FORMATION OF ENGINEERS IN ISLAMIC COUNTRIES - ENHANCING ENGINEERING GRADUATE ATTRIBUTES

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ABSTRACT

There has been a good number of national and international initiatives on the formation of engineers in order to ensure that engineering graduates are suitable and relevant to the modern market place. It is important to study these initiatives in an effort to develop a wholesome approach to engineering education and training in Islamic countries. Engineering graduate attributes for Islamic countries must be developed in order to produce engineers which can assist these countries in their economic development efforts, as well as to enable the engineers to compete in the international market. The Federation of Engineering Institutions of Islamic Countries (FEIIC) has proposed two projects to this end; the Engineering Qualification, Accreditation and Professional System (EQAPS) and the International Engineering Center (IEC) project to assist in this noble effort.

INTRODUCTION

For a total population of some 1.5 billion people and at an ideal ratio of one engineer per 100 people in a country, Islamic countries should have a total of 15 million engineers to sustain its physical and economic development programmes and in order to be competitive in this globalised world. The total number of engineers in Islamic countries is much smaller. Even the World Federation of Engineering Organisations (WFEO) can speak of representing one million engineers only. Yet engineers are important and known to have a major role in making life more sustainable in the world today. Engineering professionals in the regular performance of their duties are improving our standard of living, generating wealth and sustaining the environment; building homes, buildings and bridges, supply water, energy and telecommunications, manufacture and produce machineries, transportation systems, equipments and appliances.

Education and training of engineers however fall short of our present day requirement, both in terms of quantity as well as quality. While the more advanced countries can pride themselves of having the requisite number and quality of engineers, the majority of nations across the globe suffer from a lack of qualified engineers to support their economic and physical development programmes. At the same time, the advanced nations are able to enjoy the presence of prestigious engineering schools producing top class engineering graduates as well as a high number of engineering doctorates to support their research and development endeavour.

This happens while the education and training of engineers in developing nations remain lacking in breadth as much as they are short of depth. They are not as scientifically and technically competitive as their counterparts from the more advanced countries, and also lack the communication, networking, management, business and other skills which makes a modern engineer today.

Various initiatives have been taken to improve engineering education and training in many countries of the world. Interest towards accreditation, international benchmarking and mutual recognition of qualifications has encouraged continuous quality improvement efforts in many engineering schools today. The emphasis on the outcome based education has resulted in a clearer definition and assessment of learning outcomes. At the same time the learning outcomes of engineering graduates are now more wholesome and relevant to the complex environment that engineering graduates find themselves in the engineering workplace today.

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Since its humble beginnings when the engineering profession was largely involved in developing infrastructure, producing machines and generating power, the profession has grown by leaps and bounds, engaging in activities which are far beyond the original definition of engineering. Engineers who used to be largely involved in traditional construction, production and manufacturing and in areas closely related to national economic and physical development are now involved in the biotechnology, nanotechnology, aerospace, health and even finance and banking sectors.

Engineers are also actively involved in politics, with countries which place high importance to infrastructural development like China having a large number of its top political leadership positions being held by engineers. The current Prime Minister of China and President of Iran are engineers. And a good number of engineers are well accepted in banking and finance because of their strong analytical skills.

With the strong emphasis on capacity building nowadays and with many countries aiming to be become education hubs, a large number of engineers are involved in education and training, graduating students with the engineering certificate, diploma, degree as well as postgraduate qualifications. Engineering teachers or lecturers are important members of the engineering fraternity, contributing towards the education and training of engineers, engineering technologists and technicians as well as contributing towards research. Engineers are also required in continuing professional development (CPD) programmes. For the more advanced countries, an equally large number of engineers are involved in research and development, working hard to be at the forefront of technology and in support of stiff international business competition.

Today engineers are called upon to attend to newer areas such as natural and man-made disaster mitigation and related reconstruction work. Engineers are involved in producing weapons of mass destruction and are then called upon for reconstruction work. Engineers are engaged in exploratory work for new materials and even life in space, under the oceans and deep in the ground. Engineers are called up to assist in promoting health, alleviating poverty and sustaining the environment.

