Proximating Ethics: Perceptions of the engineering profession and implications for learning

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Abstract

BACKGROUND
Ethics is identified by the engineering profession as a core knowledge attribute, both at the level of the graduate and the professional engineer. Consequently expectations around ethics feature prominently in the graduate attributes of the international accords, in the accreditation assessments, and in the competence criteria for admission to professional membership. Nonetheless the teaching of ethics presents particular difficulties to engineering teaching institutions. One of the primary difficulties is the didactic challenge: how to contextualise the profession's relatively rule-based approach to formulating ethics, into constructs that are memorable and internalised by students.

PURPOSE
The purpose of this work was to explore what practising engineers perceived about ethics, and then use that to inform curriculum design.

DESIGN/METHOD
The approach was to survey the whole New Zealand population of professional engineers, namely those who were members of the Institution of Professional Engineers NZ (IPENZ). The number of responses received was 2276, representing a 38% return. The survey data were analysed with ANOVA to extract statistical insights.

RESULTS
Empirical data from practising engineers shows ethics is one of the most important of the soft-skill graduate attributes. Engineers with higher qualifications show greater appreciation for ethics, as do chartered professional engineers, those with more senior grades of membership, and those with more work experience. The importance of ethics has been shown to vary, sometimes significantly, between different work areas. Manufacturing and Production engineers have the lowest appreciation though this may be because they contextualise it in other more applied ways that are more relevant to them.

CONCLUSIONS
While the existing discourse in the literature is focussed on how universities teach ethics, the present work identifies that learning ethics must be a partnership between the university and the industry employer, and integrated into ongoing professional development. If anything, the latter partner needs to be doing more. Engineers who are professional educators perceive ethics much more importantly than any other field of engineering. This shows that the education sector is highly appreciative of this topic, and disproves the notion that universities are insensitive to the need to teach professional ethics. In addition the data show that graduates are reasonably well-prepared regarding ethics, at least in the sense of showing an appreciation for the importance thereof, at the point of entry to the profession. However engineers up to 6 years into their career show decreasing appreciation of ethics. This is interpreted as employers of graduate engineers needing to do more to explicitly contextualise ethics for the specific employment situation. The possible curriculum contents for an ethics course have been identified, and suggestions made for how to improve student engagement.

KEYWORDS
ethics; graduate attributes; professional competence

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1 Introduction

Engineering is expert problem solving. Since these problems are complex, and the solutions are intended to benefit other people, the international community of professional Engineers expect students to gain knowledge of ethically appropriate decision-making. This is an explicit requirement, and one of the key attributes expected from students.

8.	**Ethics:** Understanding and level of practice	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

Table 1: *Graduate competency for ETHICS, required for Engineers at the end of a 4yr study programme, as per the Washington Accord (IEM, 2013), paraphrased.*

2 Background

The engineering profession rates teamwork highly, and looks to recruit graduates who already have these skills. Collaboration –working together- is how industry gets its engineering projects done. However academic institutions actively discourage students working together on assessments. To do so is considered collusion –working together to defeat the purposes of the project – and risks expulsion from the university. The difference between collaboration and collusion is potentially confusing to students (Adair & Linderman, 1985) (Walczak et al., 2011). What it shows is that ethics is contextual, i.e. depends on the situation. Working together at university can be considered unethical, whereas in industry it is considered good-practice.

The overall object of a professional Engineer should be to navigate a whole career with integrity. Ethics provides a situationally-specific framework of behavioural expectations.The risk is that Ethics comes to be perceived as a set of rules, perhaps even arbitrary ones, with different behavioural expectations in different settings. Why do the different forms of ethics include the rules they do? Why are the rules in one situation so different to those in another?

There are no easy answers to this. While the IEM expects that engineering students will learn about ethics (IEM, 2013), the expectations of ethical behaviour are by no means universal across the sovereign jurisdictions. Examples are given in Appendix 1 for New Zealand, Australia, and Hong Kong, by way of example.

At this shows, there are common themes in personal integrity, public well-being, and health and safety. However there are many regional differences, and differences in the style of presentation, such that any engineer who had remembered all the rules in his/her jurisdiction would be unlikely to correctly anticipate all the rules in another. These items are, for the most part, prescriptive rules about what an Engineer will *not* do. They do not say what *could* be done or what the profession *does* appreciate.

Didactic complications

This is didactically problematic. There is no universal set of principles underpinning the ethics rules of the various national bodies for the profession. The common underlying morality is only implicit (Barakat & Carroll, 2005) and even then risks being too abstract for regular comprehension (Eveleth, 2007). Consequently the teaching of ethics very easily becomes simply an attempt to learn the ethical rules of the country in which study is being undertaken (McEachron, Vaidya, & Ake, 2009) (Cruz, Frey, Sanchez, & Torres, 2004). In turn this encourages learning based on memorisation, and assessment based on repetition of facts in an examination (Alfred & Chung, 2006). Such learning is superficial, lacks any philosophical grounding (Allred, 1985), and does not readily endure into applied professional practice (Barry & Ohland, 2009). Also, such learning approaches do not transfer well if the engineer migrates to another country for work, as many may do. How many engineers, when working in another country, would think to look up the local statement of ethics before they start work?

In a previous era there was criticism of universities for failing to include ethics in the curriculum (Baum, 1977; Paschkis, 1976; Winner, 1996; Ziolkowski, 1995). The early solutions to this problem were to introduce ethics, but without sacrificing time spent on technical matters (Dyrud, 1998; Krishnamurthi, 1998). In time it became apparent to universities that ethics was not something to be tacked on, but needed to be an integral part of the knowledge and skill profile of the graduate. Consequently more serious attempts were made to include the topic in the curriculum (Lynch, 1997; Marshall & Marshall, 2003; Nair & Pantazidou, 1997).

Approaches to teaching ethics

In recognition of the situation, universities have taken very diverse approaches. Typical of these is an attempt to contextualise the subject to students, e.g. by use of:

- CASE STUDIES (Alenskis, 1997; Colby & Sullivan, 2008; Dyrud, 2004, 2006; Freeman, Johnson, & Leitch, 2007; Harris & Rabins, 1993; Helmer, 1995; J. R. Herkert, 2000; Howard, 1996; Lamkin-Kennard, Lerner, & King, 2007; Rabins & Harris, 1992; Richards & Gorman, 2004; Russell & Stocker, 1996; Sanford Bernhardt & Roth, 2002; M. Vigeant & Raymond, 2005; Whitbeck, 1987)
- FAILURE SITUATIONS (Delatte, 1997; Ermer, 2008; Harris Jr, 1995; Iino, 2005; S. K. A. Pfatteicher, 2002),
- BOARD-GAMES (Bekir, Cable, Hashimoto, & Katz, 2001; Carpenter, 2005),
- IMMERSIVE SCENARIOS (Latcha & Jordan, 1996; McCalla & Winter, 1999; Michmerhuizen, 1995; Tsang & Reis, 1996),
- ROLE-PLAYING (Alfred & Chung, 2006) including simulated PUBLIC-MEETINGS (Houghtalen & Rogers, 2004),
- SCIENCE-FICTION SCENARIOS (Berne & Schummer, 2005),
- PHILOSOPHY (Bernhardt, Roth, Brandes, & Kney, 2002; Jordan, 2006; Jordan & Elmore, 2006; Koehn, 1993; Koen, 2003; Sanford Bernhardt & Roth, 2002) or DILEMMAS (Burge et al., 2007; Sindelar et al., 2003) or MORAL REASONING (Self & Ellison, 1998; Selim & Al-Bayywomi, 2010),
- MORALITY (Leiffer, Graff, & Helmer, 1995) and moral courage (M. C. Loui, 2004; Michael C. Loui, 2005) or the avoidance of morality (Vesilind, 1991),
- collective or social DECISION-MAKING (Devon, 1999),
- UTILITY THEORY (Carpenter, 2004),
- COMPASSION (Catalano, 2004; Plaza, Garrido, Medrano, Sanchez, & Llamas, 2010) or humbleness (Ghosh, 2002),
- SOCIAL JUSTICE and SOCIAL CONTRACT (Haws, 2002; Johnston, McGregor, & Taylor, 2000; Soudek, 1999; Tucker & Ferguson, 2007) including confronting own beliefs (Soudek, 1996) and feminist studies (D. Riley, 2008),
- SUSTAINABILITY (M. Manion, 2002; Seager & Selinger, 2009),
- HUMAN RESOURCE management (Marshall & Marshall, 2004; McCuen, 1990),
- LITERATURE and novels (Monk, 1997),
- PRODUCT LIABILITY (J. R. Herkert & O'Connell, 2003)
- LEGAL implications (Dulin, 2003),
- ENTREPRENEURSHIP (Ferrill & Getzler-Linn, 2006),
- personal ANECDOTES (Lehman, 1993) and guest lecturers,

- PROFESSIONAL PRACTICE (Beans & Jakubowski, 1986; Joseph R. Herkert & Viscomi, 1991).

