INTERNATIONAL ACCREDITATION OF ENGINEERING DEGREES FOR DEVELOPING COUNTRIES

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Abstract *----- An accredited degree is the first stage in the process of gaining professional status. The industrialized countries have systems for accrediting engineering degrees many of which are recognized internationally. Some have bilateral and/or multilateral mutual recognition agreements. The Washington Accord is one such agreement among major English-speaking countries. It is the only multilateral agreement of its kind that is transcontinental. This leaves a very large number of countries, particularly in the developing world, which are either without a comparable system or one that is not fully recognized as such. In order to create a level playing field in the area of trade liberalization, particularly trade in services, transportability of qualifications and reciprocity must be facilitated in both directions between developed and developing countries. There is need therefore for developing countries to have access to internationally recognized accreditation systems, along the lines of ISO quality standards in terms of their universal acceptance and applicability.*

Index Term ----- Developing countries, engineering degrees, international accreditation.

INTRODUCTION

The practice of professional occupations is influenced by culture, climate and other variables of the particular environment in which the services are offered. However the universality of the physical laws of nature has a much greater normalizing or equalizing impact on professions such as engineering. This large measure of commonality in the practice of engineering internationally is further enhanced by several factors such as globalization, which is facilitated by the relative ease of air travel and advances in information technology, and the attendant increase in multinational firms and international trade. In addition to these trends there is a substantial number of engineers and related professionals in industry, government and educational institutions, who have studied and/or worked in countries other than their native lands. Other factors have contributed to internationalization of engineering in terms of educational preparation and experience. The engineering community faces the challenge of setting an international benchmark for accreditation of degrees/diplomas for initial entry into the profession.

INTERNATIONALIZATION OF ENGINEERING

With the spread of international trade the industrial community, particularly manufacturing, has made giant strides in terms of internationally accepted standards of quality assurance. The benefits of the principles of Total Quality Management (TQM) have been acknowledged throughout the world and the ISO 9001 2000 quality management standard is universally applied. Over the last 15 years or so the principles of the ISO 9000 series of standards have been tried, tested and refined to its present form. Although they have been applied mainly to the production of goods, they have found great success in the service industry as well, but they have been confined mostly to in-country delivery of services. With the rapid increase in international trade in services there is the challenge to apply the international standard systems of quality assurance in this regard. In the case of professional services the most important element on the supply side is the provider's competencies based on educational training and experience. It may be considered the quality of professional personnel.

Liberalization of international trade, particularly as facilitated by the General Agreement on Trade in Services (GATS), has influenced the hiring practices and operations of multinational companies and has resulted in greater international mobility of professionals, particularly in engineering.

Communication technologies such as the internet and teleconferencing have led to a proliferation of distance education offerings. Distance education was largely used intra-country to access a wider national catchment and/or to provide opportunities to persons in remote areas of the country. It is now used more and more to reach international audiences. Currently, for almost all institutions, which have embraced this technology, distance education takes the form of delivery of part or all of a programme from one source to students or participants and/or use of the technology for tutorials, questions, answers, submission of assignments and administrative matters such as registration. However the technology allows for a much greater transfer of knowledge and credits between different institutions. Therefore the issues of sharing and selection of courses from diverse sources are only constrained by administrative policies.

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The use of common technology, as demonstrated by design and analytical software and other industry-standard packages (and the portability of such information through cyberspace), has also impacted enormously on the internationalization of engineering practice [1].

National Technological University (NTU)

The National Technological University (NTU) deserves special mention in the context of the internationalization of engineering education. It has made a simple but unique use of the existing telecommunications technologies with an accompanying unique administrative system to expand the access of "distance" students to graduate degree courses. The experience with the United States has prepared the NTU for expansion further afield.

The concept and operations of the National Technological University (NTU) can serve as the basis for one model of greater access and sharing of engineering education internationally. The NTU was established in the United States in the mid 1980s to share and distribute, via satellite, courses between US universities and did not itself have a regular campus where students could take a suite of specially designed NTU courses for a degree [2]. The NTU was conceived basically as a communications and administrative organization to facilitate much wider choice so the student studying for a Master's degree in certain engineering fields, could have access from other institutions to courses that their resident university did not offer, without their having necessarily to attend the distant school in person. The transfer of credit and sharing of resources among higher educational institutions in the US have been facilitated by the strong tradition of horizontal and vertical articulation of education in the US, which is the most advanced system at the tertiary level. However the range and extent of choice has been limited by distance and administrative constraints.

