

for better
education
& training
for engineer

ideas

INTERNATIONALISATION OF ENGINEERING EDUCATION

Number 8
November 2001



*Committee on Education and Training
World Federation of Engineering Organizations*

**for better
education
& training
for engineer**

ideas

INTERNATIONALISATION OF ENGINEERING EDUCATION

**Number 8
November 2001**



***Committee on Education and Training
World Federation of Engineering Organizations***

**WORLD FEDERATION OF ENGINEERING ORGANIZATIONS
FEDERATION MONDIALE DES ORGANISATIONS D'INGENIEURS**

COMMITTEE ON EDUCATION AND TRAINING

JOURNAL IDEAS N°8, November 2001

IDEAS is a publication of the WFEO Committee on Education and Training, 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 engineers.

EZ A KIADVÁNY AZ OKTATÁSI MINISZTERIUM
KUTATÁS-FEJLESZTÉSI HELYETTES ÁLLAMTITKÁRSÁG
ÉS A MTESZ TÁMOGATÁSÁVAL KÉSZÜLT.

Editor: Prof. János Ginsztler,
H-1111 Budapest, Műegyetem rkp. 9.,
phone: (36 1) 463-2471
e-mail: ginsztler@mti.bme.hu

ISSN 1605-7627

Kiadja a WFEO Oktatási Bizottság megbízásából a Logod Bt.
H-1012 Budapest, Logodi u. 49., tel.: (36 1) 214-2453,
e-mail: logod@logod.hu

Tipográfia: Logod Bt., felelős kiadó: Buday Miklós

Nyomdai munkák: Alfaprint Kft., felelős vezető: Barabás Gábor

©WFEO

PRINTED IN HUNGARY

CONTENTS

EDITORIAL – <i>Prof. János Ginsztler, President of the WFEO Committee on Education and Training</i>	5
GREECE • The Importance of the Internationalisation of the Engineering Education in Greece – <i>Stefanos I. Ioakimidis, Treasurer of the World Federation of Engineering Organizations</i>	7
SWITZERLAND • Internationalisation of Engineering Curricula. Swiss point of view, <i>Prof. Jean-Claude Badoux, former President of the EPFL-Swiss Federal Institute of Technology, Lausanne</i>	9
TURKEY • Engineering for Social Responsibility and Sustainable Development, <i>Dursun Yildiz Ce (MSc.) Vice-President, Union of Chambers of Engineers and Architects of Turkey</i>	12
UNITED KINGDOM • The Economics and Organisation of UK-based Accreditation of Engineering Degree Programmes, <i>Andrew Ramsay, Acting Director General, Engineering Council, UK</i>	14
UNITED STATES OF AMERICA • Foreign Adaptation of U.S. Engineering Education Models, <i>Dr. Russel Jones, World Expertise LLC and Bethany S. Oberst, James Madison University</i>	18
UNITED STATES OF AMERICA • Guidelines for Definition of Necessary Basic Knowledge in Engineering Education, <i>Dr. Russel Jones, consultant, World Expertise LLC</i>	24
ARGENTINA • Building a Vocation for Leadership, <i>Prof. Miguel Ángel Yadarola, Past President WFEO Committee on Education and Training</i>	28
UNITED STATES OF AMERICA • International Decade for Engineering Advancement (IDEA) On behalf of the International Committee on Engineering Education and Innovation, <i>presented by Marshall Lih</i>	33
AUSTRALIA • Global Recognition of Professional Engineers and Technologists, <i>Barry J. Grear, Foundation Chairman APEC Engineer Coordinating Committee</i>	35

Internationalisation of Engineering Education

Prof. János Ginsztler—President of the WFEO Committee on Education and Training

The globalization is one of the greatest challenge facing all university education, but especially engineering education. The environment of engineering education is changing quickly and dramatically because of the spreading of new technologies and globalization, and also because of the political, economic and social changes throughout the world. Engineering is independent of national boundaries and is indeed truly global.

Internationalisation of engineering education itself covers a wide range of related topics, like – among others –

- the internationalisation of engineering curricula;
- the role of engineering for social responsibility and sustainable development;
- the accreditation of engineering degree programs;
- adaptation of engineering education models;
- the guidelines for definition of necessary basic knowledge in engineering education;
- building a vocation for leadership;
- advancing engineering education and innovation on a global scale;
- international recognition of qualifications and challenges for international professional federations;
- quality assurance of engineering education;
- the organisation of modern up-to-date courses for the continuing engineering education with international participants;

- networking and international exchange programs;
- ethics in engineering education;
- international recognition professional engineers;
- etc.

The UNESCO may play a very important role in advancing the internationalisation of engineering education. It was a great honour for China and Hungary, that the UNESCO established an UNESCO-Chair in Continuing Engineering Education at the Tsinghua University (Beijing) and at the Budapest University of Technology and Economics (Budapest) two years ago. The establishment of these Chairs was part of the International Plan of Action to strengthen Inter-university Cooperation and Academic Mobility which has been launched by UNESCO, as foreseen in the Medium-Term Plan of the Organisation adapted at the 25th Session of the General Conference of UNESCO. The key feature of this Plan – called UNITWIN – is increased solidarity, through twinning and other linking arrangements among universities throughout the world, in order to develop long-term cooperation with institutes of higher education and research in developing countries, focussing in the transfer and development of knowledge. These UNESCO Chairs should become the focal points of a network, which links institutions of higher education in the industrially developed countries to the Institutes

of Continuing Engineering Education at the Tsinghua University and at the Budapest University of Technology and Economics.

There are existing International Education Centers at different universities of the world. They are responsible for the administrative functions connected with the different engineering programs taught in foreign languages. These centers handle faculty staff and student exchanges, co-ordinate the registration of international students and usually manage the one year Pre-Engineering Courses. These centers are responsible – at many universities – for the first year international students during the first semester and for all financial matters, related to engineering, management and cultural programs taught in foreign languages.

These Centers are also charged with building relationships both nationally and internationally.

Some words about the new challenges for international professional federations. I fully agree with the opinion of Derek Jefferies and Julia Evetts, ("Approaches to the international recognition of professional qualifications in engineering and the sciences". European Jo-

urnal of Engineering Education, Vol. 25. No. 1. p. 99-107) that the international federation concerned with the establishment and operation of professional registers face some important challenges. Among the different professions the engineering profession has provided leadership by creating the so-called FEANI model for a European professional register, which is acknowledged also by the European Community. It is one of the most important tasks of these federations to interact with other international federations and/or agencies concerned with the mutual recognition of professional qualifications awarded by them.

The reason, why we choose this title of the 8. Number of IDEAS was to share with our distinguished readers the thoughts of world-wide known and acknowledged excellent experts about these most important topics of engineering education at the end of 2001.

Let me thank very much the most useful work and help in editing this number for the members of our Editorial Board, for Prof. Miguel Ángel Yadarola, Dr. David Reyes Guerra and Dr. Stefanos Ioakimidis and also for the Secretary of our CET, for Mrs. Zsuzsanna Sárközi-Zágoni.

The Importance Of The Internationalization Of The Engineering Education In Greece

*Stefanos I. Ioakimidis—Treasurer Of The World Federation Of Engineering
Organizations (W.F.E.O.)*

The main characteristic of our time is the globalization and its effects upon the economic, political, social, cultural and educational life of all countries of our planet.

Although there is no generally accepted definition what the word "globalization" means, as everyone gives a definition of the word, according to his/her general ideas and the position of his/her country in the international life, there is a common place, not a definition, accepted by everyone. Globalization is the fruit of the very rapid development of science and technology and especially of electronics, informatics and communications. It united the world and did accessible the information to every man and woman immediately.

Discussing about electronics, informatics and communications, we have to deal with scientists, engineers and their education. It is obvious that this new world situation created by the globalization needs a new kind of engineers, possessing not only knowledge and skills but also cultural awareness, social responsibility and ability to act in a swiftly changing, multicultural international environment. This trend leads to the internationalization of the engineering curricula.

The European Union, focusing on the internationalisation of the engineering curricula, is using the programs SOCRATES and LEONARDO.

The European system for transferring study credits between countries and institutions, has the same targets. To the same direction moves also the effort of harmonizing the European University curricula.

Beyond the engineering knowledge and the skill requirements, a new value, for the mutual understanding, have the language skills of the internationally acting engineers and the study of humanities, which help the acquisition of good judgement and a better dealing with complex situations.

The quality assessment in engineering education is now of higher importance. New ways of engineering education are used: Distance learning and life long learning.

The engineering organizations knowing the importance of the internationalisation of the engineering education and profession are making efforts to put into practice common standards for the level of the education and to assure the mobility of the engineers through multilateral accords as: The Washington Accord, the ASEP Accord, the Mobility Forum and the EUR-ING title of the F.E.A.N.I. Greece, like the other Balkan and East-Mediterranean countries, arrived lately in the modernity.

The Greek revolution of 1821 was followed by 120 years of continuous wars, civil wars, dictatorships etc. up to the final formation of the today new Greek State.

Only during the last 50 years, there is a continuous progress. Now Greece is a member of the European Union, has the 70% of the E.U. income per inhabitant and is striving for continuously to reach the level of the other countries of the E.U.

Greece has today 80000 engineers, graduated mainly by the Greek Universities. Every year graduate 3000 new engineers.

Greece has accepted, for the engineering education, many years ago, the Central-European system.

Thus, the formation of an engineer is lasting 5 years, with a solid theoretical basis of mathematics, physics and chemistry. Greek engineers have a very high level as professionals and a good reputation abroad. The application of the Bologna- Prague Accord, for the Greek case, is rather difficult, because Greeks prefer the system of long studies, they have and are satisfied of its product. Maybe a solution, on the matter, for Greece, should be the solution accepted by Germany.

Greece is an open society, having strong ties with many countries. Greeks like traveling, living in foreign countries and adapt

easily into different environments. Many Greek engineers have been working for many years in Asia, Africa or Europe. Tourism and merchant shipping (the strongest in the world) are the most important sectors of the Greek economy. Both sectors are oriented to the world outside Greece.

Engineers serving such an economy as the Greek one, must have an international profile ever and ever stronger.

Consequently, there is a pressure on the engineering education system, to introduce new higher standards, to organize new curricula (protection of the environment, protection of the traditional heritage, telecommunications etc.), to harmonize the engineering curricula and diplomas with curricula and diplomas of the most advanced countries, to introduce accreditation and assessment of quality systems, in order to produce new engineers of very high quality, for the new conditions.

The 2004 Olympic Games, in Athens, will be not only the greatest athletic event, but also a proof of the high quality of the Greek engineering community.