The formation of engineers thus differs from country to country, and quite often has to be in tandem with the country's state of development. A developing nation may require more emphasis on education and training in physical infrastructure development whereas engineers in advanced countries may require training in high end research and development.

Whatever state the country is in; the formation of engineers today is broader than yesteryears, with more emphasis on human skills in addition to scientific and technical skills, such as on communication, management, leadership, finance and business skills. More and more engineering degree programmes are emphasing on breadth either with a sacrifice on depth or with the disturbing trend of extending the duration of engineering degree programmes from four to five years. A number of countries have indeed introduced the five year engineering degree programmes. Some quarters are even suggesting that a Masters degree should now be a requirement for the professional engineer.

It is for this reason that the Study on the Formation of Engineers in Malaysia concluded that to be successful in this competitive world, engineers must be multi-skilled, at the forefront of technology and must be trained to enter into leadership positions. The study emphasizes on the importance of strong scientific skills while at the same time stressing on the importance of the other generic skills.

The formation of engineers is not limited to the educational training in the universities but include the 3 years of practical training after graduation. In the old days there was a scheduled practical training for the young graduates under what was called the pupilage scheme, when the young graduates would work under active supervision of more senior engineers. Today many engineering graduates do not go through a similar scheme, thus missing on the practical experience that would be make the young graduate a good professional engineer. A mentoring or logbook scheme is practiced by some institutions of engineers but has attracted a small number of engineering graduates. Professional institutions have a responsibility to address this problem.

THE ISLAMIC WORLD – A Paradox in Wealth and Poverty

The Islamic world is endowed with a large amount of natural resources such as oil, gas, timber and minerals that could be utilized to feed, cloth, and provide shelter to its 1.5 billion people. And the Islamic world has a vast opportunity to become a group of successful nations as exemplified in the days of the Prophet and his companions, if only it learns and follows strictly the teachings in Al-Quran. Allah says in Al-Quran,

However, the Islamic world which is spread over many continents, are divided into fifty six nations under the Organization of Islamic Countries (OIC), with a large number constantly at war with big powers, with its neighbours or with each other. This state of affairs has resulted in the depletion of resources and sapped the strength of these countries. Much national resources go to highly wasteful military and security expenditures, at the expense of physical development, education, business and commerce. Unknown amount of national financial resources disappear due to wasteful and extravagant spending, corruption and sheer abuse of power.

Table 1 GDP for Top 40 Countries of the World (Source www.cia.gov/library/publications/the-world-factbook)

Rank	Country	GDP (purchasing power parity)
1	World	$ 69,490,000,000,000
2	European Union	$ 14,820,000,000,000
3	United States	$ 14,290,000,000,000
4	China	$ 7,800,000,000,000
5	Japan	$ 4,348,000,000,000
6	India	$ 3,267,000,000,000
7	Germany	$ 2,863,000,000,000
8	United Kingdom	$ 2,231,000,000,000
9	Russia	$ 2,225,000,000,000
10	France	$ 2,097,000,000,000
11	Brazil	$ 1,990,000,000,000
12	Italy	$ 1,821,000,000,000
13	Mexico	$ 1,559,000,000,000
14	Spain	$ 1,378,000,000,000
15	Canada	$ 1,307,000,000,000
16	Korea, South	$ 1,278,000,000,000
17	Indonesia	$ 915,900,000,000
18	Turkey	$ 906,500,000,000
19	Iran	$ 842,000,000,000
20	Australia	$ 800,500,000,000
21	Taiwan	$ 738,800,000,000
22	Netherlands	$ 670,200,000,000
23	Poland	$ 667,400,000,000
24	Saudi Arabia	$ 582,800,000,000
25	Argentina	$ 575,600,000,000
26	Thailand	$ 553,400,000,000
27	South Africa	$ 489,700,000,000
28	Pakistan	$ 452,700,000,000
29	Egypt	$ 442,600,000,000
30	Colombia	$ 399,400,000,000
31	Belgium	$ 390,500,000,000
32	Malaysia	$ 386,600,000,000
33	Venezuela	$ 357,900,000,000
34	Sweden	$ 348,600,000,000
35	Greece	$ 343,600,000,000
36	Nigeria	$ 338,100,000,000
37	Ukraine	$ 337,000,000,000
38	Austria	$ 325,000,000,000
39	Philippines	$ 320,600,000,000
40	Switzerland	$ 309,900,000,000