As this shows there has been considerable innovation in how academics approach the teaching of ethics. There has also been research into how to include ethics in the curriculum, for example MIXING it in with other engineering learning (Ballentine, 2008; Dyrud, 2003; Frey & Cruz-Cruz, 2007; Garland, Duerden, Helfers, & Roedel, 2001; K. Riley, Davis, Cox, & Maciukenas, 2007; Rogers & Ribeiro, 2004), creating MODULES for integration into other courses (H. Hart & Moore, 2002; H. Hart & Randall, 2005; Schmaltz, 2006), attaching ethics to DESIGN (Pearce, 1997) or capstone courses (Di Bella, 2002; Globig, 2002), presenting it as lunch-time DISCUSSIONS (Godfrey, Taylor, Fleischma, & Pickles, 2008), addressing it alongside WORK EXPERIENCE (Fleischmann, 2003).

Course design

There are also numerous accounts of the intent behind COURSE-DESIGN including one or more of the above delivery mechanisms and advocacy for specific forms of ASSESSMENT (Buckeridge & Grunwald, 2003; Killingsworth Jr & Twale, 1994; Kitto, 2001; Kline, 2001; Lighty, Battin, Harris, & Mower, 2004; Litzinger, Christman, Lau, Tuana, & Wise, 2003; Loendorf, 2009; M. C. Loui, Smith, Herkert, & Nichols; Magun-Jackson, 2005; Mallikarjunan, Whysong, & Lo, 2008; Mark Manion & Kam, 2000; McEachron et al., 2009; Monzon & Monzon-Wyngaard, 2009; Moskal, Miller, & King, 2002; Mullin, Lohani, & Lo, 2006; Narayanan, 2007; Nixon, 2011; Owen, 2009; Perlman & Varma, 2001; Sarah K. A. Pfatteicher, 2001; Ribeiro & Rogers, 2005; Schmaltz, 2006; Steneck, 1999; Stern & Pimmel, 2002; Terry, Benzley, Hawks, & Judd, 1996; Towell, 2003; M. A. S. Vigeant et al., 2005; Whysong, Mallikarjunan, & Lo, 2008; Yokomoto & Ware, 1998; Zandvoort, Van Hasselt, & Bonnet, 2008).

Challenges in teaching ethics

On the whole this body of literature is characterised by being statements of intent in specific situations, and cannot be considered evidence-based. The teaching of ethics remains a difficult area. Empirical results (Freyne & Hale, 2009; Walczak et al., 2011) have identified some of those challenges. They are the difficulty of finding space in the curriculum, the problem of how to incorporate ethics even when space is available, and difficulties finding and resourcing suitably knowledgeable lecturers. Teaching ethics can be hard work and is an unattractive activity for faculty staff (Zandvoort et al., 2008) so is at risk of receiving lower priority.

At the other extreme, and rather surprisingly, there are still countries where the universities have been slow to explicitly teach engineering ethics at undergraduate level (Atasoylu, 2007), or teach it poorly (Rosentrater & Balamuralikrishna, 2005). In some countries the local profession has been ambiguous about its ethical expectations (Brumsen, 2005).

Gaps in the body of knowledge

The research literature on ethics is limited in three significant ways. The first is that the existing research is almost exclusively focussed on proposed or actual teaching interventions, but without any measure of the efficacy of these. Almost all papers can be categorised as *advocating* for a particular approach, based on personal insight and enthusiasm, but devoid of evidence. There are exceptions, but they are rare, e.g. control groups are known to have been applied in at least one case (Davtdh et al., 2009), and the effectiveness of teaching moral reasoning has been assessed (Self & Ellison, 1998). There has also been some empirical work to determine whether teaching ethics as a module within a course, or giving it a whole course, is more effective (Drake, Griffin, Kirkman, & Swann, 2005). The results showed that there was not much difference.

This lack of empirical evidence is troublesome. Case-studies or scenarios are a common teaching strategy, but we really do not know how well they actually facilitate student learning. Some are highly critical of scenarios, claiming that they focus excessively on personal agency, and are too simplistic in their representation of the real issues in practice (Bucciarelli, 2008). Also there is some contrary evidence: teaching students about ethics (at least in certain ways) does not result in them making more ethical decisions, instead they sometimes game the system (Berry & Berenbach, 2010). So, while the research field can be characterised as innovative in its diversity of didactic approaches, it is also lacking in empirical evidence for the efficacy of all those innovations.

A second issue is the lack of a deeper underlying theory of engineering ethics. It is true that philosophy does supply theories of moral reasoning, but these are excessively abstract and have proved difficult to apply to engineering practice in a way that usefully informs the decision-making of an engineer in an ethically doubtful situation. The early approaches to the teaching of engineering ethics often did take the philosophy perspective, but that was subsequently largely abandoned as unworkable, and the case-study method dominated instead. Only recently has there been an awareness of the need to create a better theory for engineering ethics, and with that a willingness to consider how philosophy can contribute (Perlman & Varma, 2001). However such a theory remains a future idealisation rather than a present reality.

The third limitation is that the vast majority of the papers are curriculum-centric, and there is next to no research on how the engineering profession perceives ethics. It seems most research starts with the premise that the engineering profession requires the teaching of ethics and that's it. Exceptions include (Bowden, 2011) where managers in industry were asked for feedback on curriculum. So the in-situ aspects of ethics are under-investigated (Nathans-Kelly, Courter, Anderson, Nicometo, & McGlamery, 2011). If the profession is identified, it is invariable identified as ABET, rather than the IEM Accords, and in this way the USA perspective of ethics tends to dominate the discourse rather than the original documents. Also, the papers often still show a tendency to an external locus of control, that the intervention described was done because ABET required the teaching of ethics as a necessity for accreditation. This might seem a small point, but it does suggest that many academics are still doing it because they have to.

3 Purpose and Methodology

The purpose of this work was to explore the third of the above gaps, i.e. to determine what practising engineers perceived about ethics, and then use that to inform curriculum design.

The approach was to survey the whole New Zealand population of professional engineers, namely those who were members of the Institution of Professional Engineers NZ (IPENZ). This is the primary professional body for NZ and includes all practice areas. The Institute sends out an annual salary survey to all its members, and in 2009 two questions were added on engineering management:

Q17 To what extent does your current role involve engineering management?
Response categories: 5=Very Great Extent; 4=Great Extent; 3=Moderate Extent; 2=Slight Extent; 1=Not at all;

Q18 In your opinion, what engineering management topics (if any) should be taught to undergraduates? (Select as many as apply)

A list of topics was provided, see Appendix B. The list includes both management and leadership activities, and did not specifically differentiate between the two when asking the questions. The list was derived from the Washington accord graduate competencies and the literature for the engineering management curriculum. Other standard questions were also asked: qualification, years since graduation, practice area, job points, and demographics. Ethics approval was obtained from the University of Canterbury and permission from IPENZ.

The number of responses received was 2276, representing a 38% return. This is a high response rate. The population was all the professionally active IPENZ Graduate Members, Professional Members, Technical Members, Associate Members and Fellows who were living in NZ and still professionally active.

The survey data were analysed to extract statistical insights. The software tool used was Statistica®. The first analysis determined the importance of ethics relative to other topics. Thereafter the analysis determined whether engineers in different situations perceived ethics differently, and ANOVA was used for this.

4 Results

4.1 Importance of topics

Engineers differed in their rating of whether or not a topic was important, and the frequency of this was used to determine the mean score for each topic. The results show that ETHICS is the joint-third most important topic with PROJECT COSTING, after COMMUNICATION and PROJECT PLANNING, see Figure 1. This emphasises that ETHICS is a key attribute for engineers, one of the top soft-skills to acquire.

