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Evaluation of Engineering Programs towards Global Accreditation

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ABSTRACT

Several momentous and significant events happening all over the world make this paradigm change in the method of teaching in the Asian countries. The first is globalization. High technology has shrunk the world so drastically that professionals have to complete with others internationally. This simply means that if Engineering students do not learn effectively, the graduates will hardly stand a chance in the global competition. This research presents information on the status of accreditation and evaluation of engineering programs in different countries around the world. The focus will be on United States ABET criteria 2016, the Canadian Council of Professional Engineering criteria and the FEANI standards for European institutions Accreditation policies and procedures of other countries are also described briefly in the research. Information on mutual recognition agreements and the cross border recognition of engineering education will also be emphasized.

Keywords**:** Quality assurance and education; Sustainability and Engineering Education; Engineering Education research

1. INTRODUCTION

In other countries, teaching was done using the teacher-cantered teaching method. In a typical class, the teacher was the authority who teaches the power point presentation. This teaching strategy is still very in demand in use today, and unless something is done to change it, it would still be used in the future.

Several momentous and significant events happening all over the world make this paradigm change in the method of teaching in the Asian countries. The first is globalization. High technology has shrunk the world so drastically that our professionals have to complete with others in their field internationally. This simply means that if engineering students do not learn effectively, .graduates will hardly stand a chance in the global competition.

There is also a pressing need to teach the graduates that learning is a lifelong process. They must continue their education by reading and attending seminars if they want to keep abreast with the latest trend in engineering practice.

These reasons strongly recommend that Engineering education should be improved now. There are several ways in which improvement can be done, but it is important that all sections involved in engineering education must agree to undertake the process. The administrators and the teachers play a vital role in making the change and the students themselves must realize that the change is for their own benefit.

One of the most important concepts of engineering education is that knowledge taught to students is not enough. Teachers cannot teach everything to engineering students today. In order to solve this problem, several recommendations have been made which include providing students with a core set of science and engineering fundamentals. There is a common practice abroad of integrating knowledge across courses and discipline. An example of this is the course mechatronics which is a combination of mechanical and electronics courses.

Another area is the values taught to students. It is very important that engineering graduates become mature individuals that believe and practice ethics in their profession, and protect the environment. This can be done by working with others, conserving the use of resources and the environment serving others and finally committing oneself to improve the quality of life. This will be done besides doing the work would expect from an engineer.

2. QUALITY ASSURANCE AND ASSESSMENT OF ENGINEERING PROGRAMS

Today, new universities and colleges are focusing on providing a system of quality assurance and assessment of its educational programs in order to improve the quality of education, to provide accountability and to allow for allocating resources and planning of higher educational systems. The methodology consists usually of a self-evaluation report by the assessed programs, and a peer review, including a site visit by an assessment committee composed of university and industry experts [1].

Quality assessment is concerned with procedures undertaken by the institution to ensure that procedures are in place to see to it that the tasks are properly being implemented. Quality in education means defining worthwhile learning goals and enabling students to achieve them. In judging what is worthwhile, the needs and aspirations of the student, the demands of the stakeholders such as government, industry and parents are considered.

Quality assessment or audit is the procedure by which courses and degrees are judged to be satisfactory by well qualified academics and engineers. This would normally result in the giving of accreditation status to the programs that were satisfactory evaluated [2].

While different countries usually implement its own system of accreditation, what are common in each system are the procedure of self- evaluation and the validation of the results through a visit of experts

3. CURRENT THRUSTS IN QUALITY ASSURANCE AND ACCREDITATION SYSTEMS

A brief description of the accreditation and assessment methods of engineering programs of different countries follows:

3. 1. United States

The Accreditation Board for Engineering and Technology (ABET) is the accrediting body for engineering programs in the United States. It is a federation of 29 engineering societies and since 1932; it has accredited 1570 programs in 325 institutions [4]. Their new standard for assessment is called the Engineering Criteria (EC) 2000. This criterion is divided into the following: General Criteria for Basic Level or Undergraduate Programs, Cooperative Education Criteria and Criteria for Advanced Level or Graduate Programs [3,5].

