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Engineering ethics and professionalism education for a global practice

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ABSTRACT

Engineering practice today has no geographical boundaries. When considering global challenges shared by all humans, collaboration between engineers around the globe becomes a requirement for the success of any proposed solution. Therefore, globally competent engineers are critical and needed in huge numbers to lead such collaborations. Nevertheless, preparing globally competent engineers requires equipping them with a solid and relevant technical base, coupled with a thorough and robust engineering ethics and professionalism understanding, which will allow them to quickly understand the human, societal, and local context of their practice, adapt to unexpected situations, and lead improvements and innovations. This set of skills in engineering, also known in the literature as soft or professional skills, falls within the area of engineering ethics and professionalism, which make up the umbrella covering all the qualitative and evolving aspects of engineering education and practice, and needed for leadership. These same aspects are prominently emphasized by accreditation standards for engineering education programs, like the accreditation criteria produced by ABET.

Literature includes many reports investigating the different issues related to global practice of engineering as well as attempts to formulate lists of attributes of a competent global engineer. The majority of these reports include common themes related to understanding and including the human and local context while practicing engineering, as well as the tools to handle this context gathered under the leadership skillset. A major reason is because most barriers to success in international engineering practice belong to this qualitative side of engineering and the context of practice.

This paper will discuss and summarize the common themes related to engineering ethics and professionalism education, for a global practice and leadership, and provide recommendations on the best practices to incorporate or update these themes in engineering education, based on multiple sources including the author's own research and findings.

Keywords: Global engineering practice, Engineering ethics and professionalism, Engineering globalization

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INTRODUCTION

Engineering solutions are humanity's way of facing the continuous stream of various global challenges. To succeed and continue, grand engineering endeavors necessitate global collaboration. The international space lab is a good example of this global collaboration. After all, humans share the globe, with its pool of resources and concerns. These facts have revealed that engineering is a global activity and that engineers are global citizens. The National Academy of Engineers (NAE) in the US has come up with a list of 14 globally shared grand challenges.[1] Such a list helps highlight the larger context and scope of engineering activities, which dictate a change in engineering training and practice, providing opportunities for engineering professionals to become leaders of innovation and improvement of human life around the globe.

Globalization and intercultural relations are not new concepts. Since the dawn of history humans have dealt across geographical regions, particularly within the frame of trade activities. International engineering projects and activities have also been ongoing for a long time, as part of the trade framework. Exploration, extraction, and processing of natural resources, like petroleum, have been long standing activities on an international scale. However, when the interaction and effect of these activities with human lives and societies increased multifold in scale, ethics and professionalism surfaced as critical elements for engineering to continue and succeed. The scale and magnitude of sobering examples showing the impact of engineering on society and human lives, positive or negative, provided compelling reasons towards the need for integrating ethics and professionalism into any engineering practice or endeavor.[2] Engineering today is not just borderless, but it actually is influencing every individual human life each in a unique way. Consequently, ethics and professionalism become increasingly vital to engineering leadership and to engineers citizenship of the globe, to ensure a continuing positive and beneficial direction of its influence on society and human lives, as it has always been intended, and to ensure continuous respect and support of the public for the engineering profession itself. The different aspects of engineering which are influenced by globalization are presented in Figure 1, where engineers, engineering educators, and the engineering profession as a whole, are parts of this continuous dynamic, and interrelated, interaction and evolution.

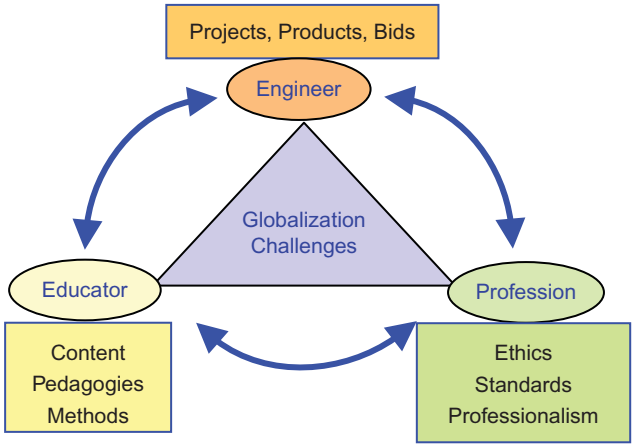

Figure 1. Dynamics of the interaction and evolution between different aspects of engineering and globalization.

