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EDUCATION FOR MOBILITY

Number 13

October 2006



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



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

COMMITTEE ON EDUCATION AND TRAINING

JOURNAL IDEAS N°13, October 2006

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.

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EDITORIAL

Education for Mobility

Prof. Włodzimierz Miszalski – President of the WFEO Committee on Education and Training

On 1 November 2005, I have taken over presidency of the WFEO Committee on Education and Training from my Hungarian Colleague – Prof. János Ginsztler, my distinguished predecessor and an acknowledged educator of engineers. János has successfully guided and managed the Committee for 8 years. In his engaged and conscientious work he was effectively aided and supported by Mrs. Zsuzsanna Sárközi-Zágoni, the WFEO-CET Secretary, who apart from being a hard worker, was also a good spirit of the Committee through all those years.

I should like to express here my sincere thanks to János and Zsuzsanna for the immense and good work they have done during their term of office. Due to them the journal IDEAS developed, became more popular and achieved a high level. Thanks to them the reader gets in hands a really good publication.

This number of IDEAS is the first one for me, as the editor of this journal. It has been dedicated to the 7th WFEO World Congress on Engineering Education devoted to Mobility of Engineers, held in Budapest on 4–7 March, 2006. Therefore the title of the 13th number of IDEAS – “Education for Mobility” – reflects the **ideas** presented by the Congress speakers as well as the thoughts which appeared during many interesting and fruitful discussions conducted in Budapest in March 2006.

The 7th World Congress on Engineering Education has been the consecutive important event in the history of international cooperation and exchange of views on education of engineers. The Congress was organized successfully by our Hungarian colleagues. More than 70 papers were presented and the number of participants from all over the world reached 280 persons. President of WFEO Kamel Ayadi, President of FEANI Willi Fuchs as well as President and Members of WFEO Committee on Education and Training were present at the Congress. The Opening session was held in the Assembly Hall of the Upper House of the Hungarian Parliament, the famous historical building. Welcome address was presented by Vice-President of the Hungarian Parliament Mr. László Mandur and greetings to participants addressed Mr. Bálint Magyar – Minister of Education of Hungary, Mr. Kálmán Kovács – Minister of Informatics and Communications and Dr. Károly Molnár – Rector of the Budapest University of Technology and Economics.

The Congress keynote presentations were followed by 7 sessions:

- Accreditation of Engineering Qualifications,
- Regional Agreements,
- Registration and Licensing,
- Curriculum to Promote the Mobility of Engineering Students,
- Case Studies from Industry on Mobility Issues,
- Establishing Substantial Equivalence,
- Special Issues of Engineering Education.

The proceedings of the Congress have been summarized and conclusions formulated during the closing session chaired by WFEO-CET President – Prof. Miszalski and its Past President – Prof. Ginsztler.

In order to present the spectrum of the broad range of Congress themes and to share with our distinguished readers the main thoughts and ideas of the Congress we have selected 11 papers grouped around four main topics:

- Towards Mobility,
- Solutions for Mobility,
- National Experiences in Education for Mobility,
- Technological Challenges.

We have also decided to introduce – to the contents of IDEAS – a new, permanent item – The Chronicle of Events which would record the most important Committee activities and events in its history.

There are many reasons for increasing mobility of engineers: the non-balanced distribution of engineering intellectual potential in different parts of the world, increasing number of global employers of engineers, development of international, world-wide technical systems.

The needs for mobility – challenges and perspectives – have been presented and discussed in the keynote presentation of Dr. Tony Marjoram, in Prof. L. Lerner and Eng. G. Lerner's paper and Dr Russel Jones' presentation.

There are also many direct and indirect ways leading to increasing mobility of engineers. These ways have been presented and discussed in the keynote text of Dr Willy Fuchs – President of FEANI, in the papers of Eng. Barry Grear (President-Elect of WFEO), Prof. Jean Michel and Prof. R. Natarajan as well as in my presentation.

The papers of: Prof. Miguel Yadarola, Prof. Bożenna Kawalec-Pietrenko, Dr. Ákos Jobbágy, Dr. Károly Molnár and Dr. Dezső Sima – present the national experiences in education of engineers for mobility in Latin America, Poland and Hungary.

The presentations of Prof. Antoni Kwiatkowski and Prof. Vollrath Hopp discuss technological challenges for future globally thinking and globally oriented engineers.

Taking over the presidency of WFEO Committee on Education and Training I would like to invite our distinguished readers to continue and develop the international exchange of thoughts and views on current issues of engineering education.

Let me extend my cordial thanks for all the eminent authors who have contributed to this number of IDEAS. I also thank Mrs. Teresa Domańska, the Committee Secretary and Mrs. Anna Jachimowicz for their help in preparation this edition of our Committee journal.

7th WFEO World Congress on Engineering Education

“MOBILITY OF ENGINEERS”



DECLARATION

Conclusions of the 7th World Congress on Engineering Education (Budapest, 04–07 March, 2006)

The participants of the 7th WFEO World Congress on Engineering Education the main topics of „Mobility of Engineers” held between March 4–7, 2006 in Budapest declared, that the Engineering Community has an essential role in promoting central issues of engineering education like quality of education, accreditation on engineering qualification, regional agreements, establishing substantial equivalence, curriculum (including interdisciplinary system-based subjects as well) and innovation.

It is essential, that engineering education of our new century – based on up-to-date research activities – must reflect issues like effects of globalization, importance of sustainability, the protection of natural and built environment, methods for poverty reduction, capacity building and must deal with initiatives in technological development and through these actions must contribute to the conditions of social welfare of humankind. Engineering education must prepare the future generation of engineers providing them with knowledge needed for the future world with knowledge, responsibility and competencies. These values are essential in order to help the mobility of engineers world-wide.

The participants agreed, that the engineering profession itself must represent a bridge between science and technology, and engineering education must reflect the interaction of engineers in industry and academia.

The Life-Long Learning for engineers should contain disciplines, which represent this bridge-role and help to take into account the global interests and help to safeguard the national interests and values as well as professional ethics.

ADDRESSES AT THE OPENING CEREMONY

WELCOME ADDRESS – BÁLINT MAGYAR, MINISTER OF EDUCATION, HUNGARY

Excellencies, Ladies and Gentlemen,

It is a special pleasure and privilege for me to welcome you, as outstanding representatives of the engineering education who have arrived in Hungary from five continents, from Africa, Asia, Australia, Europe and from North and South America in order to participate at seventh World Congress on Engineering Education.

Your presence here can be regarded as a special acknowledgment of the Hungarian Engineering Education, which can be approved by many inventions all over the world accomplished by Hungarian engineers.

The primary title of this World Congress, the Mobility of Engineers has never been so relevant as today, in a period when we have to find the solution for over-bridging the gaps between the global and national interests.

One of the main goals of the Bologna Agreement, which you are all familiar with, is to promote the mobility of – among others – engineering graduates. I am convinced that the proposals to be discussed during the congress are most the important issues all over the world, and may contribute to the further development of the national economies.

This week has been of outstanding importance for Hungarian higher education. Earlier this week Budapest hosted an international conference on the European Qualifications Framework for Lifelong Learning, where representatives of 32 countries discussed the tasks required for promoting the mobility of students and the labour force.

On 1 March 2006, in this very room of the Hungarian Parliament, we held a special session to celebrate the promulgation of the new Higher Education Act. It was here that rectors received their letters of commission and the Hungarian Rectors' Conference was re-formed. The new higher Education Act provides considerably more autonomy to higher education institutions, facilitates student mobility, focuses on quality and makes multi-level national education the general norm. Whereas there were 100 thousands students 16 year ago, more than 400 thousand students attend higher education institutions today. This figure evidences the shift from elite education to mass education, which presupposes a new legal framework, as Hungary also moves from its earlier Prussian-style education to the Anglo-Saxon system, where a Bachelor level is followed by master grades, and then PhD courses.

The third outstanding event this week is your conference, discussing engineering education, an area of special importance in Hungary. The Government understands the outstanding role that engineering education, information technology and science education play in increasing the competitive strength of the economy, therefore that you have chosen Hungary as the location of the World Congress on Engineering Education.

Higher education of engineering has been a flagship for Hungarian higher education in its transition to the educational system called for by the Bologna process. In the last two academic years our universities and colleges offered 18 engineering Bachelor degrees, and preparations are underway for 40 engineering Masters courses. I am convinced that your Congress will contribute greatly to the modernization of Hungarian higher education, and that of engineering, and to the efforts of widening international cooperation and enhancing the mobility of engineers.

Let me thank you for your presence and wish you fruitful discussions, and valuable decisions.

WELCOME ADDRESS – PROF. KÁROLY MOLNÁR, RECTOR OF THE BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS, HUNGARY

Excellencies, Ladies and Gentlemen,

On behalf of the Budapest University of Technology and Economics, let me welcome you in Hungary in the famous building of the Hungarian Parliament.

Hungary, as a new member of the European Union is in a strong economic development, which is partly due to the high-level engineering education in our country.

The Budapest University of Technology and Economics, founded in 1782, is one of the largest educational institutions in Central Europe. There are also quite a few institutions, like for example the Miskolc University, the Széchenyi University in Győr, the Budapest Tech, where ten thousands of engineering students are studying together with several thousands of students, who arrived in Hungary from abroad.

At our university there are engineering courses also in English, German, French and Russian languages as well.

We offer for our international students Pre-Engineering Courses, B.Sc. and M.Sc. Programs and Ph.D. Programmes as well in full harmony with the Bologna agreement.

I hope, that this most important world congress on engineering education will give for all of us new ideas, and the final conclusions will underline the most up-to-date issues of the engineering education for the future.

Have a very useful congress, and enjoy stay in Hungary.



KEYNOTE PRESENTATIONS

The Mobility of Engineers – Prospects and Challenges: Engineers Without Border, Borders Without Engineers?

Dr. Tony Marjoram, UNESCO, USA



Dr. Tony Marjoram is the Senior Programme Specialist responsible for Engineering Sciences and Technology in the Division of Basic and Engineering Sciences of the Natural Sciences Sector of UNESCO, and has worked for UNESCO since 1993. Dr. Marjoram has over 25 years international policy, planning and management experience in engineering, science and technology for development, relating to innovation, foresight, poverty reduction and emergency response, and has worked in university, intergovernmental and NGO contexts. He has a B.Sc. Hons in mechanical engineering, an M.Sc. in science and technology policy and his Ph.D. is on technology for development. He is a Chartered Professional Engineer and Fellow of the Institution of Engineers Australia, and is a member of the UN Millennium Project Task Force on Science, Technology and Innovation. Dr. Marjoram has worked at the universities of Melbourne, Manchester and the South Pacific, has published over 50 papers, articles and reports in national and international journals and is a member of the boards of several journals and organisations.

ENGINEERING, CAPACITY BUILDING AND DEVELOPMENT

Engineering, science and technology play a vital role in social and economic development. This is reflected in the increasing interest in “knowledge societies” and “the knowledge economy” shown by governments the world over, by intergovernmental and related institutions and organizations. The application of engineering, science and technology to social and economic development requires adequate human and institutional capacity and continuous capacity-building.

The InterAcademy Council report, launched by UN Secretary General Kofi Annan at the United Nations in New York in 2004, specifically addressed and underlined the need to build capacity in science, engineering and technology for development. Capacity building in engineering and science was re-emphasised in 2005 in the Main Report of the UN Millennium Project, “Investing in Development: A Practical Plan to Achieve

the Millennium Development Goals”, and in the report of the Millennium Project Task Force on Science, Technology and Innovation, “Innovation: Applying Knowledge in development”. Most recently, capacity building in science and engineering was emphasized in the report of the Africa Commission – “Our Common Interest”.

Capacity building relates to human, institutional and infrastructural capacity. Capacity building in engineering, science and technology is a difficult task, however, as these fields are in a state of constant motion and change. Not only are these fields in a state of motion, however – engineers and scientists are themselves becoming increasingly mobile in a globalising world.

MOBILITY AND TRENDS OF DISINTEREST

This mobility and exchange of ideas is a feature of the openness and global nature of science and engineering. But mobility becomes a problem when it is mainly one-way – when it becomes brain drain from poor countries and brain gain to the rich, reducing capacity where it is most needed for social and economic development, and to address the Millennium Development Goals. While there is some discussion about brain circulation, let us make no mistake – this may occur between similar countries, but when rich and poor are concerned – brain drain is as much a fact in engineering as it is in medicine.

The calls for capacity building in science and engineering are set against and in response to a disturbing decline of interest among young people in science at the secondary level, with fewer young people going into science and engineering courses at the tertiary level in many countries around the world. This applies particularly to mathematics, physics, chemistry, and all areas of engineering. There is also a gender dimension – in most countries, less than 25% of women in tertiary education are studying in these fields. This is the situation in most countries, including those with impressive records of innovation and the application of science and engineering to social and economic development.

These trends of disinterest, downward enrolment and brain drain, if not reversed, will have major adverse consequences in the future for capacity-related aspects of development, especially in developing countries. It is interesting to consider some of the reasons for this decline of interest in science and engineering among young people. It appears that this decline is linked to young people’s perceptions that:

- Science, engineering and technology are not interesting, boring;
- Science and engineering courses at tertiary level are demanding and are hard work;
- Jobs in science and engineering are not well paid compared to the work required, nor do they enjoy the social and professional status of other occupations and careers;
- Science and engineering have a negative environmental impact.

Borrowing metaphorically from physics, Heisenberg tells us that perceptions have a degree of uncertainty. Einstein tells us that perceptions depend significantly on the relative position of the observer. Studies in the social and human sciences tell us that

people's perceptions of reality, even if based on flawed or inaccurate information, are often real in their consequences. The fact is that many young people believe these things and, as a result, they are turning away from science and engineering. One of our challenges is to examine this phenomenon and to better understand it, so that we can devise effective ways to correct these perceptions if they are wrong, and to address them if they are right.

It is a paradox that the more industrial societies are based on and consume the products of science and engineering, the less interest there is in being involved in their production. Consumerism and environmentalism may be partly responsible for young people's increasing disaffection with science and engineering and careers in these fields. It may also be paradoxical that the increasing pervasiveness of science, engineering and technology inspires less interest than the more exotic, although science and engineering are also something of a black box to an increasing number of people in our societies. Indeed, perhaps it is as a Pandora's black box that science and engineering have given rise to feelings of both awe and fear since and before the days of Mary Shelley's "Frankenstein", subtitled or "The Modern Prometheus" – the first "science fiction" nightmare story on the dangers of taking knowledge and science from the gods.

THE NEED FOR REFORM IN ENGINEERING, SCIENCE AND TECHNOLOGY EDUCATION

We must find ways not only to teach science and engineering better, but also to develop among young people something more fundamental – an appreciation of what it means to do science and engineering on an everyday basis. There is a need to recognize the personal rewards that come from the understanding of problems and problem-solving that is the creative core of science and engineering. There is also a clear need to promote wider public understanding of and interest in science, engineering and technology. Our broad target audience certainly includes children and young people and, of course, their parents. It also includes employers, especially in productive industrial sectors. And it must include politicians and decision-makers who are responsible for developing and implementing science, engineering and technology policy.

We engineers do not of course need to be convinced that science and engineering are inherently fascinating, but others do. This requires teaching and learning processes that inspire interest, attract attention and stimulate the imagination as well as capture and harness the desire to know. If the image of science is the rote memorization of lists of formulae for repetition in the examination room, then we must change that image. If that is the actual practice of science and science education, then we must change that practice too.

It is interesting to ask a question that is central to this whole issue: how many young people have been turned off science and technology by poor teaching? This may be quite a common experience, and was mentioned as such by Mr. Matsuura, the Director-General of UNESCO, when he opened an Expert Meeting on "Science and Technology Education: Systemic Approaches to Reform", at UNESCO in 2004. The

main recommendations of that meeting included the need for networking, information-gathering, sharing of good practice in learning techniques and policy instruments to promote science and engineering. The meeting agreed that it would be useful to hold a larger forum on approaches to reform in engineering, science and technology education to discuss the need for and possible approaches to reform more broadly. Mr. Matsuura also noted that what is needed are teacher training, learning materials and pedagogies that promote good teaching. We particularly need good initial and in-service science teacher-training, educational environments that encourage personal responsibility for self-learning, curricula and study programmes that have been designed, tested and proven, and approaches to assessment that reflect the multifaceted character of the learning and discovering process in science and engineering.

Indeed, all factors that impact upon the quality of science education are in need of urgent attention. At the tertiary level, science and engineering courses need to be made more interesting and exciting, as does science teaching at the secondary and primary levels, for it is here that loss of interest in science and engineering begins. This is why systemic reform is required. Such reform must seek to make science and engineering courses at the tertiary level more interesting, lively and engaging, through better pedagogical approaches and innovative curriculum development. This would include, in particular, the use of more activity and project-based, problem-oriented learning, teamwork and continuous assessment.

Systemic reform also has implications for secondary and primary level science education – where there is a serious shortage of trained teachers and equipment, especially in many developing countries. The need to stimulate and reinforce young people's interest in science is increasingly in almost all countries. Many countries once had healthy enrolments in science and engineering, but this is no longer the case. Many students are turning to other fields of study that are less intensive and potentially more lucrative.

Making science and engineering more inherently interesting in the way they are taught and learnt will not only attract more young people, especially women, but will also help change the practice of science and engineering. This change should be linked to wider changes in social values, beliefs and expectations. For example – the quest for sustainable development has major implications for the very purposes of science and engineering, as well as the ways in which they are practiced. These considerations are important in the follow-up to the World Summit on Sustainable Development in Johannesburg, including the UN Decade of Education for Sustainable Development – for which UNESCO is the lead agency. Good practice in the teaching and learning of science and engineering needs to be shared, reinforced and promoted. This is precisely where UNESCO has an important role to play. This role, by the way, is important in its own right, but it is also a means to promote other goals of the Organization – such as intercultural dialogue.

The issues discussed briefly above are not new. They were raised at the World Conference on Higher Education in 1998, the World Conference on Science held here in Budapest in 1999, the World Engineers' Conventions in 2000 and 2004, and at many other national and international meetings on science and engineering around the world over the last

few years. These issues are reflected in the UNESCO goals in science and engineering education. Indeed, the perspective on life-long learning, science and technology education is a key area of inter-sectoral cooperation at UNESCO, along with promoting the public understanding of science and engineering. The urgent need to recognize and address the problems facing capacity building in engineering in terms of mobility and brain drain are most acute in the poorest countries – where capacity is most needed. These are the most pressing prospects and challenges we face today. Unless we address these issues, we will not have the dream of “engineers without borders”, but the nightmare of borders without engineers!

