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Ethical Issues in Engineering Education Controlling Innovation and Technology

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Abstract

Engineers design and create products and processes to improve safety, health and welfare of the public in the performance of their professional duties. This definition was partly given by the Accreditation Board for Engineering and Technology (ABET) to substantiate ethics and professionalism engineers have to have. However, in doing the first part, engineers should give paramount importance to ethics to create products to improve food production, shelter construction to make them rugged, more reliable and longer service life. They should focus and enhance methods of energy production to make it inexpensive, transportation safer and faster, health conditions excellent for living and last but not the least protection against natural and manmade calamities. Although all of this is a long shot but they are becoming realities from once dreamed of in myth and scientific fiction. The handle to the process is newer innovations overtaking the older. Ethically, people are looking for tough and reliable gadgets which compare with older generation gadgets and which are smart enough to stay that way. Ideas that move the technological market are full of iffy claims vs. Iron–Clad Guarantees. The ethical meanings of precise simple, low cost, efficient, maximize and replace are shady. Most of the innovations in modern expositions are mainly based on wireless technology such as ultrasonic level transmitters, radar level transmitters, tank cleaning monitors and such advanced medical radio frequency identification devices (RFID) and applications. However, all such technologies do not specify the range of wireless systems they use, thus, violating a primary ethical proof that they can do their job. None of the luxury car manuals tell us that if it has a power window it would not open when the car is sunk or standing in flood. The most alarming thing is that we are still not doing or teaching a thing about our environment, and wish to live in a culture of insensitivity. Engineers have now produced nano-bio convergence but have ceased to learn about energy, cost efficiency and green engineering strategies. This can only happen when materials engineer work with chemical and electrical engineers. In this paper we will discuss consequences of above and describe proactive approaches using independent research fields, now highlighting potential risks and achieved goals. It is aimed to deduce how these goals can be achieved via educational solutions in various applications.

1. Introduction

For the future, the nation will need a whole generation with inherent innovation skills, and a workforce equipped with more than literacy in reading, mathematics and science. Down the road we need a workforce with the capacities of creative thinking and thriving for a ethically sound collaborative culture. If our goal is a research rich learning environment or one that is interdisciplinary, it means that all students should have meaningful experience in ethical training in a STEM or Engineering classroom in every campus. These ethical issues in engineering are, all latently there, inculcated in public policies and new technologies and what's coming out of academia. For example, it is well known that new ethics rules are placed in action in the Capital every year, yet large lavish parties are thrown 'on the concepts to educate people on….' by the lobbyst's at the tax payer's expense, to show off lobby'st Christmas. This shows that art of circumventing ethical rules is in our nature. Engineers face a similar situation at every step of their life. Making improvements in every course by engineering and science professors, with an opening session of ethical responsiblities in that subject, will lead to academic change of better awareness and a clear vision of the future of the entrepreneurial spirit in students and the institution. Done effectively and efficiently it helps students achieve proficiency in those basic and lifelong learning skills that transcends specific job training needed by the workplace. Now focus of smooth safe and secure processes is dedicated to minimize costs by keeping engineers and processes safe. This paper intends to be a catalyst for continuous improvement[1] at a faster rate than is ongoing. Civic knowledge and engagement are not a concern, but ethical reasoning and action would be the core purpose in these pages.

2. Drivers of Change

To achieve excellence in engineering learning and instruction today's engineers not only need to acquire all the skills of the predecessors but have to understand many more and in broader areas. Faculty's weakness in engineering practice causes a sizeable breach between the lessons taught in school and what employers and customers expect from graduating engineers. Engineers design and create products and processes to improve safety, health and welfare of the public in the performance of their professional duties. This definition was given by the Accreditation Board for Engineering and Technology (ABET) to substantiate ethics and professionalism engineers have to have. However, in doing the first part, engineers should give paramount importance to ethics to create products to improve food production, shelter construction to make them rugged, more reliable and longer service life. They should focus and enhance methods of energy production to make it inexpensive, transportation safer and faster, health conditions excellent for living and last but not the least protection against natural and manmade calamities. These imperatives strongly influence how a 21^{st} Century engineer should be educated, which means that a modern engineer requires a totally different kind of education than giving him just the basic knowledge available in most engineering schools. In every field, newer commercial implementations need new training in ethics before developing the applications for global and distributed geographies. For the past few decades most computer users in the test measurement and analysis fields have been trying and relying on the File Transfer Protocol (FTP) over Transmission Control Protocol (TCP), but TCP though reliable requires an acknowledgement and produces long round trip time as well as possibility of infiltration when in wireless mode or cyber space. This should be as much a topic of ethics in computer communication and engineering field but also in computer science education in cyber security.

