Challenges for Engineers in the New Millennium—Washington Accord
Rafiqul Islam*
Dhaka University, Dhaka, Bangladesh.
E-mail: professorrafiqulislam@yahoo.co.uk

Abstract: The present paper presents views and visions in Engineering Education in the 21st century and discusses the main tasks and challenges for Engineers in the new millennium. The paper emphasizes the need of non-technical subjects in the Engineering Curricula of the 21st century. Finally, the paper discusses about the Washington Accord and Bangladesh status

Keywords: Sustainable Development, Challenges for Engineers, 21st century, Engineering Education Course Curricula, Multi disciplinary skills, Washington Accord.

I– INTRODUCTION

World’s population by 2030 is expected to reach to 8 billion from its current level of 6.5 billion. Dr. Paul Crutzen, the Nobel laureate in his special address on “The Anthropocene: The Current Human-Dominated Geological Era: Human Impacts on Climate and the Environment,” introduced various scientific findings that suggest population growth and increased human activities are becoming serious burdens to the environment. The question is, what should be done now and in the near future to ensure that the basic needs of all humans are fulfilled. The United Nations General Assembly of September 18, 2000 well defines this task as “Millennium Development Goals” [1]. It is obvious that this growth of population will create unprecedented demands for energy, food, land, water, transportation, materials, health care, etc.

The role of engineers will be critical in fulfilling those demands at various scales. Engineers have a collective responsibility to improve the lives of people in the planet. Engineering has driven the advance of civilization throughout human history. This is demonstrated from the metallurgists who ended the Stone Age; through the mechanization of the Industrial Revolution; to the unprecedented pace of achievement in the 20th century where advancements including automobiles, air travel, computers and the internet revolutionized human existence in developed countries.

Maurice Strong, Secretary General of the 1992 United Nations Conference on Environment and Development, said, “Sustainable development will be impossible without the full input by the engineering profession”.

Most engineering achievements of the past were developed without consideration for their social, economic, and environmental impacts on natural systems but now those are considered to be even more important than the technical aspects.

II– GRAND CHALLENGES FOR ENGINEERING IN THE 21ST CENTURY

The National Academy of Engineering of the United States has recently described a list of the grand challenges for engineering in the 21st century [2]. The list includes:

- Providing energy from fusion: Find a way out to sustain a controlled fusion reaction for commercial power generation.
- Developing carbon sequestration methods: Capture the carbon dioxide produced from fossil-fuel burning, and store that somewhere underground in an economic way that would not harm our environment and in addition, it is very important that Engineers should find out technology for the conversion of Carbon dioxide to useful chemicals.
- Managing the nitrogen cycle: Find ways for using fertilizer without environmental pollution. Controlling the impact of agriculture on the global cycle of nitrogen is a growing challenge for sustainable development.
- Providing access to clean water: There is already shortage of clean water for drinking as well as irrigation in many parts of the world. Water with bacteria and viruses, arsenic, chromium, mercury and heavy metal pollution needs special kind of treatments. Engineers have to develop robust and economic technology for that.
- Restoring and improving urban infrastructure: Good design and advanced materials can improve transportation and energy, water, and waste systems. Engineers need to
give designs for environmentally friendly, energy-efficient buildings both for housing and for business.

- Advancing health informatics: How do you identify the specific factors behind wellness and illness, and follow through on the promise of personalized medicine?
- Engineering better medicines: How do you find new treatments for age-old scourges as well as newly emerging diseases?
- Reverse-engineering the brain: Learning the secrets of brain function, researchers will likely improve knowledge of how to design computing devices that process multiple streams of information in parallel, rather than the one-step-at-a-time approach of the basic PC. More advanced artificial intelligence software should in the future be able to guide devices that can enter the body to perform medical diagnoses and treatments.
- Preventing nuclear terror: Challenges for Engineer’s for nuclear security represents an important and urgent task to maintain a global healthy atmosphere, which include finding all the dangerous nuclear material in the world, keeping track of it, securing it, and detecting its diversion or transport for terrorist use, besides having good knowledge on nuclear materials and safety.
- Securing cyberspace: Engineers need to give solutions for protecting the global information infrastructure from identity theft, viruses and other threats.
- Enhancing virtual reality: Use computer technology to create imaginative environments for education and entertainment. Engineers are creating entire cars and airplanes “virtually” in order to test design principles, safety schemes, access for maintenance, and more.
- Advancing personalized learning: Throughout the educational system, teaching has traditionally followed a one-size-fits-all approach to learning, with a single set of instructions provided identically to everybody in a given class, regardless of differences in cultural background, occupation, aptitude or interest and level of motivation. In recent years, a growing appreciation of individual preferences and aptitudes has led toward more “personalized learning,” in which instruction is tailored to a student’s individual needs.
- Engineering the tools for scientific discovery: Engineers participate in the scientific process of discovery in many ways. Grand experiments and missions of exploration always need engineering expertise to design the tools, instruments, and systems that make it possible to acquire new knowledge about the physical and biological worlds. Scientists still have much to learn about the relationship of genes and disease. To explore such realms, biologists will depend on engineering development of say new kinds of microscopes, or new biochemical methods of probing.