For undergraduate programs, the institution must demonstrate clearly that the programs meet the following criteria. These are students, program educational objectives, program outcomes and assessment, professional component, faculty, facilities, institutional support and finance resources, and program criteria.

Under EC 2000, the institution and programs define mission and objectives to meet the needs of constituencies and enable program differentiation. Emphasis is placed on outcomes assessment in the preparation of students of professional practice. Curricular requirements are limited to 3 years for flexibility, and the applied programs must demonstrate how criteria and educational objectives are being met.

Continuous movement is emphasized through a two-loop evaluation and assessment cycle as well as process documentation and the linking of objectives to outcomes and assessment of the criteria.

The process consists of two separate and concurrent cycles (loops), as defined by the Accreditation Board for Engineering and Technology (ABET), in the Engineering Criteria 2000 (EC2000) and ABET 2014-2015 Criteria for Accrediting Engineering Programs accreditation documents As implemented in this program, the two loops illustrated in Figure 1 have the following properties [6]: The left-hand loop (or slow loop) represents three year cycle focusing on assessment and revision of the high-level Program Objectives.

The goal of this loop is to determine whether the Program Objectives are relevant, appropriate, and serve the needs of our constituencies. This assessment loop does not attempt to determine how well the current Program Objectives are being satisfied. The details of this cycle are presented in Section 6 of this SOP. The right-hand loop (or fast loop) represents an annual cycle of activities focusing on assessment and revision of the Program Outcomes and Curriculum to improve the manner in which the program achieves the Program Objectives defined in the slow loop.

