedagogy of abundance. *Spanish Journal of Pedagogy* 249, 223-236.