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A new Framework for Measuring the Ethical Awareness and Perception Among Engineering Students in Higher Education

Bidyut Baruah[1], Manal Atesh[2], Tony Ward[3]

Abstract

Today engineers are expected to not only apply technical knowledge and expertise in their practices but they also need to understand the various ethical responsibilities involved in all their organizational commitments and work related approaches. This raises the question of when and how can engineers be trained to be ethical? Some of the recent studies have implied that ethical awareness and decision making responsibilities should be introduced at a pre-employment stage preferably integrated as part of a teaching curriculum. This study proposes a new approach by which educators from HEIs can measure the ethical awareness and decision making competencies among engineering students. Findings throw light on the effectiveness of teaching and promoting ethics in Higher Education Institutes (HEIs). It also reviews whether the Royal Academy of Engineering (RAE) principles can be used as a core basis for measuring ethical awareness and perception among students.

1. Introduction

The word 'Ethics' is usually associated with morality and human conduct. For the Washington Ethical Society, it represents "*the elements essential to human well-being and proposes principles to be used as guidelines for generating an ethical culture*" [1]. Understanding moral complexity and ethical decision making is vital in different professions including engineering. Martin and Schinzinger [2, pg 8] define Engineering Ethics as "*the study of the decisions, policies, and values that are morally desirable in engineering practice and research"*. Basart and Serra [3] emphasize how engineers today exist and operate as part of a complex network of people, organizations and groups. Various organizational projects will require engineers to team up and work with different specialists, clients, stakeholders and organizations. Such collaborative work can however, lead to a wide range of challenges and situations for an engineer. Such situations can test their ethical perspectives and decision making competences. Mills and Treagust [4, pg 2] note; engineers "*must cope with the commercial realities of industrial practice in the modern world, as well as the legal consequences of every professional decision they make*". As part of ethics training and induction, many organizations now insist on familiarizing their engineers to the codes of ethics and conduct of professional bodies like the Institute of Electrical and Electronics Engineers (IEEE), the Royal Academy of Engineering (RAE) and the Institution of Engineering and Technology (IET). Some studies however, have implied that ethical awareness and decision making responsibilities should be introduced at a pre-employment stage. For instance, Harris et al [5, pg 93] emphasize that engineering ethics "*is only learned in a professional school or in professional practice. It is an essential part of professional education because it helps students deal with issues they will face in professional practice*". This therefore, brings the challenge of designing curriculum and teaching approaches for HEIs so as to produce engineers who are not only academically competent and work ready but are also ethically competent.

2. Why teach Ethics?

Poel et al [6] highlight the main advantage of teaching ethics as a standalone course is that students will be intensively exposed to ethical issues for longer period allowing them to develop relevant skills and in-depth knowledge on ethical responsibilities. Harris et al [5] and Li and Fu [7] discuss the prospects of integrating ethics across a curriculum; educators this way will get more opportunities to address ethics discussion in various courses as well as demonstrate how integral it is to engineering practices. Few researchers note how Ethics Education can stimulate ethical will-power and confidence among students, improve their ethical judgment and moral reasoning for a given situation and help them to recognize and identify the core ethical aspects.

[1] University of York, UK
[2] University of York, UK
[3] University of York, UK

It also improves their decision making skills and help them deal with ethical scenarios with solution-oriented strategies. Evidence from the studies conducted by Atesh et al [8] suggest that students who are exposed to Ethics Education show more confidence in identifying ethical issues and their justification using moral reasoning on a given circumstance. It also boost their familiarity and understanding of the moral codes and standards associated with the engineering profession. Harris et al [5] particularly note how ethical judgement tends to improve with practice. Classrooms and laboratories according to them offer a safe place for students to make ethical mistakes and they can get an opportunity to discuss various ethical opinions and learn from that.

3. Using Codes of Professional Practice in Ethics Education

Ethics is taught using a wide range of strategies and methods; with case studies, moral theories/reasoning and professional codes of conduct being particularly popular among academic institutes. There is however, a debate on the effectiveness of some of these approaches; authors like Li and Fu [7, pg 340] for instance highlight "*a critical gap still exists in what to teach and how to teach engineering ethics in order to produce the best possible ethical engineers in today's fast changing environment*". For educators, in order to teach ethics effectively and apply appropriate teaching approaches, it is important to understand the students' current perception and awareness of ethics. So far, there are no set frameworks or measures by which one can determine ethical awareness among engineering students. Authors such as Herkert [9], Davis [10] and Colby and Sullivan [11] have recommended using the codes of professional practice in ethics education. Such code of ethics according to Herkert [9, pg 407] illustrates "*the hallmark of a professional engineering society's stance on ethics*". These codes can justify and explain "*why engineers cannot depend on mere private conscience when choosing how to practice their profession, no matter how good that private conscience, and why engineers should take into account what an organization of engineers has to say about what engineers should do*" [10, 1991, pg 154]. Colby and Sullivan [11] view such codes as a useful framework for determining the goals for student learning as part of ethics education and professional responsibility.