Internationalisation of Engineering Curricula

Swiss Point of View

*Prof. Jean-Claude Badoux—Former President of the EPFL-Swiss Federal
Institute of Technology Lausanne*

This paper will begin with a vision of what is needed for training high quality engineers from an international point of view, before focusing on the specifics of engineering curricula in Switzerland. Engineering has the fortune of being trans-national, international and indeed truly global. Unlike Law, Medicine or the Literary Arts, Engineering is essentially independent of national boundaries.

The paper will concentrate on the present approach to the internationalisation of engineering training in Switzerland, a country that is multilingual, very multi-cultural, host to a great number of engineering students from more than one hundred countries worldwide and also the birthplace of numerous students who seek work experience abroad. In conclusion, the paper will explain how engineering training should evolve in the future.

The training of engineers in Switzerland is based on synthesis, rather than analysis, and aims to develop creativity and an entrepreneurial spirit. The goal is to train engineers in the true sense of the word rather than to provide a classic scientific education. Engineering requires intelligence, expertise, excellence and qualities that are far beyond those provided by even the best scientific education; the differences between the best engineering curricula and the best scientific curricula are noticeably significant.

The training of engineers in Switzerland is provided by professors and their staff who, in the vast majority of cases, have a significant and valuable professional experience and who remain active in the real world of engineering throughout their academic career.

The training of engineers in Switzerland is both selective and demanding, with recruitment focused on the best potential students; those who can meet the challenge of such a demanding curriculum. As this curriculum becomes increasingly renowned and respected, it gains the confidence to become elitist, attracting and recruiting better and better students, in particular those that excel in mathematics, physics and biology. It is only with the best students, those who are motivated and ready to face the challenge of a very complex and rapidly changing world, that an engineering curriculum strong on synthesis has a good chance of success. Engineers must not, above all, be trained as technicians.

The training of engineers in Switzerland includes complex project work requiring many hours each week throughout a term or academic year. Certain projects are carried out individually, others in groups of up to four students. These projects must be advanced technically, cover all aspects of real world problem solving and they must be carried out in close collaboration with professors

and their staff as well as engineers from practice. At all stages of a project, students are expected to be able to present their work in order to explain and defend it with confidence.

The training of engineers in Switzerland involves the top one-third of engineering graduates going on to invest three or four years on preparing doctoral theses. This investment is a very personal apprenticeship covering research, technological development and innovation. In addition to being an investment for the graduate, it is also important for society, the community and the evolution of engineering in general.

Student engineers begin their training in Switzerland at the age of twenty, later than in many other countries. This is an important difference in an international comparison since students at this age already have an excellent foundation in languages, mathematics and physics. Engineering students can attend one of the two federal institutes of technology (EPF) or one of seven universities of applied science (HES). The minimum duration of studies is a little over three years at an HES and nine or ten semesters at an EPF, according to the field. The curricula are very challenging, with less than three quarters of students successfully completing their studies and finally graduating. From the first year, courses are normally offered that awaken students to the specific nature and culture of engineering as well as synthesis as a particular approach to problem solving. From the very beginning, students are confronted with the need for synthesis, even if only through simple project work.

Naturally, from the first semester, students study together with others from within their chosen field. However, all students from all fields – civil engineers, chemical engineers, computer scientists, mechanical engineers, electrical engineers, physicists and communication systems engineers – all study together on common courses for mathematics, biology or physics, within limits imposed by the size of classes and, above all, workshops. These fundamental science courses, so vital to engineering training, are offered whenever possible in parallel in a

choice of languages, for example, at the EPF Lausanne, in French, German and English.

Internationalisation ? It is paramount that the body of academic staff, and professors in particular, is enriched with people from many different countries, since this is the key to creating a true international environment in an engineering school. Having international experience from studies or practice abroad provides a professor with important know-how that is of benefit to students and the university as a whole. More than three quarters of the professors recruited at the two EPF's have significant international experience and more than a half hold foreign passports from a wide range of countries covering the five continents.

Through their active and vital involvement, doctoral students make an essential contribution to teaching and research in a great engineering school. Nearly one half of the doctoral students at the two EPF's hold a foreign passport from one of more than sixty countries, thus providing a vital international contribution to research and teaching. This is only possible at an engineering school that is multilingual, that offers excellent remuneration to all doctoral students, irrespective of their origin, and, furthermore, that offers an equal opportunity to all candidates as a function of their qualifications, expertise and excellence rather than as a function of their nationality, mother tongue or undergraduate university.

At the undergraduate level, the nine engineering schools in Switzerland do not have strict requirements with respect to entrance qualifications, nor with respect to nationality. This opens the door to excellent students from abroad, who are thus able to undertake all their engineering training in Switzerland, in particular at the two EPF's, where many foreign students do just this. All students are encouraged to undertake their third year of study in exchange with a foreign university. It is important for a truly international engineering school that this exchange works in both directions and that it involves a consistently diverse and significant number of students.

It is planned that in the future all nine

engineering schools in Switzerland will adopt a more cosmopolitan character, such as that already found at the EPF in Lausanne and that becoming established in Zurich. This will begin by increasing the number of foreign students and teaching staff; the support for students who stay for a year in Switzerland would then be improved and Swiss students would be actively encouraged and supported in spending a year, their third for example, in a wide range of countries, indeed the widest, around the world.

The internationalisation of engineering schools could be seen as a problem with respect to making exchange agreements and

creating uniform and compatible curricula. This is not the case. The answer is not that the whole world adopts a common, American model for engineering schools, curricula and titles. It is excellence and willingness alone that are needed in order to lay the foundations for a strong and wide reaching internationalisation of our engineering schools. In particular, it is essential to recruit a great number of foreign professors and post-graduate students. To encourage this evolution, foreign languages must be promoted to have greater importance in both pre-university and graduate studies, even for English speakers.

Engineering for Social Responsibility and Sustainable Development

Dursun YILDIZ CE(MSc)—Vice President, Union of Chambers of Engineers & Architects of Turkey.

Ethics and Selection of Profession

Traditionally the role of the engineer is to turn information and ideas into devices which are of practical use to the society. The challenge of improving the quality of life for people throughout the world, without damaging the life-support systems of the planet, is a moral as well as a practical issue.

The kind of responsibility that is necessary in this new age of information reaches beyond traditional recognition. Engineers should place their knowledge and experience directly at the service of people, providing independent professional advice and opinion. This condition requires more talented and better educated engineers in the fields of administration, social science, economy as well as social responsibility and sustainable development for the 21st Century. Although these features appear to be universal for engineering throughout the whole world, in essence the situation is quite different in developing countries and the profession suffers to a great extent from this global approach.

Engineers are affected by the macro-economic policies that are in effect in the country while they are practicing. This is a process that influences the engineer within a large spectrum, from professional satisfaction to social responsibility. It is essential that pro-

fessional organisations should be involved and active throughout the whole process, starting from education programs to professional practice in order to prevent the engineer from alienating himself from his social responsibilities and from being influenced in a negative manner within this process.

Engineers may undertake various responsibilities by working as product managers, designers, planners, organisational specialists, plant managers, production managers, as salesmen, consumers, administrators, supervisors or even politicians. Typically, engineers will perform all of these functions on top of their technical background. In other words, engineering education for the 21st Century should include a wider variety of topics, to give a multidisciplinary approach and innovative base to candidates. This formation will be even more necessary for comprehending and cooperating with other disciplines, bringing together the best brains to approach a problem from different angles. Engineers will also have to shoulder greater social and environmental responsibilities than before in order to secure a cleaner world and sustainable development. It will only be possible to provide improved and more developed engineering education programme for the 21st Century upon this procedure.

On the other hand, in developing countries, the availability of obtaining continuous

education and appropriate employment in the field of engineering practise or making progress in the academic or professional fields of the profession are definitely not comparable with the conditions in developed countries.

The effectiveness of an engineer depends not only on specialist skills and knowledge but also on the ability to communicate, influence and shape the world with the supreme responsibility of a human being and the environment.

In the 21st Century, candidates who want to become an engineer should be aware of the above mentioned responsibilities. In other

words, there is an important need to inform prospective students about these responsibilities before they choose engineering as a profession. Therefore, to prepare candidates before the selection of engineering profession is as important as the education that will be given at universities in the 21st Century.

Engineering organisations must play a more active role to inform and prepare candidates for engineering profession and to supervise members in terms of engineering ethics. The importance of the selection process for engineering profession and the role of engineering organisations in this process is very important.

The Economics and Organisation of UK-based Accreditation of Engineering Degree Programmes

Andrew Ramsay—Acting Director General, Engineering Council, UK

I propose to divide this paper in three parts. First will be an over-view of the economics of accreditation. I will follow that with a brief explanation of the way the engineering profession is organised in the UK, and finally explain how accreditation is undertaken in the UK.

Overview of the Economics of Accreditation

Accreditation can be an expensive and disruptive process. The core business of universities is research and teaching. While they increasingly recognise the need for good marketing and administration, there is an inherent dislike of external review, which can call in question the independence of the institution itself. Hence, much of the resistance to modern accreditation comes from those who argue that it is unwieldy and expensive and therefore unnecessary.

It is certainly true that it can be expensive. In the UK, accreditation required for public funding of universities can involve weeks of dedicated effort by senior academic staff, including the production of rooms-full of paperwork demonstrating that criteria have been met and systems are in place. For engineering, in the UK, we believe that most of the documents we require should already

exist within a well-run university faculty, and we encourage great flexibility in how these are produced and the form they take. Nevertheless, we recognise that there is an organisational overhead associated with accreditation, which is why we advocate a short, intense period of accreditation with the consent of the university concerned.

Accreditation is costly in time, of course. Normally about a dozen academics will devote one or two days to the processes we require. We also have our own costs to consider. For the UK, the primary costs of the time of the accreditation team to personal training, pre-audit and then the audit itself are essentially free; we simply bear the expenses incurred by individuals. The nature of our professional societies in the UK is such that volunteers give time – in part as their contribution to society, but also, in this case, for the benefit of learning others' good practice and, maybe, in industrialists' eyes, the opportunity to evaluate personally the quality of likely future graduates who may become employees of the future.

To these modest costs must be added the cost of administration, planning, preparing, documenting, reporting and subsequently following up and publishing the audit result, and the overhead of the quality assurance require-

ments we have in the UK of our own audit process. For the UK we estimate this involves the full time equivalent of about 20 staff.

Nevertheless, there are considerable benefits outweighing these costs. Nearly 30% of the 20,000 engineering undergraduates who enter Britain each year come from outside the UK. These have come to be seen as important contributors to the costs of running engineering faculties, since they pay, on the whole, higher fees than UK undergraduates, whose tuition fees are controlled by government. It seems to be true that UK accreditation of UK courses is a powerful marketing tool for universities – more powerful outside the UK than inside. While there is acceptance that there may be differences in quality between engineering degree programmes in the UK – and this is inevitable, given the rapid changes in funding and student numbers over the last decade – overseas students are more aware of the importance of comparison shopping, it sometimes appears, faced as they are with the opportunity to take their engineering degree in countries other than the UK.

