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"Improving Quality Assurance in Engineering Education"

Number 17
December 2011

WFEO/FMOI

Committee on Education In Engineering
World Federation of Engineering organizations

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WORLD FEDERATION OF ENGINEERING ORGANIZATIONS
FÉDÉRATION MONDIALE DES ORGANISATIONS D’INGÉNIEURS

COMMITTEE ON EDUCATION IN ENGINEERING

Journal IDEAS No. 17 December 2011

IDEAS is a publication of the WFEO Committee on Education In Engineering, addressed to engineering educators, educational officers at Universities and leaders responsible for establishing educational policies for engineering in each country. The articles it contains reflect the concern of people and institutions linked to WFEO, to provide ideas and proposals with the object of improving formation of engineering education. All the issues of IDEAS were and will be partially financed by World Federation of Engineering Organizations.

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Editor Engr. Abdul Menhem Alameddine
Federation of Lebanese Engineers - Beirut, Lebanon
P.O.Box 11-3118 Beirut Lebanon
Email: munim@mouhandess.org

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Assistant Editor of this issue: Dr. Antoine Abche

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Editorial

Quality Assurance of Engineering Education in the 21st Century" Objectives – results.

Abdul Menhem Alameddine,
Chairman of Committee on Education In Engineering

It is a great pleasure to be involved in the preparation of this issue of IDEAS, the Journal of the Engineering Committee on Education and Training, with the help of my Colleagues from around the World. The theme of this issue is "Quality Assurance of Engineering Education in the 21st Century: Objectives – Results". I hope that the readers will find the various topics very informative. Prof. Wlodzimierz Miszalski discusses the Improvement of the "Quality of Engineering Education" and addresses the "Role of Future World University of Technology". Professor Ahmad Jammal presents a procedure of the Engineering Education in Lebanon "towards Quality Assurance and Accreditation". Professor Xila Liu, in this paper entitled "Teaching fishing", introduces his suggestions on how to implement the "saying" in class. Professor Antoine Boulos Abche1,3 and myself discuss some aspects that are valuable in the "Preparation of Engineers for a Sustainable Future in This Modern Era". Professor Diran Apelian expresses his thoughts about the Engineering education and the profession at challenging crossroads in his contribution entitled "Quality Assurance of Engineering Education in the 21st Century". In his paper, Professor Karim J. Nasr addresses the "Quality Assurance and Accreditation of Engineering Programs for a modern world". Finally, Engr. Jacinta O'Brien, expresses her vision on "A CEAB Accreditation Perspective for Engineering Design in Undergraduate Curricula".

Also, I would like to thank all the engineers and professors for their contributions to this publication as well as the efforts of persons involved for putting this issue together, looking to see them contributing in future issues of IDEAS.

Improving Quality of Engineering Education

The Rôle of Future World University of Technology

Prof. Wlodzimierz Miszalski

Polish Federation of Engineering Associations, Warsaw, Poland

Prof. Wlodzimierz Miszalski Ph.D., D.Sc.. Professor of the Military University of Technology (Warsaw, Poland) and Director of Institute of Organization and Management. Before receiving M.Sc. degree in Computer Science and Operations Research in 1972 worked as radar devices' engineer. In 1984 was awarded D.Sc. degree in Technological Science (Electronics) and in 1991 Ph.D. degree in Management. In 1993 graduated from National Defense University (Washington, D.C., USA). Prof. Miszalski has more than 30 year experience in postgraduate education of engineers – particularly in Logistics and Management. Member of Polish Accreditation Committee. Representative of Poland in System Analysis and Studies Panel, NATO Research and Technology Organization. President of the Committee on Education and Professional Development of Polish Federation of Engineering Associations. Chairman of the Steering Committee of the 5th World Congress on Engineering Education held in 2000 in Warsaw. Since 2005 to 2010 President of WFEO Committee on Education and Training. In 2011 Prof. Miszalski was awarded the WFEO Medal „Excellence in Engineering Education". Prof. Miszalski is author and co-author of more than 200 publications (books, academic manuals, scientific papers) on : maintenance organization, decision systems engineering, disaster monitoring and relief systems command, postgraduate engineering education programs and curricula.

ABSTRACT

In the paper different approaches to estimation quality of engineering education have been described: outcomes, potential, process and hybrid approach. The importance of the quality of engineering education has been discussed from the mobility point of view. The proposal of establishing the Section of World Standards of Engineering Education within organizational structure of future World University of Technology has been presented.

Key words: accreditation, education, engineering, university, world.

INTRODUCTION

Quality of engineering education and accreditation of engineering education programs are closely connected with recognition of engineers' degrees and professional competencies which in turn is the precondition for international mobility of engineers. From the global perspective working out worldwide accepted standards of engineering education and principles of accreditation seem to be particularly important. Taking into account present diversity of educational institutions, accreditation agencies and different approaches to estimation of the quality of engineering education one can understand the difficulties and obstacles which appear within the projects of international recognition of engineers' degrees and accreditation of educational programs. Increasing international information exchange between educational institutions and accreditation agencies seems necessary to make the projects successful.

1. DIFFERENT APPROACHES TO ESTIMATION QUALITY OF ENGINEERING EDUCATION

During numerous discussions on the mobility of engineering graduates fundamental questions appear on the comparability of engineers' diplomas and subsequently on the quality of engineering education. There exist different interpretations of the notion quality of engineering education and different approaches to estimation the quality. At least three basic approaches could be distinguished:

- Education program outcomes approach,
- Education potential approach,
- Education process approach.

The **outcomes approach** is the most popular one. In general it consists in description of the required capabilities of graduates from engineering education programs. For instance European Network for Accreditation of Engineering Education (ENAEE) is maintaining and promoting the EUR-ACE (Accreditation of European Engineering Programmes) Framework Standards within European Higher Education Area (EHEA). In the Standards six following categories of education program outcomes have been distinguished [3] :

- Knowledge and Understanding,
- Engineering Analysis,
- Engineering Design,
- Investigations,
- Engineering Practice,
- Transferable (personal) Skills.

The programs accredited according to the EUR-ACE Framework Standards by authorized (national, regional or institutional) accreditation agencies are awarded with the EUR-ACE label. Similar approach represent the Washington-Accord institutions, within which following categories of outcomes have been distinguished [2]:

- Engineering knowledge,
- Problem analysis,
- Design/development of solutions,
- Investigations,
- Modern tool usage,
- Engineer and society,
- Environment and sustainability,
- Ethics,
- Individual and team work,
- Communication.

Although the **outcomes approach** seems clear, rational and relatively simple - the measures of the categories of outcomes are still subjects of disputes. In most of quality assessment manuals recommended and used by accreditation agencies one can find tables of outcomes categories and required attributes of graduates but the measures (indicators) are often left to the subjectivism of evaluators.

The **potential approach** emphasizes qualifications and prestige of faculty staff, modernity of laboratory equipment, standard of educational infrastructure - as the components of engineering education quality. It seems relatively simple and easier for evaluators to measure the components of educational potential (e.g. “qualifications of faculty staff” or “standard of infrastructure”) than outcomes (e.g. “knowledge and understanding” or “engineering analysis”). The potential approach is characteristic for governmental accreditation agencies in certain countries and the estimation of educational potential is in general highly formalized or even “algorithmized” (detailed instructions for evaluators, precisely defined indicators).

The **process approach** consists in evaluation: structure, organization and length of teaching and learning processes, curriculum, syllabus, sequence and length of particular courses and topics. In this case the evaluation seems more difficult and sophisticated than within the outcomes and potential approaches. Although the documents describing the education process are in general available for evaluators - measuring the compliance of the real process with the one described in the documents - needs employing special methods, indicators and parameters and particularly - observation the process in real time. In many cases education process reflects the specificity of particular schools and faculties. Diversity of the processes in different educational institutions makes working out standards or patterns of the process difficult. For instance Polish Accreditation Committee evaluates education process basing on the standards within which required sequences of: basic, principal and specialist subjects have been distinguished and - on the "model syllabus" which requires specification of the so called "introducing": subjects, knowledge and skills necessary to start the syllabus' subject. However the assessment of compliance or divergence of the real process with standards is subjective and depends on the knowledge and information got by the evaluator.

The **hybrid approach** – combination or integration of the three approaches has been also applied by accreditation organizations and agencies. For instance Mexican CACEI (Consejo de Accreditacion de la Enseñanza de la Ingenieria) worked out a manual published for the first time in 1996 and then renewed in 1998, 2004, 2010 in which following ten categories of analysis and evaluation have been distinguished [1] :

1. Definition and Characteristics of Programs of Engineering Teaching
2. Faculty Staff
3. Students
4. Syllabus
5. Teaching-Learning Process
6. Infrastructure
7. Research and Technological Development
8. Extension, Diffusion and Linkage
9. Administration
10. Results and Impact.

The above categories characterized by indicators, standards and parameters constitute components of the quality evaluation of the Program.

2. GLOBAL PERSPECTIVE

The differences between engineering education systems in different parts of the world and regions of the world are significant enough that the World Standards of Engineering Education seem still distant future. Nevertheless lack of the Standards is one of the obstacles which hamper mobility of engineers in global scale. On the other hand progressing internationalization of engineering education stimulates collaboration of regional organizations in working out principles for recognition of engineers' degrees and professional competencies. In the years 2006 - 2011 the Working Group on Mobility of Engineering Professionals created within the WFEO Committee on Education and Training under the chairmanship of Dr Peter Greenwood worked out the document "WFEO Policy on Mobility" (approved by WFEO General Assembly in Kuwait in 2009) and in August 2011 the "WFEO Up–dated Information Paper on Mobility". The Documents promote developing global international framework for working out standards of evaluation quality of engineering education.

Particularly important seems the idea of using the WFEO web site to share the information on the approaches, categories, attributes and indicators applied to evaluation the quality of engineering education.

The World Standards of Engineering Education (WSEE) together with the worldwide accepted Principles of Accreditation could be not only tools for promoting mobility but first of all - tools for improving the quality of education and a kind of platform for comparing and ranking the educational institutions from the global requirements point of view. They could also serve as certain level of reference for building programs and courses as well as an instrument of integration of world engineering education community.

3. DEVELOPING WORLD STANDARDS OF ENGINEERING EDUCATION

The idea of World University of Technology (WUT) has been developed since the 7th World Congress on Engineering Education (Budapest 2006) and has been subject of discussions [4,6] which focused on the mission, organizational structure, personal characteristics and professional profiles of future graduates, educational programs and curricula. Developing World Standards of Engineering Education could be one of the components of the WUT mission. Taking into account the discussed above approaches to estimation the quality of engineering education the WSEE could be considered as standards of potential, process and outcomes. The questions appear - what should be reflected in the Standards: expectations and aspirations?, the top level of engineering education in the most technologically advanced countries?, the average world level of engineering education?. The answer seems to be a challenge for international engineering education institutions oriented towards global challenges (UN Millenium Development Goals). The idea of WUT evolving from certain idealized aim of aspirations only - through some pattern or frame of reference - to the object with determined structure [5] composed of concrete elements (institutes, departments, faculties) able to fulfill the specific educational and research tasks - would be helpful in solving the problem of the WSEE. It seems useful to establish within the organizational structure of WUT special Section working on WSEE. The Section would analyze different approaches and status of international solutions for evaluating quality of engineering education and would work out categories, criteria and measures taking into account the mission of the WUT, global challenges and needs for international engineering education.

CONCLUSIONS

The worldwide accepted Standards of Engineering Education and Principles of Accreditation could be useful tools for improving quality of education and mobility of engineers. Although certain progress has been made in regional scale - the worldwide solutions seem still to be distant future. The proposal of setting the works on the Standards and Principles of Accreditation within future World University of Technology seems one of the solutions. The rôle of this institution would be also promoting the Standards and Principles as well as providing examples of education programs and profiles of graduates meeting the requirements of the Standards.

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Engineering Education in Lebanon Towards Quality Assurance and Accreditation

Professor Ahmad JAMMAL, DGHE, MEHE, Lebanon

Mr. Ahmad JAMMAL is the Director General of Higher Education in Lebanon, since 2002. He is the vice president of the Council of higher education, president of the Technical Committee, president of the Equivalence Committee and the Engineering Commission. He is in charge of the private higher education sector in Lebanon.

He is working on the dissemination of quality assurance in Higher Education and the development of procedures, criteria and standards for QA and Accreditation in Lebanon. He participated in the development of guides in this field. He is Board member of ANQAHE (Arab Network for Quality Assurance in Higher Education) and Board member of the Council of Quality Assurance & Accreditation of the Association of Arab Universities.

He has been an IEEE senior member since 1990, and a member of the Order of Engineers and Architects in Lebanon since 1995. He was a full professor of Power Electronics, Machines and Drives at the Lebanese University from 1996 to 2002, associate professor at the University Claude Bernard – Lyon I in France from 1988 to 1996 and research assistant from 1983 to 1986. He worked as research and development engineer at Leroy-Somer France in 1986 -1987. He obtained the BE in Electrical Engineering from Damascus University in 1982, the MSc, from Polytechnic Institute of Grenoble - France in 1984, his PhD in Electrical Engineering (Power Converters and Drives) from Claude Bernard University - France in 1986, and the Habilitation to Supervise Scientific Research from the same university in 1994. He supervises MSc and PhD students in France and in Lebanon in the field of electrical machines, drives, diagnosis of converters. He has published several papers in International scientific journals and conferences. He continues to teach courses in the domain of electrical engineering at ISAE-CNAM Lebanon and to supervise projects and research activities conducted by the students.

ABSTRACT

The globalization and internationalization of higher education, which is considered as the engine of development in all the countries, has encouraged countries to implement policies for the development of higher education sector. This was reflected in the increasing number of higher education institutions in all Arab countries. Similarly, the number of higher education institutions in Lebanon increased from 13 before 1995 to 41 existing today. This was accompanied by a significant increase of Faculties of Engineering. This requires the establishment of audit procedures and the evaluation of the engineering schools to maintain an adequate level of studies consistent with the international standards known in this field.

The paper presents the most important characteristics of engineering education in Lebanon, and the ratios and statistics on education inputs and basic elements. It presents also the policy plan to develop Quality Assurance and Accreditation process for engineering programs as well as the most important procedures used in the evaluation system of engineering programs in place in the Federation of Arab Engineers.

INTRODUCTION

The Engineering Education in the developed countries is considered as the fundamental cornerstones of the evolution of technology and applied science,for being the basic foundation of knowledge and innovation. So the institutions of higher education in Arab countries, should work actively on the development of Engineering Education programs to keep pace with the requirements of the labor market and the Industry. This policy must be accompanied by the improvement of Engineering programs and focus on the quality of Engineering Education and on improving its outcomes.

The increasing number of universities that teach Engineering and the increasing of similar engineering programs led to significant increase of graduates who are non-randomly harmonious with the needs of the labor market. Then, based on this reality, the engineering education in the Arab world needs to be re-evaluated.

All the people responsible of Engineering Education in Arab world considered quality assurance and accreditation of engineering programs as priority. The Federation of Arab Engineers has decided to create an Arab council for QA and Accreditation of Engineering programs within the federation [1].

Also the Association of Arab universities decided in 1999 to create a board for Quality Assurance and Accreditation within the Association and this decision was approved by the seventh conference of the Arab Ministries of Higher Education in Riyadh-KSA [2].

In 2009, through a UNDP Project, a Quality assessment of Engineering programs was conducted based on detailed internal and external reviews of engineering programs in 19 Arab universities [3].

In addition the increased mobility in the workplace is generating pressure to expand competencies beyond countries. A key indicator of changing expectations is found in efforts by Engineering Education organizations to extend themselves across countries [4].

The new requirements of the engineering profession

The challenges and opportunities in the profession can be generalized to all the sciences and professions, but Engineering Education is facing the biggest challenge because the engineers are always affected by the emergence of new technologies, and this of course puts universities and scientific institutions and professional associations in front of a big responsibility. The new challenges impose the need to improve the capabilities, and opportunities of Engineers. Then Engineers must have solid scientific background, capable of innovation, familiar with the economic and social factors, with multi-skills, ready to accept change, able to work in a team, and accepts retraining schemes as well as long life learning.

Engineers must be capable of learning new skill in fast and discrete way to meet the ever-changing requirements of their employers. Educational systems should offer courses based on e-learning models using web based tools. These courses should be offered to the practicing Engineers and should be "on a need basis" taking into consideration the Engineer's specific needs for new knowledge and skills [5].

This leads us to the following main points in the design of engineering programs:

1 - Design versus Analysis: we need to integrate the theories of probability and statistics, numerical analysis and some mathematical skills and computer engineering software.

2 - Communication skills: integrate communication skills both written and oral in the curricula of engineering with practical training.

3 - Team Work: activate science clubs and contribute to the building of the integrated personality of the students through extracurricular activities and to make it receptive to working with others and be receptive to head the head and affects and is affected with others effectively.

4 - Solid Basic and Engineering Sciences: some try to reduce this part which may have a negative effect on the qualifications of the Engineer.

5 - Importance of other sciences: The Engineer should be familiar with other sciences, like information and management systems, and the economy and some social sciences and humanities. This helps the Engineer to be more observer and capable of absorbing the problems.
6 - Professional Ethics: are important in engineering practice especially in considering practice laws.

7 - Close cooperation with Industry: it is essential to establish a close cooperation between faculties of engineering and industry in order that they may both participate in the engineering education and training.

Engineering education in Lebanon

Lebanon has a historical background in higher education with the creation of the American University of Beirut in 1868, the University of Saint Joseph in 1875. During the 20th century there was the creation of many higher education institutions and universities (HEIs). Now-a-days, we have 41 HEIs, one public that represents about 40% of the students in Lebanon & 40 private institutions. The number of Faculties of engineering in Lebanon is 16. These faculties are part of existing universities.