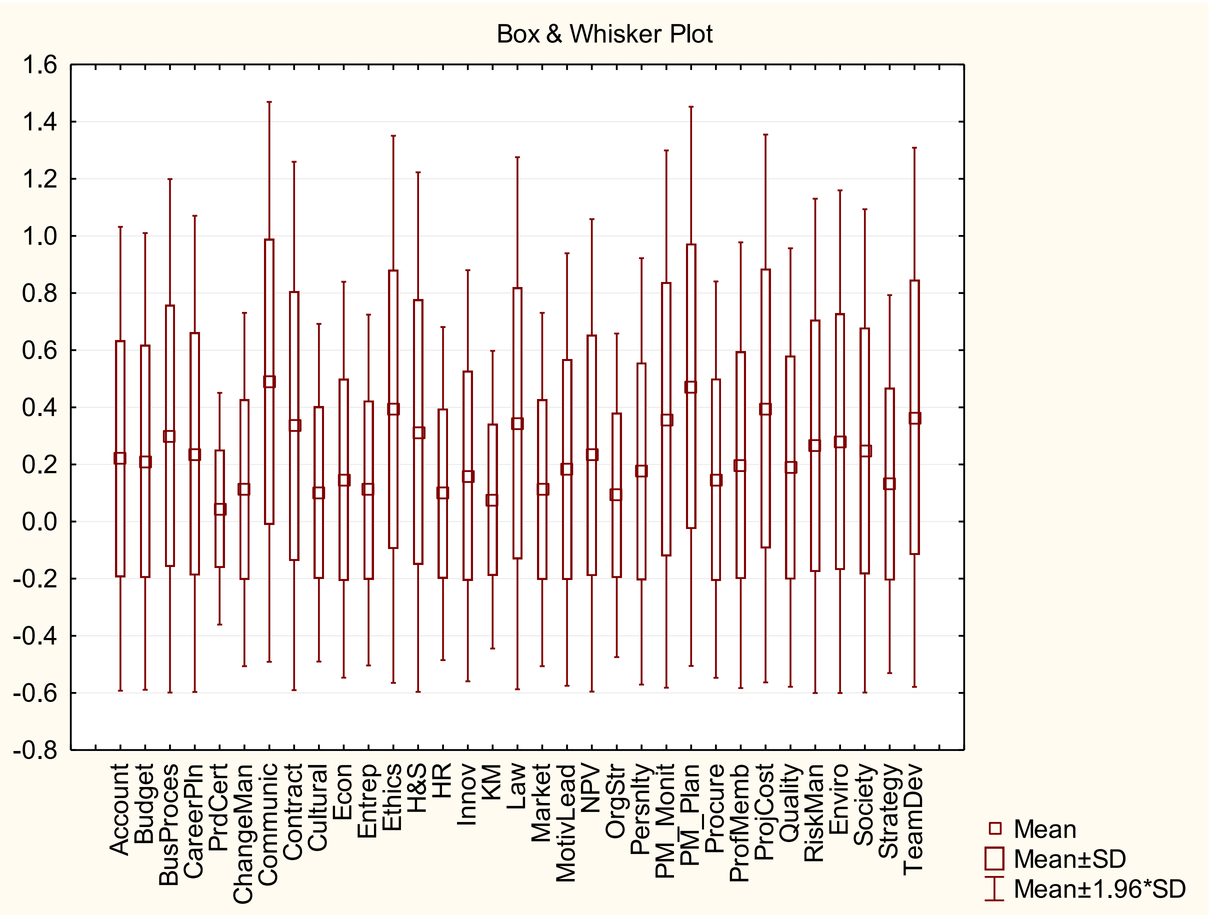

Figure 1: Relative importance of various topics.

4.2 Situational variables: Situations in which engineers find themselves

The next part of the analysis was to determine whether engineers in different situations perceived ethics differently. These categorical variables were intrinsic to the IPENZ survey, as opposed to being imposed by the researcher.

In- or With-engineering

Some engineers remain working IN engineering, whereas others work WITH engineering (IPENZ terms). The latter include managing engineering organisations, and the application of engineering skills and problem-solving methods to non-engineering work. The results show no significant difference between these categories [F(1, 2247)=1.0042, p=.31640], i.e. ethics are as important IN as WITH engineering.

Sector

The two sectors are the public and private. The results show no significant difference [F(1, 2230)=.86332, p=.35291], i.e. ethics are as important in the public and private sectors.

Gender

The results show no significant difference [F(1, 2269)=.15549, p=.69338], i.e. ethics are perceived about equally important by both genders.

Qualification

The appreciation of the importance of ethics rises with the qualification of the engineer concerned. This is particularly marked with the difference between holders of Bachelors and Doctorate degrees, with the latter evaluating ethics as more important, see Figure 2.

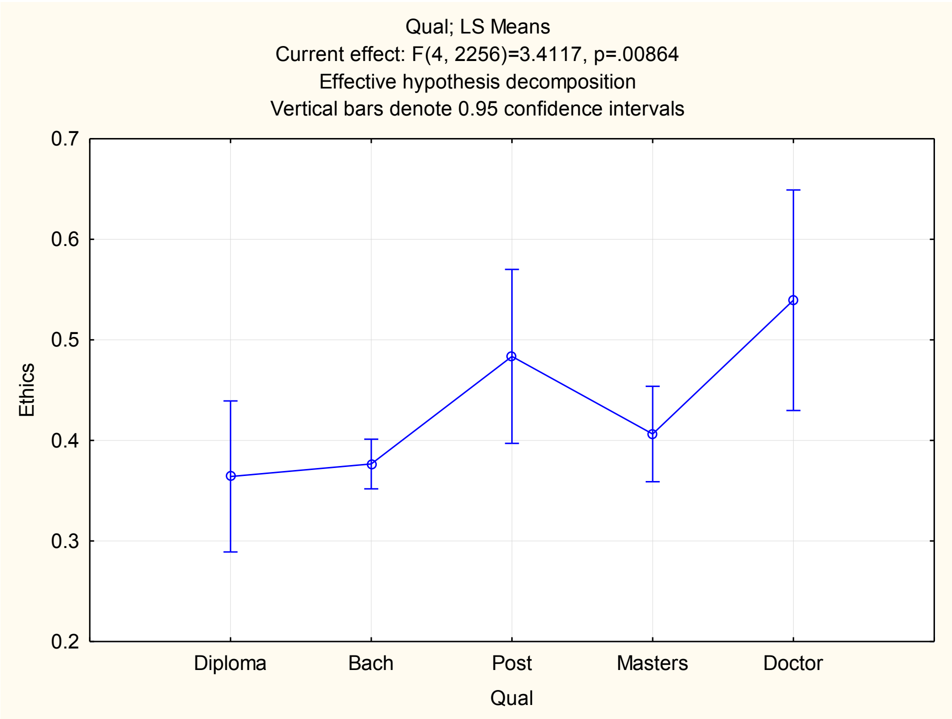

Figure 2: Ethics categorised by Qualification.

The trends in this area are marked, and the differences are statistically significant overall. A possible explanation is that ethics becomes more important as the level of complex problem-solving increases. More complex problems tend to have consequences in dimensions other than merely the technological, examples being environmental, health & safety, and client satisfaction. Thus qualification can reasonably be expected to be a proxy variable for the level of complex problem-solving being undertaken by engineers. The greater the complexity, the greater also the awareness of the effect on other people and hence an enhanced need to make ethical decisions.

Practice area

A number of *practice areas* are defined by IPENZ. The analysis shows that the Biofood and Business engineers perceive ethics as more important than do other practice areas. The manufacturing/production and chemical engineers had the lowest appreciation for ethics. It is interesting to consider whether these differences are because ethical dilemmas are encountered less for the latter practice areas, or whether the teaching of ethics has insufficiently contextualised the subject to those practice areas. However answers to such questions cannot be addressed in this survey, though they might be interesting to explore in future research. One journal paper identified the intent to teach ethics to chemical engineers in a one-hour non-assessed lecture on the Bhopal accident (M. Vigeant & Raymond, 2005), which is a lot less time than is generally reported in the literature. If this were indicative of how chemical engineers are taught ethics, then there could be reason for concern, however it seems unlikely that this would be general practice.

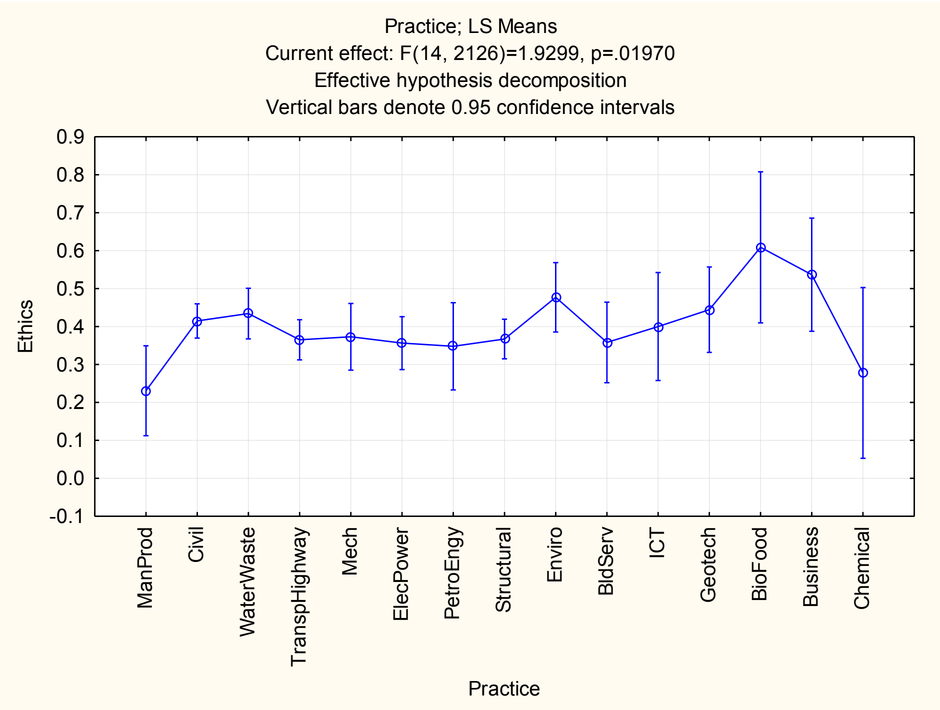

Figure 3: Ethics categorised by practice area.