More difficult to pin down, but certainly apparent, is the effect of an accreditation visit, both in terms of improving efficiencies of a faculty and in the opportunity to share good practice with others facing similar problems, or with new approaches to teaching particular subjects. An external, objective, view can clearly be of assistance to hard-pressed faculty managers with hard decisions to make about retention of staff or battles to fight for laboratory or technician resource.

Finally, the system works so well in the UK partly because the driving force is our strong system of learned societies or Chartered Institutions. Direct contact with the universities enables them to recruit membership from students as well as academics, and helps to satisfy their industrial supporters that their needs, as employers, are being taken into account. There are therefore gains all round for the participants in accreditation in the UK. Some of these are impossible to quantify financially, but make good sense for the participants in the extensive programme of accreditations being undertaken each year.

The Engineering Profession in Britain

In Britain, the organisation of the engineering profession is quite unlike that of any other country. I will describe first the structure of the profession, then how professional formation has evolved in the UK, and finish with some comparisons with overseas experience.

To understand the structure of the profession, one has to understand the unique role of the Royal Charter. Royal Charters are monopolies granted by the King or Queen of England for the professions – engineering, law, accountancy. These provide only a restriction on who may use the professional title associated with that profession. This means that legally anyone may practise engineering in the UK, although some employers will insist on membership of particular institutions and, indeed, registration as a professional engineer.

Equally powerful is the fact that professional titles awarded through these Charters are subject to annual renewal by payment of a fee. Increasingly this is associated with a requirement that the professional concerned has maintained his competence up-to-date, but this has by no means always been the case. It does, however, result in much larger memberships of our learned and specialist societies than you experience here in Continental Europe, where the professional title is granted for life, on graduation.

The power and importance of these professional societies in the UK – and some of them have assets of over one hundred million euros and substantial income from publishing and conferences – means that professional self-regulation in the UK is easy to finance and to operate. In essence, there is no cost to the public for the expense of maintaining quality or the ethical standing of professional engineers. It also means that accreditation of courses is a natural extension of that activity.

However, there is one additional Chartered Body for engineering – the Engineering Council. Our role is to maintain a common standard across the profession, and we do this by a system of accreditation of the learned societies – the other Chartered

Bodies. It is not unlike the system that our learned societies apply to universities, which I will describe shortly. Our role is to determine whether Institutions are capable of operating to the common agreed standard. Those that can, may register their members as engineers on our national registers – they also collect for us another, modest, annual fee for those members to retain their registration titles (Chartered Engineer, Incorporated Engineer or Engineering Technician).

It is useful to consider the way in which UK professional formation has evolved over the years. Unlike Continental Europe, engineering in the United Kingdom and Ireland has never been seen as a primarily university-based discipline. Until the 1950's most professional engineers were assessed through examinations set by the learned societies. Widening access to further, and then higher, education changed that only relatively recently. Degree entry for Chartered Engineers has only been the norm since 1971 and, hence, accreditation of degree programmes only really got started in the early 80's. It became properly codified in 1984, with the publication of our regulations 'Standards and Routes to Registration' or 'SARTOR'. However, the legacy remains that a university education is never seen in the UK as adequate to complete the formation of a professional engineer. We have detailed regulations on the additional skills and experiences which must be acquired before someone may be registered. Most of our professional engineers do not register until they are at least 30 years old.

While this is quite different from the situation in Continental Europe, we have greater affinity with our ex-Commonwealth and Commonwealth colleagues in the Washington Accord, who include the United States, Australia, Hong Kong and South Africa. However, we have worked hard within the FEANI group to align our two very different systems, by persuading our Continental colleagues to embrace the idea of professional formation after graduation, while we ourselves have increased the length of university courses to bring them more into line with the

levels of mathematical and engineering science commonly required on the Continent.

And now, the accreditation process itself

Only some engineering programmes are suitable for accreditation. The content and preferred outcomes for an accreditable engineering degree programme are outlined in our regulations. They are not very prescriptive – certainly not to the extent of requiring knowledge of particular theorems or physical laws. However, in interpreting these, individual learned societies may well be more explicit.

Our first act on receiving a request for accreditation is to put together a team, typically two academics, two industrialists and a staff member. Joint accreditation between Institutions is possible, and often happens. All the members of the team will receive some formal training before undertaking an accreditation. The chairman will be the most experienced of those involved.

The team will invite documentation, based on the schedule in our regulations. Details of the course aspirations, the quality of intake, the staffing, the facilities in terms of laboratories and libraries, the employability of graduates, and so on. This application is scrutinised by the team before a decision to visit is made. The visit itself normally happens over a two-day period. The programme consists of a preliminary discussion, followed by meetings where the team, individually or together, will interview staff and students and visit facilities. A preliminary decision is usually made at the end of the two-day period and any serious reservations advised to the faculty concerned. A report is then made to a governing committee of the Institution, who either confirms, modifies or rejects this before a formal statement is made to the university concerned. If the accreditation has been successful, notification is also made to the Engineering Council and the degree course appears then in our list of accredited degrees, which you can see on our website.

As I mentioned, this whole process is assessed through our own nomination and

audit process at the Engineering Council. Quality Assurance is also brought to bear through the system of external examiners in the UK, where every degree programme is required to be assessed by an academic not from the university concerned; these days universities also have their own quality assurance systems and internal audit, to ensure that course quality is being maintained.

Finally, there is an institutionalised system of teaching quality assessment through a body known as the Quality Assurance Agency (QAA). This Agency works on behalf of the Higher Education Funding Councils – the main source of funds for undergraduate education in the UK.

The Future

As far as the future is concerned, we are now working closely with the QAA to reduce duplication of effort – thus improving the economics – and to share good practice. At the same time, we are founder members of

ESOEPE, the Engineering Profession Observatory for Education of Professional Engineers. We hope to publish, on a website hosted by FEANI, the detailed procedures of the UK Engineering Council and those of the CTI and other accreditation bodies. This should enable us all to improve the quality of accreditation and to share experience and insights. Within the UK we are developing further the means to specify and measure the outputs from degree courses. These are increasingly expressed in terms that employers require, moving even further away from specific mathematics or science content and more towards skills and knowledge that employers can use.

And finally, the Engineering Council is itself in a process of change, responding to government pressure to demonstrate more clearly the involvement of industry, and also the need to widen our definition of engineering to embrace the new technologies and new skills required by industry.

But that is another story...

Foreign Adaptation of U.S. Engineering Education Models[★]

Russel C. Jones—World Expertise LLC

ABSTRACT: The U.S. model of engineering education is rapidly being adopted in one form or another by countries around the world. Given the enduring strength of the U.S. economy and its strong base in technology, it is not surprising that countries wanting to emulate the U.S. economic success would see our model of engineering education as a desirable one. But seen from the inside, U.S. engineering education appears to have significant problems – such as declining enrollments, and the utilization of its graduates as a ‘commodity’ by employers. It also appears that new quasi-engineering academic programs have opened or are being developed to allow students to take more palatable paths to entry to lucrative technology careers. What are foreign countries getting when they adapt our engineering curricula, and is that approach appropriate to their needs?

Introduction

There was nothing unusual about the circumstances: two American university professors each received an invitation to share their knowledge of U.S. higher education with fellow academics and some government and industry types in a different developing country. The invitations originated with overseas friends, but the U.S. colleagues were brought in as official paid consultants. The assignment in Jordan was long-range and specific: “Help us design a new engineering college that will meet ABET standards.” In the former Soviet Republic of Moldova, the assignment was short-term and generic: “You have two hours to teach us about the credit hour system in American higher education.” And so we went and received appropriate compen-

sation and gratitude for our contributions, but a nagging question remained: “What aspects of U.S. higher education should be exported overseas and what are the U.S. practices that, like some wines, do not travel well?”

The seminar in Chisinau, capital of Moldova, was sponsored by the Soros Foundation in support of the Moldovan government’s recent decision to implement a credit hour system in their universities. As the presentation was being written, initial worries about communicating effectively with a wildly diverse audience gave way to a larger concern. The credit hour system in the U.S. is under active attack from within, as public pressure for accountability has forced U.S. colleges and universities to look at what their students have learned rather than how much time they have spent in class. The

It was originally published in the 2001 ASEE Annual Conference Proceedings, 14-17 June 2001, Albuquerque, New Mexico; Copyright 2001, American Society for Engineering Education

emphasis over the past fifteen years has been on outcomes rather than inputs. So wouldn't the Moldovan educators be better off leap-frogging the credit hour system and instead moving directly to creating an outcomes-based curriculum?

There was no forum for raising this issue. And in the end, practical politics took precedence over a more idealized approach. Moldovan students are being hindered in their attempts to study outside of their own country because their academic credentials cannot easily be evaluated for transfer. The credit hour system will provide a commonly spoken academic "language" and provide a quick fix to a country that desperately needs signs of connectivity to the Western world.

The second experience, assisting in the initial design and startup of a new engineering college in Jordan, contained similar experiences. The newly appointed Dean was quite experienced with both Middle East engineering education and that available in Western Europe and the United States. As an experienced ABET volunteer, the consultant was asked to help in developing a curriculum that would meet world standards – but also meet the immediate needs of the graduates and the local industries by which they would be employed. Meeting both of these goals within a four-year curriculum proved very difficult, and many tradeoffs had to be made. For example, the curriculum was designed by referring to specification driven criteria, not the more modern outcomes assessment approach. This was deemed necessary in order to give the large number of newly recruited faculty members firm guidance on course development. In addition, major blocks of time in the programs had to be devoted to building the backgrounds of students in areas not typical in Western engineering education – such as machine shop experience. The resulting curriculum thus takes considerable guidance from US standards, but is carefully tailored to meet local needs in a rapidly developing country.

The events are past: the questions remain, however. What do other countries want from us? To what extent is the heralded success of the U.S. system of engineering education

site-specific? What is our responsibility, when we take on an overseas assignment, to raise questions about the suitability and limitations of our U.S. practices? Do codified accreditation standards reflect state-of-the-art thinking about the best of engineering education? Could non-traditional, experimental and highly idiosyncratic engineering programs perhaps be more suitable to the conditions in some developing countries? Whose role is it to raise these issues?

Export Of U.S. Model

Many countries are seeking to emulate the U.S. model of engineering education. Its attractiveness as a model appears to be based not only upon its inherent strengths and quality, but also from the assumption that it is a major contributor to the success of the technology driven economy in the United States.

Many countries have utilized the criteria of the Accreditation Board for Engineering and Technology (ABET), and consultative services of that body, as ways of adapting U.S. engineering education patterns to their local needs. ABET has worked closely with engineering societies and educators in foreign countries to assist in the development of effective accreditation systems based on the principles of self-assessment, peer review, and stakeholder involvement. ABET has met with representatives from numerous countries, sponsored a series of international workshops on accreditation system development, provided materials and speakers for symposia in foreign countries, and encouraged observers from abroad in all elements of the ABET accreditation process.