PROBLEMS BEFORE THE ENGINEERS, NEW DEVELOPMENTS IN ENGINEERING EDUCATION

There are certain problems that address specifically to developing countries now, while in the education curricula in USA or in Europe the attention was not attributed to such problems even some years ago but today the Engineers in developed countries are mostly educated in such a way that they possess in depth knowledge on universal problems, which may include water purification, sanitation, power production, shelter, site planning, infrastructure development, food production and distribution, communication, among many others. So to say, in recent years, course curricula of engineering education have been undergoing significant changes. According to the World Health Organization (WHO), 1.8 billion people i.e. about 30 percent of the world’s population currently live in conflict zones, in transition, or in situations of permanent instability and hence engineering education needs to address the challenges associated with these global problems.

A new, promising concept called Earth Systems Engineering (ESE) has emerged as an alternative to the usual way engineering has looked at the world. ESE acknowledges the complexity of world problems and encourages the use of more holistic and systemic tools to address interactions between the anthrosphere (i.e., the part of the environment made and modified by humans and used for their activities) and natural and cultural systems. In 1998, Allenby introduced the concept of ESE with reference to industrial ecology. The latter is defined as “the multidisciplinary study of industrial systems and economic activities, and their links to fundamental natural systems”. The engineer of the future applies scientific analysis and holistic synthesis to develop sustainable solutions that integrate social, environmental, cultural, and economic systems. Creating a sustainable world that provides a safe, secure, healthy, productive, and sustainable life for all peoples should be a priority for the engineering profession. Engineers have an obligation to meet the basic needs of all humans for water, sanitation, food, health, and energy, as well as to protect cultural and natural diversity. Improving the lives of the five billion people whose main concern is staying alive each day is no longer an option; it is an obligation. Engineers of the future must be trained to make intelligent decisions that protect and enhance the quality of life on Earth rather than endangering it. They must also make decisions in a professional environment in which they will have to interact with people from both technical and nontechnical disciplines. Preparing engineers to become facilitators of sustainable development, appropriate technology, and social and economic changes is one of the greatest challenges faced by the engineering profession today [3,4].

What can we do to help ensure that our courses and curricula are optimally designed and delivered to provide disciplinary depth while at the same time helping to broaden the student’s
Horizons and enthusiasm to address these and other globally urgent sustainable development challenges? Course curricula should be such that help students to begin to develop the multi-stakeholder, multi-disciplinary skills that are essential to helping them to be effective in sustainable development related issues when they are in their professional lives [5].

Energy is central to sustainable development. According to the United Nations Development Program, energy affects all aspects of development-social, economic, and environmental-including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues. None of the U.N. Millennium Development Goals (http://www.un.org/millenniumgoals/) can be met without major improvement in the quality and quantity of energy services. Needless to say, global energy consumption is expected to grow, especially in rapidly growing industrial countries like China and India. Major trends affecting the energy industry involve new “smart technologies,” with fuel cells, superconductivity, clean coal technologies and renewable energy leading the way.

According to the Canadian Academy of Engineering, Engineering is a profession concerned with the creation of new and improved systems, processes and products to serve human needs. The central focus of Engineering is design and that:

1. Engineering graduates should be broadly educated and technically sound in their respective disciplines of study. They should be knowledgeable about the society in which they live.

2. Leaders of Engineering faculties should ensure that their faculty members have the qualities - educational background and training, vision, ethics, needed for their promising role in preparing undergraduate and graduate students, who would be able to work effectively in our rapidly changing world.

3. The original creative work done in Engineering faculties namely research and design, should be characterized by excellence, by relevance to industrial and social issues and by concern for the life of preparation of the graduate students involved.

1. Engineering faculties should reach out beyond their own students and help in providing a modern liberal education for all university students. They should also help in improving the technological literacy of all university graduates as well as the general public.

A good engineer should have an organizing capacity and working capability in a team. Engineers who possess project management skills, will take the lead. In this era of globalization it is desired that students with sound academic career choose Engineering as their professional career and it is also desirable that a large number of them continue their studies leading to Ph.D. in the areas of engineering that can lead to innovations, necessary for the development of a nation.

Globalization is forcing colleges and universities to change their approach to education and instruction. Globalization poses unique challenges for engineers, one of which is to understand the dynamics of the global marketplace. At the same time, engineers of one discipline should not be confined to knowledge in that particular discipline only, for example mechanical engineers will also be challenged to expand their learning beyond traditional single-discipline technical skill sets into multidisciplinary areas involving chemical, biological, and electrical systems.

