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CONSIDRATION OF ENGINEERING ETHICS AS A NECESSARY ATTRIBUTE FOR PREPARING ETHICAL ENGINEERS IN PAPUA NEW GUINEA

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ABSTRACT

Unlike developing countries, interest in engineering ethics education has developed significant momentum in almost all advanced countries. The developing countries have not yet paid enough attention to such critical issues and Papua New Guinea is no different. This is probably the reason why corruption activities have become part of the normal activities of politicians, senior public servants and many other higher office holders as reported in the daily news media. As engineering work becomes more complex and diverse, an understanding of engineering ethics becomes an important attribute for adequate and ethical preparation of engineers along with their technical knowledge. This basically means that engineering students have to learn about their ethical obligations towards society, their employers, fellow engineers and themselves. This paper discusses the needs and reasons for integrating ethics into the education of undergraduate engineering students in Papua New Guinea.

Keywords: Engineering Ethics, Codes of Ethics, Professional Responsibility.

1. INTRODUCTION

Developing countries are striving to catch up with the rapid and vast development in science and technologies to develop competitive economies in the globalization era. It requires an adoption of a world-class balanced engineering program that is effective in producing highly qualified engineers and technologists in their local universities. Curriculum development for engineering programs in developing countries should be informed and guided by the state-of-the-art engineering education in advanced countries but tailored to serve local needs and constraints.

However, developing a balanced engineering curriculum is an enormous task that involves the consideration of several requirements of a graduate engineer such as the industry expectations, the expectations of the accreditation bodies and the interest of a country. Taking into considerations the requirements of industry and the accreditation bodies in the development of a balanced engineering curriculum can be accomplished by considering the inputs from industry and the accrediting professional bodies [1] [2]. However, taking into consideration the interest of a country in the design of a balanced engineering curriculum may be performed by observing the performance of the country in terms of social, economical and political behavior of the population.

It appears that advanced countries have considered ethical competency to be as important as or even more important than technical competencies. Moreover, engineering educators have become more aware of the need to address responsible and ethical behavior explicitly as part of engineering education curricula. This has led to a recent revision of the requirements of the Accreditation Board of Engineering and Technology in various advanced countries such as USA, UK, and Australia, to have acquired accreditation status only when the engineering programs have evidence that their graduates do have a clear understanding of professional and ethical responsibilities [3]. This has forced the engineering schools to foster in their students an understanding of the ethical and moral characteristics of the engineering profession and practice.

Professional engineers almost always learn ethical and moral lessons only after something has been overlooked or has gone wrong or may have done without realizing that it is unethical and morally wrong. There is no wholly adequate substitute for actual engineering experience. However, having students being aware of ethical issues such as corruption, moral values, ethical values, bribery, whistle blowing, conflict of interest, nepotism, etc. and the requirements of professional institutions like IEPNG and reflect on various realistic case studies can provide some helpful preparation for dealing with ethical and moral issues they are likely to face once they do enter engineering practice. By requiring engineering programs to introduce students to ethical and moral concerns, Accreditation Board of Engineering and Technology is taking the position that students need to begin to think about ethical and moral issues before things may go wrong. In essence, Accreditation Board of Engineering and Technology is advocating a kind of preventive ethics, which is much like preventive medicine in that one doesn't wait until

something is obviously amiss before taking appropriate action. Preventive medicine advocates good health habits as a means for minimizing the need for more serious medical intervention later. Similarly, preventive ethics attempts to anticipate possible consequences of actions in such a way that more serious problems are avoided later during practice.

Our daily news media [4] [5] reports large number of cases of unethical and immoral behavior being committed by white collar professionals including engineers such as corruption, bribery, nepotism (wantok system), conflict of interest and whistle blowing which indicate that Papua New Guinean engineers are in desperate need of preventive ethics that may assist in alleviating further more damaging ethical and moral problems that may be encountered by future engineers. Moreover, general performance and behavior of the population of the country indicates that there is a break down in ethical and moral values and requires an immediate attention if the country is to succeed economically. Therefore, it is vitally important for Papua New Guinea engineers to be made aware of ethical and moral issues such as corruption, moral values, ethical values, bribery, whistle blowing, conflict of interest, etc. and the requirements of professional institutions like IEPNG and reflect on various realistic case studies can provide some helpful preparation for dealing with ethical and moral issues they are likely to face once they do enter engineering practice. In response to this need, the Mechanical Engineering Department at the Papua New Guinea University of Technology has included a course on Ethics and Engineering in its program.