In addition, ABET has sent teams of expert consultants to evaluate foreign engineering programs on their strengths and weaknesses and to make recommendations for improvement. These evaluations closely parallel the procedures and criteria used by ABET in the U.S., but the programs are not 'accredited' -- they are instead rated as to whether they are 'substantially equivalent' to accredited U.S. programs. This status implies reasonable confidence that the graduates possess the

competencies needed to begin professional engineering practice at the entry level. Using its conventional engineering education criteria, ABET has evaluated and recognized over 70 programs at 14 institutions in 10 countries to date.

Engineering education in Europe is currently moving closer to the U.S. model, although not overtly indicating that as motivation for recent developments. The Bologna Declaration by the European Union, aimed at creating a European space for higher education, is steering higher education there into patterns typical in the U.S. The Declaration has as objectives a common framework of compatible degrees across Europe, undergraduate and postgraduate degree patterns in all countries, a compatible credit system, quality assurance at the European level, and the elimination of obstacles to mobility for students and faculty. The engineering educators there agree with the encouragement of mobility, but want to maintain the cultural diversity of national education systems. They agree with the desirability of having undergraduate and graduate degrees, but do not want an undergraduate degree to be a prerequisite for graduate study. Countries that have a 'long program' for educating engineers to an advanced level want to be able to continue that pattern. But the pressure is clearly toward the U.S. model of a four-year BS followed by an MS, and several European countries are moving to that pattern for their engineering education.

Engineering education in the United States has been undergoing considerable reform in recent years, fueled by demands for more accountability in undergraduate education overall from consumers and governments, and by a major program at the National Science Foundation (NSF) directly aimed at reform of engineering education. The NSF Engineering Coalitions Program solicited proposals from engineering schools in the spring of 1990, and began funding them for multi-year periods. During the course of this program, which is currently being phased down, some eight major coalitions were funded. Results of this major NSF effort to date have been encouraging. One primary benefit

is that the major funding and highly visible priority of the Coalitions program have made engineering education research and development credible at universities where previously only scientific research had been emphasized as appropriate activity. The model programs developed by several of the Coalitions have also provided good models for others to adopt, in areas such as:

- Inversion of the curriculum, to bring engineering subjects into the lower division in order to keep student interest in engineering high, and to provide the rationale for the study of mathematics and science which heavily dominates the first two years of engineering study

- Just in time coordination of math and science coverage, within the context of engineering problem solving courses, as the major educational stream

- Engineering design throughout the curriculum as a major theme, beginning in the Freshman year

- Holistic, integrative experiences for undergraduate engineering students

- Links to pre-college education, and increased recruitment and retention of under-represented groups

- Integrated development of educational tools, including utilization of advanced technologies in the educational process

Due to the large number of engineering schools directly involved in the various Coalitions, and the size of many of those schools, large numbers of current U.S. engineering students are being directly impacted by these experimental programs. Some 40% of all current engineering students in the U.S. are enrolled at Coalition schools, and as the experimental approaches developed are tested and scaled up, this large number of students can be expected to be beneficially impacted. In addition, due to progress reports on Coalition results to engineering education more broadly, schools outside the Coalition program are also adapting some of these new approaches for their own use. Thus, engineering education in the United States has been undergoing a systematic and healthy reform, leading to more emphasis on undergraduate education in engineering fac-

ulties and to a resulting improvement in the educational process and its graduates. These developments have been widely reported in engineering education conferences and journals both in the U.S. and throughout the world, and thus are available as models for foreign engineering schools.

But All Is Not Well

While many aspects of engineering education in the U.S. are strong and vibrant, there are several trends which raise concerns. The number of high school graduates who enroll in engineering programs in the U.S. has been declining significantly in recent years, despite a sustained and increasing demand for technical graduates by employers of engineers. In the mid-1980's, engineering schools were graduating some 80,000 Bachelors degree students per year – a number that has dropped some 25% since then. It appears that many students are selecting other, often less demanding, paths to the technical employment marketplace – such as computer focused courses of study or quasi-engineering programs with less rigorous mathematics and science requirements.

There are some interesting trends among recently graduated engineers that may also be impacting on whether young people choose engineering education for career preparation. Many engineering graduates are now experiencing major job changes every few years throughout their careers, as employers ramp up and downsize depending on market shifts and mergers. These changes are often disruptive, and often lead to lateral job placements at best, thus giving the impression that the engineer pool is a 'commodity' – rather than engineering seen as a career with progressive placements. In addition, many engineering graduates – particularly those accepting first positions out of college – are being employed by financial consulting firms and similar non-engineering employers, who want to utilize their quantitative skills for a few years while they are on top of the latest high tech state-of-the-art. At some engineering colleges, as many as

40% of the recent graduates have taken such first jobs. Engineering education is perhaps the most studied and discussed field of college and university education in the U.S. – subjected to repeated studies by educators and practitioners. While it is currently viewed as strong and healthy in terms of content and approach, the declining enrollments and developments in the employment marketplace appear to require continued attention by those concerned about the long-term well being of the profession and the technical economy of the country.

With these concerns, it behooves engineering educators and government agencies in foreign countries to look carefully at what they adapt from the U.S. engineering education model. For example, ABET has recently made a fundamental and broad change in its accreditation criteria, from a highly structured prescriptive set of criteria to an outcomes assessment format with only a few general specific criteria, called *Engineering Criteria 2000*. In seeking a model to make available to engineering educators in developing countries, the World Federation of Engineering Organizations Committee on Education and Training has recommended that such countries follow the previous ABET approach, rather than the new outcomes based approach.

Alternatives To Traditional Programs

Alternatives to traditional engineering programs have been proliferating over the past decade and a half. Some of these are offered on established college and university campuses, but others are located on corporate campuses, and still others exist in virtual space. All of these offer graduates additional entry points to employment in the booming technology sectors. James Madison University's College of Integrated Science and Technology has a program which was purposely designed to be neither pure science, nor pure engineering nor pure business, but to strategically integrate these areas of studies. The program's mission statement (<http://www.isat.jmu.edu/mission.htm>) con-

tains a claim about its superiority to traditional, narrower programs and can be read as a critique of where engineering education is perceived to have fallen short:

"The Program in Integrated Science and Technology (ISAT) educates students for positions that are often filled by graduates of the traditional sciences, engineering, and business programs. The ISAT graduate, however, is professionally prepared in a broader sense. ISAT students are educated to be technological problem solvers, communicators, and life-long learners. They are unique in having

- breadth of knowledge and skills across a variety of scientific and technological disciplines;

- formal training in collaborative and leadership methods, problem-solving techniques from many disciplines, and use of the computer as a problem-solving tool;

- the ability to integrate scientific and technological factors with political, social, economic, and ethical considerations in problem solving."

Of the thirty-nine faculty members teaching full-time in the program, fifteen have doctorates in engineering. Many of the others are in computer science, a few are classically trained physicists, and a large number specialized in applied sciences. The curricular design, however, obligates the faculty to work together, regardless of their disciplinary background.

Students are voting with their feet. The first class of majors in integrated science and technology was admitted to James Madison University in August of 1993. The first degrees were awarded to 37 students in 1997. Since then, enrollment has been growing at a fast pace, with 164 students graduating with undergraduate ISAT degrees in 2000. A continuing survey of campus recruiters and questionnaires sent to graduates indicates excellent success in placing them in jobs where their broad skills are highly valued and compensated.

If developing countries want to educate their own citizens to remain at home and engage in nation-building, they can legitimately ask about trade-offs, much as the

founding faculty of the program in Integrated Science and Technology did as they designed their curriculum. What, for example, is the wisest trade-off between teaching high technical competencies required for employment as an engineer in the US and teaching about the strategic deployment of scarce resources and how to evaluate a proposed technical solution to a problem embedded deeply in a unique political, social, economic and cultural environment?

Other non-traditional approaches are also competing with traditional engineering education. Motorola University provides large numbers of technical and business oriented courses to current employees of the multinational high technology firm within which it is contained. Novell, Microsoft and other high technology companies offer commercial short course programs to prepare graduates for highly paid technical positions in the computer field - granting such titles as "certified software engineer". The University of Phoenix, a private institution with major electronic offerings and dispersed campuses serving adult learners, offers many programs aimed at preparing their graduates for entry into lucrative technical job markets. Should developing countries be emulating some of these approaches instead of or in addition to traditional engineering education programs?

Conclusions

What do these alternative approaches to engineering education offer as value-added to developing countries seeking to educate their citizens in ways that support economic development at home? Valuable aspects to be included in the education of new generations of engineers in developing countries would be: expertise in reaching out to non-traditional and under-represented populations; commitment to meeting the continuing education needs in the profession; training in business knowledge, skills and experience; explicit consideration of appropriate uses of technology in differing cultural and social environments; careful articulation with pri-

mary and secondary schools; and an emphasis on interdisciplinary work.

As more and more American engineering educators are called upon to lend their expertise to their overseas colleagues in establishing or refining engineering programs, the first question all parties need to ask is where the students are expected to practice. A U.S. look-alike program might well be counterproductive, turning out students fit for the U.S. labor market, but missing those skills which will be most useful to their own countries.

★ ★ ★

RUSSEL C. JONES: Russel C. Jones is a private consultant, working through World Expertise LLC to offer services in engineering education in the international arena. He previously

served as Executive Director of the National Society of Professional Engineers. Prior to that, he had a long career in education: faculty member at MIT, department chair in civil engineering at Ohio State University, dean of engineering at University of Massachusetts, academic vice president at Boston University, and President at University of Delaware.

BETHANY S. OBERST: Bethany S. Oberst is Executive Director of International Education at James Madison University. She previously served as Vice President for Academic Affairs at James Madison University, Dean of the College of Arts and Letters at Southwest Missouri State University, Special Assistant to the President for Strategic Planning at University of Delaware, and Department Chair of Modern Languages at Cleveland State University.

Guidelines For Definition Of Necessary Basic Knowledge In Engineering Education

Presented by Prof. Russel Jones (USA) in Warsaw on 14. Sept. 2000

The following guidelines are adaptations of the curricular criteria developed over several decades by the Accreditation Board for Engineering and Technology of the United States of America. They are based upon the ABET criteria used prior to the year 2000, when a major reorientation was made to outcomes assessment rather than detailed specification of curricular content. It is felt that the former detailed specification of curricular content will be a more useful approach in countries which are newly instituting standards for engineering education which is globally relevant.

Curricular Objective

Engineering is that profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind. A significant measure of an engineering education is the degree to which it has prepared the graduate to pursue a productive engineering career that is characterized by continued professional growth. These guidelines relate to the extent to which a program develops the ability to apply pertinent knowledge to the practice of engineering in an effective and professional manner.