Field

Another IPENZ categorisation of work activity is *field.* The results show that all engineering fields perceive ethics as about the same importance (the differences are not statistically significant), with one exception: engineers in Education perceive ethics as much more important than any other field. This shows that the education sector is highly appreciative of this topic, much more so than any other field. This is an important finding, because there has often been implicit criticism that academics are insensitive to the need to teach professional ethics (Hibbert, 2005), whereas these data show otherwise.

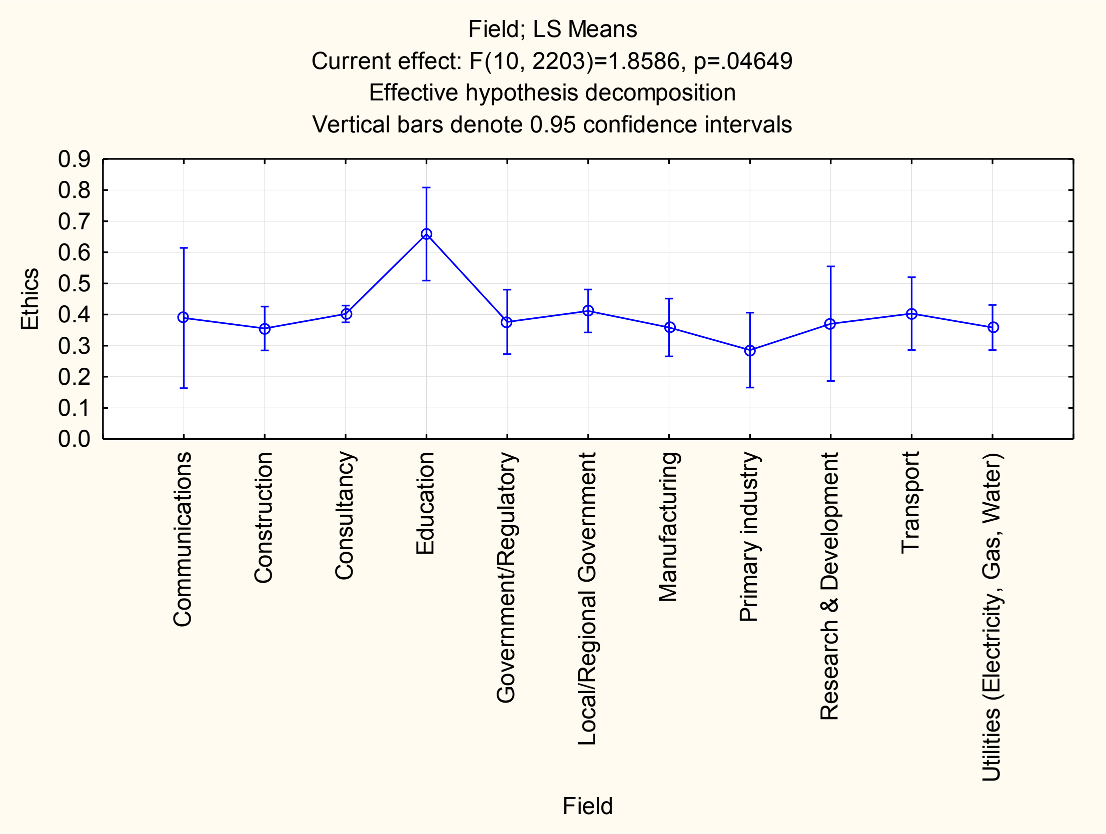

Figure 4: Ethics categorised by field.

Work activity

Again, those engineers whose work involved Teaching had a significantly greater appreciation for the importance of Ethics. They are joined by the Product Development engineers. Why product development? Perhaps this is because they are tightly focussed on delivering value to customers (product users). They understand the concepts of voice of the customer, delighting the customer, quality function deployment, the need for product safety, and the concept of product liability. It is relatively straightforward to make causal links between these subtopics and ethics generally. Thus it may be that ethics naturally lends itself to application to this area. It is interesting to note that the literature shows that several universities have deliberately attached ethical teaching to design courses. The present survey identifies that product designers are receptive to ethics, and consequently the finding tentatively supports the idea that ethics may usefully be included in design courses.

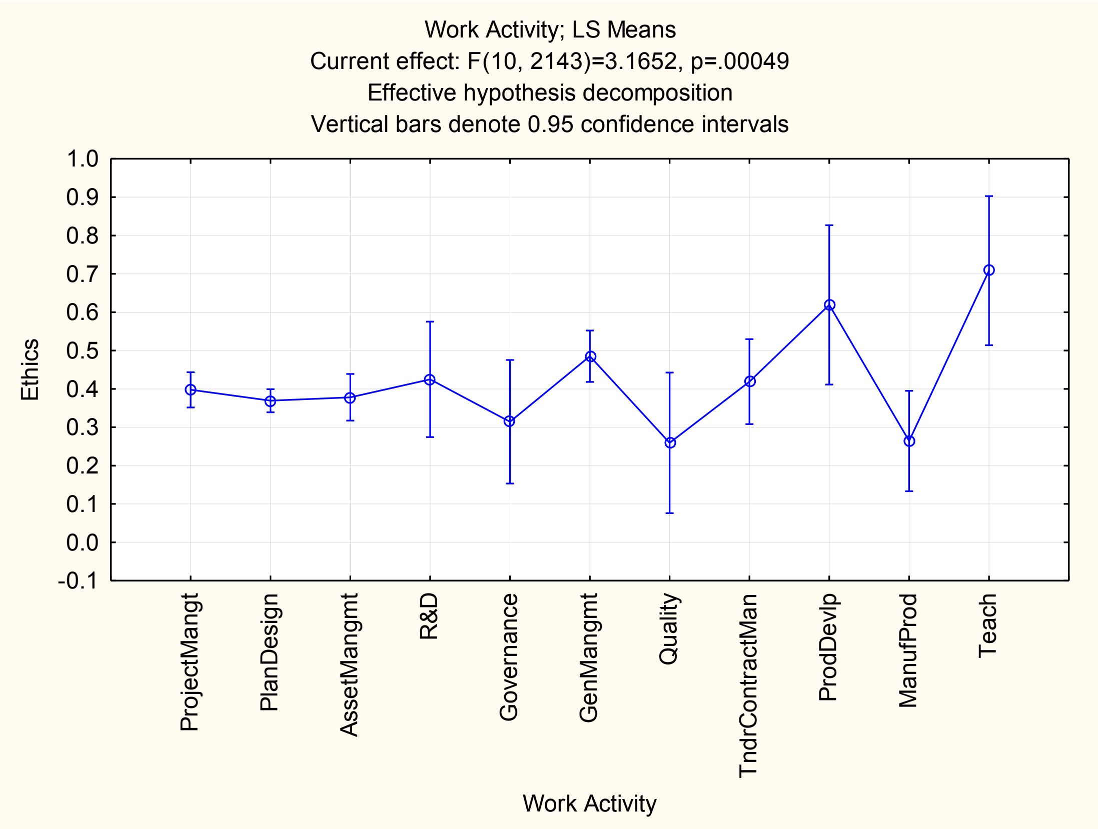

Figure 5: Ethics categorised by work activity.

Once more, Manufacturing & production engineering rate ethics as less important, an opinion shared by those working in the Quality area. A possible explanation is that these engineers are sufficiently deep in the organisation not to be exposed to ethical dilemmas regarding the customers' use of the product. This is not necessarily a bad thing. The manufacturing and quality engineers have their own well-developed theories of fitness for purpose, minimisation of waste (in all forms hence also Lean methods), maximising product reliability and value, etc. So it might be argued that they have developed a highly applied version of ethics, and therefore do not see the more abstract concepts of ethics as particularly important. Likewise the engineers in governance also rate ethics as relatively less important, which though surprising may also be explainable in the same way: governance has well-developed ideas about probity, stakeholders, delegation, strategy, and formal processes around decision-making and the documentation thereof. Possibly these applied forms of ethics decrease the importance of the conventional ethics. However this is all speculation.

Job changing

Those who had changed job in the year preceeding the survey were slightly less supportive of ethics than those who had stayed in their position. However the statistical significance is marginal (p=0.06). A possible interpretation, purely speculative, is that questions of ethics do not arise in the job-interviewing process, so the salience is reduced for these engineers. This is consistent with the concept of moral dynamics of career advancement by changing jobs (Haws, 2004), i.e. people seek personal advantage (rather than altruistic objectives) and will change jobs to achieve this. Possibly one could conclude that people who change jobs more often are more selfish and less inclined to see ethics as important.