Research shows that the supply of materials and research workers in U.S Mechanical Engineering is slipping since 1999, a finding released in a 2 page brief "Benchmarking the competitiveness of the United States in Mechanical Engineering Basic Research" published in October 2007 by the National Academies, Washington, DC [www.nas.edu]. The handle to the process is, newer innovations overtaking the older and materials engineers working with chemical and electrical engineers. Ethically, people are looking for tough and reliable gadgets which compare with older generation gadgets and which are smart enough to stay that way. Ideas that move the technological market are full of iffy claims vs. iron–clad Guarantees. The ethical meanings of precise, simple, low cost, efficient, maximize and replace are shady. Toys can now offer some valuable lessons to the design professionals. We are lucky that United Nations Framework Convention on Climate Change, Dec.13-14, 2007, in Bali, Indonesia has got U.S., China, India and the European Union agreeing to produce within two years a really significant program to offset greenhouse gases. This would also affect civil and environmental engineering students to create a "Crash" program to slash greenhouse gas emissions and how to offset the consequences of global warming, including regional droughts and eroding and submerging coastlines. For the last three years people accepted the results of global warming and the technologies are already there, but the government and education systems have yet to make a solid commitment. Another identical scenario is automatic transportation on highways. This mode of driving has to be supplemented with manual steering in the downtown, the old fashioned way. We have been seeing this idea floating since 2002 [2], but did not see commuting in auto-pilot mode. Ethically, engineers should be aware that none of the luxury car manuals tell us that if it has a power window it would not open when the car is sunk or standing in flood. Same thing will happen with its computer system, used for automatic transportation systems.

We know most of the innovations in modern electronics are mainly based on wireless technology such as ultrasonic level transmitters, radar level transmitters, tank cleaning monitors and such advanced medical radio frequency identification devices (RFID) and applications. However, though micro-relays and antennas have miniaturized all such technologies, these do not specify the range of wireless systems they use, thus, violating a primary ethical proof that they can do their job. In the wireless licensing rules there are not many rules for limited range and large range transmissions needed in medical fields. These things have to be taught in Electrical Engineering schools and incorporated before choosing an appropriate application and its technical considerations. Similarly in the field of biology and science, there are stem cells, which have been proved to regenerate new cells to repair pancreas and produce insulin but ethically the research in these fields are said to be wrong because these beliefs occupy the White House and its surroundings. There are many ethical questions that can be brought from the road of biology to materials. Bulk DNA can be purified from cultured organisms, including bacteria, yeast and mammalian or plant cells by physically breaking down the cells via mechanical disruption and or enzymatic digestion. DNA is now treated like a polymeric material and soon it can be used to construct novel materials. One of the good use that DNA can be attached to a surface via non-covalent or covalent bonds. This has allowed people to grow nano-scale arrays or scaffolds, but as a wild guess may be helping researchers to grow a finger on the nose to pick ones. Only saving grace in our technologically advanced country is that the press in this country is still free to report researchers who do such researches.

