Analyzing the perception, judgment and understanding of Ethics among Engineering students in Higher Education

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***Abstract* — The Royal Academy of Engineering, which is Britain's national academy for engineering, identifies and stresses the importance of personal and professional commitments and obligations of professional engineers to enhance the wellbeing of the society. These can be attained by adopting the highest standards of professional conduct and integrity which are now commonly represented as 'Engineering Ethics'. The engineering profession requires the exploitation of knowledge, resources and innovation and in the process; engineers face different complex situations and scenarios that regularly test their ethical judgment and understanding. A lot of emphasis is therefore placed today on familiarizing engineers with the ethical standards and moral codes of conduct involved in an organization as part of their commitment towards their roles. However, there is very little research conducted so far on the influence of Ethics Education on the moral growth of engineering students. Some recent studies suggest a growing concern among universities on the issue of increasing the ethical knowledge among their students and produce ethically responsible engineers or business leaders. Can Engineering Ethics Education reinforce students' inclination to act ethically and give a strong foundation to their ethical decision making skills? Some researchers seem to imply that students who attend an ethics based course or module are more likely to recognize the core of a moral issue in a given complex situation than students who haven't had any such prior experience. Other researchers seem to disagree on that context. There is also a degree of uncertainty and inconsistency as to how Ethics related courses can be incorporated and delivered as part of an Engineering curriculum. It is also not clear at what stage should engineering students be exposed to ethics courses?**

This study aims to bring clarity in some of these areas by examining the perception and decision making skills among two groups of students: one which has attended a course on ethics and the other which hasn't. It uses the example of the MSc Engineering Management Programme at York where a session on Engineering Ethics is delivered every year. This study will analyze the potential of Ethics Education in boosting a student's ethical responsibility, awareness and decision making skills.

***Keywords* — Engineering Ethics, Higher Education, Royal Academy of Engineering, Ethical decision makers**

I. INTRODUCTION: ETHICS IN ENGINEERING PRACTICE

Ethics in simple terms, can be defined as the norms or rules of conduct recognized in respect to a particular class of human actions in a society, group, profession or culture. Martin and Schinzinger [1] refer to these as the *"moral values that are sound or reasonable, actions or policies that are morally required (right), morally permissible (all right), or otherwise morally desirable (good)"* [pg 8]. This research area is usually associated with philosophical study that is *"concerned with studying and/or building up a coherent set of 'rules' or principles by which people ought to live"* [2, pg 11]. Resnik [3] notes that understanding ethics can help in distinguishing between acceptable and unacceptable behavior. Today the resonance and implications of ethical norms, behavior and expectation extends to any profession including engineering practices. Freyne, Abulencia and Draper [4, pg 18] observe *"Society places a high level of confidence in engineers to uphold high ethical standards"*. But do engineers always follow and maintain high ethical standards? In recent times, the global market has witnessed several high profile cases of unethical practices in big corporations, one being the infamous Volkswagen emission scandal in September 2015.

Hotten [5] from the BBC noted "*The Environmental Protection Agency (EPA) found that many Volkswagen cars being sold in America had a "defeat device" - or software - in diesel engines that could detect when they were being tested, changing the performance accordingly to improve results. The German car giant has since admitted cheating emissions tests in the US…… Volkswagen must have had a chain of management command that approved fitting cheating devices to its engines*". One of the highlights of this case was the role and involvement of the engineers despite them knowing the obvious ethically questionable practices. This now raises an obvious question: Are organizations or employees overriding their moral values and obligations towards society for profits and other monetary accomplishments? Such unethical practices according to authors like Sedmak and Nastav [6] can be key catalysts of an economic crisis. This therefore implies a growing need to promote professional and ethical responsibilities and one of the focuses for Higher Education in this context involves today's engineering students and tomorrow's engineers.