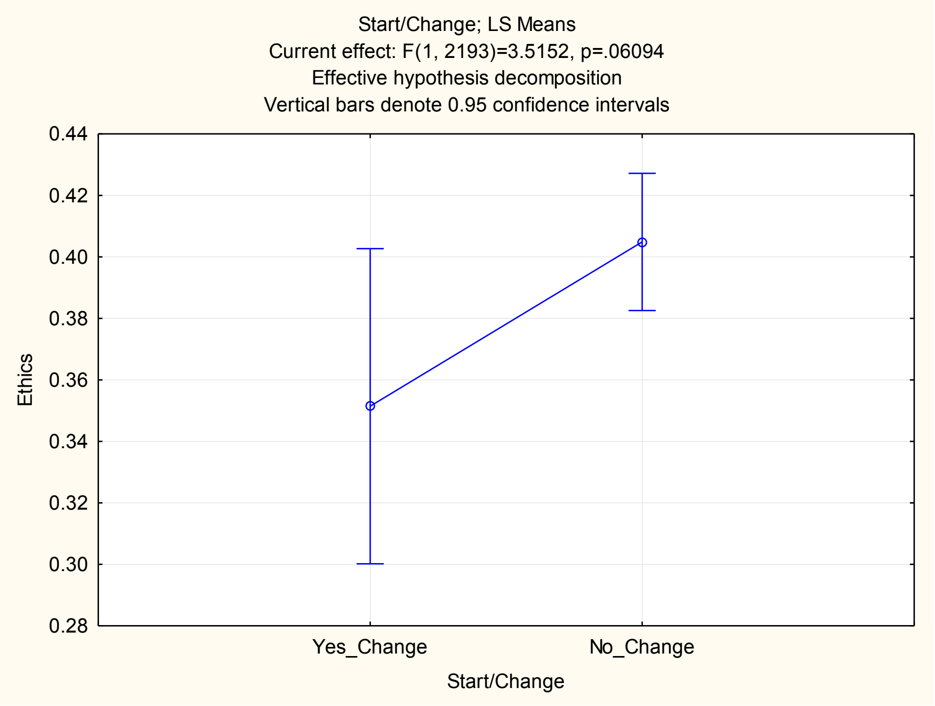

Figure 6: Ethics categorised by job-changing.

Involvement in engineering management

The importance of ethics was not significantly dependent on the engineer's involvement in engineering management activities. This shows that ethics is important in all engineering activities, management as well as technical.

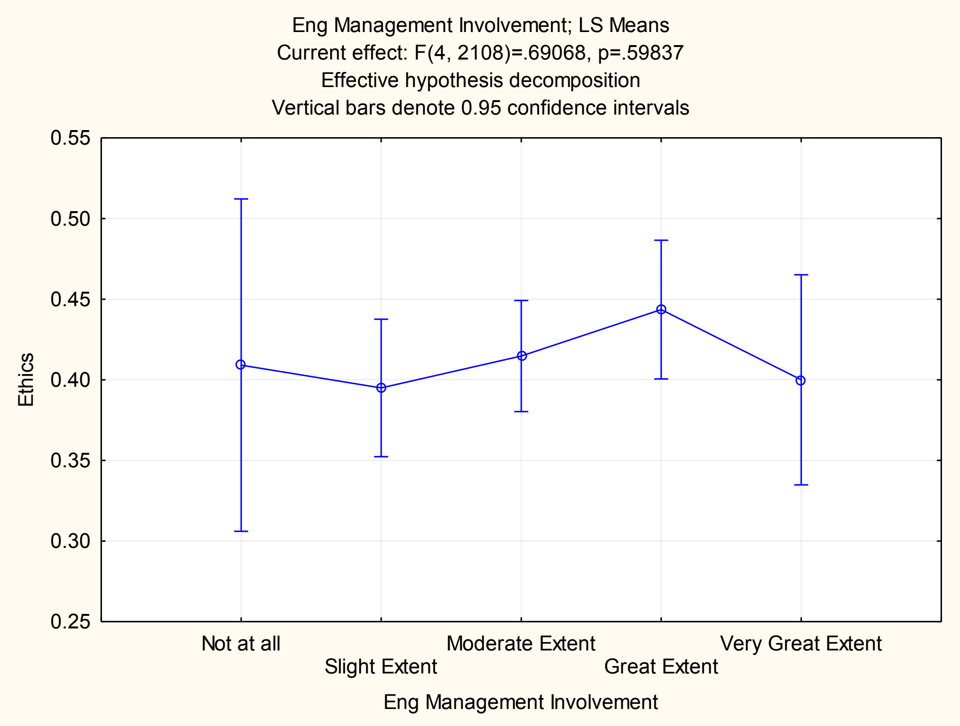

Figure 7: Ethics categorised by Engineering management involvement.

Employment

The self-employed engineers show a greater appreciation for the importance of ethics, than the salaried engineers. This is highly significant statistically (p=0.00182). In all likelihood this reflects the self-employed having a heightened awareness of the value of ethical behaviour in retaining clients, and hence providing future business. This confirms the sentiment explicitly expressed in the IPENZ practice note:

> *'The surest path to enduring success in business and in the profession is developing a good reputation. An ethical approach to work is consistent with this as it encompasses competence, integrity and the personal and professional values that support it. These values contribute to an engineer's ongoing standing within the engineering community and with existing and potential clients.' IPENZ (IPENZ, 2009)*

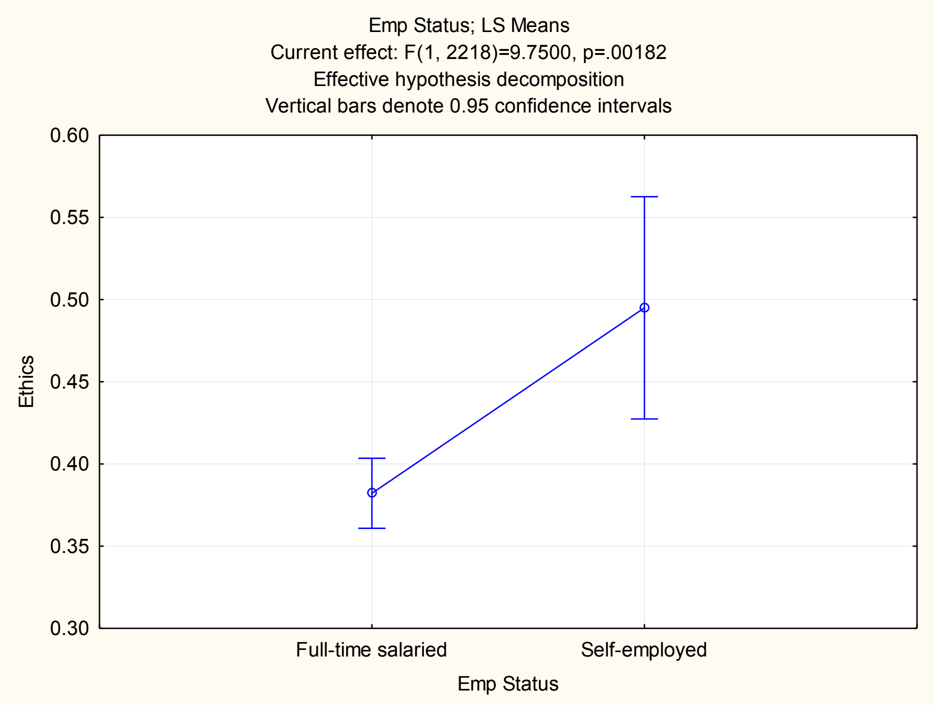

Figure 8: Ethics categorised by employment status.

4.3 Temporal variables: Progression during an engineer's career

Chartered professional status
The results for this categorisation are stark. Professional engineers overwhelmingly ($p=0.00000$) rate ethics more importantly than do non chartered engineers. The results support the conclusion that professional engineers are extraordinarily mindful of their responsibilities to behave ethically.