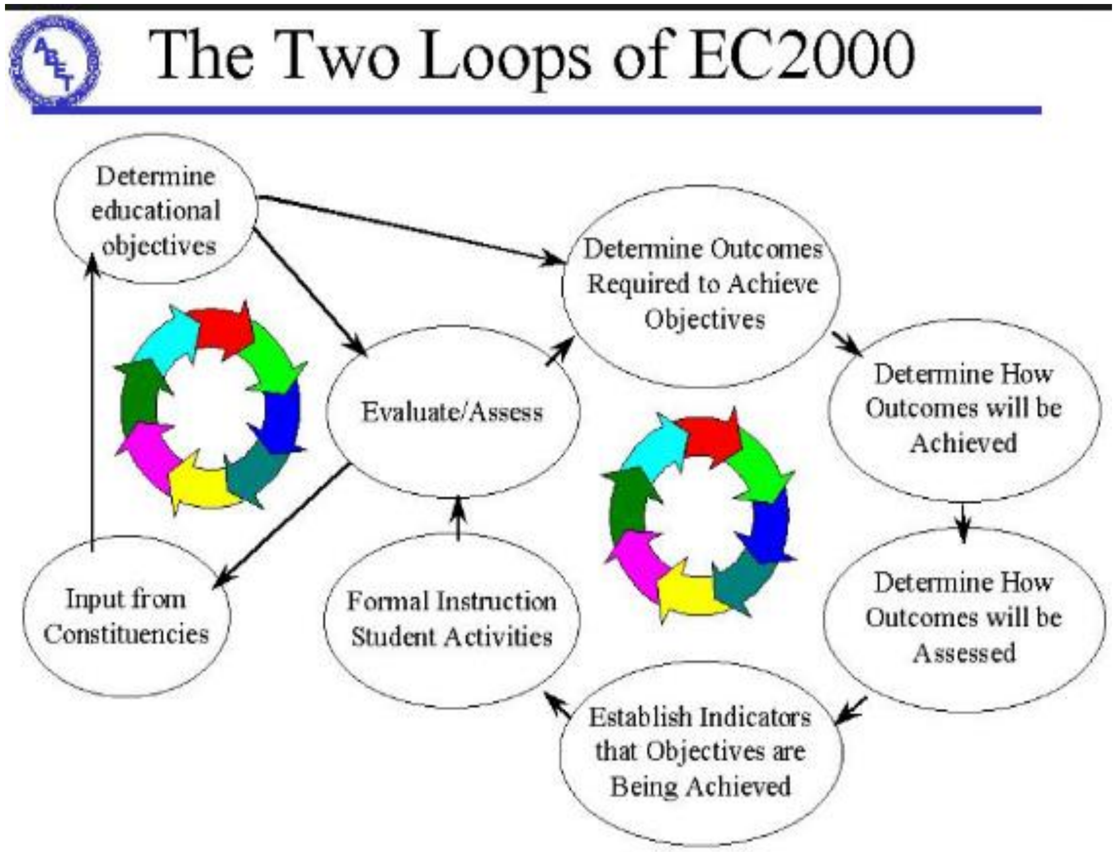

Figure 1. Two loop ABET assessment process.

3. 2. Canada

The Canadian Council of Professional Engineers (CCPE) is the federation of professional engineering associations in Canada. It has the authority to licence professional engineers to practice in Canada. The Canadian Engineering Accreditation Board (CEAB) established in 1965 is a standing committee of CCPE for the accreditation of engineering programs.

The CEAB outcome-based method for the evaluation of engineering programs identifies 12 graduate attributes (GAs) as essential to any engineering program seeking CEAB accreditation [2]. Thus, the accreditation criteria for an engineering program require not only acceptable academic governance (program authority and responsibility) and acceptable qualitative and quantitative coverage of mathematics, natural sciences, engineering science, engineering design and complementary studies, but also the demonstration of the acquired competencies of engineering graduates as measured by a minimum number of academic units (AUs) in a broad set of graduate attributes. Figure 2 illustrates the main pillars that must be demonstrated in any engineering accredited program

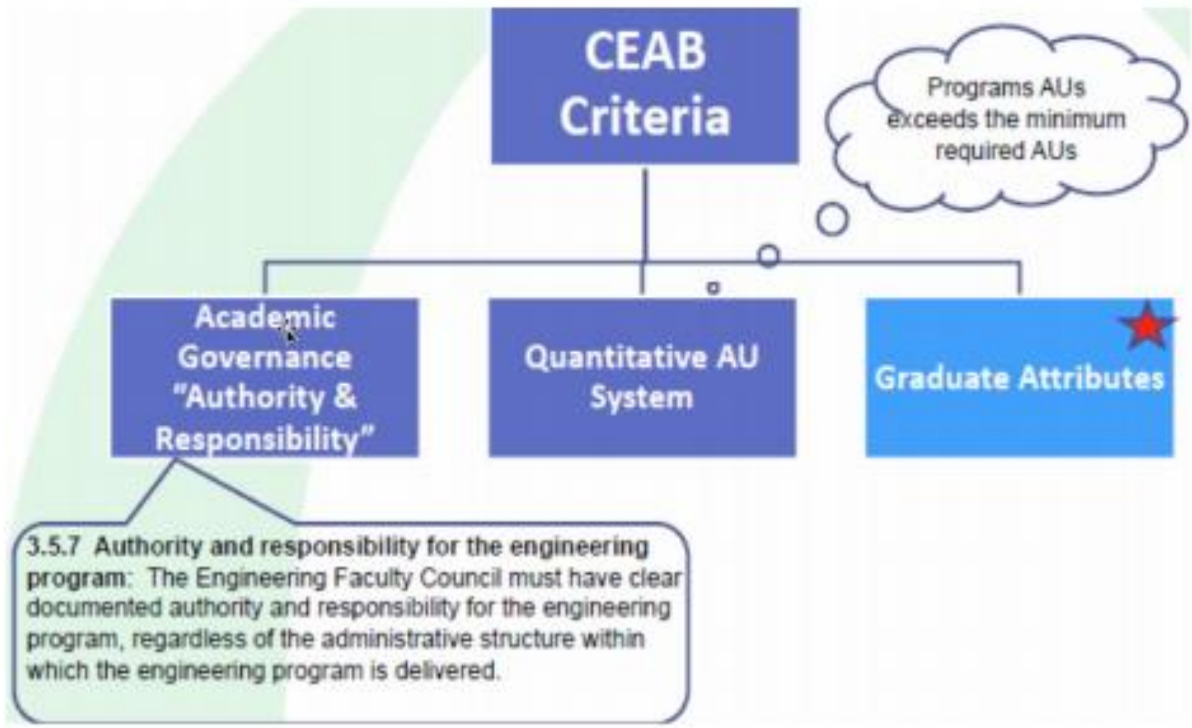

Figure 2. Three main criteria for accreditation in engineering programs in Canada