3. Philosophical affiliation

We have to make dramatic changes to stay on the cutting edge of technologies and markets that are of crucial importance to our core audience, students, researchers, engineers, engineering managers and program managers who serve bio-medical, electronics and electro-optics industries. The popularity of ethics is partly due to its long history and thus it is a well developed method of philosophical reflection of its practitioners from a country to country perspective. However, since global relations are developing faster than imagined, to sharing of knowledge, patent and outsourcing, people have unknowingly started trusting its answers without judging the consequences. Philosophically, it starts with the use of moral schemes in decision making. Getting the best out of an outsourcing negotiation means carefully setting benchmarks, and negotiating the relationship with the players so that the goals and timelines of the contract are met. Although one can nurture their vision next, it is known that with outsourcing you do not have to perform certain basic business functions. However, someone has to supervise your outsource and that someone is you or your firm. Ethically all engineering projects are social experiments that generate both new rewards and risks and engineers share the responsibilities for creating best of benefits, preventing harm and pointing out if there are any existing dangers. China has many times taken matters in its own hand in copying some of our beautifully engineered software. Any upcoming new innovation has been visualized as potential risk since the discovery of steam engine by James Watt to Apollo spacecraft, when on July 20, 1969; Neil Armstrong took the first human steps on the moon. Its alleviation has still not permeated to accident produced by human errors say due to drinking. This is not uncommon in NASA astronauts. Moral values of using a new technology in society permeate all aspects of technological development and hence ethics and excellence in engineering go together. Ninety-eight percent of the electricity produced in the United States comes from non-renewable sources such as polluting fossil fuels and nuclear power. These resources are used every time we turn on a light, vacuum the house, and even iron our clothes. Along with electricity, coal burning (~20 lb/hr); gasoline fueled vehicles and propane come many environmental and economical issues. The issue that draws attention is the issue of gasoline fueled vehicles in relation to the economy and environmental safety. Solar power was and still is being partially used as a direct renewable energy source. It was not used by mechanical systems until recently, but gradually it will. Google Corporation has invested in a big way to launch solar cells to help build society's confidence and trust in new innovations. Stanford has introduced thin film and organic solar cell research in engineering disciplines to install trust in the nano-community [3]. Over the last few months a large number of national groups have taken initiative in producing a 'responsible nano ethical code' with a steering group involving industries, academia and governments from Germany, The Netherlands and the USA. This will remove distrust of new technology and produce rapid advances in many fields. The public would feel that nanotechnologies act responsibly when developing and producing products and that they balance our economic needs with health, safety, environmental, social and ethical implications.

4. Ethical principles of economical design

It is well known that any work of engineering has implications for helping or harming living creatures and for diminishing the quality of life on earth or any other planet [4]. These implications are called ethical principles in engineering. Whenever a beautifully engineered, economical design is produced, highly skilled engineers look for order, system integration and interrelationships. All such engineering reasoning leads somewhere to implications or has ethical consequences. To yield a, critically thought, sound design one needs to: a) Evaluate the implications and consequences that follow from his/her test data and reasoning. b) Search for all, negative as well as positive implications involved in variety of ways the device can be used (technical, social, environmental, financial and ethical). c) Consider all possible implications in securing, disposing of the resources, and its sustainability.

Thus, the properly trained engineer is concerned with the ethical implications of engineering discoveries and innovations and the potential for engineering for both good and evil ideas. In every aspects of design ethical use of design principles should be taught apart from the technical ideas of low cost high efficacy design. Yang suggested that administrators of innovative programs of a multi-disciplinary nature [5] should examine the knowledge acquisition and transfer process. Every individual faculty member involved in the process should enhance their education background and knowledge by: (i) Attending professional conferences and seminars, (ii) Collaborating with major research institutions and centers, (iii) Engaging in curricular revision activities, (iv) Developing and offering topical workshops and (v) Interacting with students via classroom teaching and research.

The knowledge and preparation experience acquired through these 'think out of the box' activities and mentoring can then be transferred to students by imparting regular classes or workshops, as well as via publications.

5. Partnership

One truism about ethical education is that many valuable endeavors can be started and implemented in numerous areas of STEM and general education by informing all areas of the campus higher education community. The partnership programs can consist of three segments: classroom/laboratory using a number of hands-on activities; follow up activities at the middle school/junior high school level in science talent expositions; and reinforcing these ethical principles in summer institutes, and freshman orientations in engineering with concepts of creative thinking. In this paper we will discuss typical cases of above and describe proactive approaches using independent research fields, now highlighting potential risks and achieved goals. It is aimed to deduce how these goals can be achieved via educational solutions in various applications. We can devise 'hands on' activities enhancing learning experiences in the region of solar power. Solar power can be used to generate electricity using solar cells, one can also generate electricity using thermo-electric power devices, generate electricity using solar towers, wind powered plants and heat buildings directly, through heat pumps, and through solar ovens. Solar cells are often used to power batteries, as most other applications would require a secondary energy source, but not commonly to cope with outages, especially hurricanes. Every building has to be supported, or should have an auxiliary power plant to support their communication (+computer) system and minor power requirements up to 1 KW. Similarly, another experience in cyber security can be provided by elaborating that the personal meaning and commitments matter in engineering ethics- such as use of web and principles of philosophical responsibility (as internet never forgets) is incumbent on all engineers. In such issues and associated systems, for all types of ethical dilemmas moral values naturally shift from fear to curiosity. This is where the given nature of existing program offerings can be modified, especially in capstone and senior design projects. Testing by itself a prototype will not enhance the strategy for educational improvement, but is a vague call for better innovation.