Engineering education in Lebanon is regulated by the law 636/97 of the organization of Engineering practice in Lebanon which dates back to 1951 and was modified in 1997 [20], [21]. This law has three major issues:

1 - It setup the framework for engineering programs (5 years degree or Master of engineering).

2 - It creates a commission for the recognition of Engineers and the authorization to practice in Lebanon (obtain the title of engineer). The commission is composed of the Ministry of Education and Higher education, members from schools of Engineering, members from the Order of Engineers, members from the Ministries of Public Works and others.

3 - It Creates the Order of Engineers & Architect in Lebanon (OEA): Nobody can practice as engineer in Lebanon without obtaining an authorization from the correspondent ministry and without being member of the OEA in Beirut or Tripoli.

In addition the Technical Committee, created in 1996, supervises with the equivalence committee, created in 1955, the activities of the faculties of Engineering in Lebanon. Criteria's are defined by the law regulating the Engineering profession and by the decree number 9274/96 that define the minimum requirements for institutions and programs [22], [23].

The Order of Engineers and Architects in Lebanon provides new Engineers or practicing Engineers with all information related to the practice and with all the laws and decrees regulating the different aspects of the profession [6].

Table 1 shows the evolution of the number of engineering students in Lebanon between 2005 and 2010. We notice that there is net increasing of the number of engineering students from 11835 in 2005-2006 to 15509 in 2009-2010 with an increasing percentage of 31% during 5 years. This increasing Number is due to the creation of new universities and faculties of engineering. We notice that the number of students in the universities created after 1996 is 3665 representing 30% of the students.

The net increasing of the number of students in some universities during 5 years, as in figure 1, shows the need to introduce quality procedures to maintain the quality of Engineering education and to introduce new requirements in this education especially at the level of cooperation with industry and involvement of all the stakeholders in the process of education.

Table 1: Evolution of the Number of Engineering Students in Lebanon

University	Creation Date	Years 2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
American University of Beirut	1868	1519	1504	1596	1726	1799
University of Saint Joseph	1875	500	530	555	475	655
University St Esprit of KASLIK	1936	596	637	730	888	1011
University of Balamand	1936	557	579	588	679	772
Lebanese American University	1936	622	604	633	675	753
Lebanese University (public university)	1953	3007	3035	3204	3243	3287
Beirut Arab University	1960	2053	2040	2235	2366	2260
Notre Dame University	1986	757	980	1029	1202	1307
Al-Manar University of Tripoli	1990	0	28	10	61	81
Islamic University of Lebanon	1996	686	728	782	848	832
University Père Antonin	1996	711	680	721	763	791
Arts Sciences and Technology University in Lebanon	1999	104	87	75	65	91
American University of Sciences & technology	1999	219	151	141	209	202
Hariri Canadian University	1999	139	226	328	414	514
Lebanese International University	2000	365	424	694	1174	1154
Total		**11835**	**12233**	**13321**	**14788**	**15509**

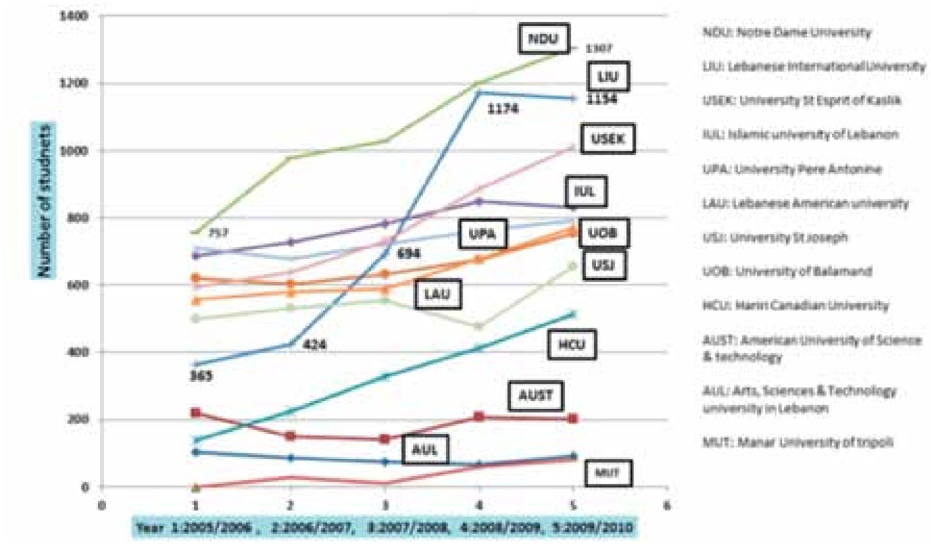

Figure 1: Evolution of the number of Engineering Students/University (Excluding Lebanese University, Beirut Arab University & American University of Beirut)

On the other hand, the engineering specialties in Lebanon are classical. Few new programs have been developed (table 2). We notice that the major number of students is in Architecture, civil, Computer & Communication Engineering (CCE), Electrical, and Mechanical Engineering. Some universities have begun in developing new programs like Chemical Engineering, Applied Energy, Environment and Water Engineering, and Engineering Management.

Table 2: Engineering Specialties in Lebanon & Corresponding Number of students

Specialty	Years				
	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
General (common)	1915	1660	2050	2464	3007
Agriculture	75	80	79	76	71
Applied Energy	0	0	0	0	11
Architecture	1272	1426	1622	1906	2067
Chemical	0	0	0	0	24
Civil	936	1209	1675	2131	2513
Construction	0	0	0	0	19
Computer	1231	984	890	781	597
CCE	2261	2268	2179	2335	2370
Elec. & Comp.	0	291	317	389	437
Elec. & Electro.	593	540	515	432	377
Electrical	916	794	799	920	997
Engineering Management	89	71	65	79	85
Electronics & Biomedical	381	423	429	402	339
Environment & Water	33	27	27	20	34
Industrial & Management	99	101	111	117	117
Mechanical	1669	1909	1989	2201	2039
Mechatronics	47	97	129	116	111
Telecoms	273	293	347	280	129
Topography	84	85	98	139	165
Total per year	**11874**	**12258**	**13321**	**14788**	**15509**

Figure 2 shows the evolution of the number of students by specialty. As we see, the number of total students outside classical ones is less than 500 students per specialty. There is a net increasing of the number of Engineering Students in Civil and in Mechanical Engineering du to the growth development in building and construction sector. A net decrease of the number in Computer Engineering of 50% is clear.

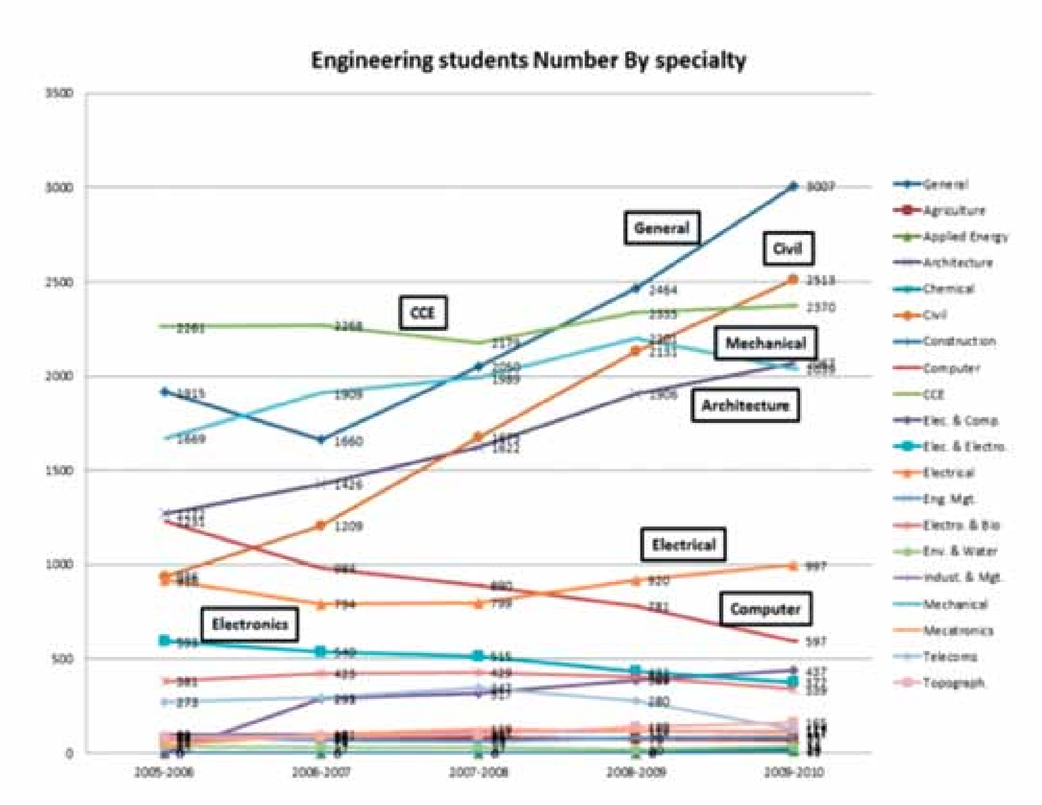

Figure 2: Evolution in the number of students by specialty

The total number of engineers registered at the Order of Engineers and Architects in Lebanon (OEA) is about 30.000 engineers, (in Lebanon the resident Lebanese population is about 4.000.000 people). Most of these engineers work outside Lebanon. The OEA propose to limit the number of students going to schools of Engineering by imposing a national entry examination. On the other hand the Ministry of Education and Higher Education works on the development of Quality Assurance and Accreditation standards for Engineering faculties and programs and through collaboration with European Engineering Accreditation Bodies. A proposal to create a Lebanese Accreditation Board of Engineering Education (LABEE) was developed [7] based on the International Standards and Procedures such as ABET and EUR-ACE. The European partners in this project were: European Federation of National Engineering Associations FEANI – Brussels, Commission of Engineering title in France (Commission des Titres d'Ingénieurs - CTI), European Society for Engineering Education (SEFI), and German Accreditation Agency for Study Programs in Engineering (ASIIN).

Recognition of engineering diplomas in Lebanon

As we mentioned before, the Engineering Committee in Lebanon, gives the certification to practice as engineer in Lebanon. The commission applies the Lebanese law of higher education, the law of engineering practice and the Lebanese regulations to recognize engineering programs in Lebanon. A list of recognized institutions and programs is amended every year by the committee.

For the programs from outside Lebanon, the Committee applies the recommendations of the international bodies regulating the profession. The Committee takes into consideration the decisions of the Federation of Arab Engineers [8], concerning the engineering schools in Arab Countries.

Regarding programs from other countries, the Committee looks for the accreditation of the program from national or international well known Accreditation Boards. The Committee recognize programs accredited by ABET and NAAB in USA, CEAB in Canada, and CTI France. For the programs from USA the accreditation of the program from ABET is necessary but not sufficient because students needs to have a Master degree in engineering. An unlimited list of recognized institutions and programs is amended by the Committee [9].

Quality assessment of engineering programs

Since 1932, the Accreditation Board for Engineering and Technology (ABET), has been engaged in a reform to encourage curricular innovation and to improve the accreditation process while continuing to assure quality in Engineering Education. The first step resulted in new criteria for the evaluation of Engineering programs, Engineering Criteria 2000 (EC2000) [10]. ABET recognized that it had to gather knowledge and gain the skills to evaluate programs using the new criteria. In addition, ABET needed to identify any major stumbling blocks that the institutions might encounter while attempting to meet the requirements of the new criteria [10], [11].

The Federation of Arab Engineers has introduced some criteria for the evaluation of engineering programs. We can summarize these criteria together with their indicators in table 3. These criteria and indicators are not enough to evaluate an Engineering program and it cannot be considered as Quality Assurance standards or indicators.

Table 3: Criteria for Evaluating Engineering Programs in the FAE	
Criteria for evaluating Engineering programs	Indicators
Age of the program	5 years at least
Faulty members	At least 3 PhD and 3 Master's degree full timers for every program
Curricula	1- Basic Sciences (Math, Physics, etc.) : about 25 credits 2- Engineering programs requirements: about 32 credits 3- Specialty requirements: about 40 credits 4- General Education (Human sciences, Communication, languages, etc.) : about 15 credits 5- The program is at least of 4 years after Secondary education and freshman year with minimum of 135 credits.
Admission requirements	• Clear admission Policy in the school • Students to staff ratio respects the international standards

There are many experiences in the Arab world (Jordan, Palestine, Kuwait, KSA) about the evaluation of Engineering programs. The initial stages of development and implementation of assessment plans for the Engineering programs at Kuwait University was developed, based upon an integrated set of strategies aimed at: establishing and maintaining a structured process that translates educational objectives into measurable outcomes and specifies feedback channels for corrective action; providing necessary assessment training; creating an assessment toolbox, and identifying and reviewing key institutional practices to ensure that they are aligned with the assessment process [12]

An assessment of the Output of Local Engineering Education Programs in the Palestinian Territories has been done [13]. The approach investigated the areas of strengths and weaknesses of the local universities Engineering graduates compared to their counterparts in universities abroad. The results indicated that local university graduates possessed overall competence and were strong in many aspects, such as theoretical and analytical abilities and computing skills.

A United Nations Development project RAB/01/002, at the Arab world level, for the "Enhancement of Quality Assurance and Institutional Planning in Arab Universities", has endeavored to help university leaders in the region understand the strengths, weaknesses and opportunities for making higher education more relevant to the dynamic demands of today's economies and labor markets. Through this project an assessment of engineering programs in 19 Arab universities has been done [14].

The evaluation report covers:

1 - Academic Standards: Intended learning outcomes, Curricula, Assessment of students, Student achievement, Overall academic standards,
2 - Quality of Learning Opportunities,
3 - Teaching and learning: Student progression, Learning resources,
4 - Quality Assurance and Enhancement,

In Lebanon, the Dissemination of Quality assurance in Higher Education started since 2002. Many European-Lebanese projects were realized on Quality Assurance [18], [19]. Many universities begin to develop their internal quality assurance processes. Since there is not a Lebanese Quality Assurance Body, many universities made appeal to well recognized Quality assurance and accreditation bodies at the institutional level. AUB and LAU obtained the accreditation from ABET. BAU works now with ASIIN in Germany, USJ with AERES in France at the institutional level. ABET Criteria was applied for the accreditation of AUB and LAU [15].

The accreditation procedure of ABET at AUB & LAU includes internal & external quality assessment with the participation of all the stakeholders: Students, Faculty, Alumni, and Employers, Program Advisory Council (Industry Leaders and Alumni Leaders).

Towards a Lebanese Accreditation Board of Engineering Programs

The purpose of engineering program accreditation is to ensure that education provided by Faculties of Engineering meet acceptable levels of quality [16].

The purposes of the accreditation process are [17]:

A - To assist all the stakeholders (parents, students, teachers, educational institutions, professional societies, potential employers, government agencies) in identifying those institutions and their specific programs which meet periodically the statutory educational body norms, standards and other quality indicators specified.

B - To provide guidelines for upgrading of existing programs and for developing new programs.

C - To encourage the adoption of a standard of excellence and to stimulate the process of continual improvements in engineering education

For all that, a complete study within a European Tempus Project has been developed to create an accreditation body for Engineering Programs in Lebanon (LABEE) with the participation of many European Engineering Accreditation Bodies. The accreditation system examines the Engineering Programs such that it [5]:

- Satisfies standard prerequisites on the contents of the study program.
- Shows the capacity to produce completely qualified students, specifically through the definition of a series of cultural, technical and professional requirements that are projected over the entire work life.
- Provides complete documentation on the means used to achieve the training objectives.
- Ensures that the objectives are achieved.

The main objectives of the project were [5]:

- To establish an organizational structure and by-laws for the proposed LABEE,
- To establish a draft of accreditation criteria,
- To establish a draft of accreditation procedures,
- To train Lebanese accreditation specialists,
- To be a consultant to the Lebanese Ministry of Higher Education and the Orders of Engineers for the equivalency of the international Engineering Degrees,
- To identify and classify Engineering Programs.

The importance of the project was by the participation of all stakeholders in the process (Order of Engineers, universities, Ministries, Students), and by the training of 18 staff from different universities on the external quality assessment. They participated in site visits to universities in Europe and participated in the meetings of accreditation boards as observers.

Conclusion

Based on the above, and based on “the reality of engineering education in Lebanon and the standards of Engineering education at the Arab and international levels, and pursuant to “the need to comply with the standards of education, we propose a number of recommendations, as follows:

1 - Developing standards focusing on quality as the main factor in the process of education of engineer to enter into professional life. This can only be achieved through the introduction of administrative and creative skills that contribute to personal development of the Engineer.

2 - Developing mechanisms to ensure implementation of standards, with the participation of institutions of formal , non-formal and informal education and related engineering profession.
3 - Focusing on the participation of professional Engineering institutions and Order of Engineers in setting standards for the adoption of Engineering programs.
4 - Revising the evaluation system of engineering programs put by the Federation of Arab Engineers, so that it might be the nucleus for the establishment of an independent Arab council for the accreditation of engineering programs.
5 - Introducing new approaches to serve the industrial applications.
6 - Linking education and training to the local market and industrial institutions.
7 - Interesting in extra-curricular programs and in encouraging students to exchange scientific visits, and in participating to workshops, seminars and conferences.

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Teaching fishing

Xila Liu
Civil Engineering Department
of Shanghai Jiaotong University, Shanghai 200030, CHINA

Dr. Xila Liu, Chair Professor of Civil Engineering Department at Shanghai Jiaotong University, Executive Member of WFEO, Executive Member of the Federation of Engineering Institutions of Asia and the Pacific Executive Member of Board of Directors of China Civil Engineering Society (CCES), Chairman of International Cooperation & Exchange Committee of CCES.