4. Research Methodology

There are four fundamental principles in the RAE Statement of Ethical Principles (Number of specific statements represented in bracket):

- Accuracy and Rigor (14)
- Honesty and Integrity (10)
- Respect for life, Law and the Public Good (7)
- Responsible Leadership: Listening and Informing (5)

Each statement was transferred into a question with one set asking how students rate its importance (Q1) and the other the level of development (Q2) in their current degree programme. A pilot study was conducted among students from the MSc Engineering Management in the department of Electronics, University of York for the academic years: 2015-2016 and 2016-2017. The students as part of this programme have undertaken a workshop on Engineering Ethics. There was 54 responses in total: 34 male and 20 female.

5. Data Analysis and Discussion

Analysis of level of importance (Q1) showed:

- Male: Mean = 3.15 to 3.74
- Female: Mean = 2.9 to 3.65.

A similar result was observed in the analysis of Q2:

- Male: Mean = 3.21 to 3.71
- Females: Mean = 2.9 to 3.37

These highlight some difference in the ranking pattern across genders. The analysis seems to imply that female students have lower perception of the importance of ethics in comparison to male students (see table 1). The results show that male students have placed the highest priority on the '**Honesty and Integrity**' aspects of the engineering profession followed by '**Accuracy and Rigor**'. For females, it is '**Responsible Leadership**' followed by '**Honesty and Integrity**'. Surprisingly, both male and female students have ranked the '**Respect for Life, Law and Public Good**' aspects of the engineering profession lower than any other principles although the statistical differences are not significantly different between genders in any of the groups.

Table 2 highlights the group statistics on how students ranked development. The results show that both male (mean=3.54) and female students (mean=3.20) have ranked '**Respect for Life, Law and Public Good**' to be the top core principle. This finding is rather surprising considering how students rated this element within an engineering profession the lowest in importance. Does this mean that students are failing to connect the importance of this principle to an engineering profession despite this being a strong emphasis in their degree programme? One of the possible explanations is that today, universities are heavily promoting academic integrity.

	Male			Female					
	Mean	N	Std. Dev	Mean	N	Std. Dev	Total	N	Std. Deviation
Respect	3.4006	34	1.28	3.2236	20	1.36	3.335	54	1.30495
Accuracy	3.4389	34	1.19	3.2768	20	1.30	3.3789	54	1.22486
Honesty	3.515	34	1.27	3.2997	20	1.27	3.4353	54	1.26179
Leadership	3.3412	34	1.25	3.41	20	1.24	3.3667	54	1.23762

Table 1: Group Statistics on the level of importance of an engineer's role

	Male				Female			
	Mean	N	Std. Error Mean	Std. Dev	Mean	N	Std. Dev	Std. Error Mean
Respect	3.54	34	0.209	1.22	3.20	20	1.36	0.30519
Accuracy	3.45	34	0.220	1.28	3.08	20	1.30	0.29159
Honesty	3.46	34	0.205	1.19	3.11	20	1.40	0.3143
Leadership	3.40	34	0.219	1.27	3.12	20	1.42	0.31868

Table 2: Group Statistics on the development of RAE principles through degree programme

The MSc Engineering Management programme has a lot of team work, leadership and decision making activities embedded in the curricula. Leadership skills are key in engineering and management careers and there has been a lot of discussion on the existence of a gender gap in leadership roles within organizations. It is therefore, encouraging to see female students rating the development of '**Responsible Leadership**' the highest for both Q1 and Q2.

Another surprising finding is the rating of '**Accuracy and Rigor**' among female students (mean = 3.08). The engineering programme at York places a lot of emphasis on keeping knowledge up-to-date and teaching students how to manage and quantify risks. The female students seem to have not considered these aspects in their ratings.

6. Conclusion and further works

Engineering ethics is an essential aspect throughout the profession of engineering and its absence can "*seriously damage both the appropriate evolution of engineering and its engagement with society at large*" [3, pg 187]. This study investigated whether professional codes can inform and influence the ethical perception and awareness among students attending courses in engineering and whether

educators can utilize these to tailor specific teaching strategies. Findings suggest some differences in the way male and female students perceive the ethical roles and responsibilities expected in the engineering profession. Similar differences were also noted in how male and female students ranked the effectiveness of their degree programme in developing ethical knowledge. Overall, female students seem to have lower ethical perceptions in comparison to male students.

An important finding from this study is that female students today are placing high priority in the development of leadership skills. Although students from both gender ranked the development of '**Respect for Life, Law and the Public Good**' high in their degree programmes, they didn't place the same priority for this principle in the engineering profession. In fact, this was rated lowest by students from both gender. This contradictory finding is very surprising. Does this indicate a gap in the academic perception and student perception of the engineering profession and what is being taught as part of ethics education? This study being a pilot has some limitations particularly with the sample size. Therefore, further research will need to be carried out in order to verify the criticality and reasoning behind the differing perceptions of ethics among engineering students.

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