Table 1 which provides a list of GDP for the top 40 countries of the world, provides a dismal picture of the Islamic world which has very few countries appearing in the top 40 ranking and none appearing in the top 10 ranking. Islamic countries have been endowed with the largest oil reserve in the world. The Kingdom of Saudi Arabia has the largest oil reserve amongst oil producing countries and Saudi Aramco, the Saudi Arabian national oil company is the top oil company in the world. And Islamic countries are not short of other natural resources such as gas, minerals, timber, rubber, palm oil and other agricultural products and do have a sizeable number of highly educated workforces either living in their own

countries or have migrated to the more advanced countries. Despite these inherent wealth and large human and intellectual capital base, the stark reality is the Islamic countries are largely underdeveloped and trailing behind the more advanced countries of the west, caught in never-ending national, regional and international conflicts and are not effectively managed and networked.

ENGINEERING GRADUATE ATTRIBUTES – An International Scenario

The Accreditation Board of Engineering and Technology (ABET) which was established in 1932 in the United States adopted the Engineering Criteria 2000 (EC2000) in 1997 which revolutionized the way accreditation was done, moving away from a largely prescriptive educational approach to one which looks at the graduate's learning outcome. A list of graduate's attributes was published and the emphasis was on a continuous improvement process with specific mission and goals of institutions and programmes. EC2000 was to encourage innovation in engineering education and training and encourage the development of new assessment processes.

Following this lead, the Washington Accord (WA) which was signed in 1989 by country representatives of six founding signatories, published its graduate attribute profiles which include academic education, knowledge of engineering science, problem analysis, design and development of solutions, investigation, modern tool usage, individual and team work, communication, the engineer and society, ethics, environment and sustainability, project management and finance, and lifelong learning.

The newly established European Network for Accreditation of Engineering Education (ENAEE), formally established in 2006 as an outcome of the EUR-ACE® project, on the other hand listed six programme outcomes for accreditation which include knowledge and understanding, engineering analysis, engineering design, investigation, engineering practice and transferable skills. Graduates must have these outcomes in both the first and second cycle of the European 3 year Bachelor plus 2 year Master engineering degrees, with the first cycle emphasis on acquiring knowledge and understanding and the second cycle requiring in-depth knowledge and understanding and ability to apply the knowledge and understanding.

The Engineers Mobility Forum (EMF) established in 2001 requires that professional engineers meet a minimum standard of competency in comprehension and application of universal and local knowledge, problem analysis, design and development of solutions, evaluation, responsibility for decisions, management of engineering activities, ethics, protection of society, communication, lifelong learning, judgment, and legal and regulatory.

A list of the graduate attributes or standard of competency for WA, ENAEE and EMF is produced in Table 2 for comparison. The list shows some similarity in the graduate attributes and standard of competency required by the different bodies.

Table 2 Graduate Attributes or Standard of Competency for WA, ENAEE and EMF

WA	**ENAEE**	**EMF**
Knowledge	Knowledge & Understanding	Comprehension & application of universal & local knowledge
Problem Analysis	Engineering Analysis	Problem analysis
Design & development of solutions	Engineering design	Design & development of solutions
Investigation	Investigation	Evaluation
Modern Tool	Engineering Practice	Responsibility for decisions
Individual & team work	Transferable skills	Judgement
Communication		Communication
Engineer & Society		Protection of Society
Ethics		Ethics
Environment & Sustainability		
Management & Finance		Management of engineering activities
Lifelong Learning		Lifelong learning
		Legal & regulatory

A good wholesome approach in the education and training of engineers is found in the capstone deign course. As the students proceed from their initial introduction to engineering in the first year to more intensive courses in the later years, the capstone design course can capture in an efficient way the mountains of knowledge and understanding which the students have accumulated over the years in a project-based learning environment. A number of universities across the globe have successfully introduced the capstone design course, which enables students to work in small teams on real world engineering problems or to develop a new product.