2. RELEVANT ATTRIBUTES OF ENGINEERING GRADUATES

It appears from experience that our engineering graduates tend to lack relevant attributes as desired by industry including ethical and moral behavior. These attributes comprise of technical and non-technical elements. Technical attributes are those related to engineering curriculum while non-technical attributes are mainly related to social science discipline. Technical attributes for engineering graduates are those related to the ability to design and develop a new product or process which includes: i) technical knowledge, ii) the ability to synthesize, iii) the ability to elucidate principles and iv) the ability to evaluate. Technical knowledge is the most important attribute of an engineer which consists of the natural laws and principles. The more natural laws and principles an engineer knows, the greater the choices available to him or her for devising efficient methods to achieve the desired objectives. The second most important attribute of an engineer is the ability to synthesize or combine natural laws and principles to achieve the desired objectives. The ability to elucidate is the third important attribute of an engineer. With this attribute, an engineer is able to discover underlying principles by interpreting data correctly and accurately conducting effective experiments. The fourth most important attribute of a good engineer is the ability to judge between alternative solutions and choose the best and optimum solution for a particular application.

The other attributes of a good engineer are mostly relate to social science disciplines which includes report writing ability, computer literacy, teamwork ability, management and leadership ability, problem solving ability, ability to work under pressure and meet deadlines, commitment to the job, willingness to work overtime, etc. Although these attributes may not seem to be directly related to engineering subjects, they are very relevant in the context of the current competitive business environment.

Similarly, it would be inappropriate to emphasize only on technical expertise without developing parallel engineering ethical framework to safeguard the industrialization conversion. In the absence of ethical abilities, it would certainly lead to high-profile cases of misconduct which may lead to some technical disasters caused by various factors including moral incompetence: negligence and corruption. Therefore, it is necessary for developing countries like Papua New Guinea to adopt engineering education systems that integrate ethics with technical competency and create policies that will aid in its development to eliminate or at least minimize the damaging effects of the adoption of technology on society and environment.

In practice, engineers are expected to know and behave according to professional norms set by their community. This includes evaluation of their worthiness as members of the community by colleagues, collaborators, students and trainees (they teach and mentor) and the society as a whole. It is generally assumed that trainees and students will observe what senior professionals do and follow their example. Unfortunately, modeling of good behavior does not always happen, and even when it does, it may not be sufficient because learning from the behavior of another requires interpretation, which varies from one to another [5]. Moreover, the rationale for any behavior, even exemplary one, is not always obvious, especially when problems are multifaceted and complex and choices must be made among competing interests and concerns. In short, there is more to being an engineering professional than simply being a technical expert [6]. Awareness of and respect for the professional values and standards of the community is a measure of one's standing in that community.

For these reasons, responsible and ethical engineering practices should be addressed explicitly at early stage of engineering engagement during the student's training at the university where the student's will be made to be aware of their ethical and moral responsibilities as well the expectations from their professional institutions. Moreover, as young engineers assume positions of increasing managerial importance, they will face decisions requiring judgments based on ethical reasoning. When this point of decision-making occurs, they should find comfort in a personal memory bank established during their student years---if not earlier---with guidelines for ethical personal conduct. Ethics should be an educational priority for an engineering program.

3. WHAT IS ENGINEERING ETHICS?

With the progress of professional societies, the formation of codes of ethics is becoming a necessity to avoid confusions and malpractices within the professions. Generally, ethics is concerned with what is right or wrong, good or bad, fair or unfair, responsible or irresponsible, obligatory or permissible, praiseworthy or blameworthy. It is associated with guilt, shame, indignation, resentment, empathy, compassion, and care. It is interested in character as well as conduct. It addresses matters of public policy as well as more personal matters. On the one hand, it draws strength from our social environment, established practices, law, religion, and individual conscience. On the other hand, it critically assesses each of these sources of strength. Therefore, ethics is complex and often perplexing and controversial which defies concise, clear definition. Nevertheless, it is something with which all of us have a working familiarity and it is everybody's business [7].