As Master's degrees are not covered by the accrediting bodies such as ABET, NTU sought and has obtained accreditation as an institution from the Higher Learning Commission. As an accredited university it is responsible for design and development of courses and programmes, selects relevant courses from participating universities and awards degrees.

NTU now offers graduate degrees in fourteen Majors, from Chemical, Computer, Electrical, Mechanical, Manufacturing and Materials Engineering to Systems, Management of Technology and an International MBA. A Special Major is also offered as an interdisciplinary graduate degree. NTU offers a few undergraduate courses, which can serve as bridging qualification courses (but are not for credit) for the Master's degrees.

The NTU has led the way by using the technology to create greater access but more importantly it has created an administrative structure to accommodate the selection of courses for one degree from a diverse set of institutional sources. The NTU has expanded its operations oversees, thus opening up the opportunity for access to individual courses from universities in the consortium.

NTU expanded to the Asia-Pacific region in 1995 with three Master's programmes and is prepared to consider other regions as the needs and demands develop. A significant feature of the NTU is the use of the Internet and World Wide Web, which have become significant modes of delivery in their own right. Five Master's degrees are conducted completely over the Internet without use of direct satellite technology. In addition to North America NTU offers professional graduate degrees in several countries in Asia, Australia and the Pacific islands [2].

Similar telecommunication transmission and exchanges have taken place in Europe and other places but the administrative structure has not been put in place to grant degrees with courses from such a wide selection as the NTU. The NTU can therefore serve as a model for more international exchanges of course offerings within one harmonized degree structure. There is a market

QUALITY ASSURANCE IN EDUCATION

Quality assurance in education at the tertiary level involves some sort of verification of the various elements of the system. This is referred to as accreditation when it is done by an external, independent organization. Systems of quality assurance in education vary from one country or region to another.

The industrialized countries have devised systems of quality assurance for tertiary level education of one form or another. The systems tend to be more developed for the professional qualifications, particularly in engineering. This is more likely due to the influence of the professional societies, industrial organizations and regulatory agencies leaving regard to the issues of public safety and liability.

In some countries the Government, usually by legislation and/or regulations administered through a commission or the Ministry of Education, is responsible for quality assurance or accreditation [3]. The accreditation committees usually comprise education administrators, relevant industrial representatives and members from professional societies. This is fairly common in Europe.

In other countries the responsibility for quality assurance in tertiary level engineering education is undertaken by the professional societies themselves [3]. This is the norm in the Anglo-American countries such as the United States, Canada, Australia and Britain, to name a few. The systems of accreditation in these countries are very well structured, national in scope and independent of the engineering schools. Although they may differ in administrative form there is a great amount of commonality in the procedures, expectations and level of outputs. The four countries above together with Ireland, Hong Kong, New

Zealand and South Africa have an agreement for mutual recognition of accredited degrees, referred to as the Washington Accord. The Commonwealth Caribbean is the only major English-speaking region that is not a member of this agreement, due in part to the non-existence of an indigenous accreditation system of similar form and stature as the signatories to the Washington Accord. The Canadians assisted Jamaica with setting up an accreditation system and a Caribbean Engineering Accreditation Council is in the process of being established.

In some industrialized countries in Europe the quality assurance systems in professional engineering schools are surprisingly not very well developed in terms of their independence, consistency and national scope. Germany is probably most illustrative of this situation [4].

The constitution of Germany addresses the issue of equality of funding, opportunity and standards in the sixteen states (Bundeslander) of the Federal Republic. This guarantees a certain measure of consistency of standards throughout the country. The educational standards are administered mainly through framework regulations for examinations. These regulations are in the form of recommendations and it is largely left up to the individual institutions to work out their quality assurance systems. Up to now the reputation of German industry and engineers has ensured international respect and recognition. This is not likely to diminish in the near future but in recent times the need for a more defined, independent and consistent national system has been enunciated by the concerns of government, industry, the profession and the educational institutions themselves. This is in part driven by internal demands for better accountability as well as external forces of the European Union and the wider international community.