II. TEACHING ENGINEERING ETHICS IN HIGHER EDUCATION

Engineering Ethics is "*the study of the decisions, policies, and values that are morally desirable in engineering practice and research*" [1, pg 8]. It represents the desirable ideals and personal commitments in the field of engineering and the responsibilities, behaviors and rights which engineers can endorse. The various implications of engineering ethics have been highlighted in the Code of Conduct of Engineering Institutions. For instance, the Royal Academy of Engineering (RAE) which is Britain's national academy for engineering identifies and stresses the importance of personal and professional commitments and obligations of professional engineers to enhance the wellbeing of the society by adopting the highest standards of professional conduct and integrity. Authors like Martin and Schinzinger [1] highlight the contributions of Engineering Ethics today particularly in innovation which leads to safe and useful technological products thereby giving meaning to engineers' endeavours and commitments. The RAE and the Engineering Council UK (ECUK) together have identified the key ethical standards at the core of the engineering practice by releasing the Statement of Ethical Principles (SEP). These principles set "*a standard to which members of the engineering profession should aspire in their working habits and relationships*" [7, pg 1].One of the objectives behind these principles is to provide support to professional engineers in the development of their ethical skills and achieve the high ideals of professional life [8]. There are four fundamental principles as part of the Statement of Ethical Principles:

- Accuracy and Rigor
- Honesty and Integrity
- Respect for life, Law and the Public Good
- Responsible Leadership: Listening and Informing.

One of the strategic challenges identified by the RAE is the fostering of better education and skills through the creation of relevant engineering education and training. This includes teaching ethics to students in Higher Education programmes. Today engineers are expected to solve problems rationally and reach the desired or specified outcomes by constructing or adopting systematic methods and approaches. However, this comes with risks, as authors like Herket [9], Bowen [10] and Bucciarelli [11] explain how engineering practice usually involves engineers working in teams where they make prominent and crucial decisions on areas like robustness, users, quality, responsibilities, societal benefit, risks, safety and cost. It requires the exploitation of knowledge, resources and innovation and in the process; engineers might face different complex situations and scenarios that regularly test their ethical judgment and understanding. A single given situation could have multiple interpretations based on a team member's own background, cultural perspective, judgment and experience. So, if there is no set guidance on ethical codes and conduct, any actions involving ethical implications could lead to varying or conflicting opinions and approaches in such organizations. Freyne, Abulencia and Draper [4, pg 1] add "*Society expects and needs engineers to be cognizant of potential ethical issues and to act with sound and expert judgment when confronted by them*". These authors argue that the study of ethics is fundamental to an engineering education. A three year study conducted by Stappenbelt [12] involving a sample of 1,136 first year engineering students revealed that almost a third of this sample did not believe that current practicing professional engineers act ethically and a similar percentage felt that it was unrealistic to expect this ethical behaviour among engineers. It is ironic to note that some of the engineering students from today might play a critical role in shaping and influencing the future economic market with their innovation and decision making skills. Stappenbelt [12] labelled his findings as alarming and recommended that more work should be done to facilitate and encourage Engineering Ethics Education and shape students' professional identities. This is one of the reasons why the familiarity and teaching of Ethics in engineering practices is highly emphasized among engineering students in Higher Education. With the rise of unethical practices in several organizations in recent times, what can be done to promote ethical familiarity and behavior among young and budding engineers? Can Higher Education curriculum adopt any specific strategy to teach and incorporate ethical practices? Authors like Jimerson, Park and Lohani [13] raise some concern over this as they feel that there are no set guidelines on effective demonstration of ethical knowledge and reasoning among students. This leads to different challenges involved with teaching ethics.