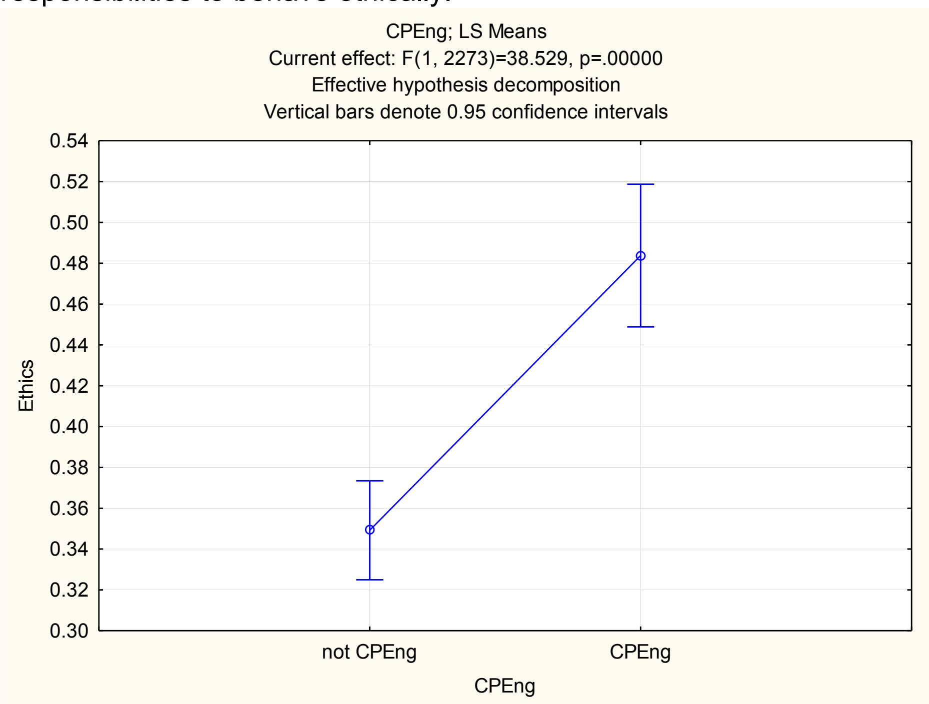

Figure 9: Ethics categorised by professional engineering status.

Having its members behave ethically is important for the engineering profession, as it engenders trust by society towards the profession, and gives the professional legislative power to be self-regulating. Thus ethical behaviour of members is an important part of creating strong institutions. These in turn uphold the values of society and are a force against moral corruption. It is the lack of trustworthy institutions that bedevils third-world and broken countries, and perpetuates corruption. The results of this survey show that New Zealand professional engineers rate ethics as very important. This suggests that the competency-assessment process that leads to professional standing is working well regarding ethics.

Membership grade

The three membership grades examined here were graduate, professional member, and fellow. The results show that the appreciation of ethics rises through these grades, and is highly significant at each stage. It is worth noting that many (but not all) professional members are also CPEng, and many fellows (again not all) are or were CPEng. So the results are consistent with the previous findings for CPEng.

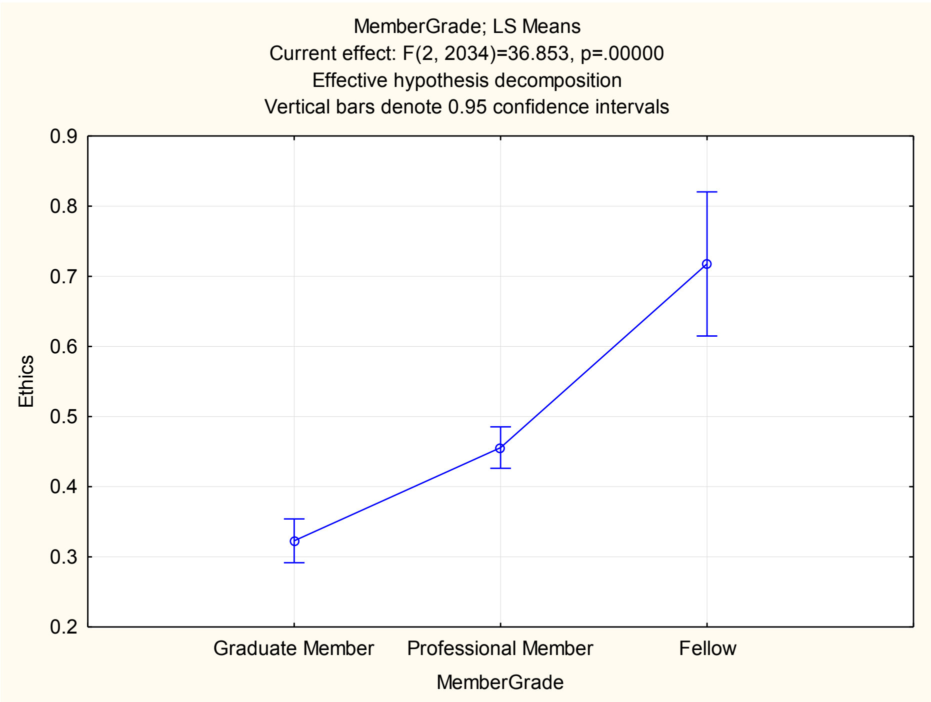

Figure 10: Ethics categorised by membership grade.

Years experience

There is a general trend of the appreciation of ethics increasing with years of experience. The overall trend is statistically significant, though not all the intermediate steps are. It is interesting to note that the appreciation of ethics *drops* in the first few years after graduation, and only recovers to the same level after eight years, though not all these changes are statistically significant.

One possible interpretation is that graduates are reasonably well-prepared regarding ethics, but their early professional experiences do not place them in ethically ambiguous situations and so ethics becomes less salient to them. In which case the implications would be that employers of graduate engineers might need to do more to contextualise ethics for the specific situation. This is consistent with the opinion of some researchers that excessively competitive company practises disillusion new graduates (Rojeski Jr, 1996) and that employers need to remind graduates of the importance of ethics (Taback, 1997).

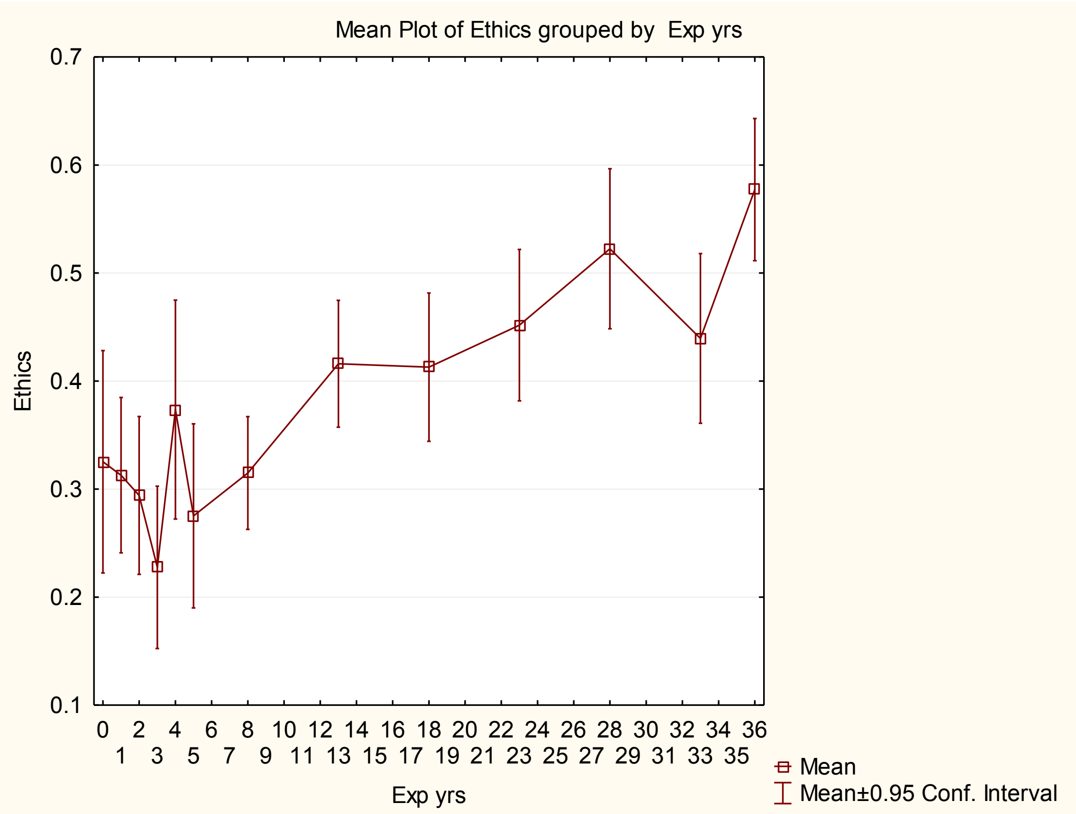

Figure 11: Ethics appreciation changes with years of experience.

5 Discussion

Findings

The data have implications for the longitudinal development of ethics knowledge and skills across both undergraduate teaching and continuous professional development. Taking the reasonable assumption that the engineers who responded to the survey were correct in their evaluation of the importance of ethics in their situations (as opposed to being cognitively lazy or misinformed), then the following implications emerge:

Learning ethics must be a partnership between university and industry

At this point it is worth noting something that appears to have been largely overlooked in the ethics literature, which is that an engineer's learning does not stop at graduation. Indeed the Accords and the professional bodies explicitly require life-long learning. Consequently the responsibility for developing the knowledge and skills in the area of ethics must be a partnership between the university and the industry employer. It is inappropriate to expect that the entire knowledge profile will be developed at university: some things can only be learned later when they are more salient to the engineer. The question is how that responsibility should be shared.