From 1994 to 2000, Dr. Liu was invited to be the Chair Scientist of the National Top Priority Research Project "Fundamental Research on Safety and Durability of Important Structures in Civil Engineering" by the State Science & Technology Commission of China. He was also invited as the principal draftsman on "The Development Strategy of Structural Engineering in China" (1991) and "The Development Strategy of Engineering in China" (1999) by the National Natural Science Foundation of China. In 2004, Dr. Liu was invited as the first principal draftsman on "2020: Research on The Development of Engineering Technology in China". Since his outstanding contribution he received an honorary certificate by the China Association for Science & Technology. In 2006 and 2008, he was also invited as Chair Scientist to write the 2006 and 2008 Annual Progressive Reports of Science and Technology in Civil Engineering for CCES respectively.

ABSTRACT

In the new century since the development of information technology (IT) activizes a new industrial revolution and the urbanization of developing counties is accelerating the education of new generation of engineers should be focused on capacity building and students-centered system. In the present paper, the author would introduce the historic Chinese saying "Teaching fishing" and introduce some personal opinions on how to implement the saying in class. Some requirements on textbooks, teaching methodology and teachers' responsibilities are all discussed.

INTRODUCTION

It is well known that since the new century started the engineering education we are working on is for the education of sixth generation engineers. The new generation engineers will face the technical globalization, the multi-disciplined development, and the computer popularization, especially the revolution of information technology. The requirements for them are not only on traditional professional knowledge but also on integrated technical management. It seems impossible to learn every thing in schools. On the other side, the urbanization process of developing countries is accelerating, such as both China and India with heavy population, a great amount of engineers are urgently needed. In this case, the frontline for education reformation for new generation engineers should be focused on two key points: one is to shift the keystone from knowledge transformation to capacity building; another is to shift the teachers-centered education system to students-centered. In China history there is a historic saying "Teaching fishing", which means that the master should guide prentices the fishing skill not just send fishes. The idea was capacity building. Almost 2600 years ago, it was Confucius era, the Chinese education was tutors system, tutor made different education program for each student. The success ratio of this education system was very high. It was very similar to the students-centered education system. It is also very clear the education efficiency in China history was not very satisfied. Almost 200 years ago China introduced "class", which was the western education system so-called teachers-centered. Following it the efficiency had been improved but the success ratio may be not so satisfied. Although the information technology is developing rapidly and people may enjoy long distance education and video classes, but it should be realized that the big problem is that teachers can not get feedbacks from students' eyes on class. They lost the face-to-face opportunity with students. In fact most experienced teachers are still familiar in teaching students directly in classes. Now, no matter in the West or in the East, we have to face the same problem, that is, how to implement the capacity building and students-centered system in class. In the present paper, the author would like to share his personal opinions with all colleagues. Particularly the textbooks, teaching methodology and teachers' responsibilities will be discussed.

ON TEXTBOOKS

In China, the Ministry of Education organizes a number of advisory committees on professional education, and the advisory committees would like to strongly recommend some so-called "National Unified Edited Textbooks". It seems a good way to guarantee education quality for middle-level or lower-level schools in China, but it certainly is obstacle to improve the education quality for outstanding schools. It is clear that the quality, capacity and knowledge of students from outstanding schools are much better than others; using unified textbook is some kind of loss. During the Spring and Autumn and Warring States Periods in China (770~221 B.C.) people liked a concept, which was so-called "let a hundred flowers blossom, weed through the old to bring forth the new". In fact most of senior authors in China need more creative spaces to present more various textbooks without unification format.

It should be also recognized that, in the new century, it is impossible to translate all the knowledge to students in class. This is way we have to shift the keystone from knowledge transformation to capacity building. As Chinese saying, it is so-called "draw inferences about other cases from one instance". In this case, the modern textbook should make every effort to emphasize basic concept. In the new century, the textbook should be thinner and thinner, should not go to opposite direction as handbooks.

For example, the course of "Matrix Analysis of Structures" has been provided more 30 years. It is a typical computerized course in structural engineering. Today what should be emphasized in this textbook? It seems not programming, because it can be done easily by many commercial softwares. In fact one of the key points should be concentrated on how to build the coordinate systems, especially to give clear explanation on the relation between the local coordinates system and the global coordinates system. Some sign conventions should be eliminated. Another key point is to present the physical meaning of matrix calculation process. To invert the structural stiffness matrix, as example, it is not necessary to show many numerical algorithms could be used, which can be easily found from any textbooks on numerical methods. The most interesting question is that: what has had happened on structure during the invert algorithm of structural stiffness. Such as, when the Gaussian elimination method is used to invert the structural stiffness matrix, during forward elimination process there are very clear physical meaning happened on existing structure at each step and during backward substitution process there are also very clear physical meaning happened at each step on the same structure. After necessary explanation on this point, students can understand the essence of inverting the structural stiffness matrix rather than just use the numerical algorithm.

IN CLASS

My American advisor asked me that where is the following famous Chinese proverb coming from, which is "Teach me, I will forget; Show me, I may remember; Involve me, I will understand". Unfortunately until now I can not find the derivation, but it is really well-known by American teachers. It seems clear that the best teacher should be good on involving students in class, as more as possible to show students in class, and to avoid using endless talking.

If the teacher would like to involve more students in class, for example, there are 40~50 students in the class, the teacher had better to remember most of the students' names in 2 or three weeks. The teacher should also recognize every student's levels and could raise some reasonable questions for different students with different levels respectively. The preparation of teaching materials in class should not only include the notes, but also include a list of questions. The teacher's speak should not be very long. In fact, it is a kind of art. In general if a teacher give a speech longer than 20~30 seconds with the same speed and tone on class the students will be very easy to enter so-called "laziness condition". The teacher should quickly find it from the first yawn of some student in class.

As mentioned by some experienced teachers a mature lecture should be taught around by six to seven times. On the class the principal should be that if the problem can be solved by teacher-students discussion there is no need to ask the teacher's explanation. In practice the so-called "mixed lectures" or "two-way lectures" are much attractive for students.

In China, teaching with PowerPoint (PPT) is encouraged. In this case, more and more teachers are mad on teaching by PPT, even it seems no need for teachers to prepare the lecture before entering the classroom. The professor may become a PPT professor, which can be simplified as "P-Professor". In this case, it seems no need for students to make notes in class either. The students just make some marks on the copies of teachers' PPT. In fact, PPT is a powerful tool to transfer some knowledge in image, but it may not very good for transferring knowledge in logic. The teaching speeds of deriving the same equations on blackboard by the same teacher may quite different which in fact is controlled by students' responses in class. Certainly, every time the teaching speeds are different.

To emphasis the capacity building we suggested that "Teaching one; Homework two; Examination three", which means the home works assigned in class should be more difficult than the examples teachers showed in class, and the questions on examination papers should be most difficult. In this way the students may be pushed to pay more attention on capacity building, which was mentioned "draw inferences about other cases from one instance".

TEACHERS' RESPONSIBILITY

It is well known that the "Engineering", to some extent, is different from "Science". The prominent points of engineering are particularities and synthesis; in this case, the engineering experience is very important for professors or teachers working in engineering schools. In author's teaching group all faculty members are required to keep both teaching and researching. Teaching is like some kind of cleaner to clear the researchers' mind, and researching can make teachers' lectures more active. Publishing papers with high qualities are very important for faculty, but from author's point of view, the engineer license is also one of the primary requirements for them. In civil engineering field, the case-study is very fundamental. If faculty members working in engineering school can only copy and present some engineering cases from other textbooks and have no their own experienced cases it will certainly be very passive.

Higher grade definitely make everybody happy, but for teacher's primary responsibility is to make students learning more. The education quality is not dependent on how much the teacher have taught in class, but should depend on how mush students really learned after the course finished. The general grade distribution should be following the normal distribution as shown as Line I in Figure 1. But it can also be found so-called "very happy" grade distribution shown as Line III (Figure 1) in schools , based on which students may give higher evaluation credits to the teacher and teacher can also easily released his (or her) teaching loading without heavy work done. The problem is serious: the teacher has lost his (or her) responsibility. Sometime it can also be found as Line II (Figure 1). In this case, the best suggestion should be given to teacher, may be, the teaching contents, teaching speed, or presentation should be improved.

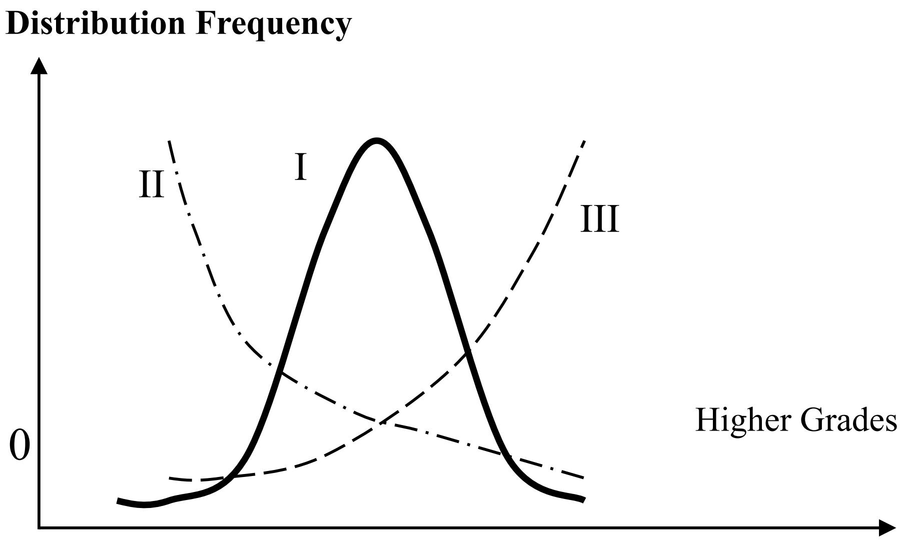

Figure 1 Three different grade distribution

Some best teachers in author's department usually have a large cycle of students as friends around them. They organize many academic activities out of classrooms, such as technical workshops, meeting with distinguish alumni, attending activities of students chapters and attending various structural design competitions with many awards. As time goes on some teachers can give more students helps not only from knowledge learning but also psychological advisements.

REMARKS

In China teachers are so-called "the engineers of human psyche" and the engineering schools are so-called "the cradles of engineers", it seems impossible to educate an engineer only from engineering school where can only transfer some basic professional knowledge. In the new century, the engineering education should focus on capacity building. To educate younger generation is the duty of teachers, among all the training programs, the top priority should be given to the students' quality.

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Preparation of Engineers for a Sustainable Future in This Modern Era

Antoine Boulos Abche[1,3] and Abdul Menhem Alameddine[2,3]
1 - Dept. of Electrical Engineering, University of Balamand, Tripoli, Lebanon
2 - Dept. of Computer Engineering, University of Balamand, Tripoli, Lebanon
3 - Federation of Lebanese Engineers

Antoine Abche received the BS Degree and MS degree in Electrical Engineering from the University of Toledo (USA) in 1984 and 1986, respectively. He received the PhD degree in Biomedical Engineering from Rutgers The State University (USA) in conjunction with the University of Medicine and Dentistry of New Jersey (Robert Wood Johnson) in 1996. Currently, he is a professor in the department of electrical Engineering at the University of Balamand. Dr Abche's research interests are: Virtual Reality, DSP, Image Processing, Analysis and Classification, Telemedicine, Image Registration, Neural Network, Fuzzy Logic, Modeling and System Identification. His interest extends to the improvement of the profession of Engineers.

Abdul Menhem Alameddine is the Chairman of the Committee on Education in Engineering at the World federation of Engineering Organizations. He was President of the Order of Engineers and Architects in North Lebanon and Vice president of the federation of Lebanese Engineers in Lebanon from 2005 to 2008. He received his B.S. Degree in Electrical Engineering in 1977, and his M.Sc. Degree in Engineering Systems with emphasis on Computer Engineering from The University of Southwestern Louisiana (USA) in 1981. He is a senior member of IEEE. Currently, he is a Lecturer in the department of Computer Engineering at The University of Balamand.

I. INTRODUCTION

One of the most important assets of a country is its citizens, especially if they are well prepared and equipped to take their places in its development (at the economical level, technology level, commercial level, etc…). This is very evident for the engineers who have to keep track with the rapid changes and advances of the technology, knowledge and techniques in their respective fields. In this context, the educational institutions, such as universities, have to develop undergraduate and graduate engineering programs that respond to the needs of the country, the society and their developments at all levels. Consequently, universities have to take a good step to face the challenges by preparing their students for a bright future and successful carriers with a good quality programs and provide them with the necessary analytical skills, a strong knowledge in the fundamental of engineering and information in their respective fields or disciplines i.e. biomedical engineering, electrical engineering, chemical engineering, mechanical engineering, computer engineering, civil engineering etc…. Similarly, the industries/companies are in great needs of well prepared engineers to be competitive in the market (local, regional as well as international) and to take the lead in the advancement and the development of the industries as well as the country. Subsequently, the academic institutions and the industries/companies should join their forces and resources (in a certain context) in order to prepare the future engineers to be a sustainable entity. However, the students should do their parts i.e. be motivated and willing to excel in order to face the challenges, be an added value (to themselves, the company, the country…), to sustain their developments at all levels (technically, educationally ...) and to be better engineers. In this context, this paper addresses the collaboration between universities and industries, the life-long learning process, collaborative approach (team work), individual approach (autonomous work) and the communication skills in the preparation of future engineers to achieve a sustainable development that will keep all parties in the realm of life, competitive and satisfied with their achievements. Subsequently, the students are a step closer to be a leaders in their respective fields [1], [2], [3].

II. COOPERATION: THE UNIVERSITY AND THE INDUSTRY

At first glance, the collaboration between the universities and the industries seems to be difficult to attain. On one hand, the universities are concerned in developing programs at the undergraduate and graduate levels to prepare highly qualified and skilled engineers in their respective fields. On the other hand, the industries/companies are more interested in making profits and increasing the value of their assets. However, if the competence and the expertise of each party are merged in a complementary manner, the cooperation between the two entities (universities and industries) can be forged and can be fruitful, effective, efficient, advantageous and beneficial for all, including the students [4], [5]. Furthermore, the engineer will become more prepared for a bright future by acquiring additional skills, knowledge and information that can be valuable for his survival in the market and of great value in facing and tackling the various challenges during the span of his working life. The cooperation can manifest itself at different levels such as practical training, research, exchange of information and employees and joint educational programs.

II.1 PRACTICAL TRAINING

Currently, engineering programs at the undergraduate and graduate levels have placed a great emphasis on the practical training of students in the industries/companies. The practical training has become an integral component towards the fulfillment of the students' engineering degrees [6]. Thus, students will have a good opportunity to have hand-on experiences, be faced with real engineering problems and be in close contact with the working engineers. Besides, the integration within the facilities of the industries/companies will help the future engineers to gain various skills (technical, practiced professional ethics, job's responsibilities, communication skills….) that are of great importance in their professional developments. Thus, they will be more prepared for successful carriers and can compete in the marketplace. In this context, the universities in cooperation with the industries should also set-up programs in which the expertise and the skills that are acquired by various students through the industrial training are disseminated to other engineering students.

II.2 RESEARCH

Besides a high quality education, universities emphasize the research as a key component for the future in order to have a further impact on the development of a country at all levels (technological, economical, etc…) [7]. Their students, mainly at the graduate level, have been one of the main powers and the intellectual work force behind the advances observed around the world. They are capable of comprehending the subjects of interest, grasping the original ideas, formulating new ideas, transform them into successful, marketable and profitable products, and advancing the research under consideration. The industries and companies are mostly interested in research that can span over a short period of time and can be quickly introduced into the market for a profit. Therefore, a joint collaboration can be highly beneficial for both parties. The industries could help funding (partial or full) such projects (short or long term) to support financially the graduate students (tuition, rent, living expenses …) so that they can allocate and spend more time on the research. Furthermore, since the joint research will be on the state of the art technology, the students will be more prepared to face the future by acquiring additional skills (for example). Subsequently, this joint venture can provide the students with a good quality education and they will be in a good position to enter the market with the least inconveniences. Also, the industries/companies will be in a position to excel and make an impact locally, regionally as well as internationally. Besides, these students might be their future employees with the least effort of recruitment.

II.3 EXCHANGE: PROFESSORS AND EMPLOYEES

The exchange of professors, instructors, engineers and researchers between the universities and industries will be another level of collaboration that can be fruitful and beneficial to all parties. The exchange will set up a platform to transfer ideas, information, knowledge, skills, competence, expertise and technology among the participants. Therefore, students will be in a position to be a part in this valuable exchange that will extend their theoretical and practical aspects and could have a great impact on their professional developments. Consequently, this type of collaboration might increase the motivation of students to learn in order to excel in their respective fields.

II.4 UNIVERSITY: INTERNATIONAL COOPERATION

Another level of cooperation can manifest itself through the collaboration of the university with regional and international universities and industries. This cooperation can further develop its relations with the local industries and can be used for the benefits of students. Besides, the professors may be exposed to advanced (state-of-the-art) technologies, skills and ideas, and consequently, they will be in a position to disseminate the acquired knowledge and information to the students who will become more prepared when they graduate.