III. CHALLENGES WITH TEACHING ETHICS

Freyne, Abulencia and Draper [4] found the practice of engineering to be extremely complex with the involvement of many ethical issues. They therefore believe that "*…ethics is not an easy subject to teach…*" [pg 1]. Although Ethics

Education has been emphasized in Higher Education and the RAE, there are several challenges when it involves incorporating it in an engineering curriculum. Ocone [14, pg e116] for instance notes "*Ethics is quite new in the engineering curriculum…*". This author feels that the current state of teaching Engineering Ethics is still at an infancy stage thereby rendering it patchy and sporadic with its delivery and teaching. Comparatively, other core disciplines are much more systematic and well established.

Jimerson, Park and Lohani [13] highlight the growing concern among universities on the issue of increasing the ethical knowledge among their students and produce ethically responsible engineers or business leaders. They further explain how there are a lot of courses within an engineering programme, some with a lot of technical information. In this context, there is a risk of leaving *"….little room for students to develop professional practices that aid them to become skilful communicators, ethical decision makers, team leaders, creative thinkers, and problem solvers*" [pg 1]. Some authors like Stappenbelt [12], Steneck [15], Bauer and Adams [16] and Abaté [17] question if ethics should even be taught in Higher Education? Stappenbelt [12, pg 4] explains "*Students' professional ethics tend to be mostly an extension of their personal ethics"* which is why there should be more emphasize on facilitating ethical reasoning among engineering students rather than instructing them to be moral members of society. It is obvious that students will have some form of perception and criteria to judge a given ethical situation and make decisions. Without having the experience of a professional ethics course, their interpretation is most likely to sprout from their day-to-day experiences and understanding. This thereby can limit their capability to be competent ethical decision makers. Attending a course on ethics might refine their understanding of ethics and give a strong foundation to their ethical decision making skills. Loui's [18] study showed that one of the advantages of Ethics Education for Engineering students is its ability to reinforce their inclination to act ethically. There is however, very little research conducted on the influence Ethics Education has on the moral growth of engineering students [12, 15]. Engineering students' knowledge of ethics is difficult to determine as some "*may lack the specific language skills and perspectives to discuss characteristics of ethics and the consequences involved from choices that are made in ethical dilemmas*" [13, pg 14]. There is a degree of uncertainty and inconsistency as to how Ethics related courses can be incorporated and delivered as part of an Engineering curriculum. This study therefore, aims to investigate some of the effective methods to deliver and teach Engineering Ethics in Higher Education. It examines if Ethics Education can effectively influence the development of professional practices among students by using a case study of the MSc Engineering Management Programme at York. In order to understand the perception and prior knowledge of ethics among budding engineers, a focus group study was utilized on a group of engineering students who had not undertaken any course or programme on ethics. Are there any significant variations in the perception and judgment of ethics among students who have undertaken a course or programme on ethics? This study will help in addressing the challenges of adopting the appropriate teaching strategies for Engineering Ethics.

IV. RESEARCH METHODOLOGY

As part of a pilot study, this paper uses the example of the MSc Engineering Management programme in the University of York, United Kingdom and focuses on the mode of delivery and teaching of an Engineering Ethics session as part of its curriculum. It also utilizes two separate focus groups: One with students who had attended a prior course on Engineering Ethics and the other with students who had no prior experience on courses related to Engineering Ethics. Both groups were provided with a step-by-step case study for discussion which looked at their decision making skills under a complex ethical dilemma. The case study was designed using scenarios that students are familiar with and could easily relate to. This thereby didn't give any added benefit or advantage to students who had prior experiences on ethics module. One of the broader overall objectives of the research project is to develop a tool that could assess ethical perception and understanding of ethics among engineering students. The results from this pilot study will help progress this objective.