The data show that (a) engineers who are professional educators have a much greater appreciation for the importance of engineering ethics than engineers in any other industrial *field,* and (b) graduate engineers with no experience appreciate the importance of ethics

more than those with up to 6 years of experience (though the statistical significance is weak). This indicates that there are no real deficiencies in the universities' side of the partnership, at least so far as sensitisation to the *importance* of ethics in staff and students. (However the question of whether students are being taught the *right* sub-topics is still open). It would appear that the industry side of the partnership is that one lacking focus on ethics, especially in the first 6 years of a graduate's career, since the data show respondents perceiving ethics as proportionally less important in those formative years.
The implications are that employers of new graduates could be doing more to explicitly contextualise ethics for the situations in which new graduates work. As a first approximation it seems that students are aware of ethics *in vitro* but need to learn how to apply it *in vivo* and therefore firms could approach this problem by application and contextualisation. Many organisations that employ numbers of graduates have formal graduate development programmes, or at least mentors, and might consider a more explicit treatment of ethics during those interactions. Questions to consider: How does this organisation see its ethical obligations? How is ethics applied in this practice area? Where do the ethical dilemmas arise in this type of work activity? What type of moral hazards can the engineer expect as his/her career progresses in this practice area?

Situations where ethics is particularly important

The following engineers identified ethics as particularly important (based on 40% or more support levels): biofood, business, environmental, geotech, civil, water & waste practice areas, research & development, product development, general management, tender & contract management work activities, self-employed engineers, professional members, chartered professional engineers. Corresponding, ethics is perceived less importantly by those in the manufacturing and production practice areas, this being the only situation where support dropped to 25% or less.

This information is useful, as it suggests that the teaching of ethics might usefully focus on contextualising the subject for those areas. For example case studies, scenarios, and other didactic approaches could be customised to emphasise those areas in particular.

There is also an implicit longitudinal development axis, in that recent graduates are invariably in cadet and technical roles, and less likely to immediately be in general management, business, self-employment, professional membership and chartered status. Consequently this implies (a) that university and in-career learning (up to 6 years after graduation) could focus on ethics in specific practice areas and fields (e.g. biofood, civil, etc.), i.e. teach engineers how ethics works in practice, and (b) that after about 6yrs the CPD focus could be on preparation for ethics in the context of general management, business, self-employment, professional membership and preparation for chartered engineer application.

Development of a curriculum

The content of an ethics curriculum is a vexed problem that has not been solved elsewhere in the literature, and is left for future work. The literature review shows that there is no standardisation of curriculum content or didactic approach regarding ethics, nor any underlying theory. The present survey of practising engineers was not designed to identify the relative importance of specific sub-topics within an ethics curriculum. Nonetheless it is possible to offer some suggestions about the contents of a curriculum, and how the course delivery mechanisms can be designed to maximise engagement of students, see Appendix C.

6 Conclusions

Empirical data from practising engineers shows ethics is one of the most important of the soft-skill graduate attributes. Engineers with higher qualifications show greater appreciation for ethics, as do chartered professional engineers, those with more senior grades of membership, and those with more work experience. The importance of ethics has been shown to vary, sometimes significantly, between different work areas. Manufacturing and Production engineers have the lowest appreciation though this may be because they contextualise it differently.

While the existing discourse in the literature is focussed on how universities teach ethics, the present work identifies that learning ethics must be a partnership between the university and the industry employer, and integrated into ongoing professional development. If anything, the latter partner needs to be doing more. Engineers who are professional educators perceive ethics much more importantly than industry practitioners. This shows that the education sector is highly appreciative of this topic, and disproves the notion that universities are insensitive to the need to teach professional ethics. In addition the data show that graduates are reasonably well-prepared regarding ethics, at least in the sense of showing an appreciation for the importance thereof, at the point of entry to the profession. However engineers up to 6 years into their career show decreasing appreciation of ethics. This is interpreted as employers of graduate engineers needing to do more to explicitly contextualise ethics for the specific employment situation.

The possible curriculum contents for an ethics course have been identified, and suggestions made for how to improve student engagement.

A Appendix: Different perspectives of engineering ethics

New Zealand perspective

The Institution of Professional Engineers New Zealand (IPENZ) has a Code of Ethics with three parts (IPENZ, 2014). The first is a set of five fundamental *values* or motivational principles. These are elaborated in Part II, as a set of guidelines. Part III describes the minimum standards, and this is the only part that is mandatory. The latter comprise: '1Take reasonable steps to safeguard health and safety, 2 Have regard to effects on environment, 3 Act with honesty, objectivity, and integrity, 4 Not misrepresent competence, 5 Not misrepresent Membership status, 6 Inform others of consequences of not following advice, 7 Not promise, give, or accept inducements, 8 Not disclose confidential information, 9 Not misuse confidential information for personal benefit, 10 Disclose conflicts of interest, 12 Not review other engineers' work without taking reasonable steps to inform them and investigate' (IPENZ, 2014).

Australian perspective

The values required by Engineers Australia (EA) are: 1. 'Public wellbeing, health and safety and sustainability, 2. Responsible leadership, 3. Personal and professional honesty and integrity, 4. Professional competence and currency of knowledge and expertise, 5. Social justice, inclusiveness and equity'. Then there are specific requirements under each (EA, 2014).

Hong Kong perspective

The Hong Kong Intuition of Engineers (HKIE) has several rules regarding ethical conduct: 'Rule 1 Responsibility to the profession: A member of the Institution shall order his conduct so as to uphold the dignity, standing and reputation of the profession. Rule 2 Responsibility to colleagues: A member of the Institution shall not maliciously or recklessly injure nor attempt to injure whether directly or indirectly the professional reputation of another engineer, and shall foster the mutual advancement of the profession. Rule 3 Responsibility to employers or clients: A member of the Institution shall discharge his duties to his employer or client with integrity and in accordance with the highest standards of business ethics. Rule 4 Responsibility to the public: A member of the Institution in discharging his responsibilities to his employer and the profession shall at all times be governed by the overriding interest of the general public, in particular their environment, welfare, health and safety.'(HKIE, 2000)

At this shows, there are common themes in personal integrity, public well-being, and health and safety. However there are many regional differences, and differences in the style of presentation, such that any engineer who had remembered all the rules in his/her jurisdiction would be unlikely to correctly anticipate all the rules in another. These items are, for the most part, prescriptive rules about what an Engineer will *not* do. These particular behaviours are not appreciated by the profession. They do not say what *could* be done or what the profession *does* appreciate.

B Appendix: Survey questions

Abbreviation	Full title	Survey variable
Account	Accounting principles	V63
Budget	Budgets, Profit and Loss Statement	v64
BusProces	Business Processes in typical employer firms	V65
CareerPln	Career planning	V66
PrdCert	Product certification	V67
ChangeMan	Change Management	V68
Communic	Communication including report writing.	V69
Contract	Contract administration.	V70
Cultural	Cultural issues including Biculturalism, Multiculturalism and Treaty.	V71
Econ	Economics	V72
Entrep	Entrepreneurship, organisation formation and growth	V73
Ethic	Ethics.	V74
H&S	Health and safety requirements.	V75
HR	Human Resource Management	V76
Innov	Product Life cycle, R&D stages, Innovation, Creativity	V77
KM	Knowledge Management, NDA, IP Protection	V78
Law	Engineering relevant law, Contracts, Product liability	V79
Market	Marketing	V80
MotivLead	Motivational Leadership	V81
NPV	NPV, Capital, and Depreciation	V82

OrgStr	Organisational Structure	V83
Persnlty	Personality Styles	V84
PM_Monit	Project monitoring	V85
PM_Plan	Project planning	V86
Procure	Procurement.	V87
ProfMemb	Professional associations including IPENZ.	V88
ProjCost	Engineering relevant Finance and project costing methods	V89
Quality	Quality, Organisational Systems	V90
RiskMan	Risk Management, including SAA/SNZ HB 436	V91
Enviro	Environment and Sustainability including Resource Management Act	V92
Society	Professional relationship with society	V93
Strategy	Strategy, External forces, Mission, Vision, Governance.	V94
TeamDev	Development and management of Teams	V95

Table A1: Available responses to Q18 Survey question.

C Appendix: Development of a curriculum

The survey of practising engineers was not designed to identify the relative importance of specific sub-topics within an ethics curriculum. This is a vexed problem that has not been solved elsewhere in the literature is left for future work. The literature review shows that there is no standardisation of curriculum content or didactic approach regarding ethics, nor any underlying theory.