The UNESCO Executive Board decided with unanimous support in April 2005 to develop a cross-sectoral program in technical capacity building. This decision noted that capacity building in engineering, science and technology is a critical aspect of promoting sustainable economic and social development in all countries, is vital in reducing poverty and therefore at the heart of addressing the Millennium Development Goals. A unit has been established in the Natural Sciences Sector to promote and coordinate the Sector’s capacity-building efforts. UNESCO looks forward to further cooperation with the World Federation of Engineering Organisations in understanding and addressing the issues relating to capacity building in engineering, and the application of engineering and technology to poverty reduction, sustainable development and the other Millennium Development Goals.

A Way to the International Comparability of Engineering Education

Dr.-Ing. Willi Fuchs, VDI, President of FEANI, Germany



Dr.-Ing. Willi Fuchs, born 1957, studied Mechanical Engineering at the University of Siegen where he obtained his degree in 1986. After lecturing at the University of Houston, Texas, until 1987 he was Head of the Department for Development and Quality Assurance at the Lemmerz Werke in Königswinter. From 1991 to 1998 he was managing director (CEO) of the Dr. Reinold Hagen Foundation in Bonn. In 1998 and 1999 he was deputy director of VDI before being appointed Executive Director and Executive member of the Board of VDI in May 1999. He is a member of several Supervisory Boards. Between 1994 and 1998 he was a member of the Executive Board of the Deutsche Gesellschaft für Qualität e.V. where he served as President from 1996 until 1998. Since August 1999 he has been President of the Accreditation Agency for Engineering, Computer Science Courses, Natural Sciences and Mathematics (ASIIN). Between September 2002 and September 2005 he was elected as Vice President and since October 2005 he has been President of the European Federation of National Engineering Associations (FEANI).

Abstract

The technical challenges of our modern world with its complex systems can only be mastered by well-trained engineers. More than ever, the focus must be on the aspects of sustainability in every technical innovation. It is beyond doubt that we see all developments and innovations in the context of a global overall system today. We should conclude from this that the education systems and contents must also meet international comparability. Especially in the case of engineering education, there is still a long way to go.

Between the years 2002–2004 the WFEO and the VDI worked together to set up an overview of the different systems of engineering education worldwide. The results show a very non-uniform picture. However, in order to solve the challenges of our time, an international comparability of engineering education is essential in the medium and long term. Two prerequisites are essential and of fundamental significance:

- a) *The competencies and knowledge of the engineer must be defined.*

- b) *A quality assurance system must be established, which guarantees achieving the comparability of engineering education.*

This paper shows approaches of how these prerequisites could appear in detail. The author is aware that, without an intensive discussion of the shown causes of thought, international comparability of engineering education cannot be achieved.

INTRODUCTION

In the past, industrialisation meant that engineers had the task of promoting technical developments, and in the role of entrepreneur they pushed economic growth. At the same time, social consciousness and also social development were at the core of their achievements. Growing industrial development caused the practise of engineering, initially of a holistic nature, to become more specialised. Additionally, the occupational field of engineers became more widely diversified [1].

The engineers of the world are expected to cope with the challenges associated with today's global economy. This involves not only advancing and pushing ahead new technologies and the development of new markets. In addition to that, engineers must recognise that every local and national action can have a direct impact on other countries and continents. An example of this are the worldwide efforts to reduce emissions of CO₂ on our planet. Therefore, especially in these times, the engineer must bear a high level of social and humanitarian responsibility [2].

For the highly-developed industrial nations of the world, productivity depends essentially on the human resources they have at their disposal. When we take a look at the population growth figures, we can easily see why the competition is extremely fierce all over the world in terms of finding and hiring the best experts. All of today's industrial nations are aging societies. For example, by 2040 in Japan and Germany almost 40% and in the USA 30% of the population will be 60 years of age and older. And the populations in the developing countries are aging too. For engineers this will mean having to work longer, which will place even more importance on continuing professional training – what we call lifelong learning.

Even just the three problem areas mentioned here clearly show that engineers are needed in every country of the world, and that together they hold the responsibility for the future of our society. But this also means comparability of the engineer study programmes in all of these countries. And here we must not confuse comparability with equality.

CURRENT ENGINEERING EDUCATION

As a result of the growing areas of specialisation in engineering, a number of sub-disciplines have developed. A further result: the social and humanitarian aspects of the workload in engineering study programmes are receding to the background, while specialisation subjects are almost exclusively coming to the fore. And as the focus in many of these sub-disciplines becomes increasingly narrow, engineering students are

focussing only on their area of specialisation [2]. The result: today's engineering students are no longer acquiring a sufficiently sound base of knowledge and skills for solving economic, social and ethical problems.

REQUIREMENTS OF AN ENGINEERING EDUCATION

If one analyses the work of an engineer, one can see that it is made up of a variety of tasks, all characteristic for the practise of engineering. These tasks depend on a variety of different factors, such as the specialist field, functional area, type of employer and size of the company, and each of these tasks demands specific requirements of the employee in terms of knowledge and skills. As different as these requirements in various positions can be, they all have one thing in common: they must be met with a basic qualification that is based on acquired knowledge and skills necessary for the practise of engineering. Rapidly changing expert knowledge reduces the value of the engineering specialisation in the basic qualification and therefore also in undergraduate degree programmes.

The basis of the necessary engineering qualification is formed by a broad spectrum of the basic elements of mathematics, natural science and technology. This fundamental knowledge is absolutely indispensable for understanding natural phenomena and their fundamental utilisation in technical applications, while at the same time serving as the foundation for building up consolidated knowledge in a chosen area of application. The broadest possible basic education is also an important prerequisite for professional communication skills between engineers and natural scientists from other specialist fields. For this reason, an undergraduate programme should not be too subject-specific and should be supplemented by practical courses and exercises.

Increasing significance is also placed on the teaching of interdisciplinary and non-technical subjects. These are intended to provide the future engineer with capabilities for creative problem solving, cooperative team work with management and communication competence, a holistic perspective of technical projects in his environment and, last but not least, for being able to work almost anywhere in the world.

However, understanding the basic fundamentals alone does not qualify the engineer for the practice of engineering. In order to meet the requirements of daily work in the profession, an engineer also needs the consolidated knowledge from his chosen area of specialisation and the special skills of the problem-solving methodology of engineers. The additionally required specialised knowledge of the application area in line with the tasks involved is acquired during the probation period and through advanced professional training measures.

Consolidated knowledge from the chosen application area enables the engineer to keep the overall scope of his duties in sight, integrate his special problem-solving skills in the final solution and master interface problems. For all this the engineer must have a thorough understanding of the system functions of a particular specialist field and be capable of using engineering methodology for realising technical and scientific possibilities. In view of the growing complexity of modern devices, equipment and systems, increasing

importance is being placed on the ability to “see the big picture”, to think in systems and to communicate on the systems level with everyone involved in a project. Engineers are expected to comply with the growing demands on their knowledge of theories and the increasingly complexity of the design, sales and marketing of state-of-the-art technical systems and products.

The engineer of the 21st century is the perfect combination of innovations manager and entrepreneur, and is therefore able to run a company and plan and achieve company growth [3].

KNOWLEDGE AND COMPETENCE OF AN ENGINEER

The core of the qualifications to be acquired in an engineering study programme should form a broad spectrum of basic mathematics, natural science, technology and interdisciplinary knowledge. All relevant courses in the study programme should fulfil this prerequisite and therefore lay the foundation for the professional mobility that will later be expected of the engineer on the job. Students must acquire a broad spectrum of basic knowledge during their education, as this is very difficult to attain later on in the practice of engineering.

Essential components of a modern basic education include not only a solid understanding of economics and ecology in an application correlation of individual technologies, but also fundamental knowledge of the principles and procedures of technology assessment.

Building upon the basic education should be the acquisition of application-related technical knowledge in the form of an exemplary consolidation in several, less technical occupational fields. The study programme should also include relevant interdisciplinary and non-technical components in specialised teaching courses.

Classification of the individual subject areas leads to an optimal compromise in engineering study programmes, as long as the three basic education blocks – the basics of mathematics and natural science, basics of technical sciences and exemplary specialisation in an area of application – fill approximately 30, 30 and 20% of the total study period respectively. The remaining 20% of the study volume should be reserved for the teaching of non-technical courses aimed at promoting the interdisciplinary capabilities of the engineer.

It is especially important to supplement the specialist structuring with interdisciplinary and problem-related content, and theory and application orientations must be closely linked. For this course content, at the expense of such conventional study forms as lectures and exercises, the university must introduce more problem- and project-related study formats that also integrate technical and specialist content, as well as interdisciplinary study content. It is especially important to intensify the cooperation between the university and industry and other cultural fields. New forms of cooperation must be developed in joint teaching projects and team work.

COMPARABILITY THROUGH QUALITY ASSURANCE

The comparability of engineering degree programmes is currently being achieved through the examination of the course content on offer. Additionally, the duration of a study programme is used as a gauge for achieving comparability. However, this does not take into consideration that not only the admission requirements in the form of school-leaving qualifications, but also the intensity of the course offer will inevitably vary from one country to another. Despite this fact, at present only these factors, content and duration, are currently being used for achieving the comparability of engineering study programmes.

But if the engineering study programmes were changed as described here, the factors of content and study duration would no longer be the sole prerequisites. Certainly, the specialised content of a study programme will continue to be important, and examining this content will not cause any major problems. The study duration of a study programme, however, will in future only play a minor role. More importantly, the acquired knowledge and skills of the student must be assured and checked using the output factors for engineering degrees, the so-called outcomes [4] [5].

The following six outcomes [5] should be put up for discussion:

Knowledge and Understanding

The underpinning knowledge and understanding of science, mathematics and engineering fundamentals are essential to satisfying the other programme outcomes. Graduates should demonstrate their knowledge and understanding of their engineering specialisation, and also of the wider context of engineering.

Engineering Analysis

Graduates should be able to solve engineering problems consistent with their level of knowledge and understanding, and which may involve considerations from outside their field of specialisation. Analysis can include the identification of the problem, clarification of the specification, consideration of possible methods of solution, selection of the most appropriate method, and correct implementation. Graduates should be able to use a variety of methods, including mathematical analysis, computational modelling, or practical experiments, and should be able to recognise the importance of societal, health and safety, environmental and commercial constraints.

Engineering Design

Graduates should be able to realise engineering designs consistent with their level of knowledge and understanding, working in cooperation with engineers and non-engineers. The designs may be of devices, processes, methods or artefacts, and the specifications could be wider than technical, including an awareness of societal, health and safety, environmental and commercial considerations.

Investigations

Graduates should be able to use appropriate methods to purpose detailed investigations of technical issues consistent with their level of knowledge and understanding.

Investigations may involve literature searches, the design and execution of experiments, the interpretation of data, and computer simulation. They may require that data bases, codes of practice and safety regulations are consulted.

Engineering Practice

Graduates should be able to apply their engineering knowledge and understanding to developing practical skills for solving problems, conducting investigations, and designing engineering devices and processes. These skills may include the knowledge, use and limitations of materials, computer modelling, engineering processes, equipment, workshop practice, and technical literature and information sources.

Transferable Skills

The skills necessary for the practice of engineering, and which are applicable more widely, should be developed within the programme.

COMPARABILITY NOT EQUALITY

Today we live in an age in which national borders no longer present restraints. We live in a global village and this applies most particularly to engineers and the engineering study programmes. In addition to teaching specialist knowledge, the modern engineering education must also provide students with a sensibility for economic, social and ethical aspects. Contrary to specialist content, these aspects vary from one cultural region to another. For this reason, the comparability of engineering education cannot be defined only by specialist content and the duration of a degree programme. This would inevitably lead to the goal of sameness, which is something modern international engineering education cannot achieve. In the future the acquired knowledge and skills of engineering students must be proven with the help of output factors for engineering degrees, the so-called outcomes. Achieving this goal is the responsibility of all engineers from science and industry, on both the national and international levels.

TOWARDS MOBILITY

Promoting the mobility of Engineers and Engineering Students

Eng. Gerson Lerner, Prof. Leizer Lerner, Brazil



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Abstract

Important for the development and spreading of modern techniques worldwide is the exchange of well-prepared engineers among countries. Our main goal is to suggest a way countries could exchange experiences through engineers' mobility. In order to succeed, engineering students and graduated engineers must be ready to live and practice the profession abroad.

Enhancing some students' skills from the graduation course on will better prepare future engineers to help their own home country, as other countries, to get a path for faster development. Engineering students would be prepared by introducing new subject(s) in the curricula of some engineering graduation courses chosen by the WFEO national member in cooperation with selected Universities. The discipline(s) would give technical and cultural information about the countries involved in such mobility agreement.

Courses for engineers should be very alike to those for engineering students' preparation except that engineers could have their subject(s)' classes organized by the countries' national engineers federation.

WFEO would support such kind of project by helping the WFEO National Members to get together in order to enhance such mobility agreement project. There is a special importance of the mobility proposed plan that is to help to develop developing countries.

Keywords: *engineers and students mobility, mobility preparation courses*

1. INTRODUCTION

Spreading of modern techniques among countries is important for the world development as a whole. In order to accelerate that process, some stimulating policies should be done to easy engineers mobility.

One of those policies is the preparation of engineers and under graduated students to live and work in a foreign country.

Other policy could be the creation of countries agreements to motivate experiences exchange through engineers' mobility among nations.

The main purpose of those policies is to stimulate plans to help developing countries by giving chances to its engineers to live and practice abroad and learn advanced engineering techniques to bring this experience back home. The knowledge upgrade, so obtained, should certainly be useful for faster development of the countries involved in such Mobility agreements.

There is the possibility of exchanging engineers' experience among countries with complementary needs and knowledge. It could be very convenient to stimulate developing countries through mobility agreements emphasizing theirs areas of engineering excellence. For instance, in the energy field Brazil is well developed in techniques of alcohol use, and India is well developed in nuclear energy techniques. An agreement plan

could be improved between those two countries to provide engineers exchange in those two engineering areas so Brazil could develop faster his nuclear energy techniques and India could have similar advantages with alcohol techniques.

In order to have this Mobility Plan working, engineers and engineering students should be adequately prepared to participate to this project. This paper suggests a way engineers and engineering students could be getting their preparation to live, work and study abroad.

2. DESIRABLE PROFILE FOR MOBILITY PLAN PARTICIPANTS

Engineers or students that wish to stay abroad for some time must be prepared to face different languages, cultures, learning processes and also the distance from family, friends and native environment.

It is fundamental that mobility candidates know the basics of the destiny country language or, at least, a useful third language of contact. Although, knowing the destination country's language, sure it would easy life abroad and also fasten up the engineering learning techniques.

It would be great if the mobility candidate already knew, before leaving his country, the host countries' main cultural habits, so he wouldn't be shocked by it while living abroad.

Each country has its own way and rhythm of teaching and learning. The mobility candidate should be someone flexible, who does not have much difficulty in learning new subjects and to accept different study methods that he is used to.

The candidate should be sure of his investment, which consists on getting a large knowledge advance in his professional area with the abroad experience he will get, and prepared to pay the price of missing for a period his country, family and friends.

3. A MOBILITY PLAN

This proposition plan focuses on the preparation of engineering students and graduated engineers.

The preparation is based on international agreements among National Engineering Organizations – either putting together a group of countries or by bilateral agreements. Countries National Engineering Organizations involved in those agreements would have the responsibility of providing cultural and technical information to each other, so the Mobility Plan candidates could be prepared to face the abroad country's culture and language, and its better developed engineering technical field.

Countries National Engineering Organizations involved in the Mobility Plan should be responsible for establishing cultural classes, either by video and/or by lectures, summarizing countries' basics culture outstanding and language.

The WFEO National Members should be responsible for the technical areas. They could provide technical materials (videos, pictures, computer programs, etc.) and the access to specialized engineers on those outstanding technical areas.

It is important, especially for developing countries, the exchange of technical experiences. Enhancing some Mobility Plan participants' skills will better prepare them to help their own home country, as other countries where they would practice, to get a path for faster development.

3.1. Students' preparation

The student's preparation could be done by introducing new optional subject(s) in some selected graduation courses and Universities.

In these new subject(s), videos and workshops about technical and cultural important aspects would be ministered. Those classes would show the main mobility countries' culture, as their traditions, habits, alimentation, and the state-of-the-art in engineering and technological areas in which the country is involved in a mobility agreement.

Example: Brazil does a mobility agreement with another country and agrees to welcome students from that country to study alcohol energetic technology (considering Brazil well prepared in this technology). In the same way, the other country reciprocates with an outstanding field of its technology.

In that case, in some Universities of that second country, it would be created a new subject called "Mobility to Brazil". The new subject would show some cultural relevant aspects about Brazil, like its main cities, people profile and habits, traditions, typical dances and music, main practiced sports, etc. That mobility preparation course would explain the basics of technological areas in which the country signed mobility agreement, in this case, basics of alcohol technology. The same would be done about "Mobility to the second country" in some chosen Brazilian's Universities.

This students plan could be stimulated by the National Engineering Society as a get-together agent among the Universities involved.

3.2. Engineers' preparation

Engineers' preparation could be very much alike to the students' general preparation. The difference could be in the deepness of the appreciation on the technical field aspects.

The WFEO National Members shall help substantially in planning and developing the engineers' mobility project. The WFEO National Members should count on the support of the specialized engineering societies in the technical fields' subject of the Mobility Plan in each country.

4. MOBILITY PLAN IMPLANTATION

WFEO could act as an umbrella to the implantation of the Mobility Plan requiring its National Members to prepare a full report analyzing their country's developing level on some of its outstanding engineering areas. In this report, the National Member specially interested in the Mobility Plan would suggest in which technical area its country is well

developed and could help other countries, and secondly which engineering technological fields it would like to receive international help for faster upgrading.

WFEO, receiving those reports, could act as a get together agent to those countries with complementary aspects, some outstanding and other less developed technological fields.

WFEO would so fulfill an important roll of an agent of development of its National Members countries.

It is to point out that this Mobility Plan could comprehend not only bilateral accords but also regional or a group of nations' agreements.

WFEO is also the adequate organization in the engineering field to count on the support of international agents of development, such as UNESCO, World Bank, etc., to make the Mobility Plan feasible.

Another WFEO important roll in this mobility project could be to help in the organization of the mobility courses in some developing countries which shall ask for it and by obtaining financial means to support its implementation.

To achieve this target WFEO could organize a Task Force. This Task Force should conduct the implantation of the Mobility Plan – organizing the consultation to WFEO National Members, analyzing the results obtained and proposing a general policy for the Mobility Plan, its support and follow-up.

5. CONCLUSION

This paper's target is to establish a feasible Plan to promote Mobility of Engineering Students and Graduated Engineers.

In our opinion, WFEO and its Members (National and Regional), are the adequate main agents to take this Plan from an intention to a reality.

The Mobility Plan should enhance and upgrade Engineering action in its main goal: bettering human existence in our planet.