Included are the development of: (1) a capability to delineate and solve in a practi-

cal way the problems of society that are susceptible to engineering treatment, (2) a sensitivity to the socially-related technical problems which confront the profession, (3) an understanding of the ethical characteristics of the engineering profession and practice, (4) an understanding of the engineer's responsibility to protect both occupational and public health and safety, and (5) an ability to maintain professional competence through life-long learning. These objectives are normally met by a curriculum in which there is a progression in the course work and in which fundamental scientific and other training of the earlier years is applied in later engineering courses.

Institutions are expected to develop and articulate clearly program goals that are in keeping with the overall institutional goals, the student body served, and any other constraints that affect the program. In addition, they are expected to demonstrate success in meeting these goals.

Curricular Content

In the statements that follow, one-half year of study can, at the option of the institution, be considered to be equivalent to 16 semester credit hours (24 quarter hours).

[For a program of 128 semester hours (192 quarter hours), one-half year of study equals

exactly 16 semester hours (24 quarter hours). For a program requiring more than 128 semester hours or 192 quarter hours, 16 semester hours or 24 quarter hours may be considered to constitute one-half year of study in any of the curricular components specified by these criteria. For a program requiring fewer total credit hours, one-half year of study is considered to be one-eighth of the total program. Programs using measurements other than semester or quarter credit hours will be evaluated on a reasonably comparable basis to the above.]

For those institutions which elect to prepare graduates for entry into the profession at the basic level, the curricular content of the program should include the equivalent of at least three years of study in the areas of mathematics, basic sciences, humanities and social sciences, and engineering topics. The course work should include at least:

- one year of an appropriate combination of mathematics and basic sciences,
- one-half year of humanities and social sciences, and
- one and one-half years of engineering topics.

The overall curriculum should provide an integrated educational experience directed toward the development of the ability to apply pertinent knowledge to the identification and solution of practical problems in the designated area of engineering specialization. The curriculum should be designed to provide, and student transcripts should reflect, a sequential development leading to advanced work and should include both analytical and experimental studies. The objective of integration may be met by courses specifically designed for that purpose, but it is recognized that a variety of other methods may be effective.

Following are guidelines for required coursework in each of the major curricular areas listed above:

Mathematics and Basic Sciences

Studies in mathematics should be beyond trigonometry and should emphasize mathematical concepts and principles rather than

computation. These studies should include differential and integral calculus and differential equations. Additional work is encouraged in one or more of the subjects of probability and statistics, linear algebra, numerical analysis, and advanced calculus.

The objective of the studies in basic sciences is to acquire fundamental knowledge about nature and its phenomena, including quantitative expression. These studies should include both general chemistry and calculus-based general physics at appropriate levels, with at least a two-semester (or equivalent) sequence of study in either area. Also, additional work in life sciences, earth sciences, and or advanced chemistry or physics may be utilized to satisfy the basic sciences requirement, as appropriate for various engineering disciplines.

Course work devoted to developing skills in the use of computers or computer programming may not be used to satisfy the mathematics/basic sciences requirement.

Humanities and Social Sciences

Studies in the humanities and social sciences serve not only to meet the objectives of a broad education but also to meet the objectives of the engineering profession. Therefore, studies in the humanities and social sciences should be planned to reflect a rationale or fulfill an objective appropriate to the engineering profession and the institution's educational objectives. In the interests of making engineers fully aware of their social responsibilities and better able to consider related factors in the decision-making process, institutions should require course work in the humanities and social sciences as an integral part of the engineering program. This philosophy cannot be overemphasized. To satisfy this requirement, the courses selected should provide both breadth and depth and not be limited to a selection of unrelated introductory courses.

Such course work should meet the generally accepted definitions that humanities are the branches of knowledge concerned with man and his culture, while social sciences are

the studies of individual relationships in and to society. Examples of traditional subjects in these areas are philosophy, religions, history, literature, fine arts, sociology, psychology, political science, anthropology, economics, and foreign languages other than English or a student's native language. Nontraditional subjects are exemplified by courses such as technology and human affairs, history of technology, and professional ethics and social responsibility. Courses that instill cultural values are acceptable, while routine exercises of personal craft are not. Consequently, courses that involve performance should be accompanied by theory or history of the subject.

Subjects such as accounting, industrial management, finance, personnel administration, engineering economy, and military training may be appropriately included either as required or elective courses in engineering curricula to satisfy desired program objectives of the institution. However, such courses usually do not fulfill the objectives desired of the humanities and social sciences content.

Engineering Topics

Engineering topics include subjects in the engineering sciences and engineering design.

The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other. Such subjects include mechanics, thermodynamics, electrical and electronic circuits, materials science, transport phenomena, and computer science (other than computer programming skills), along with other subjects depending upon the discipline. While it is recognized that some subject areas may be taught from the standpoint of either the basic sciences or engineering sciences, the ultimate determination of the engineering science content is based upon the extent to which there is extension of knowledge toward creative application. In order to pro-

mote breadth, the curriculum must include at least one engineering course outside the major disciplinary area.

Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences and mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum should include most of the following features: development of student creativity, use of open-ended problems, development and use of modern design theory and methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, production processes, concurrent engineering design, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact.

Each educational program should include a meaningful, major engineering design experience that builds upon the fundamental concepts of mathematics, basic sciences, the humanities and social sciences, engineering topics, and communication skills. The scope of the design experience within a program should match the requirements of practice within that discipline. The major design experience should be taught in section sizes that are small enough to allow interaction between teacher and student. This does not imply that all design work must be done in isolation by individual students; team efforts are encouraged where appropriate. Design cannot be taught in one course; it is an experience that must grow with the student's development. A meaningful, major design experience means that, at some point when the student's academic development is nearly complete, there should be a design experience that both focuses the student's attention on professional practice and is drawn from past course work. Inevitably, this means a

course, or a project, or a thesis that focuses upon design. "Meaningful" implies that the design experience is significant within the student's major and that it draws upon previous course work, but not necessarily upon every course taken by the student. Course work devoted to developing drafting skills may not be used to satisfy the engineering design requirement.

Other courses, which are not predominantly mathematics, basic sciences, the humanities and social sciences, or engineering topics, may be considered by the institution as essential to some engineering programs. Portions of such courses may include subject matter that can be properly classified in one of the essential curricular areas, but this must be demonstrated in each case.

Appropriate laboratory experience which serves to combine elements of theory and practice should be an integral component of every engineering program. Every student in the program should develop a competence to conduct experimental work such as that expected of engineers in the discipline represented by the program. It is also necessary that each student have "hands-on" laboratory experience, particularly at the upper levels of the program. Instruction in safety procedures should be an integral component of students' laboratory experiences. Some course work in the basic sciences should be included or be complemented with laboratory work.

Appropriate computer-based experience should be included in the program of each student. Students should demonstrate knowledge of the application and use of digital computation techniques for specific engineering problems. The program should include, for example, the use of computers for technical calculations, problem solving, data acquisition and processing, process control, computer-assisted design, computer graphics, and other functions and applications appropriate to the engineering discipline. Access to computational facilities should be sufficient to permit students and faculty to integrate computer work into course work whenever appropriate throughout the academic program.

Students should demonstrate knowledge

of the application of probability and statistics to engineering problems.

Competence in written communication is essential for the engineering graduate. Although specific course work requirements serve as a foundation for such competence, the development and enhancement of writing skills should be demonstrated through student work in engineering work and other courses. Oral communication skills should also be demonstrated within the curriculum by each engineering student.

An understanding of the ethical, social, economic, and safety considerations in engineering practice is essential for a successful engineering career. Course work may be provided for this purpose, but as a minimum it should be the responsibility of the engineering faculty to infuse professional concepts into all engineering course work.

Outcomes Guidelines

In the year 2000, ABET is changing its criteria to an outcomes assessment basis. The following list of outcomes expected from engineering education programs is instructive as a check on the detailed specification approach outlined above.

Engineering programs must demonstrate that their graduates have:

(a) an ability to apply knowledge of mathematics, science, and engineering (b) an ability to design and conduct experiments, as well as to analyze and interpret data (c) an ability to design a system, component, or process to meet desired needs (d) an ability to function on multi-disciplinary teams (e) an ability to identify, formulate, and solve engineering problems (f) an understanding of professional and ethical responsibility (g) an ability to communicate effectively (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context (i) a recognition of the need for, and an ability to engage in life-long learning (j) a knowledge of contemporary issues (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Building a Vocation for Leadership

An approach for the philosophy of engineering education

*Prof. Miguel Ángel Yadarola—Past President WFEO Committee on E&T
President Pan American Academy of Engineering
Member National Academy of Education (Argentina.)*

Alexander Pope was one of the most famous English poets and satirists. At the beginning of this paper, I want to evoke him because of two lines with which he rendered homage to a contemporary man of science, whom he admired:

**Nature and its laws were in darkness
God said: "Be it Newton",
and all was light**

Newton, born in the same year (1642) in which Galileus died was surely familiar with the work of this genius rebel and that of others that preceded him when he said: *"If I have been able to see farther than others, it is because I have been standing on the backs of giants"*.

The monumental work, where all the Newtonian mechanics are condensed *"Mathematics Principles of Natural Philosophy"* rests on three axioms that he later broadened for the entire Universe and was the great platform that served to give birth, in only three centuries, to that fantastic scenery of knowledge that constitutes today's technology and whose *creation, transformation and government are the competence and responsibility of engineers*.

The natural philosophers that continued with the works and speculations of Newton, identified themselves with the qualification

of physicists, accelerating the separation between Physics and Philosophy.

If we agree that scientific problems are mainly cognitive, whereas technological problems are, besides being practical, *ethical, human, social and cultural*, I can affirm that an engineer shall not have conflicts with philosophy. This is so while engineering does not interest itself in that *"Physical Universe"* beyond considering it a *natural resource* to be exploited, a reservoir of varied energies.

That is not how engineering is seen by respectable epistemologists, plus some engineers and the general public opinion.

Due to the fact that it is deeply rooted in *Physics*, engineering is considered as an *applied science*, or *applied physics*. As an engineer that dedicated many years to teaching *Physics*, this belief is *unacceptable*, from my own experience gained in the exercise of the profession. I saw engineering as an activity that *surpasses the speculative act* of the philosopher in his search for causes and effects of natural phenomena. That has *Science as a tool*, not as an aim. That uses scientific knowledge to generate useful technology for society.

A Mathematical note

In these considerations on *Physics* allow me to put a mathematical parenthesis with

an expression of Rankine, engineer and physicist, pillar of thermodynamics. "It is easy to introduce mathematical notes, says Rankine, what is difficult is to do something useful with it".¹

x – be beauty, and distinguished manners

z – be fortune (always necessary)

Love must have L as a symbol, says our wise man. Therefore L is dependent on x, y, z

Dependence of the form of potential functions. Let us integrate our L with respect to dt (Here t represents time and persuasion)

We shall see that, with adequate limits,

The definite integral *Marriage* is not difficult to obtain.