V. CASE STUDY

A session on Engineering Ethics is delivered each year at the University of York as part of the MSc Engineering Management Programme, Department of Electronics. This MSc programme first introduced in 2010 is the most popular postgraduate course offered in the Department of Electronics at York attracting engineering students from countries as diverse as China, India, Pakistan, Japan, Greece, Malaysia, Germany, Thailand, Saudi Arabia, Nigeria, Turkey, Kazakhstan and Indonesia. One of the highlights of this session is that it aims to familiarize students to the RAE, Statement of Ethical Principles. However, ethical codes and statements may not be sufficient to build a strong foundation on ethics or provide answers or familiarity to all the ethical areas relevant in an engineering profession which is why authors like Menzel [19] and Harris et al [20] support the use of case examples to teach ethics. Case studies have been found to be the most effective ways to understand ethical problems as it helps in the process of learning and recognizing ethical issues in day-to-day scenarios and building the necessary abilities to analyze and deal with these constructively. The ethics session taught at York therefore, puts a lot of emphasis on the use of case studies and interactive exercises. It utilizes historic cases such as the Challenger Space Shuttle (1986) or the Turkish Airlines Flight 981 (1974) to initiate and generate interest on the topic of Ethics. Examples and cases that are more current on this topic are also used to facilitate class discussion such as the Volkswagen emission scandal in 2015 or the Whistle-blowing example of Snowden in 2013. So, how do students benefit from the use of these cases? According to

Colby and Sullivan [21], discussing well known historical cases and disasters of engineering failures illustrate the essentiality of honesty, care, technical precision, potential risks when these standards are undermined and the level of danger and risk the consequences may contain. Hammond [22] and Kolodner [23] both agree on the idea that case-based teaching may provide a promising method for educating ethics, especially if the case method is based on acquiring knowledge related to the developed job experiences. There are however some arguments on the use of case studies for teaching ethics. Herreid [24] for instance, questions what make a good case study? Case based teaching approaches can also be broad and complicated. Menzel [19] concludes that the effectiveness of teaching ethics depends on the teacher and learner, whether taught as an entire stand-alone course of study or combined or embedded with other lectures, it can be effectively applied and learned when practiced in a specific manner. To understand if there were any differences in the perception and understanding of students who have undertaken a course on ethics to those who haven't, a focus group study was conducted as part of this study.

VI. FOCUS GROUP ANALYSIS

The focus group study comprised of two groups:

- Group 1: Students who have undertaken the Ethics session at York
- Group 2: Students who haven't undertaken any Ethics based course.

There were six groups in total, three in each category. All groups were provided with a step-by-step case scenario for discussion which looked at their decision making skills under a complex ethical dilemma. The case study was designed using scenarios that students are familiar with and could easily relate to. This thereby didn't give any added benefit or advantage to students who had prior experiences on an ethics module. There were six step-by-step scenarios given to the participants in the focus groups:

- An assignment is due next week on MATLAB and a significant part of it involves presenting your simulation results. One of your classmates is struggling with the simulation analysis and he comes to you asking for some help. What will you do?
- You are confident that your simulation data is 100% accurate. This student requests if he can use the simulation data from you in order to get a high score. Will this affect your previous decision?
- This student happens to be your best friend and you both have spent a lot of time studying together. On one of the previous instances, he even helped you when you were struggling with another assignment. Will this affect your decision?
- You know that this best friend of yours is recently going through some hard times with relationships/family issues and couldn't dedicate much time to do the simulation. How will this influence your earlier decisions?
- Sharing assignment data with your friends could be counted as an Academic Misconduct and could even hamper your Degree grade. It can also lead to your expulsion from University. What will you decide?
- Your best friend has recently been offered a high profile job in one of the top organizations in the UK and you have seen how hard he had to work in order to secure this job. However, you have just found out that this job is dependent on your friend getting a Distinction in his final degree. This means that he has to get a high score in this MATLAB assignment or he risks losing this job. What will you do?

The first scenario saw a majority of responses aligned towards offering some form of help in the given situation but with cautions. There were a lot of similar opinions among the focus group participants regardless of their prior experiences with an Ethics based course or module. There was a consensus among the two groups to offer help by studying together or teaching the MATLAB simulation without actually sharing the data. One of the justifications cited by some of the participants from Group 2 is that this form of help will not be counted as collusion. Some recurring themes in all the groups centered on the time needed to help or the degree of closeness to the person in the given situation.