RESEARCH QUEST

To maintain a healthy economy, the competitive edge of engineering should be preserved and improved by upgrading engineering education to incorporate the global dimension.[3] Action has been called upon towards developing higher standards for professional skills education and higher metrics to measure and evaluate these skills within the engineering education system.[4] This mandates an improved preparation of a globally competent engineer at the education level and a continuous upgrade of the engineers' skills, at the professional development level.[5] In addition to international recognition of their qualifications, engineers need the ability to function in different technical, social, and cultural setting.[2,3,6] Figure 2 illustrates the different elements needed in engineering education to

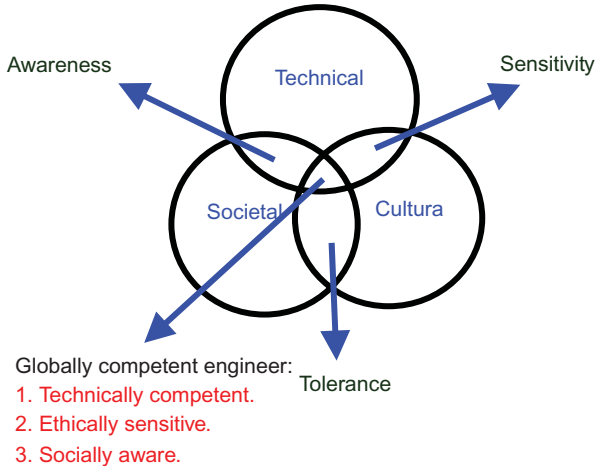

Figure 2. Fundamental elements needed in engineering education to produce a globally competent engineer and a professional leader.

produce a globally competent engineer and the overlapping relations between these elements. In fact, most of the issues related to global engineering are focused around understanding and including the human and local context while practicing engineering, which in turn requires specific skills, categorized under the umbrella of leadership skills, or more specifically what is known as ethics and professionalism skills. The context of practice, stemming from human relations, societal impact, and cultural compatibility, includes most of the challenges to global engineering success. This paper provides a closer look into this side of engineering education and practice within the following framework:

1. *Research problem statement:* What is needed to upgrade engineering ethics and professionalism education to produce a globally competent engineer and leader? What is it that has been done and how can it be improved?
2. *Research methods:* Mixed methods are implemented to produce both quantitative and qualitative results from archival information in the literature, reports by peer educators, and educational institutions, as well as a survey of engineering upper level students, graduate students, practitioners, managers, and educators. A holistic analysis of findings is conducted to arrive at the conclusions and recommendations.

LITERATURE REVIEW

An increasing number of engineering schools and universities are stressing the value of global citizenship amongst their graduates. These schools are calling for their graduates to be skilled in communication and trained to be innovative leaders of international teams.[7] The literature includes many reports of efforts emphasizing the need for a globally competent engineer and the competitive edge this competency brings to engineering graduates and professionals.[1,2,3,7] To this effect, many literature reports have investigated, and identified, the needed skills for a globally competent engineer. These skills include competent levels in: 1) technical knowledge, 2) information technology and related tools, 3) communication, 4) continuous learning and initiation ability, 5) individual and team functioning compatibility. Other reports investigated these needed skills closely and revealed a direct relationship between ethics and professional skills within ABET accreditation criteria from one side, and leadership from the other side.[7,9] Some publications went as deep as defining and articulating the challenges facing a global engineer per each ABET criteria corresponding to leadership, and in turn corresponding to ethics and professionalism elements. As a result, opportunities were identified and different approaches were designed to improve the engineering education content and process, capitalizing on this direct correspondence between ABET requirements from one side, and ethics and professionalism required skills for global competency from the opposing side.[8,10,11] Moreover, traditional challenges related to adding content or pedagogy to an engineering curriculum, at capacity, were also discussed, accompanied by data of effectiveness assessment and rationale for the selected approach and the detailed methods.[2,10,12,13]

One popular approach is to add specialized modules, courses, and exercises, as supplemental materials distributed in a scaffold arrangement throughout the curriculum.[2,6] A more difficult approach is to integrate hands-on experiential components (e.g. study abroad, international project teams, etc.) into the required engineering courses.[7,9] A combination of both approaches has also been reported but with less frequency because of the challenges associated with its implementation.[10,11] In an attempt to achieve a root solution to the ethics and professionalism globalization strong variation problem, many efforts have been reported towards building a global engineering ethics code. Examination of engineering codes of ethics in various countries around the world has revealed that while similarities and differences can be identified, sociopolitical and cultural differences are the main cause of variation where the prevailing morality of each relevant society dominates its code of ethics, although it is meant to govern engineering professionals.[14,15]

SURVEY RESULTS

To better understand what is needed for upgrading the global competency of engineers, an ongoing survey is conducted by the author, in the US amongst domestic engineers, investigating knowledge and perception of ethical and professional when practicing globally. Results from the survey were reported previously,[2] with more results reported here. The surveyed population, of a sample size over 150, consisted mainly of practicing engineers (50%), senior engineering students (40%), and engineering professors (10%). There were no significant differences between the subpopulations regarding the general findings. Three themes were targeted by the survey questions as follows: 1) knowledge of universal vs. local engineering ethics concepts, 2) knowledge of other engineering ethics in the world and how these local engineers calibrate their ethical standards relative to it, and 3) thoughts on the most important skill for success in their career globally.

Respondents of the survey provided minor differentiation between local and universal ethical standards, without any pattern to the answers. The respondents ranked three values as top universally, and thought they are a major strength in their own education, which they can share with the world, as follows: 1) concern for public health and safety, 2) honesty and integrity, 3) knowledge of environmental issues. According to the respondents: awareness of other cultures, concern for natural resources, and efficiency, were highly ranked as weakness points among the ethical values acquired by engineers within the US education system. Communication and technical competence were the highest ranked skills by these engineers as needed for global success.