In addition to being the voice of its constituent members in national and international affairs, Engineers Canada coordinates the development of national policies, positions and guidelines on behalf of the engineering profession. It also promotes greater understanding of the nature, role and contribution of professional engineers and engineering to society, and undertakes federal government relations and national media relations on behalf of, and in consultation with, the provincial and territorial association.

The CEAB Criteria is divided into curriculum, program environment and general criteria. The Curriculum content specifies a minimum number of Accreditation Units (AU), which is equivalent to 1 lecture hour or 0.5 lab hour. These are Mathematics (195 AU), and Complementary Studies (225 AU), which are courses in humanities, social sciences, management, communication and engineering economics. The curriculum should culminate in a major design experience.

The Program Environment refers to the quality of students, facilities management, anises because of the different forms of licensure facilities of the program required by CEAB.

The CEAB Criteria is similar to the ABET, but significances arise because of the different forms of licensure for engineers in Canada, and the relative number of programs to be evaluated.

It should be noted that Canada is strict regarding the 16 years of education for engineering practice. Because of this, it is currently requiring all Filipino engineers to take and pass the licensure examination regardless the number of years of professional experience before they can allow to practice in Canada [2].

3. 3. Europe

For Europe, the European Federation of National Engineering Association (FEANI) is accrediting body for the practice of engineering. It covers 27 countries and more than 1.5 million professional engineers [4].

FEANI aims to ensure that professional qualifications of engineers of the member countries are acknowledged in Europe and worldwide, and to strive for a single voice for the engineering profession in Europe through FEANI Register. The FEANI Register facilities the movement of practicing engineer inside Europe through the EUR ING registration. A set of mutual agreed qualifications has been set for the EUR ING. There are now over 25,000 EURO INGs listed in the FEANI Register. To be registered as EUR ING, one must show a minimum of 7 years of education (U), training (T) and professional practice (E) with minimum of 3U and 2E.

Through the European Monitoring Committees (EMC), FEANI sets and implements the guidelines on the accreditation of schools. All accredited schools are listed in the FEANI index. For a 3 year university engineering program, the curriculum should have about 35% Basic Sciences, 55% Engineering Subjects, and 10% Complementary Non-Technical Subjects. It should be noted that for a 3 year program, if the sum of Basic Sciences and Engineering Subjects is less than 80 or if the ratio of Engineering Subjects to Basic Sciences is less than 1, the program will not qualify for accreditation [1].

A working group from the EMC conducts visitation to collect information and make observations on the staff, studies, facilities and research activities of the program applying for accreditation.

While FEANI is trying to encourage a unified lasting of accredited schools, many of the European countries also have their own existing bodies for accrediting engineering programs.

For the United Kingdom, the accrediting body is the Engineering Council through the Board of Engineers Regulation (BER).

In Germany, accreditation is relatively new, started only in June 1999, though the formation of Accreditation Council and later the Accreditation Agency for Engineering and Sciences in November 1999.

In France, the accrediting body is the Commission des Titres d'Ingenieur (CTI) formed by law in 1954, which h sets the policies and approves applications.

The Accreditation Board for Engineering and Technology (ABET) is the accrediting body for engineering programs in the United States. It is a federation of 29 engineering societies and since 1932; it has accredited 1570 programs in 325 institutions [4]. Their new standard for assessment is called the Engineering Criteria (EC) 2000. This criterion is divided into the following: General Criteria for Basic Level or Undergraduate Programs, Cooperative Education Criteria and Criteria for Advanced Level or Graduate Programs [3] [5].