Content

Consequently this author suggests it is appropriate to apply the precautionary principle, and present learners (who may be undergraduates or working engineers) with a diversity of perspectives and content. Thus the following list of curriculum topics is suggested. The author suggests that just like the teaching of medicine takes two years to explain how the human body *should* work (e.g. anatomy, physiology, histology), and another five explaining how *doesn't* work and how to treat it, (i.e. pathology, disease, pharmacology and treatment), so a course in engineering ethics might cover both the codes of ethics and how ethical dilemmas occur. Hence the following list. The general order is to start simple with the relevant professional code of conduct, identify where the moral hazards actually emerge in practice, move to more complex theories based in psychology and/or philosophy, and close with implications for the engineer in the near (6yr) future which is professional registration:

1. Professional Expectations (IEM Accord, code of ethics of local professional body, interpretation of the rules, principles underpinning the rules, good practice guidelines)
2. Inducement (What is an illegal advantage or inducement? Why is it illegal? How does the trap operate? What are the solutions? Sunshine Test.
3. Other forms of corruption? Corruption in the supply chain: Bribes for product usage. Tender fraud.
4. It may be legal but is it ethical?
5. Product liability.
6. Ethics x Environment, Source of origin, Life cycle assessment (LCA)

7. Ethics in terms of personal behaviour, Agency, Moral hazard, Organisational incentives for perverse behaviour, Remuneration Incentive schemes, Excessive competition, Whistle-blowing, Conflicts of interest, Confidential information
8. Ethics for harmful technology (Bots, Droids, and Drones, possibly weapons)
9. Ethics from the perspective of Wisdom and psychology,
10. Implications for practitioners, postgraduate research opportunities.
11. Decision-making, Decision trees, utility theory
12. Implications when applying for Professional Engineer status
13. Ethics workshop topics, scenarios, case studies, discussion and review questions (apply throughout the above)

Delivery mechanisms and engagement strategies
So much for the possible *content* of a wide-ranging curriculum. The author is also of the opinion that it just as important to consider the *delivery* mechanisms. These need to be designed to maximise student engagement and deep learning. There are a number of methods that the author has used to achieve this, but no claim is made for proven efficacy thereof. First is the use of case studies and scenarios throughout the delivery. Topical news events can also be brought into the class: e.g. a recent failure of a tailings dam and the resulting vast environmental damage, which may usefully be related to questions of ethics, risk, environmental issues, liability, etc. A second strategy for student engagement was the presentation of course materials in a form like magazine articles: short pieces that present different perspectives and can be read in any order. This appeared to work better for student engagement than one monolithic text, which required the student to conform to (and possibly disengage from or event resent) the writer's control of the narrative locus.
A third engagement strategy was to frame ethics as an extension of what students already know well: problem solving and decision-making. Their other engineering studies focus problems in mathematical and engineering sciences that involve quantitative variables and precise mathematical formalisms that are generally devoid of any ambiguity or epistemic uncertainty. Students know these methods well. Ethics can then be presented as a higher-level decision-making process that sits above these methods, see Figure.

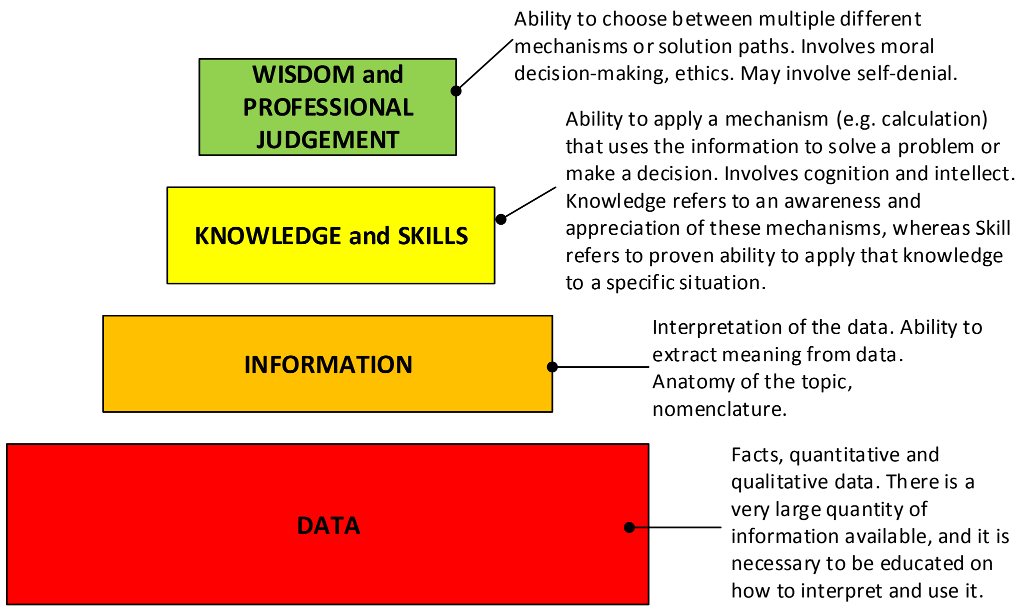

Figure 12: Wisdom and ethics are connected concepts, and involve higher order mental functioning.

This also lends itself well to explaining the otherwise rather abstract concept of PROFESSIONAL JUDGEMENT, which is one of the competency criteria for professional engineers. Diagrams like these are easy for students to comprehend, yet permit profound discussions of the issues. Another example of a diagram is the tree (see Figure) showing the types of confidential information. Drawing up this tree from first principles in discussion with the class can be a useful way for students to begin to understand the concepts. In the author's experience students initially have a poor grasp of this concept. Once the concept of confidential information is established , it is easy to link this to ethics (there is a specific item on this in the IPENZ code), and to conflicts-of-interest, whistleblowing, scenarios, and onwards to intellectual property (IP) and the legal protection thereof. In this way it becomes easy to contextualise ethics for IP, environment, consultation, product design, and practically any field of engineering activity.

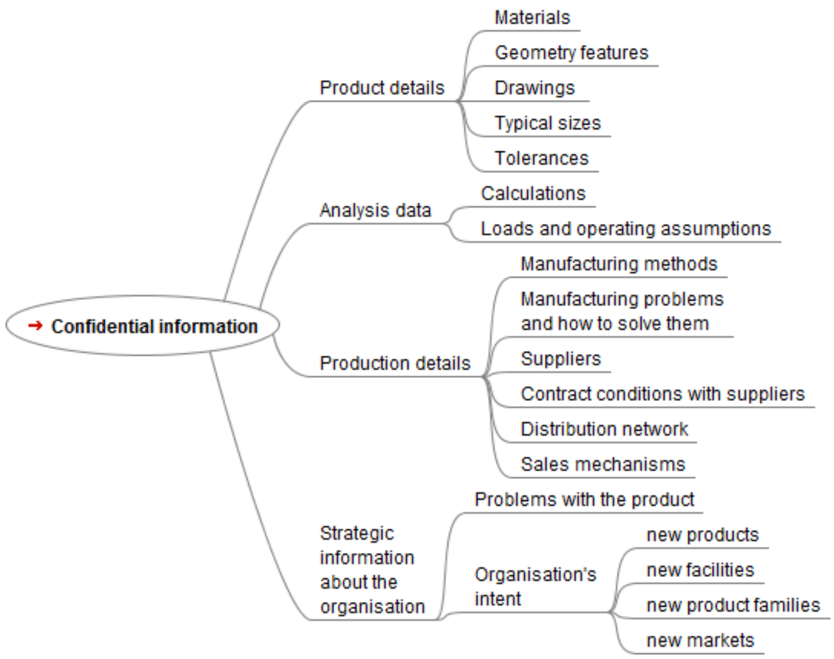

Figure 13: Typical confidential information in an engineering product development situation.

Within the literature there are voices that propose that ethics should not include morality. This might be fine from the perspective of a liberal-arts education. However research has shown that engineering students tend to score highly on conscientiousness (Van Der Molen, Schmidt, & Kruisman, 2007)(Horne, Pons, & Helton, 2012)(Balsamo, Lauriola, & Saggino, 2012). This is one of five personality attributes in the OCEAN or Big Five personality inventory, the dominant method of psychology for characterising personality(R. B. McCrae & Costa, 1990; R. R. McCrae & Costa, 1999). It is relevant to note that conscientiousness, rather than intellect or any other variable, correlates most strongly to tertiary academic performance (Poropat, 2009; O'Connor & Paunonen, 2007) including for engineering students (Horne et al., 2012). Consequently this author suggests that it is desirable to recruit the natural conscientiousness of engineering students to the topic of ethics. Conscientiousness means doing the right thing, which is not far away from morality. Thus it can be useful to explain ethics in terms of doing the right thing as regards the integrity of decision-making. This is a relatively abstract concept, but it is easy to find ways to proximate this to students, see Figure for the type of thinking to achieve this.

Figure 14: One step backwards would not be a good idea. Statements of Ethics are like markers on the cliff edge, beyond which behaviour loses integrity.

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