Impact of Capacity Building on the Mobility of Engineers

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Abstract

Technical capacity building to enhance the potential of developing countries to successfully enter the global economy is underway in several parts of the world, including Latin America, Sub-Saharan Africa, Eastern Europe and the Middle East. Local benefits of enhanced pools of engineers and applied scientists include the attraction of direct foreign investment by multinational companies, more effective utilization of foreign aid funds, and economic growth due to local entrepreneurial activity. Global benefits of capacity building efforts include enhanced mobility of engineers across national borders and the flow of technical services internationally. Such mobility involves issues of quality assurance of engineering education programs, mutual recognition mechanisms, licensure, "brain drain", and offshore outsourcing. The trends in capacity building for economic development and internationalization of engineering practice are largely irreversible, so engineering educators and the employers of engineering graduates must adapt to the new realities.

INTRODUCTION

Economic development for developing countries can be effectively stimulated by building the technical capacity of their workforce, through quality engineering education programs. A competent technical workforce base can then provide several paths to economic development: attraction of technically oriented multi-national companies, who can invest effectively in the developing country once there is a cadre of qualified local employees available; effective utilization of foreign aid funds, providing a legacy

of appropriate infrastructure projects and technically competent people to operate and maintain them; and small business startups by technically competent entrepreneurs. Both UNESCO and the World Federation of Engineering Organizations are currently actively engaged in technical capacity building in developing countries, and their efforts will be reported in this paper.

High quality engineering education is a necessary forerunner to such economic development; and quality assurance systems such as peer review based accreditation are needed to promote such high quality education programs. Such quality assurance systems can then provide the basis for cross-border recognition systems, permitting the flow of services and goods across national boundaries. This paper provides the rationale for quality assurance systems in promoting effective technical capacity building for economic development.

THE NEED

“Let me challenge all of you to help mobilize global science and technology to tackle the interlocking crises of hunger, disease, environmental degradation and conflict that are holding back the developing world.” – Kofi Annan, United Nations, 2002

“We need to encourage international commitments to promote the kind of engineering and technology that contributes to lasting development around the world.” – Koichiro Matsuura, UNESCO, 2000.

Capacity building is a dedication to the strengthening of economies, governments, institutions and individuals through education, training, mentoring, and the infusion of resources. Capacity building aims at developing secure, stable, and sustainable structures, systems and organizations, with a particular emphasis on using motivation and inspiration for people to improve their lives.

PREVIOUS EFFORTS

In a detailed study of the results of foreign aid to developing countries over the past several decades, William Easterly concludes, in his book “The Elusive Quest for Growth” (MIT Press, 2002):

- previous efforts have tried to use foreign aid, investment in machines, fostering education at the primary and secondary levels, controlling population growth, and giving loans and debt relief conditional on reforms to stimulate the economic growth that would allow these countries to move toward self sufficiency,
- all of these efforts over the past few decades have failed to lead to the desired economic growth,
- these massive and expensive efforts have failed because they did not hit the fundamental human behavioral chord that “people respond to incentives”.

Having concluded that past efforts at stimulating economic growth in developing countries have failed, Easterly outlines what he thinks would work. He argues that there

are two areas that can likely lead to the desired economic growth in developing countries, and can lead them toward economic self sufficiency:

- utilization of advanced technologies,
- and education that leads to high skills in technological areas.

WHAT OUTCOMES ARE DESIRED?

- Technical capability is needed for developing countries to engage effectively in the global economy. A base of qualified engineers and technologists will facilitate the infusion of foreign capital through attraction of multinational companies to invest in the developing country
- Indigenous science and technology capacity is needed to insure that international aid funds are utilized effectively and efficiently – for initial project implementation, for long-term operation and maintenance, and for the development of capacity to do future projects. An approach based on a solid indigenous engineering manpower pool serves to reduce brain-drain, showing people that they can partner with donor nations in helping build their own homelands.
- In order to stimulate job formation, a technical workforce pool is needed, made up of people who are specifically educated and prepared to engage in entrepreneurial startup efforts that meet local needs. A well prepared engineering workforce, when coupled with entrepreneurship, can result in societal as well as personal benefits.

Two complementary approaches are being pursued in parallel to achieve these desired outcomes:

- UNESCO “Cross-sectoral Program in Capacity Building” effort, to enhance engineering and related programs within that organization,
- WFEO Committee on Capacity Building, to provide an action oriented program for forward motion.

UNESCO PLANS FOR CAPACITY BUILDING

In 2003, the United States of America rejoined UNESCO after an absence of 18 years. The US government indicated to UNESCO that it wanted a significant portion of the increased funds that it would provide to its budget to be allocated to enhancing its programs in engineering and engineering education. A major proposal on how to mount an enhanced program, entitled “Engineering for a Better World”, was developed by the US engineering community and UNESCO’s engineering staff and submitted to UNESCO for consideration.

The overall objectives of the “Engineering for a Better World” proposal were to strengthen human and institutional technical capacity in developing countries, to promote engineering to young people, and to provide an interactive and catalytic role for the application of engineering and technological resources to sustainable economic and social development and poverty eradication. There was specific reference to the Millennium Development Goals of eradicating extreme poverty and hunger, ensuring

environmental sustainability, promoting gender equity and empowering women, and developing global partnerships for development.

Through guidance from the US Ambassador to UNESCO, and with the support of the World Federation of Engineering Organizations, UNESCO expanded this engineering effort into a new cross-sectoral effort in capacity building that will involve the science sector, the education sector, and the communications sector. This effort, to be housed in the science sector and reporting directly to the Assistant Director General for Science, will focus broadly on building personal and institutional capabilities in developing countries to address poverty reduction, economic development, and related issues.

WFEO Standing Committee on Capacity Building

Motivated by a renewed interest in engineering and engineering education at UNESCO, at least partially driven by the decision of the United States of America to rejoin UNESCO after an 18 year absence, the World Federation of Engineering Organizations (WFEO) moved in October 2003 to establish a new Standing Committee on Capacity Building, with the United States as the host of the international organization. The activities of the new Committee are to include:

- Providing pathways for the technical and professional societies of the developed world to make their expertise available to engineers in the developing world – including technical publications, conferences, codes of practice, and ethics
- Utilizing state-of-the-art distance learning technology to deliver needed information and interactions to engineers and engineering educators in developing countries
- Strengthening engineering education, both initial and lifelong learning in developing countries – including making available global best practices in curriculum reform and engineering practice
- Providing an information resource for teaching and learning materials, laboratory equipment, software, etc. for the engineering education needs of developing countries
- Addressing pipeline and diversity issues in providing the needed quality and quantity of engineers for the world's needs
- Promoting collaborative efforts between institutions in the developed and developing worlds
- Promulgating quality assurance standards and accreditation for engineering education throughout the world, particularly in developing countries
- Developing pathways for engineering volunteers in the developed world to spend time and effort working on capacity building in developing countries – including efforts in times of disaster relief

The WFEO Committee on Capacity Building, while hosted in the United States by the American Association of Engineering Societies, is an international committee consisting of members from both developing and developed countries. Members have been nominated by the some 80 member organizations of WFEO. A first meeting of the Committee on Capacity Building – a planning conference – was held in June 2004,

in Washington DC. A second meeting, focused on pursuing an action-oriented agenda, was held in Shanghai in November 2004, in conjunction with the World Engineering Conference. A third meeting, reviewing action-oriented programs in process and under development, was held in Puerto Rico during the WFEO General Assembly in October 2005.

It is anticipated that the WFEO Committee on Capacity Building will develop significant financial resources outside the UNESCO structure, and will operate programs which synergistically support the capacity building efforts within UNESCO. To date some \$50,000 of funds provided by the National Science Foundation have been allocated for startup activities of the WFEO effort, including the June planning meeting of the Committee. Significant funds have been provided for the “Engineering for the Americas” activity being conducted in collaboration with the Organization of American States, from government agencies and private industry. Additional funds have been earmarked for the committee through a US government extra budgetary allocation to UNESCO. These funds are to be utilized to retain a development consultant to assist in raising funds for the African initiatives of the Committee. It is anticipated that at steady state, the activities listed above will require a support level of approximately \$500,000 per year – with the bulk of the activities heavily supported by volunteer time and effort of the millions of engineers represented by the WFEO member country organizations.

Following is a list of the activities being pursued by the WFEO Committee on Capacity Building:

- Engineering for the Americas – capacity building throughout Latin America and the Caribbean, utilizing both a “bottoms-up” approach involving initiatives for engineering educators and a “top-down” approach with policy level decisions at the Ministerial level of government
- African initiative – development of programs for the enhancement of engineering education and its quality assurance in countries which currently have major foundation grants to improve their overall higher education
- Virtual exhibit, e-conferences – capturing of exhibits at a major engineering education conference (book displays, equipment demonstrations, hardware and software products, information services, etc.) to make available on a cd-rom to engineering educators in developing countries; planning and conducting of electronic conferences, such that engineering educators in developing countries can participate in virtual meetings even though typically unable to travel to live conferences
- Entrepreneurial conference – planning for a 2006 international conference on teaching entrepreneurship to engineering students
- Black Sea University Network workshop – planning for a workshop on best-practices in engineering education, to be held in Moldova for the dozens of engineering schools within the 100-member Black Sea University Network
- Gender issues – collaborating with two major international organizations concerned with gender issues in engineering education, to assist in getting more appropriate women into the engineering education pipeline, and on into engineering practice

- South-South interactions – collaborating with a moderately developed country to provide programs that have such countries utilize their expertise to assist lesser-developed countries
- Engineers without borders – collaborating with younger engineers involved in the growing “engineers without borders” movement internationally

CONCLUSION

Give a person a fish and you have fed them for today. Teach a person to fish and you have fed them for a lifetime. And teach them how to process and package fish for export and you have stimulated economic development.

State-of-the-art science and technology capacity must be built in developing countries if they are to be able to compete effectively in the global economy. A well-educated technical workforce pool must be in place in a developing country before technology-based multinational companies will be attracted to make investments there in production facilities and other areas. The day is past when such companies would simply introduce expatriates from developed countries to attempt such operations. Current political and economic realities require that a well-educated and trained indigenous workforce is needed to sustain technically based industrial operations in developing countries. Recent offshoring of operations to countries like India and China by companies in well-developed countries illustrate this point.

A technical workforce pool is also needed to fuel entrepreneurial startup efforts that meet local needs. Well-educated engineers and scientists in developing countries will find appropriate ways to extend R&D results to marketable products and services responsive to local needs – to their personal economic benefits as well as to the economic benefit of their countries. Further development of such entrepreneurial startups can lead to products and services that profitably extend to regional markets, and eventually global markets.

Indigenous science and technology capacity is also needed in developing countries to assure that international aid funds sent there are utilized effectively and efficiently – both for initial project implementation and for long term operation and maintenance. Too often in the past, major projects in developing countries have failed to meet desired and designed objectives because there is not a local base of technically qualified people to assist in implementation in ways that are compatible with the local culture and environment.

Thus it is clear that developing countries need their own indigenous technological expertise. They cannot afford to buy it from developed countries, and even when technical expertise from developed countries is provided by external funding it is often ineffective in appropriately responding to local needs and constraints. Capacity building of technical expertise in developing countries is thus key to enhancing their ability to become economically self-sufficient.

SOLUTIONS FOR MOBILITY

Setting Standards for “World Engineers”

Eng. Barry J. Grear, President-Elect of WFEO, Australia



Eng. Barry J. Grear AO, B.Tech, Grad Dip Bus Admin, Hon.FIEAust, FACE, FIPENZ, FAICD, MAIES, CP Eng, J. P. Barry commenced as an apprentice and then graduated as an Electrical Engineer. This was followed by a period lecturing in Electrical Engineering and then occupying executive appointments in South Australia. Barry’s involvement in the Institution of Engineers, Australia has been extensive. In 1989 he was President of the South Australian Division and was National President in 1997/98. Barry Grear has been active in the World Federation of Engineering Organisations (WFEO) for more than a decade. At the General Assembly of WFEO in 1999 he was elected as a National Member on the Executive, and in 2001 was elected as a WFEO Vice President. In 2005 he was elected as President-Elect and will be President of WFEO from 2007 to 2009. Barry was the inaugural Chairman of the APEC Engineer Register. He is also on the World Executive of RedR (Registered Engineers for Disaster Relief).

Abstract

This paper will encourage the progress of more than 20 years of steadily increasing interest in the development of international agreements which support the academic and practice requirements for:

- Graduate engineers,
- Experienced engineers,
- International engineering registers, and
- Specific purpose bilateral and multilateral agreements.

The paper will review the current experience, comment on the significant differences and propose a way forward for expanding the opportunities for engineers to work across international boundaries. It is expected that discussion by attendees will lead to a formal recommendation to the Committee on Education and Training (CET) for the next stage in the WFEO initiative of the “World Engineer”.

Keywords: *accreditation, engineer, international, registration*

INTRODUCTION

In practice, an idea for a structure, project or product may be conceived by an engineer in one country, it may be designed in one or more countries, constructed or produced with

components from many countries, operated and maintained where used and disposed of with international support.

The concept of an engineer belonging to a “country” in this era of extensive use of the internet and the availability of many internationally recognised engineering “software packages” is challenged, and may be considered irrelevant. It is, however, important for all engineering associations (and governments) to have confidence in the abilities, standards and experience of engineers working across international boundaries.

For decades there have been hundreds of bilateral international agreements and memoranda of understanding which have brought the flexibility and confidence needed. In the last 20 years there has been a growing interest in multilateral agreements for engineering graduates, criteria for working independently and for the recognition of experienced engineers.

This interest is demonstrated in papers presented by Alfredo Soeiro, Alec Hay, Willi Fuchs and others, to this congress.

CURRENT AGREEMENTS

My experience has been directly related to:

- 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.
- The APEC engineer – provides for the mobility of engineers between the signatory economies of APEC. The substantial equivalent criteria are: the completion of an accredited or recognised engineering program; eligibility for independent practice within their own home economy; a 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.
- The Engineers Mobility Forum (EMF) – provides for the acceptance of mutual recognition for experienced engineers from the Washington Accord countries. They have agreed on the broad principles of a framework which removes artificial barriers to the free movement and practice of professional engineers amongst their countries. The substantial equivalence is similar to the APEC Engineer described above.

I am also aware of:

- Bologna Accord – in June 1999, 29 European Countries signed a document called the Bologna Declaration, agreeing to reform higher education to achieve the aim of: creating a system of comparable and understandable degrees throughout the European Union; establish a clear and standard division between undergraduate and graduate studies; promote student mobility among different fields of study, institutes and nations; develop a quality-assurance process and governing body to ensure standard

qualification and quality throughout participating countries; define a European focus for higher education.

- Eur Ing title – The Eur Ing title delivered by FEANI is designed as a guarantee of competence for professional engineers, in order to: facilitate the movement of practicing engineers within and outside the geographical area represented by FEANI's member countries and to establish a framework of mutual recognition of qualifications in order to enable engineers who wish to practice outside their own country to carry with them a guarantee of competence; provide information about various systems of individual engineers for the benefit of prospective employers; encourage the continuous improvement of the quality of engineers by setting, monitoring and reviewing standards.

There are many other agreements with groupings in the following areas:

- The African Section South Africa and others
- The American Section Canada, USA and South America including Mexico
– NAFTA and UPADI
- 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

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

For decades the professional engineering institutions and societies have signed bilateral agreements to encourage the provision of a wide range of activities and the acceptance of recognition between countries. This has allowed, and in some cases encouraged engineering graduates and practicing engineers to get support and work in host countries.

During the last 10 to 15 years there has been an upsurge of interest in arrangements for the international recognition of both undergraduate engineering courses and practicing engineers.

FREE TRADE AGREEMENTS

Complementary to the interest and activities of the engineering societies is the expansion of the government sponsored bilateral and multinational Free Trade Agreements between countries and the World Trade Organisation also continues to promote the interest in trade in engineering services which supports the “Mobility of Engineers”.

THE FUTURE

Now is the time for WFEO (I suggest through the Standing Committee on Education and Training) to gather the information from each of the groups above and any other groups

that have been missed in my summary, so that the information can be available to all and regularly updated.

THE ISSUES

I believe the development of the “World Engineer” could be progressed through a series of workshops where engineering societies could explain the policies and aims of meeting the requirements their accreditation, registration, certification and so on, and where we were able to gain understanding and learn from each other.

The topics in those Workshops would need to include:

- Discussion on the assessment criteria to be applied if the discipline of the academic qualification is different to the current practice discipline
- Acceptance of the delivery of programs in a distance or external studies mode
- The requirements of and auditing systems covering continuing professional development in each economy
- The methodology for undertaking competency based assessments of academic and practice standards
- A matrix mapping of the Regulatory requirements in each economy against the APEC Engineer Framework
- Requirements and definition of continuing profession development (CPD)
- Codes of Conduct, including legal liability issues
- Definitions of key engineering disciplines to be covered by the Register
- Requirements for international review arrangements which will allow confidence between responsible bodies

It is expected that the Workshops would not only provide a better understanding of the role of the regulatory authorities in each economy but would also enable a draft generic mutual exemption model to be developed.

The next step is that 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 would agree to the key areas for negotiation. The subsequent step would be to agree on the broad principles of a framework that might enable progress towards removing artificial barriers to the free movement and practice of professional engineers amongst their countries and engineering societies.

The outcome would be a process by which the substantial equivalence in competence of experienced engineers (those who are approved to work independently and accept professional responsibility for their work) could be established.

The agreement to establish and maintain an International Register of “World Engineers” is intended to provide a framework for the recognition of experienced professional engineers by responsible bodies in each of the signatory countries. In particular, such bodies will be encouraged to use the Register as a secure benchmark for arrangements that 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 the Agreement would be 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 International Register of “World Engineers”.

At early stage in the development of the register it would be preferable to develop a draft Generic Bilateral Agreement as my experience is that they take a long time to negotiate, yet in the end of the process they have great commonality between each one.

I foresee that competency-based assessment will grow in effectiveness as an alternative approach to time-specification of academic and experience requirements.

Complementary consideration needs to also be given to the registration of a World Engineering Technologist and World Engineering Technician. Progress has been made through such agreements as the Sydney Accord, the Dublin Accord and the Engineering Technologist Mobility Forum (ETMF) although it will be more complicated as there are not the wide-ranging accreditation and registration bodies compared to the professional engineer.

It is noted that countries differ in the statutory requirements for accreditation and registration and/or certification for practice. If the key criteria are competence and an open sharing of the processes for assessment then this should be able to be overcome.

In the formal preparation of the agreements, and the subsequent quality control to ensure that standards are being maintained, it will be important for special consideration to be given to smaller countries so that the size of the economy does not prevent the engineers in those countries becoming “World Engineers”. Consideration to a pairing arrangement between larger and small countries may assist the achievement of desired outcomes.

ACADEMIC ENGINEERS

In many jurisdictions there are different requirements for the registration of academic engineers compared to engineers working in an industry or working as a consultant. There is usually a requirement for research or active industrial experience for academics to be registered. Careful consideration must be given as the integration of engineers in academia and industry.