In Universiti Putra Malaysia, the Department of Civil Engineering has been running a capstone civil engineering design project course for many years now and the response both from the students and external examiners have been very encouraging. In this course which is largely multidisciplinary, the students work in project teams, formed by purposely mixing the students around in groups of about five students, and are given an opportunity to propose a project for the approval of the lecturer in charge of the course. During the course of the execution of the project, the students were exposed to talks in such varied areas as planning, architecture, quantity surveying, construction management and arbitration by invited industry speakers, who are invited to a networking tea with the students after the talk. Each student performance and contribution to the project work was observed by tutors or teaching assistants who assess their input, group dynamics and maintenance of portfolio. Each student is expected to speak during the project brief presentation and the final report presentation, giving the students at least two opportunities for experience in public speaking.

The downside of this course is the large amount of time involved for the lecturer as well as the students. The lecturer would be handing a large number of students and project groups and the students have to gather information, data and other information from within and outside the campus. The assessment is also very intensive, requiring the lecturer and tutor to assess the student performance in a large number of learning outcomes.

INTERNATIONAL INITIATIVES – A Concerted Effort

The Federation of Engineering Institutions of Islamic Countries (FEIIC) had proposed an Engineering Qualification, Accreditation and Professional System (EQAPS) project with the objective of studying the latest developments in engineering education, accreditation and professional system in the world today and the development a good approach for Islamic countries. Despite some delay in the financing of the project by the Islamic Development Bank (IDB), it is believed that the project is important and could assist OIC member countries in developing engineering education and training in member countries, to make their engineers competitive especially in the face of imminent trade and services liberalization. At the same time FEIIC has proposed the establishment of an International Engineering Centre (IEC) to spearhead studies and projects in engineering education and training, research and development and professional practice to further enhance the engineering profession in Islamic countries.

We have to adopt a more wholesome education and training and a more holistic approach to the engineering profession. Engineers do not practice in a vacuum but have to interact with other members of other professions as well as with the society at large. Engineering graduates must learn to understand local policies and customs and must be prepared to work at the international arena. For this reason the international initiatives proposed by FEIIC are important because on the one hand we have Islamic countries suffering for lack of potable water, sanitation and decent housing and on the other the more developed Islamic countries need to be able to compete with the more advanced nations. Engineering schools in Islamic countries must be proactive to learn how to educate and train students in what they need to know to operate successfully in a future environment which is full of uncertainties and new challenges. Engineering graduates must be well equipped to address specific problems of their developing communities as well as preparing themselves for future competition at the international level.

International exchange of students and graduates is important to enable engineers to obtain a wider world view of their career and profession. Engineering industry in Islamic countries must be prepared to accept students under industrial training form within their own country and from abroad and must be prepared to provide effective supervision to young engineers that they employ.

It is recommended that we have a hard look at the way we educate and train our engineering students and graduates to ensure they receive a wholesome education in the universities and satisfactory training on graduation, in preparation for their qualification to become full fledge professional engineers, capable of contributing to national infrastructural development as well as having a qualification which is internationally benchmarked to enable successful practice at the international level. Engineers have a major role to play in the economic development of their nations as much as they have a responsibility to create a sustainable world that provides a safe, healthy and productive life. Engineering graduates must have the appropriate graduate attributes which is not limited to scientific and technical skills alone, but cover human and

other skills that make the graduate successful in his career. Engineering graduates must be given sufficient special skills that could enable them to enter into other vocations as well, such as politics, banking and finance. International initiatives such as the EQAPS and IEC must be supported to enable the development of a more dynamic and modern approach to the formation of engineers in Islamic countries.

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