The second scenario didn't show a vast change in opinions among the focus group participants in respect to the first scenario with a majority supporting their decision to help but without sharing their own data. One of the emerging themes here is that some participants in both groups associated their willingness to help as a condition of returning a past favor highlighting their dedication or priority of relationship and bonding over academic offences. However, in this case there was more reasoning and discussion to support their statements of not sharing their entire data with some linking this to issues like cheating, collusion, academic misconduct, ethically questionable practices or maintaining self-privacy. These are evident from some of their quotes like: "*It is like cheating*", "*That's not the correct way"*, "*To be honest is the most important thing"*, "*I can guide them on how they can do that on their own*", "*I must keep my self-privacy because the assignment is also their job, they could have done it earlier, taken their time and planned to do it!*". Participants from Group 2 particularly showed a clear awareness of the consequences of the academic misconduct in comparison to the participants from Group 1. Participants from Group 2 also highlighted that their willingness to help also depends on the reputation of the help seeker; if the person in this scenario has a reputation of not working hard then the participants cited their unwillingness to help. On the other hand, if the help seeker is known to be hard working and sincere then the

participants supported offering some form of help such as pushing them in the right direction.

The third scenario investigated how ethical opinions among the participants were influenced by their friendship bonding or closeness to the person in a given situation. A unanimous support was seen among all the participants from both groups to offer some form of help if the given situation involved a close friend. However, they were all very clear about not giving away their actual data. Some concerns were raised about how much time can be dedicated to help or whether helping a friend might influence their own performance. Overall, the decision making and ethical reasoning among the participants in both groups were very similar.

The fourth scenario gives an emotional situation for the focus group participants to evaluate. In this situation, there was mostly a consensus that no one would share the actual data. However, there were two distinct emerging themes: some wanted to offer some form of help while others wanted to stay out of it. Participants who wanted to help suggested offering advice on mitigated circumstances application, talking to a supervisor or seeing a doctor. Others highlighted the dangers of being involved in plagiarism by helping in this situation. Some even stated that the help seekers have a responsibility to do their own assignment independently instead of asking for help from others.

The fifth scenario saw some recurring themes from the previous situations of not wanting to share the whole data as a fear over academic misconduct. There were however a few participants who still showed a strong willingness to help if the situation involved a close friend. Some participants from Group 1 this time even insisted on adopting unethical practices such as changing their writing pattern or style so as not to get caught in an academic misconduct offence. Their priority here was placed on helping their close friend. Participants from Group 2 however, disagreed on this option of cheating. They felt that incorporating unethical activities such as changing the writing style or assignment layout can be easily traced or spotted by an academic marker and they wanted to keep out of such trouble.

The final scenario brought out many contrasting opinions among the participants in both groups. There were a few consistent consensuses on not wanting to help due to fear of collusion or academic misconduct. Some declined to offer help this time as they didn't want to jeopardize their degree or career. Some even argued that a student who is good enough to secure a high profile job should be smart enough to complete their academic assignment on time. However, major changes in opinions were evident more among participants from Group 2. Some supported unethical practices in order to secure financial gains, business networking or a reputed job in the given situation, *"If I could help him to get a really high mark, and then he would get the job, he would give me money, I can get profit out of it, or get knowledge, and get to meet the people he work for, get an insight of the company… Maybe, it would be interesting for me. Then yeah, I would definitely help him",* says one participant. Such opinions were not evident among the participants in Group 1 where the discussion centered more on how to offer support and help to a friend without actually being involved in any unethical practices. Some deep ethical justifications were cited by these participants as evident in some of their quotes: "*I can do something to support help him/her but I cannot cheat", "If he/she got this job by cheating in an assignment then that would not be a glorious thing for the company. He/she will regret in the future", "Higher self-ability should be learned first…I will advice my friend to inform the company about his/her scores… Self-ability cannot always be shown through your scores".*