NEW DISCIPLINES

A challenge for the engineering profession in the future is the increasing diversity of the disciplines which are gathered under the banner of engineering. Engineering is a dynamic profession. It has been able to extend its capability through the development of enabling technologies and the increasing interdisciplinary requirements of projects where social and health science specialisation is included.

DECENTRALISED REGISTER

I do not believe that it would ever be appropriate to have a single register. That would be inefficient to maintain and its timeliness in keeping it current would not work. The “World Engineer” register would be a decentralised one with the confidence being maintained between the registering bodies.

A DYNAMIC PROFESSION

The profession of engineering is a dynamic one. Changes in the academic, practice and discipline criteria are continually changing. A reflection on the requirements in 2006 compared with 1986 reveals enormous changes. For example, there was no internet then!

We must expect that the graduate attributes will be changing all the time because of the changing of the knowledge in society.

There will be continuous changes in the output desired/required by the accreditation and registration bodies. That is appropriate and necessary, so the detail will not be as important as the key issue of process of assessment.

THE LABOUR MARKET

The roles in government, industry, commerce and academia undertaken by professional engineers, engineering technologists and engineering technicians are influenced by the labour market. This means that the engineering societies need to continuously monitor the future requirements for the numbers of engineers in all of its specific disciplines so that the world community continues to be adequately serviced by the “World Engineers”.

CITIZENSHIP

Agreement will need to be accepted and understood about citizenship requirements. It is important that immigration is kept separate from the agreement. It may influence mobility but must be seen as a separate issue.

Similarly, citizenship or residential status is a separate issue that may influence mobility.

CONCLUSION

I believe that it would be beneficial to the worldwide engineering profession for us to not delay in undertaking the work that I have proposed above.

World University of Technology

Prof. Włodzimierz Miszalski, President of WFEO-CET, Poland



Prof. Włodzimierz Miszalski Ph.D., D.Sc., Professor of the Military University of Technology (Warsaw, Poland) and Director of Institute of Organization and Management. Before receiving M.Sc. degree in Computer Science and Operations Research in 1972 worked as radar devices' engineer. In 1984 was awarded D.Sc. degree in Technological Science (Electronics) and in 1991 Ph.D. degree in Management. In 1993 graduated from National Defense University (Washington, D.C., USA). Prof. Miszalski has 25 years experience in postgraduate education of engineers – particularly in Logistics and Management. Representative of Poland in Studies, Analyses and Simulation Panel, NATO Research and Technology Organization. President of The Committee on Professional Development of the Polish Federation of Engineering Associations. Chairman of the Steering Committee of the 5th World Congress on Engineering Education held in 2000 in Warsaw. Since 2005 President of the WFEO-CET Committee Prof. Miszalski is author and co-author of more than 200 publications (books, academic manuals, scientific papers) on maintenance organization, decision systems engineering, disaster monitoring and relief systems command, postgraduate engineering education programs and curricula.

Abstract

Since the end of XXth century the range of worldwide engineering has increased sufficiently enough to intensify the discussion on how to meet the requirements of design, construction, maintenance and management of the global scale humano-technological systems. On the other hand since at last ten years we have watched growing internationalization of engineering education (Sorbonne Declaration, Bologna Declaration, Washington Accord) and simultaneous creation within transnational companies – professional training systems for engineers, independent of traditional “national” education and training systems. The idea of World University of Technology – international establishment able to conduct the research on the worldwide scale engineering problems as well as the education of internationally oriented engineers prepared to deal with worldwide technological problems – seems to be a response to the mentioned above challenges. The way to the University and its alternative models have been proposed. The conclusions have been presented on the possible arguments against the idea.

Keywords: *engineering education, international, technology, university*

INTRODUCTION

The idea of International University is at least as old as the idea of the University itself. The Medieval and Renaissance Universities were in fact international educational institutions. Centuries XVII to XX could be considered as the age of shaping and development of national education systems.

At the beginning of XXIst century – on one hand the demand increases for engineers able to work all over the world and to deal with global engineering problems – on the other hand the educational potential: number of academics and universities experienced in international education of engineers [1], volume of knowledge and lessons learned from international engineering projects, growing experience from international exchange of students and educational personnel – seem to be sufficient enough to start thinking on the new model of international education of engineers.

The model should satisfy not only the requirements of the super advanced large scale international engineering projects but as well the needs for executing relatively simple projects and enterprises facilitating and improving the quality of human life in the poorest regions of the world – the challenge which also requires globally thinking or globally oriented engineers.

1. GLOBAL CHALLENGES

Following challenges inspire the considerations on the necessity of the new approach to international education of engineers [2].

- Appearance and increasing number of **global employers of engineers**:
 - worldwide transnational companies and corporations (organizing their own professional training systems for engineers, independent of traditional “national” education and training systems),
 - international organizations and institutions employing engineers within different projects and enterprises (humanitarian, development, international aid).
- Increasing number and variety of **given technical objects** (machines, facilities, plants) as well as **technical procedures simultaneously used in different parts of the world**.
- Growing demand for international (or transnational) staff of managers of their roots in engineering and engineers able to deal with the given **globally spread technique** (technology) independently of the country or the region.
- Appearance and rapid development of international or **global technical systems**: computer networks, satellite communication and navigation systems, worldwide pollution control systems, weather control systems, disaster monitoring and relief systems, spaceships launching, guidance and landing engineering, international energy production, conversion and transmission systems, international logistics engineering.
- Revolution in the sphere of **people’s intercommunication** (internet, multimedia networks, satellite transmission) and its consequences: appearing new methods of work organization, management, furnishing services, learning etc.

The area of international engineering increases from transnational (regional) – through continental – to global enterprises. The question arises what could be the educational response to the demand for qualified personnel for the world engineering. The idea of World University of Technology seems one of possible solutions.

2. WAY TO THE WORLD UNIVERSITY OF TECHNOLOGY

Fig.1 shows the proposed sequential steps on the way to the World University of Technology. Broad international discussion could rationalize the decisions to create the University, to determine its mission and main tasks. From today's perspective the outline of the mission appears as: **“to educate engineers able to work across political, cultural and ethnic boundaries, professionals prepared to deal with the worldwide technological systems and participate in the global scale engineering projects; to conduct the research works connected with the worldwide engineering.”**

One of the tasks could be: promoting mobility of engineers and the well-balanced distribution of engineers employment in different parts of the World. Then as a result of personal characteristics and professional profiles of graduates [2] – the educational programs could be worked out.

Next step could be establishing essential structures of curriculum together with the principles of candidates qualification (selection) and graduates employment. Finally the organizational structure of the University could be designed.

DIFFERENT POSSIBLE FORMS OF THE WORLD UNIVERSITY OF TECHNOLOGY

Several proposals may be discussed on what could be the shape of future World University of Technology like and what would be its relations with the so far existing technical universities. Following variants do not cover the entire spectrum of possible options – additionally different combinations of the variants could be also considered.

1. Federation of several so far existing (in different countries) universities (e.g. most experienced in international education of engineers). Increased exchange of students and professors. Compatible educational programs and curricula. Common system of diplomas (recognized all over the world). Cooperative research programs connected with the global scale engineering enterprises.
2. Multi-campus, distributed university with separate international management (rectorate). Campuses situated in different countries (in different parts of the World) located for instance by the already existing well-known technical universities. Integrated educational program. Common international faculty (e.g. posted to the world university from different national universities). Unified system of diplomas, curricula, students projects and practices connected with global scale engineering projects. Integrated research program.

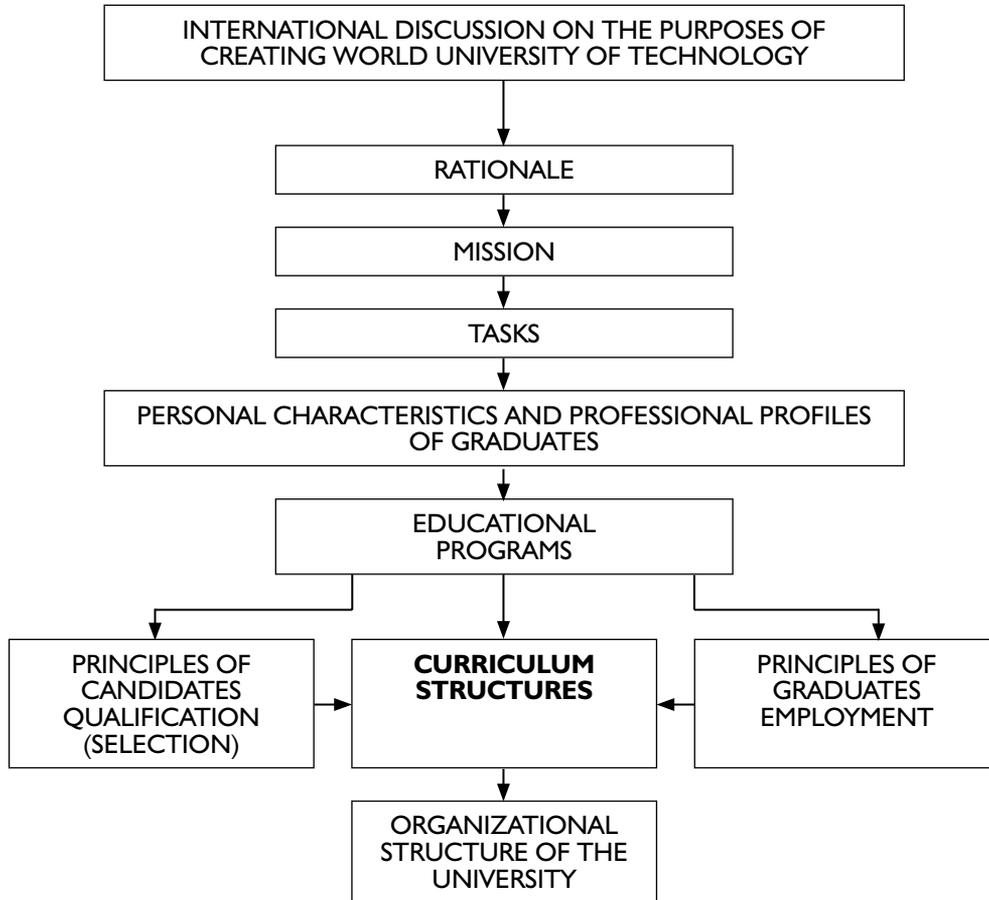


Fig.1 Steps on the way to the World University of Technology

3. Single-campus university. Specially selected international core faculty working mostly on site plus visiting and invited professors and lecturers from different countries. Students (e.g. awarded international organizations' scholarships) from all over the world, participating in engineering projects and research works connected with worldwide engineering activity. Own unique world-oriented curricula and research programs. Extended system of post-graduate curricula oriented towards the global-scale engineering projects (separate post-graduate courses for engineers – managers). Unique diplomas of high prestige – recognized and appreciated all over the world. Special employment and professional development system for graduates connecting their professional careers with the worldwide scale engineering activity.
4. Virtual university based on the distance learning educational programs [1] and the most advanced multimedia communication techniques. Connected with several

well known technical universities in the World. Managed by the team selected from different countries. Well equipped with necessary technical devices. Publishing and distributing kits of CD-s with best lectures, exercises, CAD – type programs etc. Unified world-oriented curriculum. Special system of tests and examinations under the supervision of international board.

5. Mixed real-virtual university of small-scale located by one of the famous universities of technology – basing on the faculty, equipment and infrastructure of the university, supported if necessary by international specialists. Organizing and conducting short summary curricula – particularly on demand of international institutions and organizations dealing with the global-scale engineering projects.
6. The postgraduate only – prestigious international educational establishment conducting the top quality “masters” courses led by famous worldwide known engineers. Also international forum of exchange knowledge, experience and new ideas in the world engineering.

The presented above options should be regarded as an inspiration to the ideas and discussions on the shape of the World University of Technology rather than as determined solutions. For the author the most ambitious seems option 3 but it seems the most arguable as well.

CONCLUSIONS

First step on the way towards the World University of Technology seems to be opening broad discussion on the rationale, mission tasks and shape of the proposed educational and research institution. Author hopes this paper will initiate the international exchange of views and thoughts – particularly within the circles interested in international education as well as in international activity and mobility of engineers. It seems impossible to avoid controversies and difficult questions like for instance: what is the reason for creating the new engineering education institution while many so far existing technical universities are indicating shortage of candidates for engineer profession or are not the presently conducted international curricula and exchange of students sufficient enough to fulfill the needs and requirements of international activity and mobility of engineers. Among several possible answers one seems to be the most adequate to the present day appeal for the mobility of engineers. The not too distant – predictable future will bring significantly increased demand for the global scale engineering projects meeting the requirements of sustainable development, global security, environmental problems, disaster monitoring and relief. Shaping the new personality and professional profile of engineer of international orientation – free from national or regional biases – prepared to handle global challenges – will be necessary as well as the research works connected with the worldwide scale engineering projects. Although the top class of engineers-internationals has already appeared forming (like famous international artists or sportsmen) the elite of “masters” – the growing demand for the “middle class” – mobile, flexible, able to work effectively in any country – is noticeable.

Preparing professionals to deal with engineering enterprises all over the world the World University of Technology would contribute to shaping global society.

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Globalisation and the Mobility of Engineers Integrating the International Education Engineers in the Curriculum, the European Experience

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Abstract

Developing the international mobility of engineers is a key issue. One can easily find tracks of such a preoccupation in examining the archives of engineering institutions as well as of engineering schools. A strengthening of the internationalization of engineering practices and engineering education programmes can be observed in the three-four last decades. The trend is obvious within Europe and many efforts were done in order to facilitate the mobility of engineers and of engineering students, staffs and researchers. Very recently, the Bologna Process aiming at creating an European Area in Higher

Education leads to a new step which consists in a total re-organization of the higher engineering education system in Europe, introducing also new ideas about competencies recognition. Looking at the consequences of the globalisation on engineering education, it is time to define some measures for an intelligent adaptation of the engineering curriculum and pedagogy to that new context.

Keywords: *globalisation, mobility, engineering education, Bologna process, accreditation, harmonization, internationalization*

Mobility is more and more becoming a key development factor for any professional – whatever the domain – who wants to find interesting jobs and to get a good salary and satisfying conditions of employment. Mobility of manpower, of professional competences and resources (like mobility of financial resources) is also crucial for any company or organisation which has to compete on a more “global” international market. But mobility can also generate problems, which can be counterproductive for the global economy and for people, if one does not take into account the cultural roots without which it is hard to survive and if one does not consider the need for a balanced sustainable future.

In the 60s-80s, mobility was a concept largely promoted by companies managers as well by specialists working in the fields of innovation and of human resources development. Mobility seemed to be the miraculous solution for fighting the traditional trends towards conservatism. At that period, Toeffler (The Future Shock) developed the idea that people should be encouraged, trained, to change everything, in their professional life as well as in their personal life, in a new international context offering more and more interesting possibilities. Reading again such a book in 2006, it is obvious that Toeffler’s vision was right, but certainly he failed in considering that the society would have changed rapidly. It is only now (the first years of the 21st century) that we are forced to consider mobility not only as a “plus” in career, but really as an obligation.

1. What does mobility mean? What are the many dimensions of mobility and its benefits and its limitations or constraints? And is there some specificity of engineers mobility?

Mobility is often limited, in the professionals’ debates, to the physical mobility, that is to say to traveling, studying and working abroad. Of course, this geographical mobility is the most obvious facet. However, it is important also not to forget other dimensions of mobility:

- professional or job mobility: how many times should engineers change their jobs in their life? How many companies should engineers have experienced? How many projects should engineers have managed for being considered as good ones?
- social mobility: involvements, responsibilities, representative activities in various organisations ...;
- cultural mobility: sharing views (or life) with people from other cultures for better understanding that the world is not based on a unique, linear thought;
- transdisciplinary mobility: should engineers develop other skills than pure scientific and technological ones?

- methodological mobility: problems can be solved through different ways, with different methods: how engineers are able to become flexible in that domain?
- technological mobility: it is clear that tools are rapidly changing and they can become obstacles if one is not able to use them with some distance.

In other words, mobility can be linked with mental flexibility and thus, with innovation. Mobility is a way to think one's behaviour in given contexts; it allows adaptation to these contexts, it facilitates cooperation, synergy, cross-fertilization. What we have learned from the literature about innovation and also from the concrete experience of a day-to-day engineer life, is that we generally miss opportunities by lack of mental flexibility and that we are blocking progresses because we are not mobile enough (in a global sense of the word). As consultant working with companies on that issues, I must recognize that they generally are not putting enough emphasis on the promotion of the global mobility of their employees (except to ask them to find another job...): few training sessions are devoted to the development of flexibility and mobility. In other words, a very short term approach...

2. What's about engineering education? Are our engineering courses, programmes, universities taking into consideration the development of the global mobility of the young engineers?

In the past, I had the chance to work in a very old and prestigious institution, the Ecole Nationale des Ponts et Chaussées, founded in France in 1747 and I had the chance also to access to the archives of the Ecole. I discovered that the Ecole knew different active periods of development and innovation followed often by long periods of conservatism and stagnation. The vision of the “managers” of the institution during the more progressive periods was very interesting. Most of the efforts were put on key issues:

- promoting open, interactive learning approaches or methods (avoiding rigid traditional courses);
- putting emphasis on the proper work of the students or young engineers (projects, site realizations,...);
- making the young people aware of a broad competitive environment (learning from the experience of others,...);
- offering the possibility to some students to travel abroad for periods of six months at least (this was developed since the last decades of the 18th century), with some “business intelligence” work to do;
- creating tools for the dissemination of ideas and projects, pushing also the engineers to publish in some new specialized journals;
- developing a strong experimental use of new information technologies (lithography, photography,...) for facilitating the transfer of multidimensional knowledge among the engineers community;
- strengthening the links with partner institutions, also with scientific and engineering academies and with companies;
- promoting the learning of foreign languages and inviting foreign experts to deliver courses in the Ecole.

In other words, these clever people in charge of preparing the young engineers for their future jobs, had in mind a real and strong vision of what should be a “mobile” engineer, of what should be developed as “mobile” behaviours and competencies.

Analysing the results of such policies (what the educated and trained engineers became and did for the society), I must admit that there is no reason to reject such progressive ideas. On the contrary, I discovered, also when consulting the archives of the School, how much these ideas were fought, even by some well-known scientists (for instance in France, by a group of “positivist” engineers during the years 1820-1850); and often these conservative trends imposed their law with some very rigid approaches of education:

- multiplication of specialized courses (the “content” approach of education);
- compulsory courses, with control of the effective presence of the students;
- poor evaluation methods (exams easy to organize);
- imposing the same programme to every students whatever their routes or origins;
- limiting the periods abroad for students (lack of time for training them);
- creation of rigid textbooks, etc.