A study by J.P. Trevelyan [6] says that “Technical” knowledge of a discipline is no longer enough to enable an engineer to solve complex, interdisciplinary problems.

Also a review committee, appointed by the National Academy of Engineering in the United States opines that solutions for future engineering problems must take into account economic, political, social and ethical aspects and engineering graduates need to possess knowledge on all these areas to give a complete solution of a problem [7]. Engineering projects are now executed by teams whose members come from different countries but the success of such global projects depends not only on technical skills but on communication and teamwork skills as well. The revised accreditation frameworks in many countries including that in USA and Australia demonstrate the growing global emphasis on broadening the engineering knowledge base with focus on interdisciplinary and non-technical knowledge [8].

Accreditation Board for Engineering and Technology (ABET) [9] currently requires US engineering institutions to ensure that non-technical subjects make up at least 12 per cent of an engineering degree. An analysis of the course curricula of several US engineering institutions reveals that, many institutions actually have more than that. For example, MIT has 12 non-technical subjects in its engineering degree, including 8 from humanities and social sciences, and 4 that relate to communication skills, which is more than ABET prescribes. Stanford and Cornell both prescribe one compulsory subject that relates to technology and society. Australia’s Queensland University of Technology recently introduced a compulsory course for all engineering students related to
environmental studies and sustainable development, which the students also apply in their final year of project. To prepare engineering students to work in a global economy, many institutions of USA and Europe encourage students to spend at least one semester in foreign universities and now many American and European Universities have developed exchange programs to help students better understand different cultures, languages and professional practices. The initial results of these programs are very promising [8].

Most engineering institutions in India today, including IIT, do not have in their course curricula many of the non-technical subjects from humanities, social sciences, literature and languages, which are available to engineering students in the United States and Europe. In India, until now, there has been reluctance at an institutional level to broaden the engineering education base. Part of the problem lies as majority of engineering institutions do not teach courses related to physical sciences, social science, art and management. As a result the Indian engineering institutions do not provide the double degree programs that give students in Australia, America and other countries more mobility in future careers. Nor do they provide a system of credit transfer. Even in IIT, a student must study all the subjects of a degree course from the same institution [10] and, unlike western universities, Indian students are not encouraged to study a small part of their course in a different college or university as in exchange program [11]. As mentioned before, at the Massachusetts Institute of Technology, every engineering graduate is expected to study a reasonable amount of philosophy, history and literature. At Australia’s Queensland University of Technology, a student can do a Bachelor of Engineering (Electrical) together with a Bachelor of Science (Mathematics). Even, in late seventies, I had the experience to see in the Azerbaijan Institute of Petroleum and Chemistry, one of the best educational institutions of former Soviet Union and even in Europe, if talked about disciplines related to petroleum and petro-chemical engineering, that in the Engineering course curricula subjects like history, economics, philosophy, language, environmental studies, physics, chemistry, mathematics were compulsory subjects.

According to Patricia Galloway, former President of the American Society of Civil Engineers, a solid understanding of physics, chemistry, mathematics were compulsory subjects. The Washington Accord, signed in 1989, is an international agreement among bodies responsible for accrediting engineering degree programs. It recognizes the substantial equivalency of programs accredited by those bodies and recommends that graduates of programs accredited by any of the signatory bodies be recognized by the other bodies as having met the academic requirements for entry to the practice of engineering. It is anticipated that the Accord will facilitate international mobility of engineering graduates and contribute to improving the quality of engineering education through benchmarking [13].

The signatories:
1. Accept that accreditation procedures are comparable.
2. Accept one another’s accredited degrees from the date of admission as a Full Member.
3. Agree to identify and encourage implementation of best practice.
4. Accept mutual monitoring.
5. Accept that it applies to accreditations in home jurisdictions only.
6. Accept the need to encourage licensing and registration authorities to apply the agreement.

MEMBERSHIP:
Till 2011 the following 14 countries and institutions are the Full Members of the Washington Accord:
Australia-EngineersAustralia (1989)
Canada- CCPE Engineers Canada (1989)
Ireland-Engineers Ireland (1989)
New Zealand- Institution of Professional Engineers NZ (1989)
USA- Accreditation Board for Engineering and Technology (1989)
Hong Kong, China- Hong Kong Institution of Engineers (1995)
South Africa-Engineering Council of South Africa (1999)
Japan- Japan Accreditation Board for Engineering Education (2005)
Singapore- Institution of Engineers Singapore (2006)
Korea -Accreditation Board for Engineering Education of Korea (2007)
Malaysia- Board of Engineers Malaysia (2009)
Turkey–MUDEK Association for Evaluation and Accreditation of Engineering Programs (2011)

**Provisional Members**

Bangladesh - Board of Accreditation for Engineering and Technical Education (BAETE)
Germany - German Accreditation Agency for Study Programs in Engineering and Informatics (ASIIN)
India - National Board of Accreditation of All India Council for Technical Education (AICTE)
Pakistan- Pakistan Engineering Council
Russia- Russian Association for Engineering Education (RAEE)
Sri Lanka - Institution of Engineers Sri Lanka

**Bangladesh Status**

As seen from above, Board of Accreditation for Engineering and Technical Education (BAETE) has got from this year the Provisional Membership and Bangladesh now looks forward to achieving the Status of Full Membership of the Washington Accord. Signing the accord will enhance global mobility of the engineering graduates from our country who can pursue further studies or take up jobs in the signatory countries.