And this equation of course, has no practical sense.

Technology and socio-humanistic formation

Engineering is constantly changing. We are aware of the growing responsibilities we have assumed as *executors of qualified services* for a society that demands from us the maximum efficiency in the use of resources, whilst bearing in mind *ethical, human, social and cultural values*.

Those of us who are also committed to education, are conscious of the need to form engineers capable of overcoming an amount of unexpected obstacles that will appear in the world in which they are to live, and above all capable of foreseeing the changes that will affect their profession and social environment. Even more, to anticipate them.

During many years, the function of an engineer appeared to be concrete: our judgement, sharpened by a professional formation that inspired us to conceive *what it was necessary to conceive* and to carry out everything that it *was possible to realize*. Nowadays we appreciate with more clarity that *what is possible to perform may not be desirable* and that

the problems raised by modern technology, at a large scale, are not only of a technological nature but also of a *political, ethical and social nature*. Frequently, we engineers find ourselves in the need to reaffirm our *ethical commitment* with society in order not to be accused of being "*ideologists insensitive to progress*" as Fabio Seleme² qualifies those who surrender to the fascination of technology. We know we cannot rid ourselves of the responsibility of those products that we have created but we would wish that together, *engineers and society*, agree not to continue trusting the decisions that involve technological aspects exclusive to *politicians, economists and so-called bearers of culture*.

Even today, German engineer Friedrich Heer's³ expressions still hurt us when referring to his colleagues he says: "*Happily working with our machines, buildings and shops we think that we and our work can stand aside of public consideration*".

It is alarming to see the *apathy towards public interests*, that is installed in the way of thinking and acting of many engineers. Society perceives a natural tendency in engineers to be *utilitarian* "seeking to maximize human satisfactions measured by an increase in enjoyment and decrease in suffering". It is a philosophy that seems to simply quantify costs and benefits, minimizing costs and *maximizing social benefits as a whole*, in the purest utilitarian style.

A good example of this intellectual attitude, is the work of many engineers responsible for building during years, hundreds of chimneys in Eastern Europe. They stood for plants, work, production, but also for pollution, acid rain, defoliation, damage, to the environment and degradation of the atmosphere.

It was difficult to introduce in the equation of human value, the value of one man, that man in a thousand whose death due to cancer or other illnesses seems acceptable confronted with the benefits of installing an industri-

1 William J. Rankine – Songs and Fables – Edinburgh University 1847

2 Fabio E. Seleme – El Laberinto del Ingeniero – UTN Río Grande – Academia Nacional de Educación

3 Friedrich Heer – Speech on the Day of the German Engineer – Quoted by Friedrich Karl Schädlich – Humboldt Magazine N° 73 - 1985

al plant that generates waste, radiation and polluting gas.

Technology and its consequences represent something objective, that can be quantified, whilst ethical considerations cannot. But *it is not fair for Society to unload all the responsibility on engineers*. Most of the times there are respectable politicians and economists in charge of assuming decisions before we did.

In the Engineering Faculties, we learn to be *pragmatic*, to be *logical and systematic* when solving problems. These attributes are indispensable but if their consideration is exclusive it is because education postpones or forgets ethical, human and social values. Forgets *quality of life*. "*It keeps engineering away from Society*".⁴

It is necessary to change because more frequently and with more conviction, we engineers have to assume a *leading role*. We will have to train and be capable of accepting *leading positions*.

Forming leader engineers

The world needs engineers with a general formation that can be leaders in the different working environments where they are useful to society, *beyond their specific technical competencies*.

– *Engineering needs leaders capable of managing organizations*, willing not only to *reflect with creativity*, but also to *act* in a way that can turn the organization into a model for *decision making*. They should know how to *orient and turn cohesive the talent* of key officers, evaluate their performance, linking their efforts to those of people with a different formation giving the work as a whole a *sense of finality and purpose*. Developing a *Vision*. It means handling human relationships on the basis of a *psychological, human and social formation*.

– *Engineering needs leaders in relevant positions of the country's economy*, where they can

contribute the irreplaceable tool of *analysis, synthesis and capability of reflection* for approaching and solving problems, for evolution and innovation. It means placing at the service of economy, people who have the *aptitudes to evaluate alternatives within uncertain situations*, with open minds, trained to risk solutions and transform situations of *disorder* into order. Capability to lead interdisciplinary groups, to understand and interact with *different cultures*, to express themselves fluidly in their own language and in *another European language*, trained to convincingly *defend ideas and proposals*, to identify themselves with the *objectives and policies* of the organization for which they work, with aptitudes for its *management*. Knowledge of economy, business, finance, marketing, laws, geopolitics will be required from engineers.

– *Engineering needs leaders in relevant positions of national politics* where decisions will be taken within the framework of complex enterprises. It will be very useful for them to have experience in *working groups* and leadership of human organizations. Training in *diagnosis and decision taking* will facilitate adopting *strategies* for judicious social progress. They should know how to act as *decision-makers and strategic thinkers*.

– *Engineering needs leaders in innovation* not only for its creation, but in the *selection, diffusion, transfer and application* of useful innovations to increase competitiveness in industry with the incorporation of products and processes that do not simply mean *technological progress*, but the improvement of the *organization* and the *policies* for managing human resources. "It cannot be conceived nowadays that in Europe, someone can be an engineer without having participated during his formation in an *innovative experience* in a company be it during an assistantship or in alternate courses" says Mme Cresson⁵

– *Engineering needs leaders in education*. Professors capable of stimulating their stu-

4 Aarne Vessilind – Duke University – The social role of engineers. A philosophic outlook – engineering Education. 1991.

5 Edith Cresson – Commissioner, European Union – Speech at the Annual SEFI Conference 1995.

dents to *think for themselves*, to be original and creative, to generate "transversal competencies", for a pluridisciplinary task" to develop a *vision* for a certain objective and the capability of synthesizing it to serve as a *guide* for others. To *execute an idea* risking mistakes. Because leaders are not infallible and have marked out their traineeship leaving behind mistakes and failures.

How to include all these competencies in an *engineering curricula*?

The engineering curricula

According to Klapper,⁶ "a curricula is a *body of knowledge and experiences*, selected, integrated and related, aimed at stimulating a student's development in a gradual and flexible way, and impulsing capabilities and fundamental aptitudes to *incorporate him into society* and to consciously *assume the roles and attitudes* demanded by social needs".

Fitzpatrick⁷ adds: "The preparation of an engineering curricula, requires a *basic philosophy of life*, of education and of culture".

Is it possible for an underdegree curricula to embrace *socio-humanistic, ethical and social* knowledge and furthermore, economy, psychology and politics and simultaneously include, *without diminishing its quality and pertinence*, the contents of science and technology that the engineers speciality requires?

"*There are more things to know than a man is capable of learning*" we were told by Ortega y Gasset back in the 40's, and this should make us think.

When we investigate the background, the motivations and we analyze the results of the inclusion of humanities and social sciences in the engineering Curricula, we see that *its convenience is not discussed*. The problem is *how much, how and when* during the career.

Columbia, in 1919, was the first University to notice the *excessively specialized* turn that

its engineering school had taken and decided to include "*general studies*": humanities, social sciences, economy and appreciation of arts. *Chicago, Harvard, Yale, Princeton* and gradually all universities in the United States imitated them.

In 1940 ASEE - American Society for Engineering Education adopted and advocated the *Hamond Report* that recommended including other subjects such as: history, economy, industrial psychology, accounting, english and courses of addressing public.

The experience had, for those who accepted it, only an *individual sense* of professional perfection and cultural improvement.

It was only in the 70's that some prestigious institutions such as MIT introduced courses in which problems of survival of the human mankind were studied, also the preservation of the environment and ways of social control of technology.

In spite of the richness of the contents of these studies they were not structured in a way to form engineers capable of *modifying the socio-cultural environment*, but to accompany it in its rapid changes.

The Olmsted Report⁸ arrived at the same conclusions (1968) prepared by the *Rensselaer Polytechnic Institute*. Human and social sciences not only fulfilled a *cultural function* in the formation of engineers, but also a *professional function* and to achieve identification of both functions it became necessary that they were not to be considered different entities, but *integrated within the curricular and methodological context*.

The socio-humanistic formation found a different motivation for engineers in countries that practiced or still practice *collectivism*. There every way is used in all educational levels, to *justify and strengthen* the established political system, generally compulsive, as well as creating consensus for *rights limited by ideology* and obligations towards a *committed science*.

6 Paul Klapper - Contemporary Education, its Principles and Practices. Quoted by Fitzpatrick.

7 Edward A. Fitzpatrick - Filosofía y Ciencias de la Educación - Ed. Paidós - Bs. As. 1958

8 Sterling P. Olmsted - Liberal Learning for Engineers - Engineering Education 12/68.

The many antecedents commented on and others that I have omitted in benefit of brevity allow expounding some coincidences.

– Teaching of social and human sciences cannot be limited to secondary education. There “teaching is of a centrifugal characteristic. Its image is that of a *certain number of units of knowledge and cognitive style that the student follows, without having to relate and integrate the different fields of learning*”⁹ without a total critical vision, that can be added later to professional formation.

– The content of social and human sciences in the underdegree curricula of engineering should *not appear in an isolated way, fragmenting its teaching* in several subjects. It should be *implicitly found in each subject* be they scientific, technological or professional and form part of a participative *pedagogy* that allows students to *take these contents* as if they had built them, elaborated on *the basis of experiences* that each professor should know how to *motivate*.

– Universities must give access to professors to an adequate *pedagogic formation* and stimulate them to acquire or enlarge their *interdisciplinary formation* to achieve learning that *associates their own knowledge* of their discipline with *human and social sciences*, engineering with culture.

The gradual *intensification of time given up* to non-engineering contents in engineering curricula. has brought about calls of alarm from the principal professional Societies in the United States, due to the consequent *decrease* in the total of *credit hours* in basic sciences and engineering necessary for an engineer to graduate.

The statements of *Delon Hampton*, Past President of ASCE, American Society of Civil Engineers become therefore dramatic: “There is not logical way of justifying these tendencies. Our profession *cannot adequately educate* engineers that are to practice their

profession in the XXI Century *with the curricula* in engineering in force today”...

“And that is why we are demanding from the State Boards that *Master* be the first professional degree required to be admitted in examinations aimed at obtaining the *professional license*”. The expressions of the present President of ASCE *Robert W. Bein* are coincidental: “The *average life* of the knowledge of a Civil Engineer does not today surpass *four years* and this life is one of the lengthiest if compared with other *engineering* such as *chemistry* or *electronics*. Only a solid *commitment with continuing education* of all our Members will make it possible to maintain the *level and quality* of the services that civil engineers must offer Society”.