More recently, after May 68, a lot of new perspectives were opened. Thus in France (but also in many European countries as well as in America), many pedagogical innovations were stimulated. The key words of the innovations were flexibility and mobility. It became obvious that engineers (especially young engineers) should be prepared for a more open professional life. Continuing education (long life education) started to emerge as a key issue. Active learning methods were encouraged. Flexible courses were proposed with many choices among various possibilities. The innovative experiences of these 20–30 last years were more and more well known, thanks to the development of Journals such as the European Journal of Engineering Education and to the SEFI annual conferences and others

Mobility was also viewed at that time as an interesting possibility to cross borders, to facilitate links with industry and with other academic institutions. Joint courses or programmes were established and proposed to students. Some engineering schools started to propose “Double diplomas” or “Integrated courses”. Years after years, it became obvious that one had to encourage young professionals to have experiences abroad, to learn from different cultural perspectives. At that time, the support of the European Commission was essential and one could now look back to that period with much historical interest.

3. What’s for the present decade? What are the change or innovation factors and the new global perspectives that lead to re-think and re- interpretate the concept of mobility?

Just comparing two periods – on the one hand, the years 1990–95, on the other hand, the years 2005–2010, one can easily identify new determining changes that have an impact on higher education and on engineering education:

- globalisation considered as a new dimension of economy, with the development of international markets for everything: products, raw materials, resources, manpower, services, ideas; companies are directly impacted, and now universities too;
- information and communication technologies (Internet, the digitized document, the multimedia, the networks): they are penetrating many domains, they are changing habits, they make the people more and more autonomous; education is of course immediately impacted (though much resistance from teachers);

- competences issues considered as the way to move beyond the traditional approaches of defining jobs and skills: outcomes of an educational process are becoming more important than the way how to achieve them; evaluation and recognition of real competences are in the heart of many international debates;
- sustainability or sustainable development is also a new key factor, especially when considering the evolution of engineers activities and education; sustainability means thinking and acting with a long term vision, with an integrated multidisciplinary approach, with a global analysis of what happens.

One could also mention the emphasis put on ethics, the development of biosciences and biotechnologies, the strengthening of legal or juridical constraints, and – we do not forget it – the rapid development of terrorism which can oblige engineers and engineering educators to have another look at their job, at their career and at their professional and citizen behaviour.

In Europe, specific issues can be mentioned which also lead to more flexibility and mobility:

- the enlargement of the European Union, with the participation of countries from the old East Block;
- the Euro currency that makes easier the comparison between prices (but creates also new problems);
- the specificity of the various National policies which makes difficult the evolution towards global and harmonized perspectives.

Looking at engineering education more precisely, we can point out the crucial issue of non-attractiveness of studies in that field: will the pipe-line be correctly fulfilled in the future or do we have to look at new ways or resources for the recruitment of engineering students?

For all these reasons, one has to invent new ways for educating and training engineers, with the crucial aim to make them much more flexible and mobile.

4. The European perspective for more global mobility in Higher Education: the Bologna Process and its impact on Engineering Education

For long time, Europe did not exist as such and was just a juxtaposition of Nations jealous of their autonomy. Everything was and is complex in Europe due the existence of a huge diversity (on very few distances) of policies and practices. This is really true in the field of Higher Education and, for long time, the “intra-European” mobility was quasi impossible or, if not, rare. During the 70’s (and thanks to a new European common policy), one started to promote the mobility of students and staffs. But despite the true success of many initiatives in that field, one has to recognize, at the turn of the century, that the intra-European mobility of people remains low. In a more and more international world, the European system of Higher Education seems to be not able to attract students, staffs and researchers from other parts of the world. There is also a lack of global visibility and eligibility of the European system.

For these reasons, National Ministers of Higher Education from various countries decided to build a new global, common, policy which started in 1998 with the Sorbonne Declaration and in 1999 with the Bologna Declaration. The main goal of this policy is

to prepare the convergence, in 2010, towards what was called an **European Higher Education Area**.

One has to point out here the fact that the chosen method is very original and clever. Politicians just define the asymptote line and the goal and put emphasis on some key general issues (compatibility, recognition, legibility...) but do not define everything in details at the European level. It is up to the various countries to make appropriate decisions for the adoption of the agreed common schemes and it is up to the various stake-holders (Universities, professions,...) to set up the detailed programmes, tools and rules. Every two years, Ministers meet in order to evaluate the progresses and to make decisions for the next steps. In other words, much flexibility on the one hand, and a clear vision and strong determination in terms of where to go and how to go on the other hand.

One has here to add that the convergence towards an European Higher Education Area does not mean "uniformisation". On the contrary, one recognizes the importance of the diversity of systems and solutions and one considers that such a richness should not be destroyed by too normative decisions. What has to be done is to define and accept a minimum of common rules that make the diverse National systems more compatible. And at the end of the process, mobility of people as well as ideas will become easier.

The main component of the Bologna Process consists in setting up a unique scheme of articulated degrees in Higher Education: **the 3–5–8 scheme**. A first degree (Bachelor) after around three years of studies would be followed by a two years period with a Master degree; then a Ph.D. could be obtained after three post-graduated studies. This common scheme could seem not very new and original, but taking into account the diversity of National solutions, it is true that the decision appears quite revolutionary. The various countries are now trying to adapt their National system to the common scheme (of course with many differences in the way to solve the problem). For Engineering Education, there are no serious difficulties except that the existence of two types of engineers (production engineers with a short education and scientific engineers with a longer education) creates some specific problems.

Besides the 3–5–8 scheme, the Bologna Process focuses on two other tools:

- the **Diploma Supplement** consisting in a document which provides necessary details about the studies in a given country, in a given institution for facilitating the mobility of people;
- the **ECTS** (European Credit Transfer System) defining a set of common rules for the "measurement" of educational modules in terms of length and load; each study course or programme should be designed as a set of modules, each of them corresponding to a certain number of ECTS Credits; again a solution for facilitating the mobility of students during their studies.

Another important issue of the Bologna Process consists in trying to harmonize quality assessment procedures in Higher Education and also in defining common rules for the accreditation of study programmes. But in that domain, the solution consisting in creating a unique European body or agency for accreditation is unanimously rejected. For Engineering Education, efforts were made during the 5 last years in order to solve the problem: creation of an Observatory "OESOPE" in 2000, then in 2005 a European Project EUR-ACE for setting up an European System for Accreditation of Engineering education. Progresses in that field are slow but real and one can hope to deliver the first European accreditations in 2006 (based on a set of common rules shared by the various National accrediting bodies).

Many other aspects of the Bologna Process could be mentioned here (competences evaluation and recognition, life long learning, development of an European Research Area). But what is important to say about the Bologna Process is it certainly forced governments, administrations, academic institutions, professions, employers... to re-think and re-define together the traditional approaches in the field of Higher Education. Everybody agrees that it is an important step towards a more flexible and legible educational system, with at least a potential increased mobility of people.

Last but not least, this European effort for convergence, harmonization, legibility is viewed with much interest by other Non-European countries which are also working on reforms of their Higher Education policies. The tools set up in the context of the Bologna Process could also be adapted and used in other continents, especially in the field of engineering education.

5. Towards a global, integrated and “postmodern” mobility of engineers and engineering students

In a post-modern age characterized by a more global economy and by the emergence of an information and knowledge era, it is no more possible to think at education and especially engineering education using the same concepts than those developed and used during the 50–100 last years. Mobility is becoming a key word, a key concept. It is often associated with adaptability, flexibility, reactivity, interactivity, fugacity. Living and moving in instable environments are also becoming a reality for many people, among them engineers and obviously young engineers and engineering students. We have now to help the young generation to face this new situation with positive answers.

Mobility does not mean, as perhaps we considered it during the 70's, and 80's that everybody will move, will work in other countries or continents. This is no more necessary for many of us, thanks to the digital and network revolution. Mobility is becoming more and more “virtual”, people working and acting locally but thinking globally, internationally. In other words, stimulating the mobility of the minds is certainly the key issue for the educational programmes and policies in the future.

In concrete words, that means:

- adopting rules and tools allowing the international comparisons between courses, programmes, degrees at international level as well as the recognition of studies and competencies;
- defining more precisely outcomes of educational programmes, focusing more on competencies than on loads in terms of number of hours of study;
- introducing much more diversity in the design of the courses, integrating more “foreign” inputs and perspectives, combining elements from various origins...;
- putting more emphasis on transversal issues (sustainability for instance), inter- or trans-disciplinary learning activities;
- requiring the learning and the practice of several foreign languages, introducing intercultural perspectives even in very scientific and technical subjects, inviting more foreign experts and teachers to take part in local educational courses;
- using systematically on-line and digitized resources, at world-wide level, integrated in the normal courses; making students able to benefit from the digital environment;

- stimulating works on joint projects, associating different universities and industry (learning from outside the walls);
- encouraging students to spend a substantial part of their studies in foreign environment but recognizing and integrating the outcomes of these experiences for their “local” degree;
- using life long learning (continuing education) in the aim to develop skills and competencies for working in a more global world and for becoming more mobile.

It is not possible to define here a detailed programme or agenda. However, it is important and urgent to open the debate on what could be called a global, integrated and “post-modern” mobility of engineers and engineering students with consequences on engineering education.

Two issues of the **European Journal of Engineering Education** are devoted in 2006 to globalisation and to mobility. This is an obvious sign that it is time now to debate and to invent new ways for engineering education in the next decade.

Role of Innovation and Entrepreneurship in Engineering Education for Promoting Global Competitiveness

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Abstract

Innovation is increasingly being recognized as the key to technology and business competitiveness. This paper explores the anatomy of Innovation, and attempts to

identify the key success factors promoting Innovation. The nexus between Innovation and Entrepreneurship is explored, and the desirable characteristics of Innovators and Entrepreneurs are highlighted. A number of Case Studies drawn from across the globe provide valuable lessons for promoting and sustaining Innovation in the national Education and R&D systems.

Keywords: *innovation, entrepreneurship, engineering education, competitiveness*

1. THE ANATOMY OF INNOVATION

Innovation stands for new products, new information, new knowledge and new services. It stands for renewal; recreating oneself. It requires imagination and insight. "It is more than just invention and marketing; it should extend the realm of possibilities of the organization and its people. It implies thinking beyond traditional boundaries". One creative artist explained: "Creativity is in that which I do, and not in me".

It is frequently observed that the same creative individuals will be more creative in certain environments than others. Our high-quality manpower which prefers to go abroad to pursue their professional careers, characterized as Brain Drain, cite the lack of a challenging and fair work environment as the principal "push factor" for their decisions. It is pointed out that the demanding environments abroad provide: a strong focus; a general awareness of new ideas; an open atmosphere for discussion; and a healthy balance between individual competition and social co-operation.

Kito de Boer [1] believes that Innovation per se is not a "good thing". The only universally "good thing" is performance. Good Innovation must be both new and also create wealth. Newness can come from 3 sources – preferably in combination: new to the consumer; new to the producer; and new to the channel. According to him, Innovations incorporate new *Insights* about the consumer, new *Technologies* that reinforce the producer's competitive capability, and new *Business Processes* to improve the ability of the corporation to deliver value.

2. ELEMENTS OF THE "ENVIRONMENT" IMPACTING ON INNOVATION

In his Presidential Address to the 2005 Annual Meeting of The National Academy of Engineering (USA) recently, Professor William Wulf has pointed out that "the phenomenal transformation of our quality of life has been fuelled by innovations created by engineers, and the pace of innovation, if anything, is accelerating". In fact, the NAE (USA) has compiled a list of the 20 greatest engineering achievements of the twentieth century.

While there is a widespread consensus that innovation is crucial for prosperity and competitiveness, Wulf asserts that there is no simple formula for innovation. However, a "multi-component environment" "appears to collectively encourage or discourage innovation. He lists the following as some of the essential components of this environment:

a vibrant research base; an educated workforce; a culture that permits, even encourages, risk-taking; a social climate that attracts the best and brightest from anywhere in the world to practise engineering; “patient capital” available to the entrepreneur; tax laws that reward investment; appropriate protection for intellectual property; and laws and regulations that protect the public while encouraging experimentation.

3. THE NEXUS BETWEEN INNOVATION AND ENTREPRENEURSHIP

Radcliffe [2] has described the inter-relationship of innovation and entrepreneurship. He distinguishes between creativity as “finding, thinking up and making new things (knowledge for its own sake)”, and innovation as “doing and using new things (creation of new wealth)” and describes entrepreneurs as “catalysts for change by converting opportunities into marketable realities”. He quotes IPENZ [3] that “innovation is the art of creating something new and worthwhile, entrepreneurship is the art of carrying an innovation to market in a commercial manner”. Innovation is often about “taking an idea that is obvious in one context and applying it in a not so obvious way in a different context”.

The 3M Company defines innovation as “new ideas plus action or implementation which results in an improvement, gain or profit”. It identifies three types of innovation: new market or industry; changing basis of competition; line extension. In line with the blurring of innovation and entrepreneurship in its definition, 3M has adopted the word “inventorpreneur” to describe its outstanding innovators. They invent or create a new product that fulfils a defined need; promote the new opportunity or product; and manage, organise and assume many risks in establishing a new business based on that product”.

It is also pointed out that innovation is more about creating environments that foster innovation than about brilliant individuals. An “innovative environment” has been characterized as one that: is trusting; is open to new ideas and alternative approaches to solving problems and exploiting; operates in an environment of flexibility; is goal-directed with a sense of purpose; and demonstrates that innovation is valued and recognises innovative achievements.

4. DESIRABLE CHARACTERISTICS OF INNOVATORS AND ENTREPRENEURS

The 3M company looks for people with specific traits as indicators of their potential to be innovators: creative; broad interests; problem-solver; self-motivated/energized; strong work ethic; resourceful.

Williams [4] “describes entrepreneurs as people who have both the will (e.g. desire or motivation) and skill (e.g. the ability) to project an idea or scheme into the future by backing their judgement with innovative action and persistence in order to turn that idea into reality”. He also points out that they tend to be: creative individuals with a never-ending supply of ideas and schemes; action people who make things happen; catalysts (initiators of change); aggressively ambitious and highly competitive; moderate

risk-takers (not risk-averse but not gamblers); self-reliant and independent; resourceful and shrewd; highly tolerant of ambiguity and uncertainty; determined, optimistic and persistent; and very future-oriented.

It is pointed out that the underlying factors responsible for success as innovators and entrepreneurs have been known for some time, and have not changed in spite of significant changes which have taken place in technology, business and society. As may be expected, the characteristics of the innovator and the entrepreneur overlap.

Radcliffe [2] points out that innovation is not determined solely by the skills and attitudes of individuals or even teams. Performance also is dependent upon the tasks being undertaken and the work environment. Williams asserts that “entrepreneurship is what entrepreneurs do rather than a list of personality traits”. “Innovation and entrepreneurship are contextual, enacted and holistic activities” and consequently, “attempts to extract their elemental parts via a reductionist paradigm for inclusion in a curriculum are likely to fail”.

5. INNOVATION PROMOTION INITIATIVES IN THE ACADEMY

5.1 Foundation for Innovation and Technology Transfer (FITT) at IIT Delhi:

FITT was established as a Registered Society in 1992, with the mission: “to be an effective interface with the industry; and to foster, promote and sustain commercialization of S&T in the Institute for mutual benefits”. Among the key terms of reference are: to add commercial value to academic knowledge and to market the intellectual and infrastructure resources of IIT Delhi for national development”.

5.2. Society for Innovation and Development (SID) at the Indian Institute of Science(IISC):

SID was founded in 1999 with the mission: “to enable India’s innovations in S&T by creating a purposeful and effective channel to help and assist industries and business establishments to compete and prosper in the face of global competition, turbulent market conditions and fast-moving technologies”. It has a symbiotic relationship with IISC in an industry-friendly as well as a faculty-friendly way.

6. CASE STUDIES

The following Case Studies, drawn from different countries, illustrate the different strategies adopted for promoting and sustaining innovation in technology and business.

6.1 Case Study – I – Growing Ontario’s Innovation System: The Strategic Role Of University Research [5]:

Heather Munroe-Blum, with James Duderstadt and Sir Graeme Davies, completed a Study in Dec. 1999 for advising the Ontario Government on strategies to be adopted to improve the Province’s global competitiveness. It was pointed out that “Productivity and Innovation are the strongest determinants of standard of living in the knowledge-based society, and provide the only direct route to recession-proofing the economy,

and achieving broad economic and social benefits”. *Research performance* is a robust predictor of productivity and innovation. Innovation involves *leaders* – talented, educated people, with a variety of experiences and skills. Innovation draws on the full range of: sciences; humanities and social sciences; basic and applied research; and on technology; judgement; action; timing; and investment.

In the global knowledge society, the Report emphasized, that *speed* wins. *Talent* was identified to be the primary strategic resource for innovation. “Talented people and knowledge are at the heart of innovation, sustainable growth of good jobs, and the health of nations”. Universities and university research are the chief suppliers of a nation’s knowledge, knowledge workforce, and innovative technologies. This is particularly important because talented people and knowledge are fast replacing financial and physical capital as the means to achieving prosperity and economic security.

The following recommendations were made in the Report: create an optimal university research policy environment for innovation; grow talent and university research competitiveness, and construct a world-class infrastructure; expand the impact of university research and foster entrepreneurship; foster local, national and global innovation networks and global profile; and celebrate our people, achievements and success.

It was proposed that “Innovation will be advanced by a strategic university research policy reflecting principles of: academic/scientific autonomy, competition, disciplinary inclusion, excellence, distinctiveness, vision, teaching-research synergies, service impact, and means of recognizing, rewarding and celebrating talent and achievement. Private sector investment should not displace sustained public investment in university research, but rather serve to grow the broad platform of investment in research; implementation and administration of university research policy and programs must be simple and responsive; proliferation of regulation and bureaucracy paralyze innovation. Attracting and retaining superb graduate students is essential to growing the next generation of talent”.

The ratio of Gross Expenditure on R&D (GERD) to total GDP: (GERD/GDP) is one of the most robust indicators of an economy’s innovation and research. A 1999 OECD study benchmarking knowledge-based economies revealed the following (for 1997): Research of OECD countries averaged: 2.2%; Sweden: 4%; Finland, Japan, Korea, US: 3%; and Canada: 1.6%.

6.2 Case Study – II: UK The Innovation Report: “Competing In The Global Economy: The Innovation Challenge” (17 Dec. 2003)

This Report looks at the contribution that Innovation can make for driving productivity and to achieving the vision of the UK as a key knowledge hub in the global economy. The contents of this Report are: Chapter 1: The innovation challenge; Chapter 2: High-performance innovation companies; Chapter 3: Technology Innovation; Chapter 4: National innovation assets; Chapter 5: Innovation policies across Government; Chapter 6: Regional innovation; and Chapter 7: Global links. It is pointed out that Innovation matters because it can deliver: high value-added products and services; new, cleaner and more efficient production processes; and improved business models.

The information is organised under six key themes: Knowledge Transfer: between business and the science base, from business to business, and in collaboration with international partners; Innovation in Procurement: using Government's enormous purchasing power to stimulate innovation; Skills and Workplace: Supporting high-level skills and high-performance workplaces; Regional Innovation; Regulatory Framework: IPR, standards and regulations that support innovation; and Small Businesses Supporting entrepreneurship and small businesses as key sources of innovation.