These findings revealed that the surveyed engineers had some frame of reference and sporadic previous knowledge that was probably gained through formal college education or practical experience in the field mixed with media sources. Similar findings were reported in the literature, confirming this survey, and collectively pointing at a disparately needed engineering education improvement for global competitiveness.[6,13]

DISCUSSION

Looking closely at the skills needed for a globally competent engineer, it is evident that ethics and professionalism, which are the essence of leadership, are the most dominantly needed elements in educating engineers with a global vision. This targeted skillset can actually be extracted directly from the ABET accreditation criteria for engineering programs outcomes as follows:[8]

1. d - An ability to function on multidisciplinary teams.
2. f - An understanding of professional and ethical responsibility.
3. g - An ability to communicate effectively.
4. h - The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
5. i - A recognition of the need for, and an ability to engage in life-long learning.
6. j - A knowledge of contemporary issues

This portion formulates more than 50% of the ABET engineering outcomes entire criteria, explicitly stating a requirement of understanding and recognizing the needed skills for a competent engineer to in a global human context. To capitalize on this requirement, “understanding” has to upgrade to the level of “application.” Finding ways to train engineers on implementing this understanding in their professional tasks would alleviate significant amounts of barriers towards global engineering. The literature has many examples of methods to add supplemental material to the required curriculum and

achieve the required understanding. An upgrade is through experiential learning integration into the curriculum including examples like: forming multi-national teams working together to train engineers on considering the other point of view, particularly if it carries a societal or cultural aspect with it. A local engineer usually has a better understanding of the locality and henceforth can have an enlightening opinion in different quests. Another example is study-abroad or work-abroad, particularly if it is a credited activity within the degree, where the engineering student gets to experience immersion in cultural differences first hand.

Engineers can be equipped with a basic set of common-sense concepts when dealing outside home, which are universally acceptance, to compete globally. This set includes the following elements:

1. *Ethical codes are intended to apply globally*. Changing the locality does not release the engineer from professional responsibility, including environment protection and resource preservation.
2. *One's values do not apply to all cultures*. Respect for cultural norms and laws, and avoiding moral judgment (moral relativism, laxism, and rigorism), are keys to success.
3. *Preserve and promote human health and welfare*, as well as the legitimate background institutions of the host society.
4. *Practices of the host country should be always chosen* when practices compete.
5. *Ethical and legal liability should be global*. Avoid exploitation, paternalism, and bribery. Check on the concept of gifts within the locality of practice.

Most of the instructional material and experiences in engineering education relating to ethics and professionalism are national or local in nature, with very few international elements. This fact applies also to professional codes of ethics for a particular geographical region or country. Therefore, it is not a surprise that when surveying engineers knowledge in this regard, most of the skills and values ranked as important elements for global success are usually limited by a locality and include very few signs of recognition of the effect of different socio-political and cultural settings on the success of engineers.

An ideal solution for many of these problems would have been achieved through establishing and approving an international code of engineering ethics. However, this is currently a highly challenged issue, which in turn, presents an opportunity to work in small steps toward achieving this goal in the future, capitalizing on globalization of engineering and the growing need for such a governing agreement. Meanwhile, awareness of these differences and understanding how to deal with them, and lead through them, would be the key for engineers to succeed.

CONCLUSION AND RECOMMENDATIONS

This research was carried out to investigate what has been done and what can be improved towards identifying what is needed to upgrade engineering ethics and professionalism education to produce a globally competent engineer and leader. The outcomes of this work can be summarized in the following themes:

1. Engineering leadership requires global awareness. Ethics and professionalism are the crucial elements for this leadership. As most of the engineering globalization challenges stem from the human context and societal impact, proper training and education that focus on upgrading ethics and professionalism in engineering is critical for success and continuous accreditation.
2. Global thinking and understanding requires training. Many approaches can be used, but a combination of instructional material, and an experiential component, integrated in the required curriculum, would be the recommended most effective approach. This will help them in developing competency and confidence in their ability to practice engineering globally.
3. There are basic common-sense concepts shared, accepted, and applied universally, which can be integrated in engineering education and expended globally. Ultimately, a universal engineering code of ethics can alleviate most of the challenges and issues related to engineering globalization. Capitalizing on globalization will help the small steps currently taken in this direction.
4. Continuous Professional Development (CPD) is a key element to the success and evolution of professionals and their profession. Evolution and improvement should not stop at education content and process, but should be a requirement and norm, integrated into the engineering profession: licensure, degrees, accreditation, education, and professional codes of ethics. As an example: faculty expertise of professional practice should be increased with a stipulation that accreditation should address metrics encouraging the increase of proportion of practice-experienced faculty.[4]

5. Globalization can weaken us, but can also be a great opportunity for engineers to excel, remove human conflicts, and increase chances for peace and justice.

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