II.5 EDUCATION PROGRAMS

As soon as the student is graduated from his university (even before graduation), he begins the search for a job and hope to be hired by a particular company. Thus, it will be of great importance for an industry to enter in a joint venture with the university (ies) in order to prepare the newly engineers. The joint venture could include the creation and the development of specialized programs, the introduction of particular courses in an area of interest and the creation of specialized Laboratories [8], [9], [10]. In this context, the involved parties should discuss and design the curriculum of the programs (or courses). The content is defined in order to prepare a highly-skilled and competent workforce in the area that is required by the company/industry. In the same context, the industry could donate some of its equipments (old/new) to the university to set up a laboratory in a particular area that can be beneficial to the university as well as to the industry. Also, it can provide equipments at an affordable price (special rate). Another aspect is the financial support (tuition...) of the engineering students within a certain framework (research, project …). In this context, the enrolled students can perform the practical training within the facilities of the involved industry (ies) and consequently, the latter will play a role in the preparation of highly qualified engineers who have gained the industry's experiences, professional practices, ethics, and tools.

II.6 DISCUSSIONS

The cooperation that is forged between the universities and the industries can be of great importance in increasing the knowledge and the skills of the students and consequently, it is valuable for their professional developments with a good quality education. Thus, the newly engineers can play a role in the economical growth and survival of the industries. Such cooperation could manifest itself at various levels: the development of new courses, the modification of existing courses, the modification of current programs, the development of new programs, the practical training and the joint research.

In this context, the industries should open their facilities to a certain extent to students. Industries (as well as universities) should be engaged effectively in this collaboration. Visits (of professors, engineers …) should be performed routinely between industries and universities. This will provide an opportunity to discuss common subjects and projects and to speak the same language. Subsequently, the engineers can make sound decisions about their fields of interest in which they can excel and make a positive impact (high contribution) on the corresponding industries, the society and the country. At the same time, industries can assess the motivation, the competence and the expertise of each engineer who might be a future employee.

III. LIFE-LONG LEARNING PROCESS

The life-long learning process can be viewed as a crucial step for a sustainable professional development of an engineer. The involved parties should engage effectively in pursuing this endeavor. The engineer is living in a world in which the advancement of technologies is moving at a fast pace. He should be well equipped to be competitive in the workplace in order to succeed. Otherwise, he will perish or he will keep searching for a job. In this context, he has to be up to date (technically, technologically, knowledge …) i.e. should be always in a state of learning and improve himself continuously to remain an expert in his discipline. The life-long learning process can manifest itself at different levels: read new materials through subscribing in journals of interest, enroll in a particular course, inscribe in a continuing education program, participate in conferences, attend seminars and workshops etc….

Besides, the student/engineer should be an "active person" and not a "passive person", a concept that should be pursued at his university and even at an earlier stage. He should be motivated, eager to improve himself and be encouraged (by the university, the industry…) to learn continuously (at least at his own pace). Thus, the professors/instructors should move from the traditional class setting to a setting in which the pupils are not viewed as a container of information and knowledge that should be filled during their university years. They should be seen as persons capable of producing knowledge and information, and be an integrated component of the teaching process. This approach should also be practiced by the company/industry, at least during the practical training's period. Thus, a more informed, knowledgeable and professionally developed engineer, is an added value to the industry/company and the country (economically, technically …).

IV. TEAM WORK AND AUTONOMOUS

Nowadays, the design and implementation of tasks (projects …) within industries are multidisciplinary and may require several engineers with different disciplines, competence, knowledge and skills. The tasks may not be easily accomplished by one individual engineer. Therefore, the latter has to be integrated within a group in order to achieve the work efficiently and effectively. Besides, the competition has forced the companies to accomplish the task according to a time table (within a reasonable time period) without compromising the quality of the product (or products) in order to survive in this era. In this context, each student should be able to work with others during his/her studies at the university, and even while he/she is in school.

For example, at the university level, students in a particular class can be divided into several groups and each group is composed of three or four students. Within each group, they should join forces and work together to accomplish a particular task during a problem session (or within a project…) with the supervision and the guidance of the instructor through the process (understanding, analysis, discussion of various solutions, critical thinking …). The task should be performed within a period of time. Subsequently, a presentation will be given by each group and a discussion in the class will follow. This approach will enhance, among others, the communication skills (at least verbal or oral) of the engineers and emphasize the concept of collaborative work within a team. This procedure can be implemented at the undergraduate and graduate levels.

However, an engineer should also have the ability to work individually in an autonomous way with less or no supervision. The company is not interested in hiring an engineer who is guided at every step. This will be a waste of resources, time and money for the company/industry and consequently, the engineer cannot survive in today's world. Therefore, he should be "trained" or "educated" with the appropriate tools and skills during the years at the university to perform accordingly.

V. COMMUNICATION SKILLS

Communication skills are an important factor in the professional development of the student. They define the way students/engineers/employees interact with each others. They are valuable as the various acquired skills (technical, technological …) in their respective disciplines. The engineer should be able to communicate effectively and efficiently in order to succeed. For example, he/she has to i) communicate (oral, written) clearly his/her thoughts, reasoning and ideas with fellow students within the group and/or in the class, ii) discuss problems, approaches and solutions with fellow engineers and personnel in the company and iii) disseminate to the instructors/ professors/managers the outcomes of the project. All the involved parties should speak, read and write the same technical language. If an engineer has the brightest idea which is implemented in an excellent, efficient and effective manner, it may pass unnoticed if it is not communicated clearly (and in an understandable fashion) to his supervisor(s)/instructors/managers.

Furthermore, the engineer, with good communications skills, can be a very effective and an efficient player in his team, interact easily with his colleagues (in the university or industry), and can accomplish successfully the task at hand. Besides, this provides a platform to exchange the expertise, information and knowledge.

VI. CONCLUSION

The citizens are the most important assets of a country, especially if they are well prepared to face the challenges of today's world. In this context, the engineers are living in a world in which their assets are the knowledge that they acquire, the information that they accumulate effectively, the skills (tools, analytical, critical thinking, communication…) that they master, and the hand–on experiences that they learn. These assets are needed to compete and survive in the marketplace, and to achieve their professional developments. The preparation of engineers is a lifelong process i.e. the learning is continuous (at the university, after graduation, during work in a particular industry...). Furthermore, universities and industries should work hand in hand and forge a long and lasting cooperation to pursue the above objective. In this paper, some issues were addressed: the cooperation between universities and industries, the life-long learning process, team work, working in an autonomous manner and the communication skills. These issues, as well as others, could prepare the students to be better engineers, more satisfied with their accomplishments, and to achieve sustainable carriers. The preparation begins at the universities, and even earlier, to respond to the needs of their societies and nations. Furthermore, it will be of great value to the industries to compete effectively and make their marks on the national economy or the regional economy and beyond.

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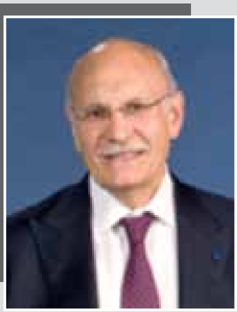
“Quality Assurance of Engineering Education in the 21st Century” Objectives – results

Submission from AIME



The below is an excerpt by Diran Apelian, Sc.D. Howmet Professor of Mechanical Engineering Director, Metal Processing Institute (MPI) at Worcester Polytechnic Institute (WPI), educated at Drexel and the Massachusetts Institute of Technology (MIT). Dr. Apelian’s research areas have included Sustainable Development, Resource Recovery and Recycling, Solidification Processing, Spray Casting, Molten Metal Processing, Light Metals: Aluminum - Magnesium - Titanium, and Plasma Processing. He is a member of the U.S. National Academy of Engineering and the National Academy of Sciences of the Republic of Armenia. He has received numerous engineering honors and is a member of the American Foundry Society (AFS), The Minerals, Metals & Materials Society (TMS), American Society of Metals (ASM), Engineers Without Borders - USA (EWB), Metal Powder Institute Federation (MPIF), and Societe Française de Métallurgie (Paris, France).

The excerpt is from Engineering Solutions for Sustainability: Materials and Resources, Workshop Report and Recommendations just released at:
http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118175859.html

The workshop was organized by the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) and co-sponsored by the American Society for Civil Engineers (ASCE) and the American Institute of Chemical Engineers (AIChE). It was hosted at the École Polytechnique Fédérale de Lausanne, Switzerland, July 22-24, 2009 and funded by the United Engineering Foundation (UEF).

A unifying theme was Engineers in All Disciplines Need to Achieve Sustainability. In essence, engineering education needs to be reconceptualized to produce sustainable engineers. Sustainable engineering requires professionals for whom engineering education is a lifelong process, not an outcome at any particular stage.

There is a need to develop engineering education systems (training materials and protocols) that embrace a more holistic design paradigm in which engineering "performance" must evolve from function, cost, quality, safety, environment, human health, and social well-being. Engineering education must also recognize and appreciate the need for transparent governance, continual stakeholder engagement, and engineering design systems that endure over the entire life cycle of the technologies and materials that society deploys.

INTRODUCTION

The topic of human resources specifically, the scientists and engineers who must be engaged to meet the world's sustainability challenges was explored during the following keynote presentation:

Diran Apelian, Howmet Professor of Engineering and Director, Metal Processing Institute, Worcester Polytechnic Institute
Human Capital Needs for Sustainable Development for the 21st Century: The Role of Engineers, Their Recruitment and Educational Imperatives.

Because of their cross-cutting nature, the concepts that were presented infused the discussions in the workshop breakout sessions that eventually developed the other topics covered in this report.

A WORLD OF NEW OPPORTUNITY – AND CHALLENGES

Engineering education and the profession are confronting a challenging crossroads. Some see it as a crisis, while others view it as an opportunity for positioning the science and engineering community to better meet the challenges of the 21st century. As Charles Dickens cited in the opening phrase of A Tale of Two Cities, "It was the best of times, it was the worst of times."

Globalization of the economy has amplified the impact of technology on modern societies in ways that could not have been predicted. The connectivity provided by the Internet has generated new markets for products and services, and has also made labor available that is often both educated and cheap. This is likely to have a profound impact on the distribution of wealth in both the developed and the developing part of the world and may, in particular, alter the socio-economic structure of countries where the general well being of the population has been taken for granted. That education plays a role in the prosperity of nations is not debated, but many authors, like Landes[1], for example, argue that it is specifically the presence of both knowledge and know-how that determines how well off societies are. The education of engineers is, therefore, critical to every nation to ensure the prosperity of its citizens, based on the following premises:

- Knowledge and know-how determine how well off societies are compared to other societies.
- Standard of living hinges on the ability to educate a large number of sufficiently innovative engineers.
- Research and development spending fuels innovation.
- Creation of wealth is related to a nation's ability to make products that other nations want to purchase.

The modern professional identity of engineers emerged in the early eighteenth century with the establishment of the École Polytechnique in France and the founding of professional engineering societies in England. The current way of educating engineers, including the structure of the curriculum, was established by the early twentieth century. The last major shift in engineering education occurred in the United States more than half a century ago when the role of science in the educational program increased significantly.[2] Although some evolution has taken place since then, those changes have been relatively modest and the basic structure and course content of a modern engineering program is very familiar to someone educated in the sixties. Moreover, the engineering curricula developed in the West are the curricula being taught in developing countries, perhaps with more intensity.

The time for another major re-examination of engineering education is overdue.

That the world has changed in fundamental ways during the last decade or two is self-evident. Computers have fundamentally transformed the ability to deal with information and data. Society is rapidly moving rapidly toward a world where - for all practical purposes - people can *process information infinitely fast, store an infinite amount of data, and transmit data instantaneously*, to paraphrase a statement made by Henry B. Schacht, the first chairman and chief executive officer of Lucent Technologies Inc. in his commencement speech at Worcester Polytechnic Institute (WPI) in 2001. As a result of the emergence of the Internet, knowledge has been "communalized." Everybody has access to information about anything and - perhaps equally important - knowledge is no longer "owned" by the experts. Computers have also empowered the average man and woman to create products that previously required large corporations with significant resources. In many aspects of digital media, if something can be imagined, it can be created. As computer speed and software advances, this trend will continue until, in the not-so-distant future, a high-school student with a laptop will have the capability to create a full-length movie with virtual actors of the quality currently only produced by major filmmakers. The same transformation is likely to happen to the creation of engineered artifacts, although the timeframe may be somewhat longer. Ordering components online and receiving them in the mail is now part of everyday life, and e-manufacturing - where the customer sends an electronic description of a part to a manufacturer that makes it and mails it back - is emerging.

The globalization of the world economy affects everyone. The motion of laborintensive, but low-skill industries, to countries with low labor costs is not new. Such transfer has been largely responsible for the low cost and abundance of most manufactured goods. Today, however, the rise in education in nations where salaries are low, coupled with the connectivity that makes this cheap and educated talent available worldwide, are gradually changing the nature of jobs worldwide.

The mechanization of labor and advances in transportation, taking place during the last century, in tandem with the more recent information revolution and globalization of the economy, has brought unprecedented opportunities and challenges. On the positive side is that the increase in material wealth makes it - for the first time in history - realistic to talk about eliminating extreme poverty.[3] On the negative side is the possibility - for the first time in history - that human consumption of materials and energy may irreversibly damage the entire global environment. Engineering in the new world is, therefore, both a daunting and an exciting undertaking.

BUILDING "LEARNING ORGANIZATIONS"

To compete in the "knowledge era," organizations have to be capable of learning and embracing a culture of learning in order to improve products and services continuously. Learning organizations are those where information and knowledge flow freely throughout the institution, not just from the top down. In the learning organization, every worker and every work site is a listening post for new ideas and product improvements. The mass production organizations of large corporations, big government, and higher education do not have that kind of sensitivity. The dilemma is that by merely installing flexible technology and flexible work systems and giving workers the autonomy to exploit the new flexibility has proved to be insufficient. Empowering people without enabling them with skills necessary to use their new autonomy is really a hollow exercise.

In a global economy driven by relentless innovation, what a company knows has become as important as what it produces. Success in the marketplace is increasingly linked to an organization's ability to manage and leverage its intellectual capital—the intangible and often invisible assets such as knowledge and competence of people, intellectual property, and information systems that do not show up directly on the bottom line, but are just as valuable as financial assets.

The dramatic changes in today's economy are fueled by technology, global competition, and deregulation. These forces are likely to accelerate in the years ahead and cannot be ignored or legislated out of existence. They require a new way of working, a new paradigm of the workplace, and investment in society's most important capital—its human assets.
Education models and paradigms for the engineering profession need to address these critical issues.

THE ENGINEER OF THE 21ST CENTURY

Engineering education has changed in the past to adjust to the needs of society. The evolution must continue to address current and future needs. With many approximations and generous error bars, the major trends in engineering education can be summarized by the following classifications (for a more fine-grained classification see[5]):

19th Century and First Half of the 20th Century: The Professional Engineer

As engineering became a distinct profession, early engineering programs focused on providing their graduates with considerable hands-on training. However, the role of science and mathematical modeling slowly increased and gained acceptance.

Second Half of the 20th Century: The Scientific Engineer

Technological progress, including the successful harnessing of nuclear energy, as well as geopolitical realities as materialized by Sputnik, drove home the need for engineers to be well-versed in science and mathematics and the engineering curriculum adjusted. This structure has, to a large degree, continued until the present time, although "design" content increased slowly. In the early nineties, it was clear that more than science was needed and many schools started to emphasize non-technical professional skills, such as teamwork and communications.

The 21st Century: The Entrepreneurial/Enterprising Engineer

The rapid changes that the world is currently going through, coupled with changes in engineering education that started to take place in the nineties, are likely to result in an extensive re-engineering of engineering education. While the new structure will, almost certainly, continue to be based on a solid preparation in mathematics and sciences, it is likely to emphasize the professional role of the engineer, and then demand new qualifications suited for the new world order.

It is impossible to say what the engineering profession will look like a hundred years from now. The intense discussions that are currently taking place [6, 7, 8, 9, 10] among leaders of the profession and educators suggest that innovation will be a central theme. The premise is that skill is a commodity and that routine engineering services will be available from low cost providers that can and will be located anywhere in the world. Engineering education, therefore, needs to add value beyond just teaching skills. This does not mean that future engineers will not possess skills. Quite the contrary, they will have to be more technically proficient than those today who practice narrowly defined tasks. This new breed of engineers must constantly be able to gather information and decide on a course of action, including what tools are needed for a given task. The technical skills, the people skills, and the innovation required of the future engineer can be summarized with only modest exaggerations - as follows:

- Know Everything: Find information about anything quickly and know how to evaluate and use the information. The entrepreneurial engineer has the ability to transform information into knowledge.
- Do Anything: Understand engineering basics to the degree that he or she can quickly assess what needs to be done, can acquire the necessary tools, and use these tools proficiently.
- Work with Anybody, Anywhere: Possess the communication skills, team skills, and understanding of global and current issues necessary to work effectively with other people.
- Imagine and Make the Imagination a Reality: Exhibit the entrepreneurial spirit, the imagination, and the managerial skills to identify needs, come up with new solutions, and see them through.

Achieving the first goal knowing everything is relatively easy. Search the Internet for any concept and an abundance of information can generally be accessed in a matter of seconds. The communalization of knowledge, mentioned earlier in this chapter, makes it essential that the professional engineer be able to judge the quality of the information that he or she acquires. Teaching how to deal with this vast array of available information and to judge its relevance and quality will be the educational challenge.

As to the second goal, engineers have always learned as they tackle new challenges. The explosion in the availability of tools, however, suggests that engineering educators must rethink how students are prepared in the foundation of their disciplines. Computer programs that do virtually anything, from conducting simple calculations, to simulating complex systems, to designing a complete engineered artifact, empower the modern engineer to do more than his or her predecessors could ever imagine. However, these tools not only require that the engineer knows how to use them. Engineers must also possess the ability to assess what tool is appropriate for a given task and then be able to evaluate the result in a critical way. The importance of common sense will be even greater when design and analysis are done exclusively on the computer. While teaching engineering students how the physical world works is at the core of engineering education today, re-examining how to teach the fundamentals of engineering science to students is needed. Knowing the scale of phenomena and the distribution of knowledge over multi-scales are critical attributes.