6.3 Case Study – III: 2005 Value – Added Scoreboard – The Top 800 UK & 600 European Companies By Value Added – Dept. Of Trade & Industry (DTI) – UK

Value Added is defined as the wealth created by activities of a company and is specifically designed for the scoreboard as sales less the cost of bought-in goods and services. It can be calculated from a company's audited annual accounts. It was pointed out that US and Japanese companies do not disclose enough information in their accounts to enable value-added to be calculated. The Scoreboard is intended for 3 main audiences: companies – for benchmarking; investors – to provide perspective on a company performance; policy makers in business, sectoral and government organisations.

6.4 Case Study – IV: R&D Scoreboard 2004 – UK

In his Ministerial Foreword – Lord Sainsbury, Under Secretary of State for Science and Innovation, points out that Innovation is at the heart of productivity growth, and R&D is one of the key drivers of innovation. The R&D Scoreboard highlights the relative strength of the UK economy in some R&D-intensive sectors such as: pharmaceuticals & biotechnology, aerospace & defence, and health, where both the UK's proportion and intensity of R&D are at or above international levels.

What the R&D scoreboard contains: Details of R&D investment; capex; sales; profits; employee numbers; growth of these quantities; key ratios; and market capitalisations, for UK and international companies. All data are extracted directly from company annual reports & accounts; and key ratios are calculated for each company and sector. Companies are classified by FTSE sector and by country.

What the Scoreboard does not say: That the R&D reported in company's annual accounts is the only measure of innovation. Other methods of gaining competitive advantage include: investments in capital equipment; market development; skills; new ways of working; new business processes; other intangible assets; and linkages with other organisations.

6.5 Case Study – V: Germany's Technological Performance Report To Bmbf, 1997

It was pointed out in this Report that the prospects for the Future were good because of the foundation provided by five factors: highly skilled labour force, particularly in fields that are key to Innovation in the technological and organizational areas; productive, high-powered R&D facilities that produce marketable S&T findings; broad store of know-how in firms; intensive application of know-how in Industry, and integration of generic technologies into the broad industrial spectrum; and industry's highly developed ability to translate know-how into technological innovations, products for global markets, and top-quality services and processes.

In the matter of R&D and Innovation Systems, it was pointed out that decoupling R&D efforts and successful innovation would only work for a short time. A good business outlook is a vital pre-requisite for expanding R&D capabilities. Internationalisation of R&D was progressing rapidly in research-intensive industries, such as Telecommunication and Semiconductor Products. It was also shown that Innovation has a selective impact on the job market. Employment among the highly qualified was rising, whereas unskilled labour was experiencing a worsening situation. This trend was found also in the service sector, which was looked upon as the magic remedy for alleviating unemployment problems.

This was also the case in the US, where even a booming job market could not close the growing gap between rich and poor. Innovation leads to job cuts because it raises productivity levels. On the other hand, without innovation, international competition would be a direct threat to unproductive jobs. Hence, there is no alternative to innovation-oriented policies.

Germany's national innovation system is described as "a model of cooperative consensus". It does not produce as many "radical innovations" as in the US, where new technologies have only loose ties to prevailing industrial structures. In Germany, innovation develops primarily on an "incremental" basis, as the result of close cooperation between Science, Research and Industry. Innovators in Germany are similar to a centipede: "They move forward slowly – but systematically and surely – on their many legs".

7. THE INNOVATOR'S DILEMMA – CLAYTON M. CHRISTENSEN, 1997

Clayton Christensen, in his insightful book, postulates that the logical, competent decisions of management that are critical to the success of their companies are also the reasons why they lose their positions of leadership. "Good" companies often begin their descent into failure by aggressively investing in the products and services that their most profitable customers want. An organization's historical choices about which technological problems it would solve and which it would avoid, determine the sorts of skills and knowledge it accumulates. Firms fail when a technological change destroys the value of competencies previously cultivated, and succeeds when new technologies enhance them.

When *disruptive* innovations – which are typically cheaper, simpler-to-use versions of existing products that target low-end or entirely new customers – emerge, established companies are paralyzed. He calls this phenomenon "asymmetric motivation". He identifies it as the core of the "innovator's dilemma", and suggests that it is also the beginning of the "innovator's solution".

7.1 Peter Drucker's new rules for R&D

Peter Drucker, who has been quite successful in advising the corporate sector to successful performance and in defining the future course of management paradigms, has proposed some new rules for R&D. He proclaims that R&D should be business-driven, not technology-driven. According to him, the starting points of the new R&D paradigm are the business goals and strategy of the firm; for example, RCA color TV, and Sony

VCRs, fax machines and copiers. First-rate R&D labs need to be set up as free-standing businesses. The R&D function would be better managed by a “Technology Manager” than a “Research Director”.

Every new product, process and service begins to become obsolete from the time it breaks even. In the context of result-based approach to R&D, any distinction between “pure” and “applied” research is meaningless. In effective research, physics, chemistry, biology, math, economics, etc. are not “disciplines” with determinate boundaries; they are tools and resources for creative use towards accomplishing performance objectives. R&D work comprises three different but complementary dimensions of effort: improvement, managed evolution, innovation. R&D efforts should aim high to make a real difference in the customer’s life or business. Effective R&D requires both long-range and short-range results. Effective R&D requires “organized abandonment” of products, processes, services and research projects, when: there are no more significant improvements; new products, processes, markets or applications no longer come out of managed evolution; and long years of research fail to produce commercially useful results.

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NATIONAL EXPERIENCES IN EDUCATION FOR MOBILITY

Mobility of Engineers in The Latin American Area

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Abstract

Latin America has an old tradition in mobility agreements for university professionals. Six South American countries signed the first, in Montevideo in 1889. It allows any native with a valid degree to practice in the other signatory countries. The wide mobility agreed was justified by the scarcity of professionals in the Region. Until 1998 another twelve agreements were signed covering all the Latin American area. In 1991 the Mercosur is born, a Free Trade Agreement between four countries that is complemented in 1992 with general criteria for the mobility. Engineering has made progress in the implementation of common dispositions for the acknowledgement of degrees by means of bilateral Agreements between the Registration Bodies of each country. The support of Educational Mercosur was decisive.

Other agreements are analysed. The controversial ALCA (Free Trade Area for the Americas) sponsored by USA, and NAFTA. ALCA is not equilibrated to harmonize the internal regulations of the countries and does not eliminate the existing differences.

AN ANCIENT TRADITION FOR MOBILITY

Long before free trade agreements started to be signed between countries and regions with the purpose of mobilizing products, services and moneys, in Latin America there existed agreements for the mobility of professional services aimed at facilitating

exchange between countries of people with university degrees capable of complying with the demands shown by a certain country in the region where the growth of population, mostly immigrants, was the step that followed its independence from the colonization of Spain and Portugal. These treaties, agreements and conventions had in common the generous spirit of complementation between countries of similar development, with cultural and language identity and respectful of their respective sovereignty and habits.

The first Latin American regional agreement better known as the “**Montevideo Treaty**” was signed in that city in February 1889 and included Argentina, Bolivia, Paraguay and Peru joined later by Colombia and Ecuador. Article 1 of this Treaty shows the generosity of its objectives: “Any native or foreigner that in any of the signatory States, possesses a degree or diploma granted by a competent national authority, to practice liberal professions, are considered apt to practice in the other States”. The broadness of this Treaty seems to show a certain resignation of the States to exercise their control faculties on professions that could mean a social risk, a control that exists today in all countries, regarding degrees granted by their educational institutions.

The Montevideo Treaty is followed by the “**Mexico Convention**” on liberal professions. Signed in January 1902 by Bolivia, Chile, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Peru. With an amplitude similar to that of the Montevideo Treaty but with certain reservations for the degrees of Surgeon and Chemist. Apparently this Treaty did not consider that the activity of engineering could bring risks to health and welfare of people. Other Agreements and Treaties refer to the mutual acknowledgement of university degrees: 1908 Argentina, Peru; 1911 Bolivia, Colombia, Ecuador, Peru and Venezuela – Bolivarian Convention – 1916 Chile, Uruguay; 1917 Chile, Ecuador; 1921 Chile, Colombia; 1939 Ratifying the Montevideo Treaty (1889) but with larger demands: Argentina, Paraguay, Uruguay; 1962 Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua; 1992 Argentina, Colombia; 1994 Argentina, Ecuador. The Treaties and Agreements mentioned so far were signed by Ministers of Education representing the Governments and ensured mobility of professionals with university degrees in the signatory Latin American countries. Most of these Agreements are still in force. It is remarkable that Brazil has not taken part in any of these Treaties which included practically all Spanish speaking countries of the American Continent. The reciprocity of the treatment between Brazil and the remaining Latin American countries for across the border practice starts to come true with the Mercosur Treaty the details of which will be commented on later.

GLOBALIZATION IMPACTS WITH EXTRA REGIONAL AGREEMENTS

As from 1995, the creation of the WTO (World Trade Organization), an improved form of the GATT (General Agreement on Tariffs and Trade) established in the wake of the 2nd World War, meant the appearance of an umbrella agreement for trade, not only in goods but also in services. This fact, one of the consequences of globalization, rushed the celebration of zonal agreements that included some Latin American countries as is the case of the **NAFTA – North American Free Trade Agreement** signed between

Canada, USA and Mexico which came into force in 1994 but that only incorporated a mutual recognition agreement MRA on the engineering profession in June 1995. After the NAFTA was signed, the Latin American countries begin to feel tempted to sign the NAFTA with Canada and the USA, countries that were interested in increasing the penetration of their industrial production in the region and thus displace the growing trade with Asia. On this road the following have already signed: 1997 FTA Chile, Canada; 2003 FTA Chile, USA; 2004 USA, Central America, **CAFTA – Central America Free Trade Agreement** – not yet ratified by the USA Congress.

The last chapter on the subject of Treaties of a Hemispheric nature (all America) is the ALCA Spanish acronym for Free **Trade Area for the Americas** (Área de Libre Comercio para las Américas) that was initiated with an initiative of the President of USA in 1991 and was consolidated at the “Summit Conference of Presidents of American Countries” in 1994. In practice, ALCA tries to be a continuation of the NAFTA, involving 34 Countries more that until now had resisted the pressure of the major partner to sign this hemispheric agreement. It is a treaty that suits the policies of the WTO and the IMF. The bilateral agreements already mentioned with Chile and Central America to which can be added others with Colombia, Peru, Ecuador and Bolivia seem to be a way to break the stagnation of ALCA.

The distrust shown by Latin American countries to sign the Treaty is based on a negative background that NAFTA shows regarding their only Latin American partner; Mexico, related to subsidies for agricultural production and exports, intellectual rights, resolution on competencies, public sector acquisitions. In this sense the new agreement that is proposed for all the hemispheric area, ALCA, intends to be an integrating project that harmonizes economic and social interest of all countries, but it is seen as a possible generator of asymmetries, due to the differences in scales with USA that have 75% of the IGP of the entire Continent and because it could deepen the social differences regarding salaries, social security and taxes. Besides, when reading the ALCA it appears that the transnational services companies will have competitive rights to provide governmental services and the right to judge any government that resists them, with power to question laws and local rulings.

As regards engineering services and other professions with social risks, the transnational professional practice will be submitted to the same restrictions that Mexican engineers have at present and that make it very difficult or almost impossible to talk about reciprocity.

The Federal system of the USA imposes the obligation to register having previously approved two exams at the State Board in the jurisdiction when the engineer wishes to practice. On the other hand in the majority of the Latin American countries engineering degrees are in themselves qualified to practice and there are records of a national nature that enable practice in all the country. It could be said that the USA have a unified register for professional engineers, the United States Council for International Engineering Practice USCIEP, but only North American engineers can register in it who wish to work in signatory countries of the Engineers Mobility Forum EMF, Asia Pacific Economic Conferences APEC and NAFTA. The USCIEP is formed by the Accreditation Board of

Engineering and Technology ABET, National Society of Professional Engineers NSPE, National Council of Examiners for Engineering and Surveying, NCEES and American Consulting Engineers Council ACEC. Under no circumstance can USCIEP negotiate agreements that oblige the Member Organizations, or the State Boards. Each State should adhere to the Agreement, and so far only Texas did so in 1996. There are besides other types of restrictions that create obstacles for the employment of engineers in the USA originated in migratory demands (visas) that have an annual quota (1.400 for Chile), internal security norms (terrorism, uplifts, traffic of drugs), work in sensitive areas, non military and for engineering consulting firms. An abnormal asymmetry in the benefits that the Treaty grants the Small and Medium Enterprises (SME). In USA the SME are the firms that have around 200 employees. In Latin America SME employ between 10 and 20 persons.

The governments of the three countries that signed the NAFTA, have transferred the responsibility of establishing requirements for the practice of engineering in professional organizations such as the Canadian Council or Professional Engineers CCPE Canada, USCIEP USA and CONCI – Consejo Nacional de Certificación de la Ingeniería – México. This way of professional participation is meritorious, but the mutual requirements are not: to be able to practice professionally for a time (three or four years with annual renewals afterwards) an engineer must show 12 years of prior experience if his degree arises from an accredited educational program and 16 years if it is not accredited.

To summarize: if ALCA is to be an extension of the NAFTA, transnational mobility of engineering services will be a chimera to be enjoyed by engineers with a lot of experience, generally associated in consulting firms and that usually have very deep roots, both family wise and in business in their home countries. They will not be tempted to emigrate.

The other face of the medal, are all those young Latin American engineers that want to practice in USA or Canada, that must try their luck getting jobs in consulting firms or industrial corporations on the basis of a good university formation acquired at home or in developed countries and some professional experience.

This migration of talents or Brain Drain has been warned as pernicious for the development of the countries of the third world, and constitute a very controversial matter particularly between those who strongly value individual freedom and migration mobility and those who enhance the cultural belonging of this human capital encouraging well trained engineers to stay in their countries to promote social solidarity and equitable development. A recent paper written by WFEO Past President Eng. Contrado Bauer “Brain Drains – Desirable Remittance or Irrecoverable Losses?”, published in an Argentine newspaper¹ quotes among other things: “If there is a true intention of overcoming the tremendous inequalities among countries and of cooperating to promote an authentic development of the poorest, it seems necessary, essential, that the modernization and expansion of educational systems, and international assistance programs for capacity building should

¹ Brain Drain – C. E. Bauer – El Día, August 26, 2005

be effectively complemented by plans of economic development and creation of jobs and real work opportunities which allow developing countries retain the highly-skilled and best-trained people, thus consolidating a harmonic circle, leader of a legitimate improvement". The dichotomy that this clear warning by Eng. Bauer represents has been presented to the new WFEO Standing Committee on Capacity Building, chaired by Dr. Russel Jones, so that the Committee can study solutions that, without hindering the free mobility, encourage initiatives that motivate a well trained engineer to work in his own country and furthermore, to expatriate those that emigrated because they did not find an attractive field of activity be it economic or professional for their work.

Along the same lines of action is the initiative of the "Engineer for the Americas" which arose from the Ibero American Summit on Engineering Education held in Sao Paulo in March 2003, with the participation of Schools of Engineering, Industrial Companies, Professional Societies and Accreditation Boards. This initiative is efficiently promoted by Dr. Luiz Scavarda, Vice Rector of the Catholic University of Rio de Janeiro and adopted as a working program by the Organization of American States OAS in the meeting of Ministers of Science and Technology held in Lima, in November 2004. The favourable project of the "Engineer for the Americas" could become the hemispheric version of the APEC Engineer or the Eur Ing. At this time, a working group is trying to define the competencies and skills that will define this Engineer in the frame of the Declaration and Plan of Action of Lima 2004. The initiative calls for enhancement of engineering education, development of quality assurance mechanisms, harmonization of degree patterns, fostering innovation and government commitment to provide and upgrade engineering education. The Engineer of the Americas will certainly be an answer to the mobility directed by globalization.

If a premise for this mobility will be "to facilitate the flow of work and human resources throughout the Hemisphere to optimal locations" then the Action Plans of the Capacity Building Program of WFEO and UNESCO should foresee the necessary actions and stimulations to motivate and retain highly trained engineers in each country so that these human resources serve to foster and promote sustainable development. A well designed policy should stimulate investments that in each country of America offer well paid working opportunities to highly trained engineers thus promoting a technological, economic and social development that will slowly eliminate the asymmetries of wealth and cultural barriers that exist today between the different countries of the Continent.

ENGINEERING SERVICES IN THE MERCOSUR

In March 1991 the Presidents of Argentina, Brazil, Paraguay and Uruguay signed the **Treaty of Asunción** by which the "**Common Market of the South**" is created or MERCOSUR that is a wager on the scale economies with a regional vision.

As regards the practice of engineering and related professions, a fundamental step was taken in June 1992 with the creation of CIAM Commission for the Integration of Architecture and Engineering of the Mercosur with representatives from each country appointed by the professional representative Organizations. In December 1992 this

Commission agrees on the minimum principles for the different competencies that define the professional field for each degree and in 1993, a Code of Ethics.

In 1998 the governments of the four countries sign the **Protocol of Montevideo** by which they commit themselves to establish an area for free trade of services with a maximum time span of ten years for the elimination of existing barriers. Within the frame of this Protocol, the CIAM agreed on basis for Temporary Professional Practice for engineers graduated in universities of the MERCOSUR and with that paved the way for the decision taken by the Council of the Mercosur in Montevideo in December 2003 approving “Guidelines for the Celebration of Agreements of Reciprocal Acknowledgement between Professional Entities for the Granting of Temporary Licenses”.

The same decision taken in Montevideo established that each State partner shall create a “Focal Center of Information and Management” for each profession or group of professions to gather information and make true the implementation of the Framework Agreements, the purpose of which is the reciprocal acknowledgement of the competency of university degrees and their registration in a “Temporary Professional Register”. Temporary licenses are granted for a two-year period according to the duration of the service contract.

It is only in June 2005 that working groups are organized by profession and activities and the creation of a Permanent Register is agreed, focused on the “Technical Professional Achievements” in which can be included professionals that are at present registered in the Registration Boards of each country. This Achievement Register, besides responding to international models is a protection demanded by the multilateral organizations that finance projects at a regional level. It follows the model of the Euro Record project (European Record of Achievement) developed in 1998 by Universities, engineering organizations and industrial corporations. The Register will issue, at the request of an engineer, a certificate stating the University in which he graduated, the competencies of his degree, subsequent studies for specialization and updating, and his experience with a listing of the works related to his professional degree.