Developing countries do not have the industrial maturity and reputation of countries such as Germany so it is even more incumbent on them to develop systems of accreditation that are at once internationally recognized and at the same time relevant to local conditions.

ENGINEERING ACCREDITATION AND THE GENERAL AGREEMENT ON TRADE IN SERVICES (GATS)

It is in the interest of the international engineering community to develop an international accreditation system that can be used by countries that do not have indigenous systems or systems that are not very well developed or well structured. This would obviate the necessity for each country to devise completely new systems, which may be diverse and could become entrenched by law and/or practice, thus creating unnecessary obstacles and delays in arriving at multilateral agreements for the recognition of engineering degrees. This would facilitate the rapidly increasing international trade in engineering services in a more equitable manner. This is particularly important for less industrialized and developing countries, which already suffer from several constraints and deficiencies in international trade in services.

It is not readily recognized that general agreements such as the GATS require underpinning supporting systems if they are not to work to the disadvantage of developing countries, ˙particularly the small states. Recognition of qualifications and competencies is paramount among them. It is not practical in the near future to deal with all levels of personnel because of the large variability in levels and standard of training, certification and cultural norms of practice throughout the world. However at the professional level, particularly in engineering, academic training is much more consistent in form and substance so that efforts to determine levels of training are not as daunting and in fact are not too difficult, provided there is the will. Equity in trade in services should drive the establishment of an international accreditation system, which is in the economic and educational interests of developing countries.

ENGINEERING SHOULD TAKE THE LEAD IN INTERNATIONAL ACCREDITION

Engineering is well placed to take the lead in establishing an international accreditation system, which may be used by any country or region which does not have an accreditation system in place or which wishes to implement practices that are more in harmony with the more standardized processes that do exist.

Engineering traditionally has been the most organized of the professions, arising for the most part from the historical organizational strength and influence of the craft guilds, which originated in medieval times, and further enhanced by the organizational necessities of the industrial revolution. Today professional engineering associations exist in almost all countries of the world. Whereas in smaller societies one professional organization may represent the range of disciplines, in the larger states each branch of engineering is usually represented by one institution (e.g. Institution of Mechanical Engineers in the UK) with an umbrella body (like the Engineering Council in the UK) to coordinate and represent the engineering community nationally and internationally. In addition to the national professional associations there are groupings of engineering organizations in every region of the globe and there is the World Federation of Engineering Organizations (WFEO).

In the area of accreditation there are well-developed systems in several countries. As mentioned previously, in the Anglo-American countries the systems are national in scope, consistent, driven by the profession and independent of government and the engineering schools. They are also long-standing systems and in the case of Britain and the USA they are in use in many other countries of the world [5,6]. It makes sense therefore to consider these as the basis

for an international system, taking the "best" features of other structured and well-developed systems.

REGISTRATION AND LICENSURE

Registration and licensing authorities invariably stipulate two conditions to be satisfied – educational preparation of adequate standard and relevant professional practice of a minimum period. The international norm for professional practice is a minimum of four years, the adequacy of which is not too difficult to ascertain. However certain aspects of engineering practice, particularly in the area of design, are constrained by the requirements of registration and licensure (which are almost always circumscribed by legislation) in the country of delivery of the service. The educational requirements, on the other hand, could pose a problem if the level and/or breadth of training is considered inadequate or if the quality assurance system is uncertain or deficient.

The regulation of the engineering profession and designation of professional status vary from country to country and even from state to state within one country. In some instances it is the responsibility of a statutory body such as an Engineering Board or Commission, or it may be left to the professional association(s) [3]. In the former case the professional association(s) usually have formal recognition and representation, which may be stipulated as majority membership.