In addition to the changes in the technical skills engineers must possess, their non-technical professional skills must be suited for the modern way of doing engineering. Considerable progress has already been achieved in the United States to make communication in the broadest sense an integral part of the engineering curriculum.[3,11] Most programs now require their graduates to exhibit proficiency in oral and written communications and to be able to work on diverse teams. Engineering, possibly more than most professions, requires accurate and efficient communications. In today's global society, the ability to communicate takes on a much broader meaning. Not only are engineers frequently working on products that will be made in a different country and marketed to people of different cultures, but product engineering is increasingly done by teams consisting of people located in different nations and with diverse cultural backgrounds. Such interactions obviously present enormous potential for misunderstanding and conflicts. As illustrated by Ron Zarella, chief executive officer of Bausch and Lomb, during a globalization workshop at WPI:

> *"We make a product called Interplak. The electromechanical design for this home plaque-removal device is done in Germany and Japan. The batteries are supplied from Japan, the motors are built in the Peoples Republic of China, the charging base is made in Hong Kong, the precision molded plastic pieces are manufactured in Atlanta, the brush head is made in Ohio, and the final assembly is done in Mexico."*

Preparing young engineers to work in a worldwide community is no longer something that engineering schools can treat as an extracurricular activity, available only to those who have the time and resources to spend an extra semester abroad. Every student must now develop the attitudes and skills necessary to function globally, right from the time they first enter the workforce.

Finally, the engineer of the future must be able to do more than just perform technical tasks. There have always been extraordinary engineers who have had the imagination, vision, dedication, and endurance to change the world. Those who do not possess these traits have, in the past, been able to make a living performing routine engineering tasks . The young engineers of the future must, on the other hand, all be extraordinary. They will not be able to enjoy the comfort of well-paid jobs where routine tasks are performed more or less unchanged year after year. More and more, the engineer of the future will be responsible for creating new ideas and solutions and seeing them through. Innovation has already been identified as one of the most important factors in the future prosperity of both nations and individuals.[1, 9, 10, 12] However, not only must the engineer innovate, he or she must be able to help the innovation become a reality. The education of the engineers of the future must prepare them to see new opportunities, as well as to give them the skills needed to marshal the resources to realize their ideas.

SOCIETAL ISSUES AND ENGINEERING AS AN ENABLING PROFESSION

Innovation, creativity, and entrepreneurship, as well as the societal context of engineering, ought to be central to the new engineering curriculum. Linkages between the engineering profession and societal needs ought to be explicitly articulated, as this will inspire and attract students to the profession.

Engineers solve problems, make things happen and enhance the quality of life on this planet. This has been a constant. What has changed over time have been the needs of society and how engineers have responded to those needs. During the late 1800›s, engineers are credited with profound innovations and inventions to meet the needs of the Industrial Revolution. Engineers made things, built bridges, and established mass production. In so doing they transformed the Western world from an agrarian society to an industrial one. In the 1900›s, with the advances in solid-state physics and the understanding of the atomic structure, engineers learned science and became scientists because they needed the science base to solve the problems facing society. This included everything from defense technologies to the development of the semiconductor and the electronic materials revolution, among many other inventions

For the 21st century, engineers need to be enterprising and must lead to address the needs of a global society. With 20 percent of the world population living in absolute poverty, 18 percent of the population lacking access to safe drinking water, 40 percent having no access to sanitation, energy consumption increasing at a higher rate than population growth, and healthcare needs and expectations out pacing health care delivery, there is no doubt that the engineer of the future needs to be a social scientist, as well as an enterprising leader to meet these needs.

At present, public perception of engineers and engineering does not reflect reality. It is a fact that many top industrialists and successful CEOs are engineers. Surgeons and physicians have a first degree in engineering, as well as bankers and financial tycoons. There is no limit to what engineers can do. The image of engineering needs to reflect the boundless opportunities and lifestyles that await those who pursue this course of study.

In the early 1900’s, engineering educators did not pay attention to management issues and essentially allowed management to leave the engineering curriculum. This was a mistake. Interestingly, the mathematician Laplace, who was one of the founding directors of the École Polytechnique, in France, said:

> *“The École Polytechnique should aim to produce young people destined to form the elite of the nation and to occupy high posts in the state”*[13]

This was the view of the Polytéchnicien back in 1794. Perhaps it is time to revert back to this image and engage young people about the leadership opportunities that engineering offers. Also, the message regarding engineering as a career path is fragmented, as articulated by civil engineers, mechanical engineers, metallurgists and materials scientists and engineers, electrical engineers, petroleum engineers, and chemical engineers. To be effective in presenting the full measure of all that engineering offers, as well as its impact on society, a strong, unified message is needed.

During the next century, the world population will increase to about 9.5 billion people (from 6.5 billion) and much of this growth will occur in developing nations. Societal needs regarding energy resources, transportation, housing needs, packaging materials/recycling, and biomaterials and health will only escalate. The challenges presented for a sustainable development of the globe are immense. This is precisely why engineering should be so attractive to the next generation. The case needs to be made that engineering is an enabling profession, with the connection between engineering and sustainable development of the globe made explicit.

To educate engineers ready to face the challenge of ensuring a sustainable world for all people, the profound changes that have transformed society in the last few decades must be embraced and progress needs to be made to ensure that the engineering profession is a social enterprise. There is a need to educate engineers that are more akin to the French Polytéchnicien model: professionals who understand the societal context of their work, have an understanding of the human dimension around the globe, coupled with innovation and creativity. The challenge is daunting, both in academia as well as in industry. It will be appropriate to conclude by remembering what the Red Queen says to Alice in Through the Looking Glass: “Now, here, you see, it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!”

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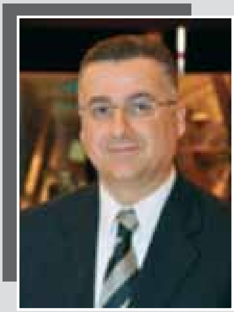
Quality Assurance and Accreditation of Engineering Programs for a Modern World

Karim J. Nasr, Ph.D., Assistant to the President for Academic Advancement, Professor of Mechanical Engineering, University of Balamand



Prof. Nasr holds a Ph.D. (1993) and a MS (1990) from Purdue University and a BS from Oklahoma State University (1987). His technical background is in experimental and numerical heat transfer and fluid flow. Prof. Nasr served as a member of SAE, ASEE, ASME, ASHRAE, the World Energy Council, and also an EC2000 ABET Evaluator for the accreditation of engineering programs. Dr. Nasr published numerous journal papers in the fields of thermal engineering and sciences prior to assuming an administrative role at the University of Balamand as Dean of the Faculty of Business and Management in 2004. Dr. Nasr's educational research interests focus on the enhancement of students' learning experience and on the effectiveness of educational programs. Prof. Nasr is a recipient of SAE's Ralph Teetor Educational Award (1998), Kettering University's Outstanding Teacher Award (2000), Outstanding Applied Researcher Award (2000), CETL's Best Poster Award on Educational Research (2002), and TRW/CETL Educational Scholar Award (2003). Dr. Nasr serves additionally as Assistant to the President for Academic Advancement (since 2007), mapping Quality Assurance and Control initiatives for the University of Balamand.

KEY WORDS *quality assurance, accreditation, attributes of engineering graduates, assessment*

ABSTRACT

This paper addresses Quality Assurance and Accreditation of Engineering Programs for a modern globalized world. It attempts to provide answers to questions like: What role does quality assurance/accreditation systems play in the generation of modern industry-ready engineers as well as the updating and upgrading of engineering *programs and institutions? How do we create a "quality-centered" culture? What are the needed hard and soft skills (abilities, attributes and competencies) expected of graduating engineers? What are the processes and related instruments which are used for assessment and evaluation? What transformation does engineering education programs have to witness to accommodate both notions of accountability and continuous improvement? What is the role and scope of each of the constituencies of engineering education? It focuses on the creation of a "quality culture", presents suggestions for quality-based processes and procedures, and highlights the emphasis on accountability, evidence, continuous improvement, and transparency. The paper makes recommendations to the different constituents on their roles for the generation of responsive and modern engineering graduates.*

INTRODUCTION

Not long ago, an engineer was assigned a cubicle in an engineering firm and given the task to design a system or a component to meet a particular need. The tools were drawing papers, a ruler, and perhaps a calculator. Nowadays, an engineer is a skilled applicator of science equipped with fundamental technical knowledge, versed with technological tools, and ready to take on problems never seen before in a world that is open and competitive. Technology has undoubtedly infiltrated everything we do and the use of technological tools has become a casual part of how we live our lives. Technology's presence in our lives has made our world rather flat and small. Anything and everything is at our finger tips. Our society has become a knowledge - based society. The knowledge is rather infinite, yet accessible, and growing at an exponential rate.

Another major difference nowadays is the need to reach as many learners as possible having varying learning styles and preferences. Engineering programs need to diversify their instructional methods. Good quality education necessitates a constant updating of the teaching and learning methods. In a student-centered environment, the emphasis is more on "learning" rather than "teaching". Learning is ensured via a number of assessment methods and through evidence exhibiting students' work. There are a number of teaching methods which are being used for delivery purposes as well as conveying the knowledge to be mastered. New and improved pedagogies for teaching have surfaced in response to the demand for better and deeper learning. Aside from the standard lecture method, a diverse set of methods such as the case method, the discussion method, active learning, cooperative learning, and problem and project based learning are being employed. New methods of teaching and learning often make use of technology via the internet and intranets and often involve engaging students in research activities.

Besides, much research has been carried out for the purpose of defining the attributes and competencies of engineering graduates. Two notable studies on educating future engineers are worthy of presenting a synopsis on. The first study is carried out by the UK's Royal Academy of Engineering (2007) and is titled: "Educating Engineers for the 21st Century." Industry and academia emphasized that "university engineering courses need redesigning for the modern economy". "Industry wants graduates with more experience of problem solving, group "design and make" projects, and applying theory to real industrial problems. Students need opportunities to work in genuine industrial environments through work placements and projects and university staff need to be able to develop new teaching material with input from companies, learning from the success of academic-industrial research links." The second study was carried out by the U.S. National Academy of Engineering in 2004 and is titled: "The Engineer of 2020: Visions of Engineering in the New Century". The report stated that "technology has shifted the societal framework….. [with] new developments in nanotechnology, logistics, biotechnology, and high-performance computing. The impact will be seen in medical breakthroughs, new energy devices, materials with characteristics not available today, remarkable light sources, and next-generation computers and tele-communications developments. The economy in which we will work will be strongly influenced by the global marketplace for engineering services, a growing need for interdisciplinary and system - based approaches, demands for customerization, and an increasingly diverse talent pool. The steady integration of technology in our infrastructure and lives calls for more involvement by engineers in the setting of public policy and in participation in the civic arena."

Previous editions of IDEAS have featured themes and activities closely related to Quality Assurance and Accreditation. To name a few: 1994 - Accreditation of Engineering Studies; 1996-Accreditation and Professional Practice; 1997 - Accreditation, Engineering Education and Practice; 2000 - The necessary basic knowledge and abilities for engineering graduation; 2002- Quality of Engineering education; 2005 - University graduates' managerial knowledge and skills- way to global excellence. It is noteworthy to mention as well that graduate attributes and professional competencies have received a substantial interest in many organizations and across many disciplines (medicine, business and management, computer science, etc.). In edition 16 of IDEAS, Greenwood states that "accreditation and assessment manuals include tables of attributes and competencies". By following such procedures graduate engineers on the International Register of Professional Engineers (of the IEA) should as far as possible be similarly competent." However, it is not sufficient to provide a wish list for desired attributes. The real work is not in the listing of attributes, it would indeed be highly useful and desirable to recommend a corresponding list of evidence-based activities for the engineering programs to ensure achievement of desired outcomes. Therefore, this paper will address notions of quality assurance and accreditation for a changing and evolving world, will feature sample desired attributes of graduating engineers, and will focus on continuous improvement - driven assessment processes. It also highlights, in the context of accountability, the constituents of engineering education. With advancements in technology and its infiltration into our personal and professional lives and with the undeniable presence of a globalized world that is founded on a knowledge-based society, recommendations are made for the generation of a modern engineer.

QUALITY ASSURANCE AND ACCREDITATION

Quality management procedures in H.E. have involved both quality assurance and quality enhancement. Quality assurance involves ensuring fitness for purpose" (West - Burham and Davies, 1994) while quality enhancement is more transformative and it requires a deliberate change process that is concerned with adding value" (Jackson 2002). The challenge of course is to manage improving quality while simultaneously assuring it. Quality assurance in Higher Education, being a broad term, is of international and global interest. It may cover assessment and evaluation; accreditation; and audit (internal and external). In order to avoid any confusion about the terms and what they might encompass, we define:

Quality Assurance (QA): The institution has the means of assuring that, informed by its mission and the published criteria for accreditation, academic standards are defined and achieved in line with equivalent national and international standards, and that the quality of learning opportunities, research activities and community involvement are appropriate and fulfill the expectations of the range of stakeholders.

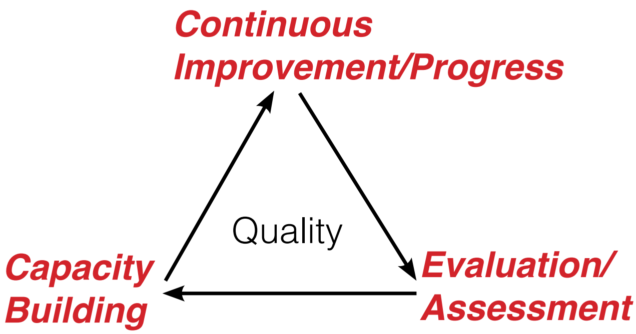
Accreditation: An assurance that a program or institution meets established quality standards. An alternative definition: The recognition accorded by an accrediting body to an institution which can demonstrate that its programs meet acceptable standards and that it has in place effective systems to ensure the quality and continuing improvement of its academic activities.

Turning our attention to quality assurance, it helps if we define its features:

- ⇨ QA helps universities become accountable towards their constituents.
- ⇨ QA embeds continuous improvement processes throughout Faculties, programs and supporting units.
- ⇨ QA is based on faculty-developed goals, strategies, and indicators (metrics) for the evaluation and assessment of goals' achievement.
- ⇨ QA is the umbrella under which teaching, learning, research and administration are audited.
- ⇨ QA promotes an institution and its image.
- ⇨ QA presents a performance-based "measuring stick" for universities and their programs.
- ⇨ QA generates competitive world-class programs.

- ⇨ QA brings accountability to the forefront and emphasizes professional responsibility.
- ⇨ QA facilitates global professional mobility of University graduates.
- ⇨ QA is a "must" for an institution to become an international/global player.
- ⇨ QA is the basis/foundation for acquiring international accreditation.

To create a "quality-centered culture", it all starts with an emphasis on teaching and learning and on assessment processes. For successful results, let continuous improvement be the driving force, design for it, and build around it. Of course, investment in human resources (capacity building) is needed. The figure below presents schematically how these concepts are inter-related and supportive of each other so that "Quality" is indeed at the center.



The evaluation/assessment corner addresses having an internal review, a self-study, and generation of data and evidence. The capacity building corner involves workshops, seminars, training, and rewards and recognition. The continuous improvement corner emphasizes the need for reflections, continuous self-evaluation against pre-defined standards and metrics, goals' setting, and loops' closing.

Quality assurance processes are meant to address both accountability and improvement/enhancement. The accountability measure employs an evaluation system driven by QA processes designed for control and validation. The evaluation system prompts a frank and open internal study, produces a self-evaluation report, offers recommendations to remedy shortcomings, and cites areas for continuous improvement. Control and validation involves setting minimum requirements, setting outcomes that each graduate must possess, checking if programs are meeting such outcomes (a stamp of accreditation), and moving the process from internal self-study to external validation. Given the two seemingly different measures (accountability and improvement), QA initiatives need to be executed within a context of constructive accountability. This means that accountability is not done with a policing attitude but rather with a spirit of continuous improvement.

Elaborating more on accreditation, accreditation was a ritual (even for those who created it) – something to go through to say they are "legitimate" or on the "list" of accredited institutions. A large volume of articles can be found on QA/Accreditation. Between 2002 and 2004, more than 1300 journal articles were published about accreditation. (Baker and Dunn, 2006). Accreditation is the mechanism for QA in the United States. It was designed to ensure a basic level of educational quality. Yet, the U.S. Ministry of H.E./Government exercises a "hands-off" approach. The Council for Higher Education Accreditation (CHEA) "accredits the accrediting agencies". The purpose of accreditation is to evaluate educational institutions and programs using peer evaluators (Department of Education, Accreditation in the U.S.). Accreditation has also been described as a process an institution undertakes to evaluate its educational activities, and seeks independent judgment to confirm that it achieves its objectives. (Young et al., 1983). Accreditation is viewed to be a means to establish educational quality assurance and integrity, yet preserving educational effectiveness and academic freedom. (Trash, 1979). It is also viewed as a mechanism to halt or prevent proliferation of unneeded or inferior quality institutions. (Scearse, 1989). The U.S. has relied on a voluntary system of self-regulation or what is called peer-regulation through accreditation. Accreditation via peer-regulation places a value on "Quality" by not being a "rubber-stamp" operation. Most importantly, accreditation is evolving and changing. Even at the places where accreditation was conceived and invented. Prior to 2000, whether we speak of QA or Accreditation, the "evaluation exercise" amounted to checking (placing ticks on) boxes. Then the notion of outcomes-based assessment was the result of reform of the processes for QA and accreditation. Later in the paper, assessment and evaluation processes will be addressed in details as they anchor claims and promises made by programs to documented evidence and continuous improvement practices.