3. 4. Mexico

A civil association called the Consejo de Accreditacion de las Ensenanza de la Ingieniera (CACEI) given legal status in July 1994. It is the accrediting body for engineering programs in Mexico. The Board is composed of members from industry and associations. A CACAI Accreditation manual published in 1996 contains the policies and procedures for accreditation, which are similar to that of ABET. Thirty programs have been accredited by CACEI [1].

3. 5. Columbia

Accreditation in Columbia started only in 1995, with the establishment of the National Council of Accreditation (CNA). The CNA is an advisory board of the quality policy and executor of the high quality accreditation processes for both academic programs (undergraduate and postgraduate) and higher education institutions. It is part of the structure of the Colombian Educative System, which follows the educational policies defined by the Ministry of National Education and the National Council of Higher Education (CESU).

The Accreditation System for Engineering Programs (SAAP) has the following components. These are curriculum processes, resources and environment. Currently, there is a minimal response and lack of interest to accreditation due to lack of derivable practical benefits [1].

3. 6. Costa Rica

The accreditation system for engineering programs in Costa Rica is under the Colegio de Ingenieria y Arquitectos (CFIA), a federation of engineering and architecture associations. Criteria were established only in 1998 [2]. An accreditation Council to establish policies and rules and make final decisions is still to operate

3. 7. Japan

It is interesting to note that the Japan Accreditation Board for Engineering Education (JABEE) was established on November 19, 1999 [3]. JABEE has a structure similar to ABET. It is a non-governmental body supported by professional engineering societies, industry, and government through the Ministry of Education, Science, Sports and Culture (MONBUSHO).

A feasibility study started last April 2000 by training of examiners, examining programs through self-study reports, and campus visits. These are General and Program Criteria and evaluation is based on educational outcomes and continuous improvement processes similar to ABET. JABEE is encountering problems in the grouping of the engineering disciplines and financial support from the industry due to the economic crisis and implementing reforms in the traditional rigid system of education in Japan

3. 8. China

In 1998, there were 7.19 million total enrolments in the degree and sub degree programs in China. Approximately 40% of this is in the engineering education. Quality assurance of these programs is vested on the Higher Education Department of the Ministry of Education [2,6]. At present, the quality assurance is implemented through strict approval of new specially programs, guidance program on teaching and learning through government experts, and quality assessment. Quality assessment has three forms. These are basic level assessment for universities with weak and short history of undergraduate education, excellent level assessment for universities with good reputation and high quality teaching, and a random level assessment for universities between basic and excellent levels.

3. 9. Australia

The Institution of Engineers Australia, often shortened to IEAust and/or trading as Engineers Australia, is a professional body and non for organization dedicated to being the national forum for the advancement of the engineering field within Australia and a member of Washington Accord. As of 2013, it has over 100,000 members in nine geographic Divisions from all engineering disciplines, including 41,000 [14] Students, 4,400 Engineering Technologists and Engineering Associates, 55,600 Professional Engineers.[1] The members all belong to one or more of nine Colleges covering the different fields of engineering practice. 20,000 members are Chartered Engineers

It sets the requirement for the practice of engineering and the recognition of engineering programs. Its newest quality assessment methods are the National Generic Competency Standards (Stage 1) and Engineers (Stage 2). Stage 1 refers to graduate engineers while Stage 2 applies to experienced engineer. The unique about this standard is its sets the core and effective units and competencies or abilities needed for the practice of engineering in three categories. These categories are engineering associate, engineering technologist and professional engineer.

3. 10. New Zealand

Similar to IEAUST, the Institution of Professional Engineers in New Zealand (IPENZ) is the federation of professional engineers in New Zealand. Aside from registering engineers, IPENZ sets the accreditation rules and policies for engineering institutions starting in 1995 [5]. Accreditation criteria are similar to that of ABET, with emphasis on acquisition of skills through a required 800 hours of practical experience for the student prior for granting a degree.