THE SUPPORT OF THE EDUCATIONAL MERCOSUR

All mobility agreements must have as a basis previous agreements related to a university formation achieved in accredited programs with standards internationally acknowledged. With this objective, the Ministers of Education of the four countries approved, in June 1998 a “Memorandum of Understanding to Implement Accreditation of Engineering, Medicine and Agronomy programs, and three Consulting Commissions of Experts were created formed by representatives of Professional Organizations. Since the Mercosur was enlarged in 1996 with the inclusion of Bolivia and Chile as Associated States the Commission also included representatives of those countries who have actively participated in all the meetings. In the Summit of the Presidents of the countries of the Mercosur in June 2005, Colombia, Ecuador and Venezuela were incorporated as Associate States and these countries, together with Bolivia and Chile, will be invited to form part of the Commissions.

In the Engineering area, the Consulting Commission of Experts agreed, as a first step, on the Basic Curricular Contents and Laboratories Training to evaluate Programs for Civil, Mechanic, Electric, Electronic, Industrial and Chemical Engineering. For the process of evaluation a group of criteria and indicators of evaluation were designed which were submitted to a preliminary testing process for their validation by means of a visit of experts to different universities counting on the voluntary participation of Universities from Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay. It was made clear that the intention was not to evaluate the institutional quality, or that of the programs, but to verify the clarity, pertinent, relevant and applicability of the criteria and indicators of the different university contexts. In this manner 41 Essential Criteria and 42 Complementary Criteria were established, to which the analysis of Consistency of the Process of Evaluation must respond. The Accreditation Agencies of each country, should suit their criteria and indicators when the accredit an engineering program with validity in the Mercosur. The process of evaluation is similar to all the processes in practice all over the world, starting with the acceptance by an Educational Institution, of the criteria and indicators, and then perform on that basis, a self-evaluation and, when considered opportune, be submitted to the evaluation of a Committee of Peers appointed by the National Evaluation Agency. Finally, accept the judgment issued by this Agency that will be informed at the Meeting of Ministers and to the rest of the National Agencies.

As can be surmised from this description, many hopes and efforts have already been made to achieve coincidences in the process of integration of Latin American countries that mean harmonizing economies, agreeing on criteria for an excellent higher education and making compatible different juridical rulings with transnational institutions of community rights. In all this process there exists mutual respect of the countries for the diversities that may have been built up after many years of an independent and autonomous life. But strong identities of origin exist: culture and language that overcome distrust and possible misunderstandings. The Mercosur is an accomplished fact. It only needs consolidating.

THE SOUTH AMERICAN COMMUNITY

On December 8, 2004, the new attempt enters the scene to broaden the Latin American area of Agreements already in force, the Mercosur and the Andean Community of Nations CAN. This happened during the Third Summit of South American Presidents that represented 12 nations of South America among which are the four partners of the Mercosur, Argentina, Brazil, Paraguay and Uruguay, the five partners of the CAN Andean Community of Nations, Venezuela, Colombia, Ecuador, Perú and Bolivia, and besides Chile plus Surinam and Guyana, the latter lacking tradition of association with the rest of the South American countries.

The Presidents that met in Cuzco, Peru, decided to create the CSN – South American Community of Nations (Comunidad Sudamericana de Naciones) with the object of establishing an area of free trade in the region for the year 2010. The Presidents assumed the commitment of strengthening the Mercosur and the frail Andean Community but not to replace them, considering that the progress made, especially in the Mercosur could be

a starting point to build the scaffolding for sectoral agreements. The CSN will represent a population of 360 million with a surface of 17.6 million square kilometers (45% of the entire Continent) with an IGP of US\$ 973 Billion. Will the CSN be an alternative for the ALCA? Will the CSN be equal to the NAFTA? Only time can answer these questions.

New Education Standards for Engineers at Selected Faculties of Universities of Technology in Poland

Prof. Bożenna Kawalec-Pietrenko, Poland



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European Federation of Chemical Engineering (EFCE) 1999–2004; Chairman of the Section on Environmental Protection and Sustainable Development (EFCE) since 2005. Member of the Scientific Council of the Faculty of the Food Science at the Warmia-Mazury University in Olsztyn/Poland since 2001. Member of the Executive Board of the Polish Association of Chemical Engineers since 1986. Member of the Committee on Education and Training of the Polish Federation of Engineering Associations since 2001. Member of the Scientific Council of the Scientific-Technical Institute of the Pomeranian Technical Organisation since 2002. Chairman of the Editorial Board of the journal „Chemical Engineering and Apparatus” since 1998. Chairman of the Editorial Board of the journal „Chemical Industry” 1999–2003. Creator and organizer (since 1986) of the Polish Conferences of Multiphase Flow as well as organizer or member of scientific committees above ten Polish and international conferences in the field of chemical engineering. Author and co-author above 20 publications and conference lectures. Research: hydrodynamics and design of multiphase reactors, downstream processing in biotechnology, purification of waste water and gases.

Abstract

The paper should be understood as the material for the discussion. The free education market approaches the final point. Engineering education has becoming more and more global. The important education problem is to ensure the adequate relation between the general education and the basic technical education. In opinion of numerous academic teachers the present education curricula reflect the local politics frequently. Therefore, the education standards should occupy at least 80% of total number of classes included

into the curriculum in order to avoid the transformation of the chemical technology studies into the chemistry studies. The cooperation between universities of technology and the industry is necessary for the good education of chemical engineers. It is necessary to create the curricula and to provide selected classes by experts from the industry.

It is stated that the traditional role of engineers is going to the past. It is foreseen the requirement for the number of the educated engineers will decrease. The first level degree engineer will be employed as process engineer in industry. The second (M.Sc.) and the third (Ph.D.) level degree engineer will be needed in the industrial corporations carrying out own investigations and projects. The mass production of engineers should be replaced by the high quality engineering education of a smaller number of students with the technical preferences.

Keywords: *Bologna process, education standards, cooperation university – industry, number of students, present role of engineer, future role of engineer*

INTRODUCTION

The frames of science were created by philosophers i.e. wisdom amateurs. Philosophers were engaged in the observation of the nature and the man. As a consequence of this observation, they tried to find the logical connection between various phenomena occurring in the surrounding world, in the nature.

European universities were founded in the tenth century with only one aim: to educate lawyers. Philosophy, theology and medicine were included in the education next centuries. The syllabus of the medicine included also the technology of medicines. Probably the fermentation technology and the technology of medicines were the first chemical educated technologies.

Skills in the range of the technics/technology were transmitted for the next generation in the way completely different from that existing at the universities. It was not the typical school system, but the individual education of each candidates. The candidate was educated from the journeyman to the master in several stages. The master examination was very serious and very hard. Nevertheless the master obtaining the diploma was frequently an illiterate.

About four hundred years ago an English philosopher has divided philosophy into two parts namely speculative and operative. The operative philosophy has dealt with the transfer of theory into the practice and, in a fact, it has been a starting point for the school education of the technology.

The “engineer” name came into existence in the artillery school in France in seventeenth century. The high school was founded in France in 1794 as the first model of the university of technology.

The chemical technology curricula at Polish universities of technology drive still more intensive drift at the chemistry curricula. Therefore the aim of the presentation is to show the possible way of changes of such trend and to discuss requirements of the industry with reference to the present engineering education in connection with the anticipation of the future employment of engineers.

SHORT CHARACTERISTICS OF THE CHEMICAL TECHNOLOGY CURRICULA

The education costs represent significant position in the budget of Poland, because all universities of technology are public universities, where the education is free of charge. It is important to notice that the number of students at the universities of technology increased distinctly during the last 15 years.

The number of students of chemical technology dependent on the universities is up to about five time higher than 15 ÷ 20 years ago.

Faculties of chemical engineering as well as so called chemical faculties (faculties of chemistry exist at usual universities not universities of technology) exist at Polish universities of technology. School-leaving students of both faculties obtain the chemical engineer title. Such title is reflected perfectly in the syllabus of the chemical engineering faculties

It is another situation taking into account the curricula of the chemical technology study direction at chemical faculties. The chemical technology curricula were saturated with practical classes up to about eighties of the last centuries. Students of the chemical technology study had weekly usually above 40 hours of classes. Later a number of hours diminished step by step and now unfortunately the weekly number of hours is only about 30. Unfortunately, the decrease of the weekly hour number concerns first of all the laboratory courses (chemical engineering) and the process design classes (chemical engineering, apparatus). Week laboratory hours decreased in spite of the fact that the practical knowledge is fundamental for chemical engineer who must know e.g. how to identify critically the process parameters at the laboratory scale regarding the scale-up of the process.

At present the changes in the education system in Poland are transformed in connection with the Bologna process which gave a general education frame without giving detailed curricula. Therefore, the education curricula were and are discussed and created in a country by groups academic teachers from chemical faculties. The so-called standards (minimum hours of classes) of the engineering curriculum are created as a result of these activities.

The standards make distinctly under 50% of the total hour number of classes included in the chemical technology study curriculum. The rest is determined at the individual universities. Unfortunately most frequently the rest is the various type of chemistry and the expectation of the industry is totally not or only very slightly taken into account. It means that the final chemical technology curricula reflect frequently the local politics of the university which offer the study.

ROLE OF THE EXTERNAL INSTITUTIONS IN THE EDUCATION

Since 11 years Polish Association of Chemical Engineers organizes annually the Conference on Transformation of the Chemical Industry in Poland. Among others, the scope of the Conference concerns the education of chemical engineers. There are

discussed the engineering education as the global enterprise as well as the quality of the engineering education at Polish universities of technology. In my opinion the Polish Association of Chemical Engineers and other engineering associations try to be the active transmitter of the relevant opinions between universities and industry.

One of the most important opinion of participants of the Conference is that as the result of the existing chemical technology study curricula the school-leaving student is not enough educated as engineer. He is, in fact, a chemist. Therefore, at least, the first stage of the engineering education of the above mentioned education standards have to occupy at least 80% of total hour number of classes indicating the clearly named engineering subjects as the obligatory subjects. In this point it is necessary to take into account the opinion of the industry representatives.

Industry needs good educated chemical engineers with knowledge allowing understand the industrial processes. Therefore, representatives from the industry consider the general engineering education as the more valuable than the detailed education in a very narrow specialty. It means, that the chemical engineer should be universal to a relatively high extent, in order, to start successful his first job at various positions in the factory. He will self-educate in the specific chemical production process existing in the given factory.

According to the opinion of the industry representatives the base of the education of the graduated chemical engineer should ensure to attain the actually required position-dependent knowledge as a result of the self-learning in the reasonably short time. The chemical engineer with the general theoretical knowledge, with the thorough laboratory experience and the good knowledge of unit operations and engineering calculations can better and in a shorter time find and understand relations between phenomena occurring in a given technological process. Therefore, such chemical engineer can adapt effectively to various tasks resulting from his job position.

The idea of treating of various processes of the chemical industry as a series of unit operations was first brought out as a basis for a new technology in 1920's last century. Before, the engineering of chemical plants was regarded as the individual technological line. Chemical and process engineering prepares the mathematical description of various unit operations. The same description can be applied to the design of given process e.g. countercurrent absorption, in different technological processes using appropriate physicochemical properties of components creating the actual system. Good knowledge of the mathematical description allows for the engineer to apply similar analysis to a variety of problems. Students have to understand enough the methods of mathematical description before they will solve practical problems themselves during their job.

The numerical answer for chemical engineering problems are essential to become familiar with different techniques, therefore the answer (solution) should be obtained by elaborated systematic methods, not using only intuition. Students have to know, how to consider the technological process as the system of unit operations from the various point of view i.e. fluid flow, heat and mass transfer. Therefore, it is necessary to change the curricula of chemical technology study direction saturating it by the chemical engineering and other engineering subjects.

The cooperation between universities of technology and the industry is necessary for the good education of chemical engineers. It is well known, that the technical universities unfortunately do not use or use to a little extent, the industrial experiences. It is suggested to give some part of the university classes by experts from the industry. They can teach skills related to the future workplace.

According to the opinion of representatives of the chemical industry the graduated chemical engineer should be able:

- to maintain and control the existing production systems,
- to know how carry out the rationalization of existing plants,
- to create chemical and technological conception of new processes,
- to participate in the introduction of new technological production line,
- to work about projects,
- to undertake activities in the range of the environmental protection,
- to undertake activities in the range of the process safety.

Besides of the professional knowledge, the studies should develop the following characters:

- skill of the independent finding of various problems and the solution of the problems,
- skills to work group,
- personal inclination to development of own knowledge,
- imagination of the state of emergency in the chemical production,
- habit of the permanent hard work,
- skills of effective thinking and working independently on the workplace.

According to the opinion from industry, the program of studies have to take into account the expectation of the job market i.e. chemical factories. The engineer in the industry should be creative not only in the range of the technology, but also to some extent in the range of the marketing. He has to predict the transformation of the production factory. Therefore the better knowledge of economy, marketing, disposition, ordering as well as law regulations is needed. The education in the range of the personality coaching and negotiations capacity with potential clients is also needed.

Taking into account the sustainable development of the industry the integration of disciplines is fundamental. Academic education and university research must cover more disciplines. Integration should allow an interactive approach of the process development including the synthesis, down-stream processing and plant lay-out.

ROLE OF ENGINEERS IN FUTURE

The above described skills characterize the classical chemical engineer. At present, most of technologies are prepared perfectly and carried out in the full automatic systems. Process parameters are established at the optimal level and changes of parameters are impossible. It can be formulated the opinion, that the traditional role of engineer is going slowly into the past.

It can be anticipated that the required number of the graduated chemical engineers as creative engineers in the factories will be decreased. Taking into account the stages of the education according to the Bologna suggestions, it can be concluded, that in the industry,

besides of course of the damage situations, the first stage educated engineers will be wanted. They have to be prepared enough to the service of the production process. The high level of the engineer intelligence will be of course still required.

In spite of the perfectly optimized character of traditional technologies of course further discoveries can not be excluded e.g. new generation catalysators or materials changing their properties during their life time according to our expectation. It is very risky to put some hypothesis. Therefore, the higher (M.Sc., Ph.D.) educated engineers will be necessary. They will be employed in the research and development centre of the large industrial corporations having their own investigations.

STUDENT NUMBER AND FELLOWSHIPS

Actually the number of students of study direction of chemical technology is much too high also taking into account costs of the studying. It is possible to estimate the number of annually graduated chemical engineers needed for the industry. The number of students should be limited and this limited number should be educated for excellence taking into account requirements of the industry.

The industrial representatives indicated the depreciation of the engineers title. Engineering studies are difficult in comparison with the many another studies where the studying does not require so much individual work and the students can be employed permanently to have money. Students of universities of technology need much time to prepare projects, reports concerning the laboratory experiments etc. It is observed at present, that the majority of engineering students of engineering faculties is permanently employed because students need money. It is clear that it is impossible to create an excellent engineer in the actually obligatory number of study semesters in such conditions. Therefore, in my opinion engineering students should obtain a fellowship covering all basic necessities of life. Of course, scholarships should exist for the strictly limited number of good students. Students obtaining fellowships from public money should be not allowed to be employed.

CONCLUDING REMARKS

It is indicated that the system of the education at chemical faculties of technical universities produces engineers not enough familiar with engineering knowledge because of too low hour number of classes of chemical and process engineering, apparatus, system technology etc. Unfortunately, the syllabus of the chemical technology education at the universities of technology in Poland drifts still in the direction of chemistry. Therefore, the essential problem is to preserve the adequate relation between the general education and the basic technical education.

It is clear that the epoch of the free education market approaches the final point. Engineering education has to be global. However engineering curricula reflect rather the local politics of technical universities. Therefore, the greater part of subjects included in the curriculum should be named clearly and should be indicated as the obligatory study

hours in the standards at least at the first stage of the engineering study. The standards should indicate clearly about 80% of the total number of classes included into the curriculum. It will allow to avoid the transformation of the chemical technology faculties into the chemistry faculties.

Cooperation between universities of technology and the industry is necessary for good education of chemical engineers. The close cooperation is necessary in the creation of the curricula and in providing selected classes by experts from the industry.

The mass production of engineers should be replaced by the good quality engineering education of a smaller number of better students with personal technical preferences.

In the opinion of several experts the traditional role of engineers is going to the past. The requirement of the number of the educated engineers will decrease. The first stage engineers have to be excellently prepared as process engineers of the technological line. Second (M.Sc.)/third (Ph.D.) stage graduated engineers will be needed first of all in the industrial corporation carrying out own investigations and projects.

Two-Cycle Engineering Education in Hungary Promotes Mobility

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Abstract

According to the Bologna Declaration most European countries significantly changed their education system in order to develop a competitive European Higher Education Area built on a two-cycle system with comparable qualifications and encouraging mobility. A stocktaking of the actual state is given in [3].

Our paper outlines the process of introducing the two cycle education in Hungary while focusing on engineering programs. Beforehand, national criteria for setting up and launching B.Sc. and M.Sc. programs were elaborated and both college-level and university-level engineering programs were analysed in detail. As a result a consistent system of B.Sc. programs was created that promotes student mobility and gives a solid basis for M.Sc. programs.

Keywords: *engineering education, two-cycle higher education*

INTRODUCTION

The Hungarian engineering education has been acknowledged world-wide. Up to 1990 this was basically due to the elite-education. Approximately 10% of the age group could get into higher education, and in technical universities the students/staff ratio was much more favourable than the Western-European average. Within a decade mass education became prevalent [1]. More than 50% of the age group study in higher education. The students/staff ratio deteriorated, at Budapest University of Technology and Economics it is about twofold compared to Delft University of Technology. The two-cycle system suits better to mass education. Elite education can be realised within mass education, based mainly on project and individual work.

The Bologna Process promotes mobility, however, language is a difficulty for small countries. Several Hungarian universities offer programs in English and German, some courses are available in French and Russian as well.

The conversion from the traditional dual education system to the linear two-cycle system needs the support of the society. Would-be students, their parents and potential employers must be well informed. In the field of engineering, experts working in industry played an active role in elaborating the rules of the conversion.

TRADITIONAL DUAL SYSTEM

At present Hungary has both colleges (similar to the German Fachhochschule) and universities. Traditional college- and university-level programs have started in 2005 for the last time. From 2006 on only B.Sc. and M.Sc. programs will start in Hungary with a few exceptions (undivided programs leading to master's degree: in medicine, veterinary studies, pharmacology, dentistry, law and architecture). In the engineering field college-level programs last for 3 years, university-level programs for 5 years. In Hungary degree

programs in higher education must be in accordance with the governmental decree concerned. There are general requirements for major fields and special requirements for each program. The most important general requirements of the technical and engineering programs (valid for all currently existing programs) are the following.

College-level programs last for either 6 semesters (180 credits) or 7 semesters (210 credits). The number of contact hours is at least 2160.

University-level programs last for 10 semesters (300 credits), the number of contact hours is minimum 3600.

The main fields of study within technical and engineering academic programs and their required proportions are given in Table 1 (180-credit college-level program is supposed). The details are specified in governmental decree [4].