Particularly, one may define engineering ethics as the standards of care and values used by engineers in their daily practice of profession towards society, employer and themselves, that is often called professional responsibility that is, moral responsibility based on an individual's special knowledge. Apart from the fundamental commitment of engineers to a fundamental commitment to public health, safety, and welfare, engineering ethics is typically concerned with conflicts of interest, the integrity of data, whistle-blowing, loyalty, accountability, giving credit where due, trade secrets, and gift giving, bribes [8] and nepotism or wantok system.

Engineering ethics is the rules and standards governing the conduct of engineers in their role as professionals. It encompasses the more general definition of ethics, but applies it more specifically to situations involving engineers in their professional lives. Thus, engineering ethics is a body of philosophy indicating the ways that engineers should conduct themselves in their professional capacity. It is critical for an engineer to maintain an ethical reputation within his/her engineering career. The main principles that an engineer should work and live by are to hold paramount the safety, health, and welfare of the public, perform services only in areas of their competence, act for each employer or client as faithful agents of trustees, avoid deceptive acts, and conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession. An engineer's negligence may be assessed by measuring the engineer's actions relative to the standard of care of the profession using the five elements of the ethic of care [9]: attentiveness, responsibility, competence, responsiveness, and integrity. It is to be noted that care is identified as an ethical framework suitable to provide guidance for engineering activities [10].

4. PROFESSIONAL CODE OF ETHICS

A professional code of ethics state the principles and core values essential to the work of a particular occupational group. One of the characteristics of the professions that distinguish them from other human endeavors is the habit of developing codes of ethics to guide the actions of their members. The codes of ethics for engineers are intended as guidelines to protect the public, to build and preserve the integrity and reputation of the profession, and to describe proper relations between engineers and their employers and clients. The codes of ethics are intended to play a number of roles which may have negative and positive consequences [11]: i) inspiration and guidance, ii) support, iii) deterrence and discipline, iv) education and mutual understanding, v) contribution to the profession's public image, vi) protecting the status quo and vii) promoting business interests.

A typical code of ethics begins with general introductory section, followed by a series of fundamental statements. Then, the statements are expanded and explained as a means of providing guidance in particular situations. The Code of Ethics of Engineers, published by the Accreditation Board for Engineering and Technology (1985), begins with the following statement of fundamental principles [12]:

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

I. Using their knowledge and skill for the enhancement of human welfare;
II. Being honest and impartial, and serving with fidelity the public, their employers and clients;
III. Striving to increase the competence and prestige of the engineering profession; and
IV. Supporting the professional and technical societies of their disciplines.

Primarily, a code of ethics provides a framework for ethical judgment for a professional. Note that it is only a framework as no code can be totally comprehensive and cover all possible ethical situations that a professional engineer is likely to encounter. It may only serve as a starting point for ethical decision making and it can also express the commitment to ethical conduct shared by members of a profession. It is important to note that ethical codes do not establish new ethical principles but they simply reiterate principles and standards that are already accepted as responsible engineering practice. This is confirmed with the three key concepts being revealed when analyzing several engineering codes of ethics [13]: 1) the public interest, 2) qualities of truth, honesty, and fairness, and 3) professional performance. It can be seen that a code expresses these principles in a coherent, comprehensive, and accessible manner where it spells out the ways in which moral and ethical principles apply to professional practice. Moreover, a code of ethics helps create an environment within a profession where ethical behavior is the norm. It also serves as a guide or reminder of how to act in specific situations and also can indicate to others that the profession is seriously concerned about responsible and professional conduct.

A code of ethics developed from the basic principles of concepts would be acceptable whether it is defended from altruistic or self-improvement motives.