Surprisingly, the analysis didn't show any significant variations in the perception, judgement and understanding of ethics among the participants in the two categories. The findings suggest that participants from both groups showed similar instances of ethical decision making skills on a given circumstance. In fact, the group who had no prior experience of an ethics course showed a better understanding of academic integrity and practice than the group who had. One of possible reasons could be that the participants from Group 2 have had more experience of an academic environment having spent longer time in the university than the participants from Group 1 which is why they might be more familiar to the university academic guidelines and conduct. However, participants from Group 2 were quick to change their opinions and ethical grounding on the given scenarios than participants from Group 1. This was evident particularly in the final case scenario when some participants from Group 2 contradicted their previous support of ethical practices to now favoring monetary profits, corporate networking and job security. This shows a degree of inconsistency and biasness in their decision making skills. On the other hand, participants from Group 1 mostly maintained their consistency and ethical grounding throughout these scenarios demonstrating maturity and depth in their decision making and ethical judgement. Did their experience of an ethics course in the university play a role in this or is it because these participants from Group 1 have some organizational work experience? The focus group method followed in this study suffered from few disadvantages particularly with participants' views and opinions being influenced by their peers thus introducing bias. To get a more comprehensive and definitive answer, more research needs to be carried out in these areas possibly using surveys and in-depth interviewing.

VII. Conclusion

Today there is a strong emphasis on familiarizing engineers about the standards of ethical frameworks and professional conduct within an organization. Engineering programmes in Higher Education are thereby incorporating ethics based curriculum or standalone ethics modules or courses to support and facilitate this process. Ethics education might provide several benefits to engineering students particularly at the time when the global market is witnessing a

significant rise in several high profile unethical practices in different corporate firms. It appears that Ethics education might help students frame their decision making from a more ethical grounding or basis and make critical analysis of a given situation. Such education might help students reinforce or refine their decision making skills and prepare them to manage difficult ethical dilemmas or situations encountered in an organizational career. There have not been many studies to highlight the effectiveness of such ethics based education. This study therefore looked at some of the effective ways to teach ethics to engineering students in Higher Education. It utilized the case study of the MSc Engineering Management Programme at York where a session on Engineering Ethics is delivered each year using case studies and interactive exercises.

Using focus groups, this study analyzed the differences in the perception, judgement and decision making skills among two sets of students: one who have attended an ethics based course and the other who haven't. The findings surprisingly didn't show much variations among the participants in these two groups. Participants from both groups demonstrated similar instances of ethical decision making skills on a given circumstance. The group who had no prior experience of an ethics course surprisingly showed a better understanding of academic conduct and practice than the group who had. One of possible explanations is that the participants from Group 2 have spent more time in the university than the participants from Group 1 which is why they might be more familiar to the university academic guidelines. However, one of the facts noted in this study is that participants from Group 2 had more changes in their opinions and ethical grounding on a given scenario than participants from Group 1. This shows a degree of inconsistency and bias in their decision making skills and was particularly evident in the final case scenario when some participants from Group 2 favored monetary profits and job prospects over ethical practice thereby overturning their previous support towards ethical practices. Participants from Group 1 showed more consistency and maturity in their decision making and ethical judgement. These findings do raise the obvious question: What factors influence the ethical decision making styles of engineering students? Ethics education might shape the decision making and critical evaluation skills among budding engineers. To get a more comprehensive and definitive answer in these areas, further research should be carried out. The focus group method utilized in this study suffered from a few disadvantages such as participants' decision making or opinions being influenced by their peers thus introducing bias in their judgement and some students' unwillingness to participate in the group discussion limited the diversity in their opinions. Further research could possibly benefit more from in-depth interviewing with students from different academic years to understand if their decision making and ethical reasoning changes over the course of a programme and what key factors play a role in this process?

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