Board of Accreditation for Engineering & Technical Education (BAETE) has been established by the Institution of Engineers, Bangladesh, the sole professional body of graduate engineers in Bangladesh, which has around 20,000 members, who are now eagerly awaiting for global recognition of engineering degrees that would enhance their global mobility.

The Board is an autonomous body, independent of the Institution that examines and accredits Engineering degree programs in Bangladesh. Board evaluate whether programs in engineering education conducted by institutions of higher education such as universities reach the levels expected by society and accredit those programs that reach such levels.

Albeit Accreditation Parameters & their Weightages that are considered in Bangladesh may need a further thought, it needs to be mentioned that even in the oldest and most reputed Public General University, Dhaka University in the Dept of Applied Chemistry & Chemical Engineering under the Faculty of Engineering & Technology, the modern concept of Engineering Course Curricula is followed here since eighty’s though the University is Non-Technical. As for example to obtain a graduation degree in Engineering, besides courses of Chemical Engineering and Technology, students have to take courses of Physical Sciences- Physics, Chemistry, Mathematics and also Industrial Economics, Psychology & Management, Computer Science and Engineering, Environmental Engineering that incorporates study on Sustainable Development, Energy Conversion Engineering & Environment, Fluid Mechanics, Fuel Technology and Petro-Chemical Synthesis, Solid Geometry & Engineering Drawing. Physical Training and Student’s Counseling are also undertaken by the students. High importance is given in the course curricula to include Process Technology, Industrial Tour and Training in every year and as such Industry-Institution Interaction is given a high priority. Students also have to take Projects on Contemporary Scientific and Engineering Problems and also carry out Thesis which is publicly defended before the Examination Board giving a Power Point Presentation. Though the official language in Bangladesh is Bengali but the medium of instruction here is English and this with other co-curricular activities like Seminar, conference, Workshops, Debating, etc help students to enhance their Global Communication Skills in international language of trade. Students from here are doing quite well globally. However, even in some purely technical institutions, with exception of Bangladesh University of Engineering & Technology, the oldest and most reputed technical institution of the region, course-curricula in line with the modern conception of Engineering education, may need a revision and the policy and the inherent outlook of the teaching staffs need to be changed.

**Engineers Mobility Forum (EMF)**

Bangladesh is a Provisional Member of International Agreements: Engineers Mobility Forum (EMF). The purpose of EMF is to establish and maintain an International Register of Professional Engineers and facilitate their international mobility. Bangladesh Professional Engineers Registration Board (BPERB) requires that applicants for PEng status have an accredited degree (recognized by BAETE).

EMF Full Members are: Australia (IEAust), Canada (CCPE), Hong Kong, China (HKIE), Ireland (IEI), Japan (JABEE), Korea (KPEA), Malaysia (IEM), New Zealand (IPENZ), South Africa (ECSA), United Kingdom (ECUK), United States of America (USCIEP).

EMF Provisional Members are: Bangladesh (BPERB), India (IEI).

**The Federation of Engineering Institution of Asia and the Pacific, FEIAP**

Institution of Engineers Bangladesh (IEB) is a member of FEIAP. FEIAP is an independent umbrella organization for the engineering institutions in the Southeast Asia and the Pacific region, the objectives of which is to encourage the application of technical progress to economic and social advancement throughout the world; to advance engineering as a profession in the interest of all people; and to foster peace throughout the world.

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(456)
Network of Accreditation Bodies for Engineering Education in Asia, NABEEA

Full Members: Bangladesh, Chinese Taipei, Japan, Korea, Malaysia, Philippines, Singapore and Thailand.

CONCLUSION

Engineering is a powerful and transformative force in this world. For the international mobility of students of Engineering discipline the course curricula and the standard of education have to be such that they are capable of competing with each other and can prove the justification of their global recognition and mobility. The engineering community must continue to assert its global leadership and take advantage of its recognition in emerging markets to succeed in meeting the present and future challenges of our world. Through their dedication to creating and innovation of new ideas, engineers are at the forefront of shaping this world towards peace, prosperity and tranquility and thus help people enjoy happier and healthier lives in the new millennium.

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