4. MUTUAL RECOGNITIONS AND EQUIVANCY OF ENGINEERING PROGRAMS

More countries are moving towards cooperation in the mutual recognition of the engineering programs in their institutions. International Mutual Recognition Agreements (MRA) are being signed by accrediting bodies to signify that the engineering programs in their countries are essentially equivalent. It is worthwhile to mention some of these agreements and opportunities for participation.

4. 1. The Washington Accord

The agreement recognizes that there is substantial equivalence of programs accredited by those signatories. Graduates of accredited programs in any of the signatory countries are recognized by the other signatory countries as having met the academic requirements for entry to the practice of engineering. Recognition of accredited programs is not retroactive but takes effect only from the date of admission of the country to signatory status. The Washington Accord covers undergraduate engineering degrees under Outcome-based education approach. [2] Engineering technology and postgraduate programs are not covered by the accord, although some engineering technology programs are covered under the Sydney Accord and the Dublin Accord. Only qualifications awarded after the signatory country or region became part of the Washington Accord are recognized. The accord is not directly responsible for the licensing of Professional Engineers and the registration Chartered Engineers, but it does cover the academic requirements that are part of the licensing processes in signatory countries.

4. 2. The Dublin Accord

The Dublin Accord is an agreement for the international recognition of Engineering Technician qualifications. In May 2002 the national engineering organisations of the United Kingdom, Republic of Ireland, South Africa and Canada signed an agreement mutually recognising the qualifications which underpin the granting of Engineering Technician titles in the four countries [1]. Currently there are 8 Signatories to the Dublin Accord; Australia, Canada, Ireland, Korea, New Zealand, South Africa, United Kingdom and the United States.

4. 3. The Bologna Declaration

The Bologna declaration in full, joint declaration of the European Ministers of Education convened in Bologna on 19 June 1999 is the main guiding document of the Bologna process. It was adopted by ministers of education of 29 European countries at their meeting in Bologna in 1999 [2].

It proposed a European Higher Education Area in which students and graduates could move freely between countries, using prior qualifications in one country as acceptable entry requirements for further study in another.

The principal aims agreed were: (1) Adoption of a system of easily readable and comparable degrees". That is to say, countries should adopt common terminology and standards. (2) Adoption of a system essentially based on two main cycles, undergraduate and graduate. Access to the second cycle shall require successful completion of first cycle studies, lasting a minimum of three years. The degree awarded after the first cycle shall also be relevant to the European labours market as an appropriate level of qualification. The second cycle should lead to the master and/or doctorate degree as in many European countries.

The Bergen meeting subsequently refined the second point, and produced a three-cycle framework of qualifications, which in the UK terminology (adopted, at least partially, by many European countries) would be Bachelor for a first degree of three years, Master for subsequent study, and Doctor for a degree which has "made a contribution through original research that extends the frontier of knowledge by developing a substantial body of work".

For engineering programs, the FEANI Register and Index would ne the articulation of The Bologna Declaration

4. 4. The Sydney Accord

The Sydney Accord is an agreement between the bodies responsible for accrediting engineering technologist qualification programs in each of the signatory countries. It recognizes the substantial equivalency of programs accredited by those bodies, and recommends that graduates of accredited programs in any of the signatory countries be recognized by the other countries as having met the academic requirements for entry to the practice of engineering technologist. The Sydney Accord was signed in 2001 [6].

The Sydney Accord covers engineering technologist qualifications. The scope of the Sydney Accord only covers the academic requirement for an engineering technologist qualification. Engineering technologist titles do not transfer directly between signatory countries that don't have reciprocating agreements, because the signatory countries reserve the right to scrutinize foreign titles and compare them to their own licensing criteria. However, this does not mean the titles are not respected by employers within those signatory countries.

The engineering technologist may be hired within a country by an employer where a formal license is not required. The industrial exemption clause negates formal engineering registration within the United States for those who meet the criteria.