SAMPLE REQUIREMENTS OF PROGRAMMATIC ACCREDITATION AND QUALITY ASSURANCE AGENCIES

Specialized (programmatic) accreditation is normally offered by an independent accrediting agency. ABET, an American accrediting agency for engineering programs, specifies criteria for accreditation.

1. Students
2. Program Educational Objectives
3. Student Outcomes
4. Continuous Improvement

5. Curriculum
6. Faculty
7. Facilities
8. Institutional Support

Criterion 3 lists what is called "Student Outcomes", also commonly known as Program Educational Outcomes. They are a mix of hard and soft skills each and every graduate must demonstrate having by the end of their undergraduate programs. In addition, criteria 5, 6, 7, and 8 represent primary mechanisms and vehicles to ensure acquisition of desired outcomes.

Under ABET's Criterion 3 (Student Outcomes), an array of abilities and attributes are specified. Here are some key clauses:

a) apply knowledge of mathematics, science, and engineering
b) design and conduct experiments, including data analysis
c) design a system, component, or process to meet desired needs (addressing economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability concerns)
d) function on multidisciplinary teams
e) identify, formulate, and solve engineering problems
f) have an understanding of professional and ethical responsibility
g) communicate effectively
h) have the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) recognize and engage in life-long learning
j) have a knowledge of contemporary issues
k) use practice-needed techniques, skills, and modern engineering tools.

Criterion 5 (Curriculum) addresses the professional component, it is noted that the curriculum would include a general education component which would complement the technical content and that graduates must be prepared for engineering practice.

Criterion 7 (Facilities) addresses adequacy, suitability, upgrade and availability of facilities (to include modern tools, equipment, computing resources, and laboratories)

Criterion 8 (Institutional Support) addresses needed resources to acquire, maintain, and operate infrastructures, facilities, and equipment.

In addition to the Student Outcomes outlined under Criterion 3, there are additional program-specific criteria, in reference to the curriculum and faculty, for a particular area or discipline. Such specific criteria are normally dictated by the professional societies linked to the discipline or major. Also, those desiring their M.Sc. programs to be accredited, depth in the area or discipline is expected as well as satisfaction of the criteria for the undergraduate program.

Other accrediting bodies, around the world, have specified similar graduate qualities. As a result, many documents have been produced in the literature. Refer, for example, to the International Engineering Alliance (IEA) and the World Federation of Engineering Organizations).

Therefore, much has been written on the attributes of graduates as expressed by accrediting bodies and engineering organizations around the globe. One immediately identifies with them and agrees with their importance. An argument for finding an alternative listing would be frankly considered an exercise in futility. The challenge then does not lie in "describing the specs" of the engineering graduate, it lies in making sure that such outcomes have been acquired. It is the evidence that is lacking in demonstrating that the graduates indeed have the desired abilities. Especially that we live in a globalized digital world!

GLOBALIZATION AND OUR MODERN WORLD:

Many write in defense of globalization and many see it as widening the divide between the rich and the poor especially in developing economies. The divide is also widening between developed countries (with advanced creation and integration of technology and scientific advancements) and developing countries (being consumers and not producers suffering from an extensive lack of knowledge creation and for the most part advancement). The International Monetary Fund confirms the opportunities linked to globalization but see its progress as skewed. Without going into the pros and cons of globalization, its presence and impact in world's societies are quite noticeable. Here are some relevant challenges related to globalization and certainly affect engineering education and its quality assurance:

- Mobility for graduates
- Compatibility of programs and of graduates
- Standards selection
- Internal/external QA systems/policies
- Jurisdiction of QA/accreditation agency
- Institutional specifics and region-level contexts
- Reciprocity and mutual recognition of accreditation decisions
- Classification (perception) of external/international agencies as "businesses"
- Reputation of H.E. (and engineering education in particular) locally, nationality, regionally, internationally, and globally

- ♦ Emergence of non-traditional institutions and programs
- ♦ Quality assurance in transnational education and across borders

Our world is a knowledge-based world that is built on knowledge/information production and transmission. Production of knowledge makes it necessary to focus on high-technology industries and investments as well as the need for highly-skilled workers (e.g. engineers). Transmission of knowledge and information requires the use of communication networks collaborating together using technology. It is indeed an advanced world that is supported by information technology and quite different from the world we lived in when we were educated to become engineers. An OECD report (1996) codifies knowledge as four different types: know-what, know-why, know-how and know-who.

> Know-what refers to knowledge about facts.
>
> Know-why refers to scientific knowledge of the principles and laws of nature.
>
> Know-how refers to skills or the capability to do something.
>
> Know-who involves information about who knows what and who knows how to do what. It involves the formation of special social relationships which make it possible to get access to experts and use their knowledge efficiently.

The know-what and the know-why are readily taught and acquired from reference books, textbooks, lectures and seminars. They will continue to form the foundations for the education of engineers. The know-how and the know-who are based on practical experience and on the presence of communication networks. Thus, we can no longer expect to see the production of knowledge done within the walls of educational institutions but rather within the context of shared responsibilities of both academia and industry. In addition, learning by doing is essential. Hence a partnership between industry and academia becomes an urgent need. The "information society" is rather supported by the digital revolution relying on extensive electronic networks, communication devices, e-tools, and digital libraries Morell (2007) states that "success depends largely on the capabilities of people who are credentialed in meaningful and consistent ways……need to educate problem-solvers who can build the technical infrastructure for sustainable change. Engineers are the ideal problem solvers." World's organizations (such as UNSECO and the World Federation of Engineering Organizations –WFEO) invest in technical capacity building and view it as a key factor in becoming contemporary and competitive.

A SERIES OF PERTINENT QUESTIONS ARISE:

(1) What role does quality assurance/accreditation systems play in the generation of industry-ready engineers as well as the updating and upgrading of engineering programs and institutions?
(2) How do we create a "quality-centered" culture?
(3) What are the needed hard and soft skills (abilities, attributes and competencies) expected of graduating engineers?
(4) What are the processes and related instruments which are used for assessment and evaluation?
(5) What transformation does engineering education programs have to witness to accommodate both notions of accountability and continuous improvement?
(6) What is the role and scope of each of the constituencies of engineering education?

ASSESSMENT/EVALUATION PROCESSES AND METHODS

Since their move towards outcomes-based cultures, QA and accrediting agencies assume that engineering programs have made the move from bean-counting operations to specifying program objectives and graduate qualities (program or student outcomes). The emphasis now is to transform the cultures towards providing evidence. Programs need to engage themselves in "assessment". Assessment is the process of collecting and examining data for the purpose of determining what students know and are able to do as a result of having undergone an educational experience. It is an iterative process resulting in the identification of changes, which when planned well and implemented, has the potential of yielding enhanced learning. Grounded in continuous improvement, assessment establishes a culture of accountability towards learning as well as towards teaching. It helps in making informed decisions with regards to curriculum reform; extent of learning; and resources' allocation for enhanced learning. Assessment should be well-planned and integrated. An integrated assessment process is driven by the notion of outcomes-based assessment. The figure below presents an assessment cycle for teaching and learning.

A committee of faculty members puts together program mission, objectives, and outcomes; maps program objectives to program outcomes; and maps curriculum courses to program outcomes. To realize the mission of the program and achieve its objectives, engineering programs must engage themselves in the design and delivery of quality programs of high standards and must carry out continuous assessment and evaluation. The standards need to conform themselves to international, best-practice criteria, procedures, and benchmarks.

On a course-level (or module-level), individual faculty members:

- ⇨ Write course learning objectives and course learning outcomes
- ⇨ Specify pre-requisite body of knowledge, skills, and competencies
- ⇨ Map topical coverage to course learning outcomes
- ⇨ Ensure availability of resources to promote learning
- ⇨ Select assessment instruments
- ⇨ Design assessment methods to capture achievement of outcomes
- ⇨ Gather samples of students' work as evidence
- ⇨ Develop or state metrics/rubrics
- ⇨ On the basis of established rubrics, evaluate for continuous improvement
- ⇨ Build a course file through documentation.

Evidence of learning is obtained from basically two types of Methods (Palomba and Banta, 1999):

- Direct-methods of collecting information that require the students to display their knowledge and skills.
- Indirect- methods of asking students or someone else to reflect on the student learning, rather than to demonstrate it.

Some methods which provide direct evidence (adapted from Peggy Maki, 2001) are:

- ⇨ Student work samples
- ⇨ Collections of student work (e.g. Portfolios)
- ⇨ Capstone projects
- ⇨ External juried review of student projects
- ⇨ Externally reviewed internship
- ⇨ Performance on a case study/problem
- ⇨ Performance on national licensure examinations
- ⇨ Standardized tests
- ⇨ Pre-and post-tests

Some methods which provide indirect evidence (adapted from Peggy Maki, 2001) are:

- ⇨ Alumni, Employer, Student Surveys
- ⇨ Focus groups

- ⇨ Exit Interviews with graduates
- ⇨ Percentage of students who go on to graduate school
- ⇨ Job placement statistics
- ⇨ Faculty/Student ratios
- ⇨ Percentage of students who study abroad
- ⇨ Enrollment trends
- ⇨ Percentage of students who graduate within a specified timeframe

What matters is continuous process improvement. Through documentation of assessment loops (loop closing), the results are used to drive continuous improvement. The key message here is the emphasis on evidence and continuous improvement. Needless to say that if data is not used, then there is no point of collecting it! Also, if process lacks documentation, then it lacks credibility. Using the results:

- ⇨ Tells clearly to what degree graduates have acquired stated knowledge and skills we expected them to.
- ⇨ Gives direction to what needs to change to ensure increased achievement of outcomes.
- ⇨ Permits making informed and evidence-based decisions
- ⇨ Practices continuous improvement and closes assessment loop.

Thus a transformation is needed from [inputs and resources] of evaluating the quality of academic programs to [processes, outcomes and evidence]. Consistent and coherent assessment processes, systems, and indicators need to be developed.

Constituencies of Engineering Education:

A basic question is often asked and it deserves an answer: “Who are the stakeholders?”. Engineering educators spend a substantial amount of time trying to pin point the constituents who would be linked to or affected by an engineering education program. Depending on the context where engineering education is provided and who is providing the education (public or private institutions), these constituencies vary in role and in magnitude (scope). For example, if tax money is used to make engineering education possible then the government is a major constituent. Conversely, parents and students would be a major constituent if they pay the tuition bill. Engineering programs often run through the exercise of defining their constituents for QA/accreditation procedures, the following provides a probable listing:

1. Engineering Programs
2. Academic Institutions
3. Students

4. Parents
5. Support Foundations
6. Government
7. Industry/Profession
8. Advisory Boards for Engineering Programs
9. Accrediting Agency
10. Professional/Licensing Bodies (Order of Engineers, Professional Engineer, etc.)
11. Ministry of Higher Education and related committees on initiation and certification.

Recommendations for the Constituencies of Engineering Education:

This paper offers a number of recommendations to the various constituencies as they each have a role within QA\accreditation processes and they contribute to the making of the "engineering graduate" in a globalized modern world:

To Engineering Programs and the Academic Institutions

1. Universities bear the responsibility of providing assurance of quality. Avoid having the government "control" QA/Accreditation activities
2. Create/sponsor rewards and recognition systems for instructors and staff who engage in QA\accreditation processes
3. Establish outcomes-based assessment processes focused on evidence
4. Engage and partner with industry to carry out curriculum reform
5. Count pedagogical research and instructional innovation as worthy as discipline-based technical research
6. Upgrade and update the list of needed skills and competencies of graduating engineers
7. Integrate technology into the curriculum
8. Offer contemporary courses acknowledging the presence of a globalized interconnect digital world
9. Involve and partner with "Professional Orders/Bodies" to sustain QA activities and help safeguard the profession
10. Promote assessment/evaluation processes as an accountability-based culture.

To Students, Parents, Support Foundations, and Government

1. Hold engineering programs accountable with regards to their promises (governments hold off support if QA\accreditation processes and relevant outcomes are absent)

2. Support the notion of Outcomes-based assessment by asking for evidence on the abilities of the graduates
3. Partner (support foundations and government) with universities and industry and invest in creativity and innovation
4. Support high schools in strengthening science and mathematics curricula and the professional development (training) of high school teachers.
5. Partner with universities in promoting the importance and relevance of engineering in making a difference in our everyday lives.

To Industry and Advisory Boards of Engineering Programs

1. Make industry a true partner in the generation of a modern engineer. That is be open and available to visiting professorships, residencies, seminars, and internships opportunities for students
2. Partner with universities and government in promoting technology/innovation in sciences and engineering and rewards such efforts
3. Invest in meetings (man-power and time) with professional societies as they spell out program-specific criteria and interact with QA/accrediting agencies
4. Engage students in problems relevant to industry as well as capitalize on the tremendous talents at universities
5. Engage and assist in curriculum reform providing mechanisms for making curricula relevant
6. Make man-power available to assist accrediting bodies in the evaluation of engineering programs.

To Professional/Licensing Bodies, Accrediting Agencies, and Ministries of H.E.

1. Let objectivity drive decision-making for accreditation agencies
2. Make accreditation processes focus on continuous improvement
3. Make certification a cyclic process that is based on evidence
4. Make launching engineering programs be based on a rigorous process exhibiting satisfaction of programs' initiation criteria
5. Make becoming a licensed engineer based on "true" abilities not just a formality. Perhaps make practicing the engineering profession (and holding the title) be based on some form of assessment.
6. Utilize practitioners from industry to help in the accreditation processes as well as in the assessment of the graduates' attributes
7. Promote the concept "substantial equivalence"
8. Join an International Network for Quality Assurance (see for example INQAAHE).

CONCLUSIONS

The problems engineers will face in the future will be multidisciplinary and thus engineering programs will have to get themselves outside the box of teaching within silos. As technology continues to infiltrate our lives and as advancements in technology continue to take place at a rapid pace, engineering programs must equip their graduates with contemporary and modern technological tools. In fact, they must take leadership roles in the design and delivery of these tools since such tools constitute the best evidence for graduates' abilities. With pressures of accountability and credibility, the future seems to be moving towards giving the government an enhanced role in assuring quality/accreditation, especially for universities/programs which receive funding from the government. The various constituencies have basic roles in the assurance of quality and each must bear corresponding responsibility. Accreditation faces the challenge of maintaining balance between the independence of the accreditation process and accountability towards constituents. Accreditation agencies need to collaborate and share best-practices since globalization seems to be driving convergence of H.E. QA systems and policies. Assessment and evaluation processes and the manner by which they are implemented have an impact on the success of QA initiatives. In other words, an atmosphere of constructive accountability needs to be put in place. New methods, such as Qualifications Frameworks and Ranking Systems, may have an impact on the future of QA and accreditation processes. The future emphasis will be on accountability, verifiable outcomes, and transparency.
The Report has identified

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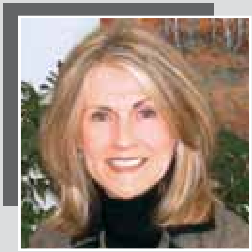
Engineering Design in Undergraduate Curricula: A CEAB Accreditation Perspective

J. O'Brien, M.A.Sc., P.Eng., FEC

Past-Chair, Canadian Engineering Accreditation Board and Principal, Strategic Alternatives

marcat1@sympatico.ca



Jacinta O'Brien, M.A.Sc., P.Eng., FEC received her Bachelor of Applied Science (Civil Engineering) and her Master of Applied Science (Civil Engineering) from the University of Toronto, 1986. Currently she President of the Board of Directors of Canadian Environmental Law Association, also Advisor to the Board of Directors of Engineers Canada and is on the Canadian Engineering Accreditation Board. She is Principal of Strategic Alternatives and served as Director of Policy and Government Relations Ontario Society of Professional Engineers. She is a Fellow of Engineers Canada (FEC), conferred in 2009 Ontario Volunteer Service Award for 20 years of continuous service to the engineering profession.

ABSTRACT

To validate the ongoing high quality of engineering programs, Canada's engineering profession established a quality assurance mechanism in the form of the Canadian Engineering Accreditation Board. This paper describes the antecedents of the CEAB. It also presents a history of the development of the accreditation criteria used by the CEAB, with particular attention paid to the approach taken by the CEAB to assess the teaching and learning of design.

1. INTRODUCTION

"Today, society is demanding an increasing amount of design by innovation" [1]. Despite the reference to "today", this quote is in fact more than 40 years old, yet it still holds contemporary relevance.

According to a survey released in 2009 [2], 44% of practising engineers ranked design highest among the four most important aspects of their current work responsibilities. For engineers who were 35 years of age and younger, the proportion identifying design as one of their four most important job responsibilities was 50%. According to the survey report, so significant is design, that it may be regarded as the defining technical function of engineers.

The foundations for design knowledge and ability are laid in undergraduate engineering educational programs. Through a combination of activities, comprising lectures, laboratories, and projects, engineering students are taught, learn, and put into practice the skills and knowledge they need to become successful practitioners.

2. ENGINEERING IN CANADA

In Canada, engineering is a self-regulated profession. The foundation for self-regulation is contained in the Constitution Act, 1867. Section 92(13) of the Act places professions within the jurisdiction of the provinces and territories, which in turn have delegated the legal authority to certain professions[1] to regulate themselves. The philosophy underlying self-regulation is that members of the profession are "best qualified to determine the appropriate standard of professional competence and ethics required for the protection of the public [3]".

There are twelve provincial/territorial regulatory entities, referred to as associations/ordre, that have been established through provincial and territorial legislation to regulate the practice of professional engineering.

Each association/ordre is under a statutory obligation to protect the public by ensuring that only fully qualified candidates are licensed as professional engineers, that minimum entry standards are met, and that anyone taking responsibility for engineering work is licensed to do so.