Most Universities in developing countries have a *pending debt* with their nation: the continuing professional development (education) of adult engineers. We do not have serious *programs*, permanent and with a quality comparable to some of those in force in the *European Community*. Programs that being *financed* by industry, the Government and the Universities themselves, *avoid charging the cost* of continuing professional development to adult engineers. They are investing *time and effort*. The concept “*Lifelong learning*” is rooted in Europe facilitating besides the creation of the *EuroRecord* register that concentrates the *achievements and requirements of learning*, on the basis of a “*Professional Life Project*” designed by each engineer.

If we are concerned about keeping engineers’ professional services competitive and efficient we can affirm that in short the *deficit of educational results* will be visible, not because of the formation that young people studying engineering receive nowadays, but because of what those who *finished with the educational system* years ago and today, half way in their careers, are not receiving fresh knowledge and training to keep updated.

9 Hans Mauksch – Quoted by Henry Knepler in Cultural Education and Formation of Engineers – International UNESCO Colloquium – Bucarest 1972.

An Integrative Approach to the Cultivation of Engineers and Technology for Global Wealth Creation and Human Condition Improvement in the 21st Century

International Decade for Engineering Advancement (IDEA)

Presented by Marshall M. Lih in Moscow, in September 2001

On behalf of International Committee on Engineering Education and Innovation

The proposed International Decade for Engineering Advancement (IDEA) is a major ten-year collaborative endeavor in advancing engineering education and innovation on a global scale, with particular emphasis on mobilizing developing countries and their peoples. The goal is to cultivate a new generation of engineers and engineering technology capable of significantly improving wealth creation and distribution in order to enhance the quality of human life and conditions worldwide.

The plan is to create two multi-national working partnerships during each of the first five years of the decade in a staggered fashion. Each partnership could be in one of many technological areas, depending on the needs and interests of the participating countries, such as environmental sustainability, bio-engineering, food technology, health-care delivery, infrastructure and transportation systems, manufacturing, telecommunication, nanotechnology, etc. Each partnership could encompass undertakings such as engineering education, research and development, faculty enhancement, curriculum reform, design

competitions, indigenous technology teams, industrial and executive internships, mentoring, etc. By working and learning across national boundaries, much latent potential in all nations can be developed and utilized. For example, developing countries around the globe find it difficult if not impossible to participate effectively in the global economy, in many cases not even meeting their own technological needs. One of their main problems is the lack of a state-of-the-art and well-trained technical workforce to develop local industries or attract multinational firms to invest in branch operations there.

The International Committee for Engineering Education and Innovation (ICEEI) and its predecessor efforts have been working for over a decade to develop mechanisms to stimulate and maintain adequate engineering education in developing countries. The aim is to develop their potential to continue learning on their own. Pilot projects in faculty development and continuing education, technology transfer, sibling university exchanges, use of satellite technology to deliver courses, and quality assurance

method development have been successfully undertaken. Now time is ripe to scale up these efforts under the banner of a proposed expanded effort, the *International Decade for Engineering Advancement* (IDEA).

Selection of areas and projects will be based on technical quality, innovativeness of the proposed ideas and process, potential impact on global or regional development, timeliness of thematic area(s) chosen, vision and rationale for the partnership, appropriateness of opportunities vis-à-vis needs, personnel availability, commitment of institutional, international and industrial partners in terms of both cost-sharing and actual participation, and the methodology for monitoring progress and assessing outcomes.

IDEA will be overseen and coordinated by the ICEEI, a group of prominent professional leaders with extensive international experience and connections in various fields. Collectively they possess a substantial record of technical accomplishments, executive responsibility, and financial accountability.

At the implementation level, ICEEI will be assisted by a number of cross-disciplinary and multinational task groups and workshops convened to generate and elaborate on ideas, assess area needs and viability and the quality of proposed effort. Both developed and developing nations will be appropriately represented. One tenet of the endeavor is that learning between them will be mutual and not one-sided.

Global Recognition of Professional Engineers and Technologists

*Barry J Grear—AO, FIEAust, FIPENZ, FACE, Foundation Chairman,
APEC Engineer Coordinating Committee, Past National President,
The Institution of Engineers, Australia*

Introduction

For decades the professional engineering institutions and societies have signed bi-lateral agreements to encourage the provision of a wide range of activities and the acceptance of recognition between countries. This allowed engineering graduates and practicing engineers to get support and work in host countries. During the last decade there has been an upsurge of interest in arrangements for the international recognition of both undergraduate engineering courses and practicing engineers.

This paper comments on some of the agreements which have been developed and that have attracted an increasing number of countries to also become signatories.

The agreements covered are:

- The Washington Accord
- The APEC Engineer Register
- The Engineers Mobility Forum.
- The Sydney Accord
- The Engineering Technologists Mobility Forum

The Washington Accord

The signatories to the Accord have exchanged information, have examined their

respective processes, policies and procedures for granting accreditation to engineering academic programs, and have concluded that these are comparable.

Through the Washington Accord, the signatories recognise the substantial equivalence of programs in satisfying the academic requirements for the practice of engineering at the professional level.

1. Accreditation of engineering academic programs is a key foundation for the practice of engineering at the professional level in each of the countries or territories covered by the Accord. The signatories have agreed:

- that the criteria, policies and procedures used by the signatories in accrediting engineering academic programs are comparable;

- that the accreditation decisions rendered by one signatory are acceptable to the other signatories, and that those signatories will so indicate by publishing statements to that effect in an appropriate manner;

- to identify, and to encourage the implementation of, best practice, as agreed from time to time amongst the signatories, for the academic preparation of engineers intending to practice at the professional level;

- to continue mutual monitoring and in-

formation exchange by whatever means are considered most appropriate, including:

- regular communication and sharing of information concerning their accreditation criteria, systems, procedures, manuals, publications and lists of accredited programs;
- invitations to observe accreditation visits; and
- invitations to observe meetings of any boards and/or commissions responsible for implementing key aspects of the accreditation process, and meetings of the governing bodies of the signatories.

2. Each signatory has agreed to make every reasonable effort to ensure that the bodies responsible for registering or licensing professional engineers to practice in its country or territory accept the substantial equivalence of engineering academic programs accredited by the signatories to this agreement.

3. The Accord applies only to accreditations conducted by the signatories within their respective national or territorial boundaries. The foundation signatories in 1989 were Australia, Canada, Ireland, New Zealand, United Kingdom and United States of America. Since that time Hong Kong, China, Japan and South Africa have become signatories.

Five other Countries attended the 2001 meeting and are planning to submit applications to become signatories. FEANI also attended the meeting and will continue discussions on behalf of all of its member countries.

It is my belief that there will be a steady growth in the number of signatories and perhaps 25 countries may have signed up by 2025. Changes in the accreditation requirements prompted by changes occurring in universities, the requirements of the professional bodies and the engineering industry will require continuous monitoring of the criteria for becoming a signatory.

The Washington Accord is, therefore, a living document and the signatories expect to meet biannually to maintain the standards and accept new signatories.

The APEC Engineering Register

I have been privileged to be actively involved in the development of the APEC Engineer Register since 1997.

The APEC Engineer project was initiated by the APEC Economic Leaders, i.e., The APEC Human Resource Development Ministers, the APEC Business Advisory Council and the Professional Engineering Institutions.

On behalf of the APEC Economies the Australian Government appointed a consultant to undertake the leadership of the project. As a result of that appointment the APEC Engineer project proceeded at a pace greater than what we may have imagined was possible.

The significant first workshop after some preliminary discussions and fact finding was held in August 1997. So, it is not very long ago in terms of these international activities that the APEC Engineer Register agreement has been put in place.

An expert committee held workshops on two occasions. The expert committee was significantly influenced by professional engineering bodies that determine the applicable criteria for registration of engineers in their economies.

The Ministers established a Steering Committee comprised of government representatives as well as representatives of the professional institutions. This Steering Committee was the key controlling body for the work being undertaken and the acceptance by the governments of the progress of the project.

The Steering Committee met for the last time in a "face-to-face mode" in November of 1999 and it met again in "virtual mode" in October of 2000.

The Coordinating Committee met for the first time in November 1999, the second meeting in June 2000 and the third meeting was held in October 2001.

The Coordinating Committee is the continuing responsible committee and includes a representative of each of the Monitoring Committees. Each of the economies has a Monitoring Committee to monitor standards

and the effective operation of the APEC Engineer Register for their particular economy. The Coordinating Committee, therefore, has one representative of each of those Monitoring Committees that have had an acceptable assessment statement.

The APEC engineer project agreed that the Monitoring Committee report, being an extensive report (main report with many attachments), would be the document on which the various economies will assess the processes that are being used by each of the economies.

1st November 2000 became the formal commencement date of the APEC Engineer registers of those economies that have met the requirements.

Since that date:

- Australia has 249 on the Register
- Canada 15
- Hong Kong China are negotiating a commencement date expected to be April, 2002
- Indonesia approved in October 2001
- Japan 1534
- Korea 828
- Malaysia to launched on 1 July 2001
- New Zealand expects to launch in April 2002
- Philippines approved in October 2001
- United States of America approved in October 2001

The definition of an APEC engineer is proving to be robust and appropriate. It provides for the mobility of engineers between the above economies.

The substantial equivalent criteria are:

- the completion of an accredited or recognised engineering program
- eligibility for independent practice within their own home economy
- minimum of seven years practical experience since graduation, including at least two years of responsible charge of significant engineering work and continuing professional development at a satisfactory level.

Although not all of the economies involved with the APEC Engineer have continuing professional development as a requirement for registration within their

home economies, they have all accepted that to be an APEC Engineer, candidates have to demonstrate that they have been exposed to appropriate continuing professional development.

The question regularly asked is "What happens when APEC Engineers leave their home country and turn up in a host country and how will they be treated?"

As a general statement it can be said that the APEC Engineer will be treated no more or less favorably than the person who has graduated, met the registration standards and works within their home country. This means that they may be required to sit further examinations for some particular certification or registration in the same way as the home country people are required to do. APEC Engineers will be treated no more or less favorably than the persons who have been developed within their own country.

Engineers mobility forum agreement

As a result of an agreement by the Washington Accord signatories to explore mutual recognition for experienced engineers, representatives of the engineering profession in each of the signatories to the Washington Accord, together with observers nominated by the European Federation of National Engineering Associations (FEANI), met in March 1996, and, with the addition of observers from the Japan Consulting Engineers Association, in January 1997.

The participants in these meetings, having exchanged information on, and made a preliminary assessment of, their respective processes, policies and procedures for granting recognition to experienced engineers, concluded that these were sufficiently comparable to justify further examination. They agreed on the broad principles of a framework which might enable progress towards removing artificial barriers to the free movement and practice of professional engineers amongst their countries. Agreement was reached on the principles and outline process by which the substantial equivalence in com-

petence of experienced engineers could be established.