Registration in a particular country or state, in the context of licensure, will continue to be dealt with on a case by case basis, because of local requirements regarding practice that may be technical, legal or social. Technical competencies, in the context of local conditions and applicable standard specifications, may involve such climatic considerations as wind loads, seismic activity and applicable materials. In respect of materials a common case in point is the availability of local aggregate (for concrete), which may vary considerably from one location to another. Non-technical issues often involve local laws and regulations and may include labour, health, safety and the environment, liability and other ethical considerations.

Notwithstanding the variability of the experiential component, on this issue of recognition of professional qualifications or status (i.e. the combination of acceptable educational training and practical experience), international standards can, and have been, set that prescribe a minimum period of post-graduation practical experience that has to be satisfied to be designated a Professional Engineer. The international norm, as mentioned previously, is four years of adequate training and responsible charge of engineering works of adequate breath. In small companies and particularly in developing countries a structured training component, monitored by a professional engineer, is often not feasible. Guidelines on experience requirements are flexible enough to accommodate these realities and may compensate by requiring more time or a certain minimum amount of local experience. Most country or state specific non-technical requirements for registration and /or licensure are usually catered for by a relatively straightforward professional examination.

ENGINEERING ACCREDITATION IN DEVELOPING COUNTRIES

As mentioned previously, the accreditation systems in North America and Britain are used by universities in several other countries. The two systems are comparable in most respects except that the American system is much more output based.

Use of the British System Internationally

Throughout the British Empire the system of education was essentially the same, with students doing the same university matriculation examinations, which originated from Cambridge University and the University of London. The universities in the Empire were established along the lines of the British model, including the quality assurance system [3,5]. Even though the colonies gained independence most maintained ties with Britain, particularly in respect of educational systems.

The more developed and larger countries of the Commonwealth (as the grouping of Britain and the former colonies is referred to) developed their own accreditation systems, with similar criteria and standards. The universities in the less developed and smaller states continued to depend on internal quality assurance mechanisms and the external examiner system. Some without an indigenous accreditation system have opted for international accreditation from the British Institutions. A good case in point is the Faculty of Engineering of The University of the West Indies.

The Faculty of Engineering The University of the West Indies

The University of the West Indies (UWI) serves fourteen English-speaking countries in the Caribbean, former British colonies. There are three main campuses. The University started with the Mona Campus in Jamaica in 1948 as the University College of the West Indies, initially as a college of the University of London. The St. Augustine Campus, in Trinidad and Tobago, was established in 1960 and the Cave Hill Campus in Barbados in 1963. Currently (in 2002) there are over 20,000 full-time students and an even larger number doing part-time and extra-mural studies.

In 1961 the Faculty of Engineering commenced in St. Augustine and currently there are well over 1,200 students who are pursuing Bachelor's, Master's and doctoral degrees. From inception The University of the West Indies adopted the British internal quality system, including comprehensive external assessment, whereby all examinations and a representative sample of scripts are scrutinized by external examiners, of the rank of full professor, from outside the

region. In the 1980s, with the increased demand generally for internationally recognized quality management systems, the UWI Faculty of Engineering initiated the additional quality assurance mechanism of accreditation. In the absence of a local (or regional) system the British Institutions were invited, being the only internationally recognized bodies, which, at that time, accredited degrees overseas. Within the last five years The University of the West Indies has gone further and has established a formal Quality Assurance Unit whose mandate includes assisting Departments with quality management systems, organizing quality assurance reviews, auditing specific ancillary functions and supporting the professional Faculties and Departments with preparation for accreditation visits [7].

Use of the American System internationally

The American Accreditation Board for Engineering and Technology (ABET) has seventy (70) years experience and currently accredits well over 2,000 engineering and technology programmes and over 50 in engineering-related disciplines. The latter has increasingly engaged the attention of ABET which has to deal with an escalating number of requests for accreditation of programmes that are not designated as engineering.

ABET, and more recently the Canadian Engineering Accreditation Board (CEAB), conduct evaluations of overseas degrees for "substantial equivalency", using the same criteria, procedures and standards as for their domestic programmes.

ABET started evaluations of foreign degrees in the 1980s and increased the activity substantially in the 1900s. ABET has also worked closely with various engineering organizations and educators in several parts of the world covering the five continents. In 1995 ABET signed a Memorandum of Understanding with the UNESCO Regional Office for Latin America and the Caribbean to assist in the establishment of national and regional accreditation systems.