In order to encourage consistency in licensing requirements and to promote both national and international mobility for licensed engineers, the associations/ordre created a national coordinating body in 1936, originally called the Canadian Council of Professional Engineers, and now Engineers Canada.

1) In Canada, there are more than 40 regulated professions and occupations including medicine, nursing, dentistry, engineering, geoscience, architecture, chiropractic, technology, and veterinary medicine.

In respect of educational requirements necessary for licensure, Engineers Canada established the Canadian Engineering Accreditation Board (CEAB), originally called the Canadian Accreditation Board, in 1965, with the mandate to accredit undergraduate engineering programs at Canadian universities. A main impetus for creation of the CEAB was to reduce the then prevailing duplication of effort and variation in standards for evaluating engineering curricula [4] among the associations/ordre.

The creation of the original CEAB represented the first time in Canada that a national coordinating body undertook to accredit education in any profession [5]. At the time of the CEAB's creation in 1965, there were nineteen post-secondary institutions in Canada offering 102 undergraduate engineering programs [5]. Despite initial resistance from the engineering schools, all had requested accreditation reviews by the early 1970s.

3. ACCREDITATION OF ENGINEERING PROGRAMS

In the Canadian context, the purpose of accreditation is to identify those engineering programs that meet certain minimum criteria.

The CEAB develops the criteria, and also develops the processes and procedures for conducting accreditation evaluations.

Accreditation is a voluntary process. The CEAB undertakes accreditation assessments only at the invitation of an institution and with the consent of the association/ordre of the jurisdiction in which the institution is located. The CEAB also provides pre-accreditation services for new programs, in the form of curriculum reviews and informal visits.

The accreditation system is achieving intended results: graduates from accredited programs are considered by the associations/ordre to have fulfilled the academic requirements for licensure, and accredited programs are of a uniformly high quality. International recognition of Canada's undergraduate engineering accreditation system provides external validation [6].

In Canada today, there are 261 accredited undergraduate engineering programs at 43 post-secondary institutions representing 62 different areas of study [7]. Collectively, these programs account for almost 55,000 students and approximately 10,400 graduates per year [8].

4. ACCREDITATION CRITERIA

The criteria used by the CEAB for the purpose of accrediting undergraduate engineering programs are intended to reflect the minimum educational standards acceptable for professional engineering licensure in Canada. The Engineers Canada

Board of Directors, which comprises representatives from the associations/ ordre, must approve all criteria changes.

The first set of criteria used by the CEAB was developed in consultation with the associations/ordre and dates from 1968 [5]. The intention at the time was to provide "general criteria, and not to present an inflexible detailed schedule of regulations [9]". Annual publication of the criteria began in 1975, and included information about the work of the CEAB over the preceding year [10].

In terms of program content, the criteria specified the following minima, based on a four year Bachelor's degree program [11]:

- One-half year of mathematical foundations;
- One-half year of physical science foundations;
- One-half year of appropriate humanities and social sciences;
- One year of engineering sciences; and,
- One year of design and synthesis.

As the list shows, right from the start, the Canadian Engineering Accreditation Board recognized the value of design, stating in 1975 that design was considered "the hallmark which characterizes the engineering and engineering science curricula [12]".

The CEAB's treatment of design in undergraduate engineering curricula has evolved over time. This evolution has resulted from suggested enhancements raised by:

- The profession, principally through the associations/ordre;
- The institutions, alone or via the National Council of Deans of Engineering and Applied Science; and,
- The CEAB itself.

In 1979, the accreditation criteria were amended to include the concept of the role of engineers and society, making reference to the "complex and difficult problems [13]" then being faced. A further modification was made in 1984, requiring undergraduate engineering programs to provide "…a sound preparation in engineering design… [14]".

4.1 DEFINITION OF ENGINEERING DESIGN

Up to the mid-1980s, the CEAB made reference to engineering design, but provided no definition or explanation. That changed in 1987, when the CEAB defined design as "the ability to use appropriate knowledge and information to convert, utilize and manage resources optimally through effective analysis, interpretation and decision-making", and included a description of expectations regarding the place of design within the overall curriculum by specifying that "engineering design integrates math, the basic sciences and complementary studies in developing elements, systems and processes to meet specific needs" [15].

In 1993, the CEAB expanded the definition of design, adding that it "is a creative, iterative and often open-ended process subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may relate to economic, health, safety, environmental, social or other pertinent factors". One more modification to the definition was made in 2002 when "interdisciplinary" was added before "pertinent" [15], and this is the definition that is currently used by the CEAB.

5. ENGINEERING DESIGN CRITERIA

Along with changes to the definition of engineering design, the CEAB also made changes to the accreditation criteria for evaluating design in undergraduate engineering curricula.

In 1995, the CEAB moved away from measuring years and half years and implemented Accreditation Units as a tool for quantifying curriculum content. Accreditation Units (AUs) measure contact time between students and faculty members who are delivering the program.

5.1 SIGNIFICANT DESIGN EXPERIENCE

The following year, in 1996, the CEAB revised its criteria by including a requirement that the curriculum of all engineering programs must culminate in a "significant design experience", which would bring together the knowledge and skills acquired earlier in the program, give students an opportunity to work in teams, and allow students an opportunity to put their project management knowledge to work. This culminating significant design experience is commonly referred to as the capstone design course or capstone project.

The CEAB makes allowance for research projects to be considered to satisfy this requirement, so long as the elements of design, as defined by the board, are fulfilled in the project. This allowance recognizes that the most common source for capstone projects is faculty research [16].

Students spend considerable time beyond regularly scheduled lectures and laboratories working on their capstone projects [17]. Additionally, engineering design teaching can require considerably more time on the part of faculty members for course development, project selection, and student consultation [18]. Thus, there is a need to more equitably determine the quantitative value of the capstone project course than would result by calculating AUs based on contact time alone.

One method that is commonly used is to calculate the AUs on a proportionality basis. By taking the sum of AUs for all common core and compulsory courses and dividing that sum by the sum of all academic credit units for the common core and compulsory courses, a factor, referred to as k-factor, can be derived. This k-factor can then be applied to the academic credit units assigned to the capstone project to estimate its AU value [19].

5.2 GRADUATE ATTRIBUTE CRITERIA

The most recent revisions to the CEAB criteria took place in 2008 with the introduction of graduate attributes, and the requirement that institutions must demonstrate graduates from accredited programs possess specific skills and capabilities at the time of graduation. The publication and implementation of the graduate attribute criteria mark the CEAB's move away from input-based evaluation and toward outcomes, something that has already been embraced by most other engineering education accreditation organizations around the world.

The 2010 graduate attribute criteria define twelve broad competencies that students are expected to demonstrate at the time of graduation, ranging from a knowledge base for engineering all the way to the an ability to engage in life-long learning. Design competency is a unique attribute among the twelve; the CEAB expects that engineering program graduates will demonstrate "an ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations [21]".

Concomitant with the requirement to demonstrate that graduates possess certain competencies is the expectation that engineering programs will continually improve. The 2010 criteria require institutions to have processes in place that show program outcomes are being assessed in the context of the graduate attributes, and that assessment results are being applied to the further development of the program [20].

6. EVALUATION OF DESIGN CONTENT

The CEAB criteria require that the curriculum of an accredited program have minimum content in each of five curriculum categories:

- Mathematics;
- Natural Science;
- Engineering Science;
- Engineering Design; and,
- Complementary Studies.

In undergraduate engineering programs, Engineering Design content is generally found in two places, namely in: (1) subject-specific courses in which design is taught, often in combination with other curriculum categories; and, (2) design projects, including the capstone project.

6.1 VALUING CURRICULUM CONTENT

The CEAB's current rules require that individual courses cover no more than three curriculum categories, and that no one category be less than 25% of the total for the course. Some relief from these requirements can be given if reasonable justification is provided by the institution [22].

However, the separation of curriculum (and to some extent, learning) into "categories" is not an exact science. The change to measuring curriculum content using AUs, while providing an absolute rather than relative value, carries with it the misguided inference that institutions and the CEAB can measure curriculum content with increasing precision and accuracy. Submissions from institutions seeking accreditation often contain tables of AU values taken to one significant digit, sometimes two. Considering that assignment of curriculum categories is somewhat subjective, calculating AU values to such a fine degree of precision perpetuates a fallacy, and the values themselves can be the subject of debate between those who propose them and those who review them [23].

6.2 INDIVIDUAL COURSES CLAIMING DESIGN

For subject-specific courses in which design AUs are claimed, it should be evident that students in the course are aware that they are learning about design. To demonstrate this, there should be evidence of creative activity and "open ended" problems that normally accompany such learning. The CEAB does not usually expect to find the entire scope of the definition of engineering design in subject-specific courses. Rather, the engineering design content depends on the amount of design teaching and learning, and on the specific elements of the definition that are the main focus of the course.

In all cases, the CEAB must be satisfied that the institution›s assessment is reasonable, and it is the mandate of the accreditation visiting team members to make that determination. The CEAB's expectation is that visiting teams will consult the faculty members delivering the design courses and will make adjustments, based on best professional judgement, if claims about the amount and quality of design content are not justified based on the evidence presented at the time of the visit.

6.3 CAPSTONE COURSES

In the case of capstone projects, as stated above, the k-factor is generally used to determine a value for total AUs, which, in turn, is used to determine the contribution the capstone project makes to the overall design content of the curriculum.

Before the quantitative content can be evaluated, however, there is a need to evaluate the qualitative aspects of the capstone project, to ensure that the culminating significant design experience criterion is satisfied. In conjunction with the criterion itself, the definition of engineering design that the CEAB publishes is used as a guide. The course description, its administration, and student work are all examined in the context of the criterion and the definition. From the CEAB's perspective, the capstone projects, especially as evidenced by student reports, should conform reasonably to the definition in order for the course to be accepted as 100% engineering design.

6.4 ANALYSIS IS NOT DESIGN

A common issue that visiting teams and the CEAB face is the misinterpretation of problem analysis as engineering design. A clear distinction can be made between analysis and design: typically, when seeking to solve an analysis question, there is only one correct answer; when seeking to solve a design question, there are many answers [24]. The CEAB's definition requires integration of mathematics, natural science, engineering science and complementary studies. It also refers to the open-ended nature of design. Hence, the application of analysis alone to a purely technical problem does not qualify as design.

However, the application of engineering analysis to a purely technical problem may be interpreted as design if the exercises are open-ended and there is some degree of integration of material from other curriculum content categories.

Clarifying course content can be accomplished in a relatively straightforward way, by answering basic questions. "Are the hands-on laboratories demonstrating fundamental science principles or are they applications?" should be sufficient to affirm whether or not the content is best described as natural science or engineering science. Similarly, examining course materials, such as examinations, mid-term tests, tutorial problem sets and assignments, and answering "Are the assignments and tests dealing with open-ended problems or are they pure analysis?" can help to distinguish content that is primarily design from that which is mainly analysis.

6.5 REPORT WRITING AS DESIGN CONTENT

Many courses involve the writing of reports of various kinds. If the reports are written and evaluated for their structure, grammar, audience focus, and effectiveness in communicating an idea, or are evaluated by non-engineering faculty members, such as from or Humanities, or by communication specialists, then the CEAB considers the reports to be evidence of complementary studies curriculum content.

On the other hand, if reports are evaluated by engineers for technical content, and there is evidence demonstrating the integrative nature of the design process, then the CEAB may consider such reports to comprise engineering design content.

6.6 THE INTRODUCTION OF A GRADUATE ATTRIBUTE TO DETERMINE DESIGN COMPETENCY

The above dealt with current practices and these will continue, at least for the short term. The next generation of accreditation involves assessment of graduate outcomes, including what students are expected to know and be able to do in respect of design.

Assessing the achievement of graduate attributes will involve identifying, and in some cases developing, measurement tools. All engineering schools are already using some forms of outcomes measurement, in the form of examinations, student work, and capstone project reports and presentations. The difference between past practice and how these items are used to determine achievement of design competence will involve developing new ways to analyze the information and results each potential measurement tool presents.

The CEAB recognizes that engineering programs cannot adapt to the 2010 criteria immediately, so there is a transition period to 2014 to allow for full implementation of the graduate attribute and associated continuous improvement criteria. During this time, the engineering schools and the CEAB are working to create performance benchmarks, assessment measures, rubrics, surveys, and exemplars for the twelve graduate attributes.

7. LINKING THE TEACHING OF DESIGN TO THE PRACTICE OF ENGINEERING

It is hard to conceive of an engineering student learning design under the guidance of someone who has no professional practice in it, except in perhaps the most limited sense of technical aspects. In the same way that there is an expectation that licensed doctors teach medical students and practicing lawyers teach law students, so too should licensed engineers teach engineering undergraduates. This is the philosophy underpinning the CEAB's assessment of the teaching of design. The CEAB relies on two criteria to aid in the assessment:

1) Faculty delivering curriculum content that is engineering science and/or engineering design are expected to be licensed to practise engineering in Canada, preferably in the jurisdiction in which the institution is located. Furthermore, in those jurisdictions where the teaching of engineering is the practice of engineering, faculty teaching design are expected to be licensed in that jurisdiction; and,

2) Capstone projects are expected to be conducted under the professional responsibility of faculty licensed to practise engineering in Canada, preferably in the jurisdiction in which the institution is located.

In recognition of the fluid nature of the faculty complement at most engineering schools, and to provide bounds around the interpretation of the criteria, the CEAB issued a guideline, in the form of a Statement of Interpretation [25], which sets out minimum requirements in terms of curriculum content that must be taught by faculty members who are licensed as engineers.

8. FUTURE CONSIDERATIONS

Engineering design is synonymous with engineering practice, and it will continue to be a defining function for the profession going forward. Graduates of engineering programs can expect to continue to begin their careers in design functions that draw on their training [26]. Demand side legislation specifying the need for engineers to undertake certain roles and liability considerations are two reasons why engineers will continue to take a leading role in design [27]. The role of engineers will become ever more critical as designs become more complex, advanced or specialized, and where sophisticated design strategies are required [28].

Canada's prominent role in the international engineering community is also a consideration [29]. Canada is a leading exporter of engineering services, ranking third overall, after the United States and the United Kingdom, with infrastructure design ranked as one of the top three international markets for Canadian engineering services. Specialized technical skills, usually in design areas, are considered to be one of the key attributes of competitiveness in the international engineering market, where such skills are in short supply and can command a significant premium.

Engineering undergraduate programs continue to respond to the need for robust design education. This response is partly aimed at addressing CEAB requirements, which have historically specified qualitative and quantitative curriculum content minima, and now also specify design competency as a learning outcome among engineering graduates. By continuing to emphasize design as an integral component of the undergraduate curriculum, Canadian engineering programs can take a leading role in the success of engineering graduates into the future.

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CONSTITUTION

Approved by the General Assembly September 8, 2011
Effective January 1, 2012

Article 1 THE FEDERATION

The World Federation of Engineering Organizations (the Federation) is an international, non-governmental organization. Its duration is unlimited. The Offe of the Federation and its Executive Director shall be at such a place as is recommended by the Executive Council and approved by the General Assembly.

Article 2 OBJECTIVES OF THE FEDERATION

The objectives of the Federation are to work with Members: to encourage the application of engineering and technological advancement to economic and social progress throughout the world; to advance engineering as an equal opportunity profession in the interest of all people; and to foster peace throughout the world.

Article 3 MEMBERSHIP OF THE FEDERATION

Section A

The Federation shall consist of: National, International, and Affiliated voting Members; and Corresponding, Associate, and Technical non-voting Members.

Section B

A National Member shall comprise the national professional engineering organization, or the union/association of organizations within a country, that is considered most representative of technically competent engineers according to the national standards within that country.

Section C

An International Member shall be a union/association of national professional engineering bodies organized on a multi-lateral basis, either according to a regional interest or other international basis and has proven itself capable of undertaking ongoing activities.

Section D

An Affiliated Member shall comprise the professional engineering organization or organizations existing in a specified geographical area, considered the most representative of technically competent engineers according to the standards of that special geographical area.

Section E

A Corresponding Member shall be a National professional engineering organization not able to participate fully as a national member, but wishing to participate by correspondence in the activities of the Federation.

Section F

An Associate shall be an engineering organization, corporate body or individual, which registers as such for the purpose of supporting the Federation, and receiving regular information on its activities.

Section G

A Technical Member shall be an international non-governmental professional organization devoted to activities in a particular area of engineering.

Section H

Application to any category of membership shall be made to the Executive Director. The application shall be assessed by the Executive Board. Election shall be by vote of the Executive Council and effective upon receipt by the Executive Director of a full year subscription.

Article 4 ADMINISTRATION OF THE FEDERATION

The governing body of the Federation shall be the General Assembly. Between meetings of the General Assembly the affairs of the Federation shall be directed by the Executive Council. The business of the Federation shall be dealt with by the Executive Board, supported by the Executive Director. Except as provided otherwise in this Constitution: actions by the General Assembly, Executive Council, or Executive Board shall be by majority vote; voting may be in person during a regular or special meeting, or by electronic means with a thirty (30) day voting period; and the presence of one half of the voting Members shall constitute a quorum.

Article 5 THE GENERAL ASSEMBLY

Section A

The General Assembly shall consist of the representatives of Members in good standing. Representatives of one-third of all voting Members shall constitute a quorum. Each voting Member in good standing shall have one vote. Voting at regular or special meetings may be by proxy assigned to a representative of a voting Member in good standing by letter delivered to the Executive Director prior to the beginning of the meeting. Members shall inform the Executive Director prior to meetings of their representative and any other members of its delegation.

Section B

A regular meeting of the General Assembly shall be held every two years, at a place and date determined by the General Assembly at the previous regular meeting, or failing that, by the Executive Council. The President shall call a special meeting of the General Assembly if requested to do so in writing by one-third of the voting Members, or the President may call a special meeting with the consent of the Executive Council.