At a subsequent meeting on 29 October 1997, the Accord signatories agreed to establish a forum, to be known as the Engineers Mobility Forum (EMF), through which they, as the representatives of the relevant engineering organisations in their respective countries or territories, would:

- 1) develop, monitor, maintain and promote mutually acceptable standards and criteria for facilitating the cross-border mobility of experienced professional engineers;
- 2) seek to gain a greater understanding of the existing barriers to mobility and to develop and promote strategies to help governments and licensing authorities manage those barriers in an effective and non-discriminatory manner;
- 3) encourage the relevant governments and licensing authorities to adopt and implement mutual mobility procedures consistent with the standards and practices recommended by the signatories to such agreements as may be established by and through the EMF;
- 4) identify, and encourage the implementation of, best practice for the preparation and assessment of engineers intending to practice at the professional level;

This Agreement to establish and maintain an EMF International Register of Professional Engineers is intended to provide a framework for the recognition of experienced professional engineers by responsible bodies in each of the signatory economies. In particular, such bodies will be encouraged to use the Register as a secure benchmark for arrangements which provide mutual recognition or exemption and/or streamline access by professional engineers to licensing or registration in economies other than that in which they first gained recognition.

Nothing in this Agreement is intended to limit the rights of any signatory organisation to conclude bilateral or multilateral agreements with any other organisations on different terms from those implied by the requirements for entry to the EMF International Register of Professional Engineers.

The signatories agreed to create and main-

tain a decentralised EMF International Register of Professional Engineers and to grant entry to that Register only to those practitioners who can demonstrate that they have:

- 1) reached an overall level of academic achievement at the point of entry to the register in question which is substantially equivalent to that of a graduate holding an engineering degree accredited by an organisation holding full membership of, and acting in accordance with the terms of, the Washington Accord; and
- 2) been assessed within their own economy as eligible for independent practice; and
- 3) gained a minimum of seven years practical experience since graduation; and
- 4) spent at least two years in responsible charge of significant engineering work; and
- 5) maintained their continuing professional development at a satisfactory level.

As competency-based assessment grows in effectiveness as an alternative approach to time-specification as described above, Assessment Statements from Signatories that include an alternative route of this kind may be considered for approval by the International Coordinating Committee.

Applicants must agree to be bound by the codes of professional conduct established and enforced by each economy within which they are practising. Such codes normally require that practitioners place the health, safety and welfare of the community above their responsibilities to clients and colleagues, practise only within their fields of competence, and advise their clients if and when additional professional assistance becomes necessary to implement a programme or project.

Applicants must further agree to be held individually accountable for their actions, both through requirements imposed by the licensing or registering authorities in the economies in which they practise and through legal processes. By applying for registration, applicants authorise the signatory organisations to exchange such personal and other data as may be necessary to ensure that the application of a sanction or penalty in any economy in which an engineer is registered or

licensed to practice will be taken into account in deciding upon their continued designation and will be appropriately recorded in the Register.

To ensure consistency in application of the agreed criteria, ultimate authority for entering persons on the EMF International Register will remain with an International Register Coordinating Committee. The primary objectives of the International Register Coordinating Committee will be to facilitate the creation and operation of an authoritative decentralised International Register of Professional Engineers, and to promote acceptance by the bodies responsible for licensing or registration in each economy where signatories have standing that the technical and professional competence of practitioners whose names appear on the International Register is in accordance with the provisions of section 3 above. The Engineers Mobility Forum has taken the APEC Engineer Manual as the basis for the requirements of registration on their register.

It is desirable that there be a continuing convergence between registers as there are a number of countries/economies who are members of more than one of the registers.

Such groups are:

- The APEC Section: ASIA/Pacific
- The European Section: UK, Ireland, and FEANI
- The African Section: South Africa and others
- The American Section: Canada, North and South America including Mexico – NAFTA
- The Asian Section: ASEAN
- The Arab Section: A number of Arab countries are accepting each others engineers
- The Indian Section: India, Pakistan, Nepal and Bangladesh

The following countries ratified and signed the Agreement in June 2001:

Australia, Canada, Hong Kong, China, Ireland, Japan, Korea, Malaysia, New Zealand, South Africa, United Kingdom and United States of America.

It was agreed that the Members of the EMF Register prepare to commence operation of their register at a date of their choice between 1 January 2002 and 30 June 2002.

The Sydney Accord

Recognition of Equivalence of Accredited Engineering Technology Education Programs defined as the programs through which practitioners normally satisfy the academic requirements for the engineering roles currently known amongst the initial signatories as:

- CANADA:
Certified Engineering or Applied Science Technologist
- HONG KONG, CHINA:
Associate Member of the Hong Kong Institution of Engineers
- IRELAND:
Associate Engineer
- NEW ZEALAND:
Engineering Technologist
- SOUTH AFRICA:
Professional Technologist (Engineering)
- UNITED KINGDOM:
Incorporated Engineer
- AUSTRALIA:
Engineering Technologist

The term "engineering technologist" is used throughout the Agreement to refer to practitioners engaged in any or all of the above roles.

The accreditation of academic programs is a key foundation for the practice of engineering technology in each of the countries or territories covered by the Accord, and:

◆ the criteria, policies and procedures used by the signatories in accrediting engineering technology academic programs are comparable;

◆ the accreditation decisions rendered by one signatory are acceptable to the other signatories, and that those signatories will so indicate by publishing statements to that effect in an appropriate manner;

◆ the signatories will identify, and encourage the implementation of best practice, as agreed from time to time amongst themselves, for the academic preparation of engineering technologists intending to practice at the professional level;

◆ the signatories will continue mutual monitoring and information exchange by

whatever means are considered most appropriate, including:

- regular communication and sharing of information on their accreditation criteria, systems, procedures, manuals, publications and lists of accredited programs;
- invitations to observe accreditation visits.

Engineering technologist mobility forum

The signatories of the Sydney Accord countries discussed the possibility of establishing an Engineering Technologist Mobility Forum.

The signatories to this Memorandum of Understanding, having exchanged information on, and made a preliminary assessment of, their respective processes, policies and procedures for granting recognition to certified / registered / licensed engineering technologists, have concluded that these are sufficiently comparable to justify further examination.

The practitioners concerned are those who undertake the engineering roles variously known amongst the initial signatories as it was mentioned earlier:

- **CANADA:**
Certified Engineering or Applied Science Technologist
- **HONG KONG, CHINA:**
Associate Member of the Hong Kong Institution of Engineers
- **IRELAND:**
Associate Engineer
- **NEW ZEALAND:**
Engineering Technologist
- **SOUTH AFRICA:**
Professional Technologist (Engineering)
- **UNITED KINGDOM:**
Incorporated Engineer
- **AUSTRALIA:**
Engineering Technologist

The signatories have agreed on the broad principles of a framework which might enable progress towards removing artificial barriers to the free movement and practice of certified / registered / licensed engineering technologists amongst their jurisdictions. In particular, they have agreed on the principles and, in outline, the process through which the substantial equivalence in competence of practitioners who intend to practice internationally could be established. The signatories wish to pursue these goals by establishing a body to be known as the Engineering Technologists' Mobility Forum whose responsibilities will include coordinating the development and maintenance of a decentralised register of certified / registered / licensed engineering technologists. Certified / registered / licensed practitioners must have satisfied the signatory by whom they have been assessed as eligible for independent practice that they have:

- ◆ completed an accredited or recognised engineering technology program;
- ◆ gained a prescribed minimum period of practical experience since completing that program;
- ◆ gained a prescribed minimum period in responsible charge of significant engineering work; and
- ◆ maintained their continuing professional development at a satisfactory level.

Conclusion

I believe that it would be beneficial to the worldwide engineering profession for us to aim for all international engineering registering bodies to have equivalent criteria. Then if the requirement for independent practice could also have equivalent criteria we would be 80% on the road to having a *World Engineering Register*.

WFEO EXECUTIVE COUNCIL 2001–2003

President: Prof. Dr. Eng. José Medem (Spain)

President-Elect: Eng. Lee Yee-Cheong (Malaysia)

Treasurer: Eng. Stefanos Ioakimidis (Greece)

VICE PRESIDENTS

Eng. Ifedayoi Akintunde (Nigeria) Eng. Yuri Gulyaev (Russia)

Eng. Samir Doumit (Liban) Prof. Jean Michel (France)

Eng. José Francisco Gasca Neri (Mexico) Eng. Mohammed Rashid Khan (Pakistan)

Eng. Barry Grear (Australia) Mrs. Quian Yi (China)

VICE PRESIDENTS AND COMMITTEE CHAIRS

Ing. Kamel Ayadi (Tunisia) Information and Communication (CIC)

Prof. János Ginsztler (Hungary) Education and Training (CET)

Eng. Ganesh P. Lal (India) Engineering and Environment (EEC)

Eng. Don V. Roberts (USA) Technology (ComTech)

Executive Director: Ir. Pierre-Edouard de Boigne (France)

WFEO COMMITTEE ON EDUCATION AND TRAINING 2001–2003

President: Prof. János Ginsztler (Hungary)

Past President: Prof. Miguel A. Yadarola (Argentina)

Vice Presidents: Dr. Russel C. Jones (U.S.A.) and Hisham Shihaby (Bahrein)

FULL MEMBERS

Prof. M. A. K. Azad (Bangladesh) Dr. M. P. Chowdiah Prof. (India)

Leizer Lerner (Brazil) Dr. Hasan A. Al-Sanad (Kuwait)

Dr. Ruzena Petriková (Czech Republic) Dr. Bachir Zaouk (Lebanon)

Prof. Xila S. Liu (China) Prof. Fernando Ocampo Canabal (Mexico)

Dr. David Reyes-Guerra (El Salvador) Prof. Włodzimierz Miszalszki (Poland)

Dr. Nicole Bécarud (France) Pavol Molnar (Slovak Republic)

Dr. Vollrath Hopp (Germany) Andrew Ramsay (United Kingdom)

Stefanos I. Ioakimidis (Greece) Mr. John Whitwell (United Kingdom)

Eng. Jeremy Ascough (Zimbabwe)

Secretary: Mrs. Zsuzsanna Sárközi Zágoni (Hungary)

ALTERNATE MEMBERS

Ing. Enrique Melara Ruiz (El Salvador) Prof. Husain Al-Khaiat (Kuwait)

Dr. William S. Butcher (U.S.A.)

CORRESPONDENT MEMBERS

Barry J. Grear (Australia) Dr. Mohammad Elizzi (Iraq)

Mr. Peter Parr (Australia) Prof. Carlos Santana Morales (Mexico)

Prof. Saad El-Raghy (Egypt) Dr. A. J. Bowen (New Zealand)

8