This code is to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment. Avoid real or perceived conflict of interest possible, and to disclose them to affected parties when they do exist. To be honest and realistic in stating claims or estimates based on available data, to reject bribery in all its forms. Improve the understanding of technology, its appropriate application, and potential consequences. Maintain and improve technical competence and undertake technological tasks for others only if qualified by training or experience, or after full discloser of pertinent limitations. Seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others. Treat fairly all persons regardless of such factors as race, religion, gender, disability, age or national origin. Avoid injuring others, their property, reputation, or employment by false or malicious action. Assist colleagues and co-workers in their professional development and to support them in following this code of ethics. It is anticipated that the development of these types of codes may provide people and officials with guidelines to establish a better corporate ethical and moral culture and to improve management. It may also minimize the risk of white collar crimes and improve ethical decision-making resulting in the promotion of high standards of practice and ethical behavior and enhances trust and respect from the general public.

5. TEACHING ETHICS AT ENGINEERING SCHOOLS

As discussed above, ethics is a framework for making value-laden choices, which basically means that ethics can be taught despite skepticism of the feasibility and legitimacy of this undertaking [14]. A central question, often asked, that raises a fundamental issue is whether or not ethics can be taught in engineering schools. This is because there is a widespread assumption that students at university level have already developed specific moral characters. Skeptics both within academy and without further argue that moral character is formed in the home, church and the community, and cannot be modified in a classroom. This may sound correct to some extent. Although, morality does need to have an early beginning in our lives, the story of moral development is anything but over once we move beyond these early years [15] [16] [17].

However, moral autonomy is the ability to think critically and independently about moral issues and to apply this moral thinking to situations that arise in the course of professional engineering practice. Teaching ethics should foster the moral autonomy of future engineers. Moreover, the various approaches described above can be explained and contrasted, and students can be challenged to apply their own moral values to cases and to learn from the experiences of others. Student engineers can be taught to think ethically and to sensitize them to important ethical issues before they have to confront them during practice.

The following should be the appropriate goals for adopting engineering ethics in engineering programs in a developing country: i) promoting the sense of responsibility; ii) increasing awareness and knowledge of professional ethical standards iii) increasing students awareness of the ethical dimensions of science and engineering; iv) providing students and trainees with experience in making and defending decisions about ethical issues; and v) helping individuals develop strategies for addressing ethical issues and identifying resources to support decisions.

Integrating ethics at all levels of education emphasizes to students and faculty that ethics is a core competency. The content of engineering ethics courses should be widening to cover as much ethical issues and related topics as possible such as ethical implications of public policy relevant to engineering (risk and product liability, sustainable development, health care, and information technology etc.). Accordingly, teaching of engineering ethics courses should cover topics such as basic concepts and methods in ethics, typical professional engineering society code of conduct, history of engineering and technology, organizational loyalty versus professional rights, engineers and the environment, risk and the engineering decision-making process, whistle blowing, and social responsibility versus legal liability [18].

There are a number of ways to present engineering ethics. Studying accidents in terms of historical case studies to analyze both ethical conduct and social implications is a traditional approach in teaching engineering ethics [19]. Developing major-specific interactive cases may help to ensure that students do not ignore the social and environment contexts of engineering while taking engineering science and technical courses. Another approach is to focus more on culturally embedded engineering practice, that is, institutional and political aspects of engineering, such as contracting, regulation, and technology transfer [20]. Knowledge of such non-technical, but nonetheless ordinary engineering practice may provide engineers with the insight to anticipate safety problems before they are escalated into technological disasters.

In order to make the teaching of engineering ethics effective program, the following characteristics have to be considered: i) Ethical issues must be addressed explicitly. Good role models are necessary but not sufficient for teaching ethical behavior and standards ; ii) interactive discussions between students, staff members and senior professionals that may provide ample opportunities for students to think through problems and cases arise in their own projects; iii) the participation of many staff members and senior professionals, demonstrating that the community as a whole values responsible behavior; iv) a focus on topics relevant to the discipline and the local ethical dilemmas; v) programs that begin early in the curriculum and continue throughout graduate and postgraduate education, demonstrating that standards within the community continue to evolve and that, with experience, students and trainees become more sophisticated in addressing complex problems; Activities that are effective in an

educational setting can be adapted for the workplace; and vi) reinforcement of professional standards and ethical and moral values through a variety of programs and activities, including courses, team meetings, informal discussions with advisors and mentors and departmental seminars.