Section C

The Executive Director shall communicate the place and date of each regular meeting of the General Assembly to all Members and to all Members of the Executive Council at least one year in advance, and the place and date of each special meeting at least three months in advance.

Section D

The agenda of a meeting of the General Assembly, prepared by the Executive Director with the approval of the President, including proposed items from Members, shall be communicated by the Executive Director to all Members at least three months before the beginning of the meeting.

Section E

The General Assembly shall determine the policy of the Federation; and, in addition to any other duties specified elsewhere in this Constitution, have the following powers and obligations:

1. To elect the Officers and National Members of the Executive Council.
2. To approve the annual subscriptions to be paid by Members, upon recommendation of the Executive Council.
3. To establish a Standing Technical Committee (STC) based on a proposal by a National member (the host), elect the host, ratify the host's nominated STC Chair (with the rank of Vice President), and cancel the STC, upon recommendation of the Executive Council.
4. To establish, set the terms of reference, and cancel, any Committee or Board, upon recommendation of the Executive Council.
5. To review and ratify or amend the decisions of the Executive Council, the Executive Board, and the Executive Director made since the previous regular meeting of the General Assembly; and to review any activity of the Federation.

Article 6 THE EXECUTIVE COUNCIL

Section A

The Executive Council shall consist of the following voting Members:

1. The Officers: President, President-elect, Past President, two Executive Vice Presidents and Treasurer;
2. Eight National Members;
3. All Vice Presidents (Chairs of STCs);
4. Six International Members.
5. Non-voting Members are the Deputy Treasurer, the Executive Director, and Chairs of other Committees.

Persons in each of these positions, with the exception of the Deputy Treasurer and the Executive Director, may remain in their respective position as long as their sponsoring Member is in good standing.

Section B

The President-Elect shall be elected by the General Assembly at its regular meeting and take office at the end of that meeting. At the end of the following regular meeting of the General Assembly the President-Elect shall move to the office of President. In the event the President is unable to complete his/her term, the President-Elect shall also assume the duties of President for the remainder of that term.

Section C

The President shall hold office to the end of the next regular meeting of the General Assembly and then become the Past President until the end of the next regular meeting of the General Assembly. The President shall chair the meeting of the General Assembly, the Executive Council and the Executive Board, and may appoint a temporary chair.

Section D

The Executive Vice Presidents and National Members shall hold office until the end of the second regular meeting of the General Assembly following their election. Their elections should be arranged such that half of each category shall be in their first term while the remainder shall be in their second term. The Treasurer shall hold office until the end of the next regular meeting of the General Assembly.

Section E

The Executive Council shall meet at least once a year. The Executive Director shall communicate the place and date of each meeting of the Executive Council to all Council Members at least six months in advance. A special meeting shall be convened by the President upon written request from one-third of its Members or may be convened by the President with the approval of the Executive Board with one months notice by electronic means. The agenda of a meeting of the Executive Council, prepared by the Executive Director with the approval of the Executive Board, shall be communicated by the Executive Director to all Council Members at least one month before the beginning of the meeting.

Section F

In addition to other duties stated in this Constitution, the Executive Council shall have the following powers and obligations:

1. To approve the biennial budget of the Federation, showing income and expenses, and report same to the General Assembly.
2. To submit to all Members, four months in advance of a regular meeting of the General Assembly, names of nominees submitted by voting Members in good standing for the offices of President-Elect, Executive Vice-President, and National Members of the Executive Council and the Executive Board's nominee for Treasurer.

3. To receive the reports of the Treasurer and the Audit and report same to the General Assembly.
4. Establish, set the terms of reference, and cancel, any Task Force or Working Group, upon recommendation of the Executive Board.
5. To review and ratify or amend the decisions of the Executive Board and the Executive Director since the previous regular meeting of the Executive Council.

Article 7 THE EXECUTIVE BOARD

Section A

The Executive Board shall consist of the following voting members: President, President-elect, Past President, two Executive Vice Presidents and Treasurer; and non-voting members the Deputy Treasurer and the Executive Director.

Section B

The Executive Board shall appoint the Internal Auditor, the Deputy Treasurer, and the Executive Director.

Section C

The Executive Director shall inform all Federation Members of the actions of the General Assembly, the Executive Council, and the Executive Board.

Article 8 FINANCE

Section A

The financial year shall be from 1 January to 31 December.

Section B

Each National, International, and Affiliated Member shall agree to pay an annual subscription as determined by the General Assembly. Subscriptions are due on 31 January of each year. For those Members meriting special consideration, an application may be made by 31 January to the Executive Director for approval by the Executive Board for delay to 31 July of that year.

Section C

In the event of resignation or termination of membership, the Member concerned shall be liable to pay its subscription for the current financial year, and shall have no claim on the funds of the Federation, or any part thereof.

Section D

Any Member of the Federation which by 31 December, or the date of a General Assembly that year, whichever date is earlier, has not fully paid its annual subscription, nor had special consideration by a decision of the Executive Board, shall be considered not in good standing and not be entitled to exercise or benefit from any right or privilege of membership, and its membership in the Federation may be terminated by vote of the Executive Council.

Section E

A Member in arrears for four consecutive years will automatically have its membership terminated, unless other action is taken by vote of the Executive Council.

Section F

A Member having had special consideration by the Executive Board may, on presenting a formal request signed by its President, be restored to full membership by paying in full any subscription due for the current financial year, but is not required to pay any subscription for any year that it was not required to pay under its special consideration status.

Section G

Special projects, so designated by the Executive Council, shall be financed wholly or in part by voluntary contributions.

Section H

The Federation shall have power to accept donations of funds from any source approved by the Executive Council.

Article 9 RESIGNATIONS AND EXPULSION OF MEMBERS.

Section A

A Member wishing to resign from the Federation shall give six months notice in writing, addressed to the Executive Director.

Section B

The General Assembly may by a two-thirds vote terminate the membership of any Member which has failed to fulfill its obligations to the Federation, or maintains activities which are counter to the objectives of the Federation.

Article 10 SEPARABILITY

If any portion of this Constitution is found to be contrary to law by any judicial procedure in the Country of Registry, the remainder of this Constitution shall remain in force.

Article 11 INDEMNIFICATION

Unless otherwise prohibited by law, the Federation may indemnify and hold harmless any current or past officer, Executive Council member, or employee, by resolution of the Executive Council for acts, errors omissions arising within the scope of duties and responsibilities as an officer, Executive Council member, or employee of the Federation. The Federation shall not indemnify or hold harmless any current or past officer, Executive Council member, or employee for any criminal offense, or for liability to the Federation for damages arising out of negligence or misconduct in the performance of a duty to the Federation. The Federation may authorize the purchase of insurance on behalf of any officer, Executive Council member, or employee for acts, errors or omissions asserted against or incurred by him or her which arises out of his or her status as an officer, Executive Council member, or employee of the Federation.

Article 12 AMENDMENTS TO THE CONSTITUTION

This Constitution may be amended by two-thirds vote of the General Assembly based on specific text recommended by the Executive Council and submitted to all Members at least five months in advance of the beginning of a regular or special meeting of the General Assembly. This process may be initiated by one or more Members of the Federation in good standing through communication with the Executive Board.

Article 13 DISSOLUTION OF THE FEDERATION

The General Assembly, when convened for this specific purpose, may by two-thirds vote dissolve the Federation. In the event of the dissolution of the Federation for any reason, the General Assembly shall appoint a liquidator and shall determine his/her powers and if required her/his remuneration, and shall designate the recipient or recipients of the residue of the funds of the Federation.

Article 14 PARLIAMENTARY PROCEDURES

The President or chairman of any Federation meeting may appoint one or more advisors on Parliamentary procedures, or rely on the provisions of Roberts Rules of Order to govern the transactions of business.

CHRONICLE OF EVENTS

January 2010 – december 2012

March 2010:
A meeting for the Executive Council took place in Barcelona to discuss the proposal of hosting the CEIE Committee after Poland decided to be execused from hosting the Committee for financial reasons. Argentina and lebanon were the candidated for hosting the Committee. A decision by the Executive Council was made and Lebanon will host the Committee for the next term of 4 years.

August 2010:
A meeting was held in the main headquarters of WFEO between President Wlodzimierz Miszalski, Luis Vaca Arenaza, the Chair of the Organizing Committee for Engineering 2010 Argentina, and Abdul Menhem Alameddine, the next Chairman of the CEIE Committee. The puepose of the meeting is to discuss the organization of the Argentina conference adn the program for the hand over of the Committee.

October 2010:
The regular meeting of WFEO was held and the WEC conference was a succesful one. At the same time, the handover of the Committee of Education in Engineering did happen at the end of the meeting of the Committee, and Mr. Alameddine will Chair the next meeting of the Committee in Geneve in 2011.

Geneve 2011:
The meeting was the first meeting for the Committee for the new period 2011 till 2015 for Alameddine as Chair. The discussions were focused on the next WCEE to be held in 2012 in Lebanon.

Lebanon 2011:
A new website was created for the Committee and was launced at the beginning of the year 2012. The link for the web is
http://www.wfeo-ceie.org/welcome.php

Committee meeting in Argentina 2010

Committee meeting in Argentina 2010 – handover ceremony

CHRONICLE OF EVENTS

Round table presentation in Argentina 2010

Round table presentation in Argentina 2010

CHRONICLE OF EVENTS
Argentina

Round table presentation in Argentina 2010

Dr. Miszalski past President of WFEO-CEIE receiving thanks award from Executive Council

Committee meeting in Genève 2011

CHRONICLE OF EVENTS

Committee meeting in Genève 2011

CHRONICLE OF EVENTS in Genève

Committee meeting in Genève 2011

Committee meeting in Genève 2011

CHRONICLE OF EVENTS in Genève

Committee meeting in Genève 2011

CHRONICLE OF EVENTS
Argentina

Round table presentation in Argentina 2010

Dr. Peter Greenwood making his presentation on the Taipei, Taiwan International Engineering Alliance (IEA) event in June 2011

BUENOS AIRES DECLARATION

We, the professionals at the World Congress "ENGINEERING 2010-ARGENTINA: Technology, Innovation and Production for Sustainable Development", organized by the World Federation of Engineering Organizations (WFEO) together with the Argentine Union of Associations of Engineers (UADI) and the Argentine Center of Engineers (CAI), consider that it is necessary to:

1. Call upon the institutions that bring together engineering professionals to spread out what has been done by this Congress and assume the responsibility of contributing to advancing towards the integral development of our societies, both with their proposals and works.

2. Encourage the action of engineers and that of governmental and private organizations to boost the capacity to innovate and to increase business efficiency and competitiveness, applying knowledge and new technologies to meet the growing needs and demands of an inclusive and sustainable development.

3. Call upon public authorities to give the necessary priority to the development of vocations and the promotion of engineering courses of studies, with particular interest in a greater participation of women.

4. Urge UNESCO to implement as soon as possible the "International Engineering Programme" (IEP) suggested by WFEO World Engineers' Convention in Brasilia (WEC 2008) and ask that its implementation should be shared or led by WFEO.

5. Foster the systemic participation of engineering institutions, integrating honorary advisory councils, to cooperate in analysis and decision-making processes of governments and organizations related to development.

6. Ask national governments, multilateral banks and agencies, and the system of the United Nations to accept the cooperation of WFEO and to support politically and financially the action of engineering institutions and engineers, to contribute to minimize the effects of natural and technological disasters and to further the effective accomplishment of the world commitment to overcoming hunger, extreme poverty, social segregation, gender inequality, environmental damage and climate change threats.

Buenos Aires, October 20, 2010.

2011 World Engineers' Convention
Geneva
4-9 September

Geneva – September 7th, 2011

Geneva Declaration – Call for Action

Challenges

Meeting the world's growing demand in energy services and at the same time addressing serious concerns about greenhouse gas contributions to climate change are enormous challenges today. The growing world population – UN estimates are 9 billion people in 2050, growing economies in developing countries, particularly China and India, and improvements in the standard of living around the globe will lead to an increase in energy consumption by about 40% as expected by the IEA current policy scenario. With fossil fuels continuing to be the main energy source, without carbon capture and storage the Intergovernmental Panel on Climate Change (IPCC) suggested target to limit global warming to +2-degree C will be missed. Moreover, climate change has occurred and will continue to occur for decades, even if GHG emissions are reduced, and engineered facilities need to be functional and safe in the environments resulting from climate change.

There can be enough energy

The total energy from various sources around the globe might be sufficient to meet the needs of the population in the current century. Alternative renewable energy is abundant and by far exceeds the global energy consumption. However, alternative sources are either very low density requiring extensive collection systems or associated technologies that still require development to demonstrate feasibility. Today, oil, gas and coal provide 80% of our energy requirement, while most of the remainder is supplied by biomass, nuclear and hydro power. Renewable energy is still a minor contributor to the total energy mix.

Some of the technologies needed are not yet economically viable. In particular we have not yet learned to harness the abundant solar energy at a competitive cost, although costs are coming down fast. In addition, building the necessary infrastructure to bring large scale renewable electricity from places with high yields (areas with high insolation or strong winds) to the places with high consumption requires huge investments and long lead times, as well as development of mechanisms to encourage infrastructure investment.

In addition to an increased share of renewable energy in the world's energy mix, energy efficiency measures will help reduce the energy intensity of national economies and, therefore, slow down the increase of primary energy demand.

Available knowledge and technologies

The use of fossil energy accounts for most of the global CO_2 emissions. According to IEA's 450 ppm scenario, a mix of low-carbon options is available to limit greenhouse gas emissions from the energy sector. End-use efficiency, power-plant efficiency, biomass, biofuels, nuclear and carbon capture and storage need to contribute. While hydro and wind power are suited to be deployed for the long term, current nuclear technologies need to serve as a stopgap solution and, for large scale use in the future, they have to be made inherently safe.

Renewable technologies – hydro, wind, biomass, geothermal, solar thermal, solar photovoltaic and ambient heat - have experienced a tremendous technical and economical progress over the past decades. Energy storage technologies – e.g. pumped hydro and compressed air storage, batteries for transportation – are key to the management of intermittent renewable energy sources. The latter are either mature technologies or are making big strides, while geothermal power ("hot dry rock") still awaits the "proof of concept". Carbon capture and storage (CCS) is being developed and demonstrated at large scale. Today, wind and concentrated solar thermal power are close to being cost competitive in developed countries or in regions where other energy sources are in short supply.

For transportation, extensive effort is going into the development of biofuels and electrical vehicle drive chains and battery storage. The impacts of large scale usage of electric vehicles and the need for "charging stations" on electricity networks through "smart grid" developments is also being actively pursued. Huge efforts go into the development of biofuels for transportation and electrical vehicles. Thus, the technologies needed for a low-carbon economy are being made available, or expected to be competitive soon if external costs are to be taken into consideration.

Research is needed to define the extreme loadings for which engineered facilities should be designed, operated and maintained. Historical records, which have been the bases for engineering decisions, can no longer be considered to define the environments our facilities will face in the future.

Investing in our future

Investing in renewable technology means high "first costs" and low "fuel costs". Thus, the transformation from today's energy mix into a low-carbon energy system requires a substantial increase in investments into infrastructure such as power generation equipment, new grid capacity, new transportation infrastructure and new vehicles. The estimate by World Energy Outlook (IEA) is an additional investment of USD 9.3 trillion (9.3×10^{12}) for the 450ppm scenario as compared to the reference scenario.

According to the European Commission, approximately € 1 trillion (1×10^{12}) need to be invested starting soon in energy infrastructure until 2020 to secure the supply of oil, gas and electricity in Europe for achieving the 20-20-20 target by 2020, i.e. a renewable share of 20% in the energy mix, 20% energy reduction by efficiency measures and a 20% reduction of greenhouse gases compared to 1990. Further investments will be needed to meet the yearly per capita goal of 2 tons of CO_2 per person by 2050.

Besides financial resources, well trained, creative and highly motivated engineers are a pre-requisite for the successful development of the sustainable technologies needed and their implementation. The role of engineers in attaining energy security has to be emphasized.

We can do it – let's do it!

To achieve the goals suggested by IPCC, the entire energy cycle – generation, transmission, distribution, and use – has to be considered, as well as the sustainable primary energy sources, renewable sources, efficiency in use and transmission, and environmental and economic consequences ought to be included. The solutions are necessarily customized for each region. Sustainable models for power interconnection of countries in a given region to complement their energy supplies will have to be pursued and implemented.

Sustainable primary energy is well distributed and available in sufficient quantities in many places. Hence, transforming the energy system at regional, national and international levels will require both autonomous and cooperative action with the aim to minimise impacts on natural competitive advantages.

Regions showing high per-capita CO_2 emissions are encouraged to start the transformation towards a more sustainable energy mix by identifying their specific way of achieving this transformation at lowest cost and impact to their economy and global competitiveness. Change and providing the incentives to invest and minimise the impacts on consumer budgets are manly a political decision.

Conclusions

1. To guarantee a good quality of life for everyone, all available energy sources must be considered. Greater energy efficiency will slow down growth in energy demand but will entail costs that are not necessarily negligible.
2. The use of any given technology requires a thorough analysis of the technological, economical, and environmental feasibility of implementing scientifically sound and efficiently engineered solutions.
3. The technologies we need to supply energy for substantially improving global quality of life are available or at an advanced stage of development or are currently being demonstrated. The goal is to secure a low-carbon energy supply. If the +2-degree C target is to be met, it is important that GHG emissions – and CO_2 emissions in particular – be drastically reduced during the production and consumption of different forms of energy.
4. Switching to a low-carbon economy will take substantial investment and time. In the transport sector, modifying unsustainable energy consumption patterns will necessitate difficult social adjustments.

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