ABET is part of several groupings related to the internationalization of engineering education and practice. In addition to the Washington Accord ABET has been the major driving force behind such entities as the Engineers Mobility Forum (EMF) which includes the eight Washington Accord territories as well as China, Japan, Korea and Malaysia. The EMF was formed to facilitate cross-border practice by experienced professional engineers based on mutual recognition of national assessment systems, supported by mutual participation in the operation and evaluation mechanisms of these systems. Participation will increase among the twenty-one countries of the Asia-Pacific Economic Cooperation (APEC) through the APEC Engineer Coordinating Committee. APEC constitutes countries from all the major trading regions of the world and includes the most industrialized countries, except the European Union. APEC countries account for about 50% of global trade.

Use of the ABET System as an International Model

It is recommended that the ABET system be used as the basis for an international accreditation system along the lines of ISO 9001 2000 [9], incorporating as well the "best" features of other well-developed systems.

There are several well-established accreditation systems in several parts of the world [9-14] and in other places systems are currently being developed [15-16]. However, the American model of engineering accreditation has several attributes, as outlined above, that recommend it, more than any one system, as the starting block for an international engineering accreditation standard.

Probably the most significant feature of the ABET accreditation system is the simplicity and flexibility of Engineering Criteria 2000 which gives general guidelines for attaining quality of an engineering degree programme [9]. This is a great plus for use as an international standard, as opposed to the more prescriptive systems that currently exist. Another significant feature of this new ABET system is the emphasis on outcomes as opposed to inputs.

The British system [9] is also well-developed and is used by several institutions in several countries. However the new British model is still very prescriptive and there is the added complication of a Matching Section, which is supposed to be a top-up year of professional-cum-academic preparation added onto the traditional 3-year degree, in order to qualify for accreditation at the corporate level of the Engineering Council, as a Chartered Engineer. The more direct route is the 4-year Meng degree. The system is still under intense debate in Britain, particularly the structure and format of the Matching Section which is yet to be satisfactorily resolved, but which is the resort of a large number of 3-year degree graduates who aspire to chartered status but could not do the 4-year programme because of the input restrictions on entry qualifications.

Implementation of the International Accreditation Standard

The implementation of the international accreditation standard should be done in a manner similar to certification in the ISO 9001 regime. A visiting team of internationally recognized accreditors would proceed along the same lines as any ABET team. This could possibly be administered by a special committee of the World Federation of Engineering Organizations (WFEO). An intensive programme of training would have to be undertaken in two vital aspects of the operation of such a system. Institutions must be made aware of the underpinning philosophy of the process, procedure and expectations and accreditors must be trained from among the indigenous cohort of academics, industry and government personnel in the various countries and regions where the system is expected to be implemented.

CONCLUSIONS

- The establishment of international standards of quality has been driven by the spread of international trade, particularly in the trade of goods.
- Communications technologies, among other things, have contributed to a dramatic increase in international trade in services and the functioning of multinational teams of engineers and other professionals.
- Communications technologies have also led to a similar increase in cross-border distance education, including engineering.
- Most of the industrially developed countries have well-structured quality assurance systems in place for their educational institutions, particularly at the tertiary level.
- Many developing countries have comparable quality assurance systems in place, but they (particularly the smaller ones) do not have the reputation or resources of the larger or more economically endowed states to establish and/or maintain an independent, indigenous accreditation system.
- Engineering has traditionally been the most organized of the professions and therefore is well placed to take the lead in establishing an international accreditation standard, along the lines of ISO 9001.
- Such a standard can be used by countries and regions that either do not currently have an accreditation system or wish to implement more standardized practices.
- There are several initiatives with regard to mutual recognition of professional level engineering degrees. It is in the interest of developing countries to be part of these initiatives.
- The system of the American Accreditation Board for Engineering and Technology (ABET) is best suited as the model for an international accreditation standard.
- This can be administered by a committee of the World Federation of Engineering Organizations (WFEO), accompanied by an intensive programme of training.

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