6. Educational solutions and conclusions

This paper has identified and elaborated on several areas that should provoke serious thought within community scholars and suggested methods of developing and administering programs to meet the changing needs but the most important and easiest part is finding a useful topic of discussion and report writing on the first day of class to elaborate ethics related reasoning as a homework in freshman classes. In every class where design and innovative technology is introduced this can be made a group project and should also be graded by the contemporary groups to spread the knowledge amongst each other. These groups can reorient and change their participatory responsibilities after every fortnight to thoroughly understand their ethical responsibilities in doing a certain innovation. Even if this process is followed in all higher classes and in middle or junior high, it will prepare them for the real world. Till our college curriculum is fragmented and incoherent, and newer research fields are being developed, it is linked to all disciplines for educational coherence. Till now our education system is resistant to change and feeling complacent in introducing ethics as a required course is evident but the evidence is mounting that many of the innovations urge a new commitment to ethical issues. Ethical findings should be introduced in every subject and in all parts of post secondary education especially in students from less advantaged backgrounds, because they are not exposed to more powerful hi-tech innovations. Modified educational objectives should be set to test their critical thinking faculty. If our alumni take four or five students as mentees and each mentee has four or five mentors every student can have a strong dialog on ethical questions in a way of active engineering training. Since science and engineering have basic principles of truth loosely adhered to in practice, it is found that innovation is independent of scientist's or engineer's personal and political proclivities. It would be timely to realize how ethical rules are evolved in introducing every new technology. Scientists would continue to collaborate and cooperate pretty much regardless of ethical, geographical and political boundaries – a symbol of and impetus for the breaking down of such barriers.

7. References:

1. Wm A. Wulf and George M. C. Fisher "A makeover for Engineering Education", http://www.nap.edu/issues/18.3/p wulf.html.
2. T. K. Grose, "Down the Road", ASEE Prism, Vol. 21, March 2002, p.20.
3. M. Pitkethly, "Seeking a nano code", Nano today, Vol.2, No.6, p. 6.
4. R. Paul , R. Niewoehner and L. Elder, "Thinkers Guide to Engineering Reasoning", Foundation of Critical Thinking Press, p.44, 2007.
5. A. Yang, "Computer Security and Impact on Computer Education", The Journal of Computing in Small Colleges, Vol.16, Issue 4, April, 2001.

Response to the Reviewer's Comments:

I appreciate fully the comments of the learned referee. However, I agree to disagree partially with his/her observations. This is due mainly to the title and the scope of the paper, "Ethical Issues in Engineering Education Controlling Innovation and Technology." It provides methods of acting ethically in all engineering efforts, but does not specifically go to the premise of turning out 100% ethical engineer. It suggests processes which tend to govern ethically sound researches and new innovations of modern technology. It is not consumer preference but commitment to excellence in moral values that govern ethical use of technology. Let us presume a critically thought sound design follows from ethical values. As an example, ethical responsibility of producing a well designed plastic ball pen will be that it should have a strong transparent body with a semi transparent refill inside so that people would easily figure out when it is running out of ink in a critical moment, or it is going to work longer. It should be biodegradable with no color or dyes harmful to human digestive system. Most of them, however, can give you the pleasant surprise of being empty when you need them most.

I have rigorously followed suggestion of taking bullets out of the paper and explained in the narrative some more on ethical responsibilities and how to foster them. It would be nice to elaborate on active engineering but I thought more philosophical than educational expansion of the term is needed. Thanking you gratefully.

Author