Foreign titles may be utilized as a foundation for recognition of professional licensing. The titles can be supplemented with additional experience and/or training to meet the local definition of formal registration. This serves to underline that a foreign technologist covered under the accord does not arrive in a fellow signatory country without merit. The Sydney Accord is therefore not a hollow agreement without advantages.

The Canadian Council of Technicians and Technologists (CCTT) and the United Kingdom's Institution of Incorporated Engineers (IIE) signed a reciprocating agreement of recognition for engineering technologist. In 2006, the IIE merged with the Institute of Electrical Engineers (IEE) to form the Institution of Engineering and Technology (IET). The CCTT also signed a reciprocating agreement with the National Institute for Certification in Engineering Technologies (NICET). NICET is a United States organization sponsored by the National Society of Professional Engineers (NSPE). The formal recognition of the CCTT as a common link between NICET and the IET has not been realized.

As an international representative of the accord the UK offer a registration program for individuals from any country. However since the standards for technologist are higher in UK (B.Sc. and B.Eng. in Engineering) only 25 UK (emigrating) registrants up to this date applied for registration as "Technologist" indicating the failure of the Accord within UK. In the UK the term "engineer", "professional engineer" or "engineering" have no meaning in law so anyone can call them a professional engineer, or technologist without restrictions. However the titles "Chartered Engineer", "Incorporated Engineer" and "Engineering Technician" awarded by The Engineering Council (UK) are protected by law. United States' graduates may apply for a peer review by the Engineering Council UK if they belong to one of the organizations or societies that are not explicitly mentioned as a member of the accord. Individuals that graduate from a regionally accredited technology program are likely to receive acceptance through professional engineering registration as an Incorporated Engineer.
U.S. professional registration is a state concern. While the profession of engineering technologist is not specifically recognised, many states provide engineering technologists with a pathway towards Professional Engineer (PE) licensing that bypasses national engineering requirements. This is opposed by the national regulatory and representative bodies for professional engineers, the National Society of Professional Engineers (NSPE). Notably, the Washington Accord does not apply to American PEs who has obtained this status through a technologist route.

4. 5. SEFI's E4 Project

The European Society for Engineering Education (SEFI), composed of individual and institutional members from the European community is embarking on a project entitled Enhancing Engineering Education in Europe (E4). Institutions in 23 European states will be involved in five major activities. These are employability through curricula, quality assessment and transparency for enhanced mobility and trans-European recognition, engineering professional development in Europe, enhancing the European dimension and innovative learning and teaching methods [3]. The project proposes network in higher engineering education to complement the efforts of promoting the necessary dimension in European higher education. The University of Florence in Italy was spearheading the project

4. 6. ABET's Credential Services

In response to request the equivalencies coming from different countries in the United States, ABET has operationalized the Engineering Credentials Evaluation International (ECEI), a body to authenticate and evaluate international engineering programs. Before 1997, equivalency was limited only to countries with mutual recognition agreements from the Washing Accord and also with the CEAB.

Since 1997, evaluation is extended to countries with MRA for countries with Substantial Equivalency Agreement (SEA). Those evaluated for SEA have comparable program content and level of educational experience but are identical in delivery

The Criteria Mapping Evaluation assesses the General Educational and Program Structures, and makes a comparative analysis of the curriculum. 128 minimum semester hours are required for the curriculum with the following minimum for credits: Mathematics and Basic Sciences (32), Humanities and Social Sciences (16), Engineering Topics (48) and Electives (22) [4,5]. After evaluation, ECEI shall decide whether the applied program meets the general and program criteria.

5. CONCLUSIONS

It can be seen from the information provided that quality assurance in engineering education is primary importance globally. Accreditation of engineering programs is necessary for the mutual recognition of program globally and for public accountability. Even the accreditation process has changed from the simple qualitative measures for outcomes assessment, or how the programs are able to show that they are meeting the objectives. Benchmarking of engineering programs for the purpose of gaining equivalency is also gaining popularity. Change will be the only global constant in the foreseeable future. It is hoped that this paper will encourage a review of existing accreditation system of engineering program for the purpose of improving and to meet the needs of globalization.

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