6. PREPARATION OF STUDENTS FOR ETHICAL AND MORAL CONDUCT AT THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY (UNITECH).

There is an increase of industrial activities throughout the country and engineering is at the heart of all these technological developments. As such any decisions being made and implemented by an engineer is affecting many people, including: consumers, clients, the engineering profession, different communities, different cultures and traditions and the future generations. At the heart of any professional decision making is how the engineer defines and fulfills his or her responsibilities to all of these groups, something that professional codes can clarify but not exhaustively describe.

Therefore, Unitech engineering programs must include engineering ethics in their respective programs where students are made aware of ethical and moral issues such as corruption, moral values, ethical values, bribery, whistle blowing, conflict of interest, etc. and the requirements of professional institutions like IEPNG and reflect on various realistic case studies that can provide some helpful preparation for dealing with ethical and moral issues they are likely to face once they do enter engineering practice.

The Mechanical Engineering Department at Unitech has included a course on Ethics and Engineering (ME 303: Ethics and Engineering) in its program. The course is designed to make the students to be aware of the ethical and moral issues (corruption, moral values, ethical values, bribery, whistle blowing, conflict of interest, loyalty, confidentiality, etc) that they are likely to encounter during practice [21]. The course also covers codes of conduct and the requirements of professional institutions like IEPNG, IMechE, ASME and IEAust. emphasizing that principles are ethical and moral standards that define good behavior. These principles are the tools by which engineers can know they are doing the right thing in the right way. Engineers who work by these principles will build a strong practice, based on professional excellence. Principles underlie laws and societal values such as show respect for individuals and their property, help others, do not cause harm to others, conserve our environment and being honest at all times.

One of the effective methods that have been used to teach engineering ethics is the use of real life case studies such as mining companies dumping mine waste into the rivers, developing huge dams for hydro power generation, dumping palm oil factory waste into the rivers etc. The use of case studies has been found to be successful for students in understanding engineering problems on related ethical issues. This is due to the fact that ethical inquiry begins with problems that professionals can expect to have to face. This is in contrast to beginning at a highly theoretical level and only later considering how rather general principles and rules might apply to actual situations. By beginning with realistic cases, students have been able to immediately appreciate the relevance and importance of giving serious thoughts to ethics and morality.

Other avenues for ethical and moral development of students being provided by the university on campus include student counseling services, promotion of religious activities such as Tertiary Students Christian Fellowship (TSCF), church services, rallies etc., inviting prominent religious leaders for open lectures to the student population and the university community. The student body is being encouraged to participate in these extra curricula activities that will strengthen their ethical and moral development.

It is of paramount importance that the university community (SEM, HODs, departmental staff - both academic and support, etc.) must create the environment that is conducive to ethical and moral conduct if our graduates are to be ethical and moral. It must be the responsibility of the university community to instill ethical and moral values to the students by being role models on campus. Ethics and morality must be seen as a core value and an ethical environment as fundamental. Note that academic and support staff who are in direct contact with students must “walk the talk”, by initiating and supporting an ethics program that develops, maintains and enhances the ethical work and study environment for students. In addition, the due diligence of faculty and individual staff can be used to show appropriate public accountability in the event of an unanticipated ethics incident or crisis.

7. CONCLUSIONS

It is evident that high quality engineering education is a key ingredient required by developing countries as they strive to develop their economies to allow for effective entry into the global marketplace. Moreover, quality engineering education is vital for effective exploitation of rich natural resources in a developing country like Papua New Guinea. In these countries, teaching of ethics to engineering students have to be considered as part of a strategy for building engineering capacity to secure sustainable development and betterment of the human conditions. Special programs have to be adopted to bring engineering ethics to the mainstream of education with teaching aiming at implantation of professional responsibility and standards of care in daily engineering practices towards employer, society and environment. It is vital for engineering schools to consider various mechanisms that will ensure effectiveness of engineering ethics programs such as interactive discussions, seminars and reviewing of real life case studies of corruption, disasters, etc.

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