Table 1. Main fields of study within traditional engineering programs.

	college-level		university-level	
	percentage	credits	percentage	credits
basics of natural sciences	15–25	27–45	20–30	60–90
economic subjects and humanities	10–15	18–27	10–20	30–60
general professional subjects	40–55	72–99	30–40	90–120
special professional subjects	20–30	36–54	30–40	90–120
total		180		300

Credits assigned to

compulsory subjects:	40–70%.
elective subjects from a given set:	25–55%
freely selectable (optional) subjects:	min. 5%
thesis work: college-level: 15 credits,	7–8%
university level: 30 credits,	10%

45–60% of credits belong to subjects mainly based on lectures, 10–30% to seminars and 20–40% to laboratory work.

The special requirements for concrete programs define the fields of studies in more detail and give all further criteria and expectations. As an example, special requirements for the university-level program in electrical engineering state that fields of studies must include the following:

- basics of natural sciences: mathematics, physics, material sciences, programming,
- economic subjects and humanities: selected subjects from the field of economics, social informatics, technical law, management,
- general professional subjects: electrical signals and systems, analogue and digital design, networks and systems, informatics, electromagnetic fields, electronics, measurement, automation, basic engineering knowledge,

- special professional subjects: electrical energy systems, energy conversion and transmission systems, telecommunication and telematics, communication engineering, measurement and system design, control systems and robotics, micro systems and module circuitry, computational systems and their application.

In the traditional higher education there were about 450 different degree programs. Up to now about one hundred B.Sc. programs have gained accreditation, 18 in engineering. Degree programs must differ from each other. The difference must be at least 40%, mainly in the field of general and special professional subjects.

NATIONAL CRITERIA FOR B.SC. PROGRAMS IN ENGINEERING IN HUNGARY

We analysed the college-level and university-level programs of the same field. The common subjects add up to approximately 90 credits (ECTS) that can be acquired in three semesters. Keeping all subjects that are different in the college-level and in the first six semesters of engineering-level programs, and augmenting them with the common subjects would mean a first-cycle program with 270 credits, lasting for 4.5 years! No government would finance such a B.Sc. program. It is clear, that B.Sc. programs in engineering are different from college-level programs (contain more theoretical subjects), and also from university-level programs (contain more application oriented subjects). This is only possible if B.Sc. programs in engineering are rather general.

Hungary formed a National Bologna Board to co-ordinate the transition from traditional dual higher education to two-cycle higher education. In engineering higher education sub-committees were formed in all major fields (e.g. mechanical-, civil-, electrical engineering). Experts of both colleges and universities are members of these sub-committees.

The National Bologna Board accepted that first-cycle engineering programs last longer than programs in other fields. Details about the Bologna Process in Hungary are given in [2]. Most engineering B.Sc. programs last for 7 semesters, 210 credits (ECTS) are required for the diploma. The main fields of study are given in Table 2.

Table 2. Main fields of study within B.Sc. engineering programs.

	percentage	credits
basics of natural sciences	20–25	40–50
economic subjects and humanities	8–15	16–30
general professional subjects	35–52	70–103
special professional subjects	20–30	40–60
elective (freely) subjects	min. 5	min. 10
total		210

15 credits are assigned to the thesis work. Minimum 60 credits must belong to subjects developing practical skills. A minimum 4-week practical work is required in most engineering programs.

NATIONAL CRITERIA FOR ENGINEERING M.Sc. PROGRAMS IN HUNGARY

Table 3. Main fields of study within M.Sc. engineering programs.

	percentage	credits
basics of natural sciences	17–30	20–36
economic subjects and humanities	8–17	10–20
general professional subjects	8–25	10–30
special professional subjects	38–50	46–60
from it: thesis work	17–25	20–30
elective (freely) subjects	min. 5	min. 6
total		120

The minimum credits assigned to basics of natural sciences in B.Sc. and M.Sc. together is equal to the minimum credits in university programs. The maximum is about the same. Those who get their M.Sc. diploma will have about the same knowledge in natural sciences. The range for economic subjects and humanities seems to have been reduced, from 30–60 to 26–50. The majority of university programs in engineering used to have credits in this field within the latter range, thus the change is negligible. The range of professional subjects (giving both general and special knowledge) has become wider. This is necessary to cover the quite different B.Sc. and M.Sc. degree programs in engineering. In most cases the total number of credits assigned to B.Sc. and M.Sc. is about the same as in the similar university program.

The B.Sc. and M.Sc. programs together request the accumulation of 330 credits, 30 credits more than the university programs. The increment mainly belongs to the second thesis work.

As a rule we can say that engineering B.Sc. programs give general knowledge of the field. Graduates with a B.Sc. diploma either go directly to the job market or continue their studies in an M.Sc. program. B.Sc. graduates can work in production, service, marketing and sales and product development. M.Sc. graduates will work in research and development, in the latter field mainly system development. Basic research requires an M.Sc. diploma, this is also a prerequisite for Ph.D. studies.

CHANGES INDEPENDENT OF THE BOLOGNA PROCESS

The traditional Hungarian engineering higher education used to have some features which caused difficulties to students who spent a semester abroad. The examination

period in Hungary has been six weeks long in each semester. Many students prepared only for the exams, which is very ineffective. In Europe the examination period is much shorter – very often only one-week long – this caused difficulties in organising the study abroad. Compared to foreign technical universities, much less individual and especially project work was expected from engineering students.

For the B.Sc. programs Budapest University of Technology and Economics shortened the examination period to 4 weeks, at the same time limiting the number of examinations in the curriculum for each semester to four. In parallel with it the B.Sc. programs contain more individual and project work than the five-year university programs. This will help mobility: students can work on their projects also abroad.

Experts working in industry and in research institutes are welcome as teachers in engineering education. Project work is more attractive and effective if it aims at real-life problems. The academic and industrial supervisors help students develop both theoretical and practical engineering skills.

Elite education in the dual system is possible mainly in university programs. In the two-cycle education elite education must be offered within the B.Sc. programs, i.e. within mass education. This is based on individual/project work. Individual work also helps mobility: students can proceed with their work abroad. This is also a possibility to host foreign students in Hungary. As English language is fluently spoken by most staff members, supervising project work is easily realised in the field of specialisation of the professors/lecturers.

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TECHNOLOGICAL CHALLENGES

Human Activity Supporting Machines and Their Evolution Towards Multifunctional, Universal Cyberrobots

Prof. Antoni Kwiatkowski, Poland



Antoni S. Kwiatkowski – pensioned professor, Ph.D. of chemical sciences, full member of Engineering Academy in Poland, deputy chairman of Science-Technical Committee for Improvement of Personnel of Polish Federation of Engineering Association NOT. During the years 1978–1989 member of Science Section about Materials of PAN (Polish Academy of Science) Branch in Poznan. During the years 1974–1982 Dean of the Material Engineering Department in the Higher Engineering College of Koszalin. During the years 1982–1989 Deputy Rector and Dean of Fire Protection Department at the Main School of Fire Service in Warsaw.

Abstract

Simple tools used by primitive people have been improved by many generations. Together with the acquisition of skills in their operation, they have been upgraded and made more effective in work.

Inventions of modern specialized and systematically upgraded computers have evoked revolutionary changes practically in all fields of science.

The successful coupling of computerization with work automation has proved especially successful for solving contemporary and future problems of mankind.

The research work started at the end of XX century on creating artificial intelligence covers:

- practical application of achievements in “cyborgization”,*
- transmitting the memory load of a human being to the constant and operating memory of a robot,*
- enabling for a continuous coexistence of man with robot in a “twin” form.*

The co-existing populations of human beings together with the human brain robots will cause that the achievements of human intellect will not vanish.

The cyborgization will help people to have a hope of transferring their memory resources to cosmos dwellers, capable of reading and understanding of the achievements of mankind that has come into being during its existence on the Earth.

Simple tools used by primitive people have been improved during many generations so as to make them more and more effective. It led to the combined, multifunctional mechanical equipment.

Due to the progress in machines design and consecutive inventions in, among others, electronic computing technology applications, manufacturing quality and productivity were better and better. Multifunctional machines arrangement into manufacturing lines led to the decreased number of independent workplaces operated by qualified employees.

Since the second half of the 20th century, the majority of large, strategic industrial enterprises manufacture their final products using partly- or fully-automated production lines, supervised by small highly qualified staff supported by computerized quality control systems. Liquidation of directly man-operated workplaces led to the necessity of retraining some employees and, following plants modernization, significant reduction of permanent posts.

Direct human activity decreased in agricultural, animal breeding, leisure and recreation areas, on roads and railways, when robots containing an appropriate software were built and widely applied. Robots supervise sophisticated mechanical works, supporting or replacing human activity. Currently, modern robots replace larger and larger groups of people involved in direct work process. Some examples:

- many home and around-home works;
- work in mines, underground tunnels, places of construction and geological disasters and in poisoned atmosphere;
- planes, railway and road cars control;
- water and underwater vehicles control and maneuvering;
- diagnoses, remotely-controlled treatments and surgeries in hospitals;
- home care for the elderly or ill, with doctor on duty available by phone;
- robot and computer sets installed in manned satellite space stations, as well as unmanned space stations and interplanetary probes;
- research robots used on lunar and Mars surface.

The more and more serious problems are created by a difficult task of finding permanent jobs for growing number of people in their productive age, as well as by health deterioration of humans living in large municipal and industrial agglomerations. It is already today when human skeleton prosthesis, like substitution of hip joints with metal prostheses or implantation of plastics-made internal organs (e.g. heart) become necessary. Table 1 and fig. 1 show some human-cyborgizing prostheses and artificial internal organs.

The process will be developing during the 21st century. Increasing number of fully automated and mechanized manufacturing plants will to the greater and greater extent eliminate expensive human workforce which requires systematic payment of wages according to the work contract also during necessary periodic production stoppages, when its trade unions force wage increases and organize strikes.

The already observed phenomenon of society stratification will be more apparent. The society tends to divide into:

- small groups of incredibly rich people;
- people living in controlled wealth, directly connected with the group 1;
- people living in controlled want who, by different causes, will not afford to increase their qualifications in professions currently needed on the job market when changing their place of employment, with no hope to pass to the group 2;
- people living in poverty, even in an abject poverty.

Irrespective of attachment to any of the above groups, continuous battle against diseases triggered off by mutating bacteria and viruses will constitute threat for human longevity. Other threats for longevity will come from non-observance of healthy life style and nutrition rules, use of stimulants and drugs, abortions, chemical contraceptives, genetically uncontrolled spouse selection, wars, violent crime, terrorism, as well as religious dictates and proscriptions inconsistent with the knowledge about the human communities existence rules. The above threats will accelerate processes of health loss and ageing of human and cyborg organisms.

Living human brain is the highest awareness file known in the surrounding world. It is a material object that consecutively stores the gathered information and processes it appropriately to enable understanding of phenomena observed and felt. The brain uses its possessed knowledge in the process of electrical pulse flow excitation and addressing it to the specific brain places to enable a systematic information gathering and development, making use of newly gathered information. The brain joins together and enables cooperation of already gathered knowledge on the humanities, rules governing the world of animated and unanimated nature, mathematical logic, useful technical activities and newly discovered surrounding world phenomena.

Design of the modern, specialized and systematically improved computers prompts great changes in practically all areas of the contemporary technological civilization, scientific research, sophisticated and reliable equipment manufacturing, transport, radio and TV, military technologies, medicine, organization and management, virtual education at all levels, as well as archives of the mankind scientific achievements.

The increased number of scientific workers in institutes and universities of technology, who will train engineers in future-oriented and prospective branches, is necessary for technical and technological development. In many countries, including Poland, engineers specialized in material engineering, nanotechnology, biotechnology and genetic engineering are trained. The graduates participate in R&D, design and manufacturing of modern high-tech products.

Since the middle of the 20th century regular works are conducted on the artificial intelligence through the gradual cyborgization of people who agree to participate in such experiments. The experiments cover:

- brain-connected chips containing a definite store of knowledge, to support or increase knowledge possessed;

- making use of achievements in works on independent computer-generated thinking and expectations; the computer that won the chess match against Kasparov can be an example here;
- works on contemporary computers self-consciousness which, after crossing Turing test barrier, could reach and exceed human intellect capabilities;
- construction of a cyborg based on permanent co-existence of biological human brain with inorganic computer brain, in which their memories would gather information entered, store it permanently and would be able to its operative transmission.

In case of the biological death of cyborg's human brain, its computer brain-contained memory could still exist and assimilate new information. This memory can be then carried into the robot of a specific shape, e.g. resembling a man or another shape optimal for fulfilling tasks of the robot. As a result, the dead man's intellect would still be able to consciously exist further on, in a new shape, and to continue his activity which was not broken by death of his protein-based biological form.

Mankind intellectual achievements will not be lost. They will develop further on and can constitute an important contribution into the civilization of beings who inhabitate the Earth and the outer space.

Table 1

Replaceable parts made of plastics, titanium and laboratory-bred fragments of a human body

BRAIN	– chips implanted deeply into the brain, used in treatment of patients suffering from Parkinson disease. Memory supporting implants. Thinking and memory improving microcircuits, prosthesis of hypocamp memory (one of the most important brain parts) for long-term memory construction and memory effectiveness increase.
EYE	– a camera sending a signal to the microcomputer, which transmits electrical pulses to electrodes located in the brain fragment responsible for black-and-white picture reception.
EAR	– an implant transmitting pulses to the aural nerve ending. Microphone with a processor sending processed sounds direct to brain stem is located over the ear.
TEETH	– made of corundum, titanium or plastics.
LARYNX	– made of plastics.
TORSO	– nanoequipment to monitor internal organs operation and blood composition.
SLOPE	– slope bionic part is moved by pulses coming from nerve system.

HEART	– heart-simulating pump (of 8 blood liters per minute yield) is made of plastics and titanium. Ventricles operation is ensured by a small battery implanted under the skin. Cardiac valve is made of plastics.
LUNG	– consists of micro balloons pulsating three hundred times per minute to increase blood oxidization capability. Microballoons are located in semi-permeable membranes.
PANCREAS	– macro capsule with insulin-producing cells.
KIDNEY	– biological and mechanical filtration equipment.
BLOOD	– artificial liquid protecting patient against being infected by an ill donor.
MUSCLES	– muscle fragments taken from a donor are bred on the appropriately formed polymeric matrixes.
BLADDER	– laboratory-bred from cells taken from live human organism bladder.
VAGINA	– formed from donor piece of skin, laboratory-bred up to the size required for the operation.
PENIS	– flexible pipes fed with compressed air from a tank are wound on its outside surface to create erection of persons with erection disturbances.
BONES	– fragments of bone are bred till appropriate size is reached. THIGH BONE is made of titanium. Due to the internal screws, children prostheses can be elongated under magnetic field action, enabling their gradual elongation during child growth.
LEG	– bone replacing prostheses are made of titanium and joined to the appropriate skeleton parts. Works on creating an “intelligent leg prosthesis” – artificial leg bionically joined with human corpse – are in advanced stage.
ARTIFICIAL JOINTS	– endoprostheses (“intelligent leg prostheses”) of knee, hip and elbow joints made of titanium, biologically neutral metal alloys and plastics.

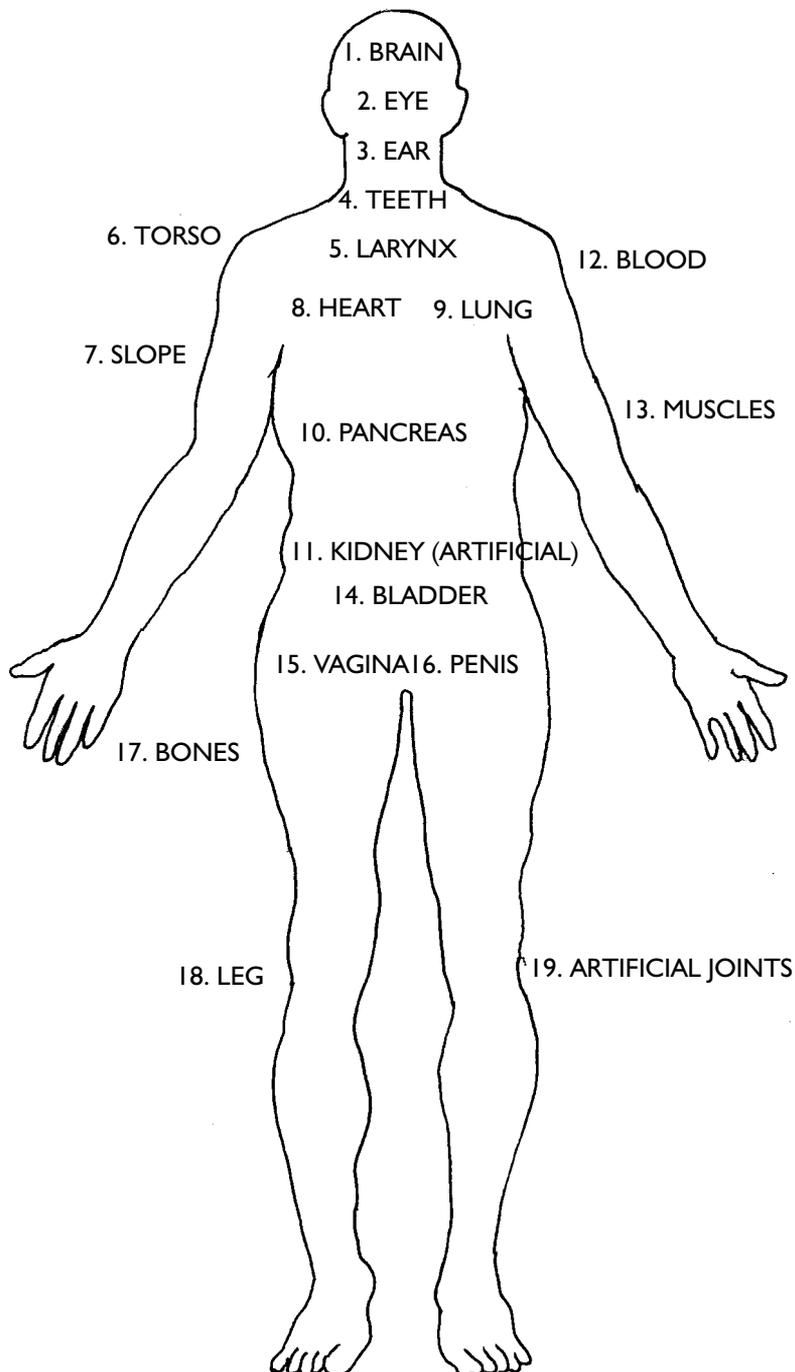


Fig. 1. Replaceable parts

MORE INFORMATION ON ARTIFICIAL BODY PARTS – SEE WWW.BIONIC...

Nano-Science and Biology – Innovative Fields at Present – in Consideration of an Education Curriculum

Prof. Dr.-Ing. Vollrath Hopp, Germany



Prof. Vollrath Hopp has studied chemistry and technology at the Technical University of Berlin, and received a doctorate in 1960. He worked in the chemical industry in Germany. In 1966 he joined Hoechst AG as head of vocational and advanced training in science and engineering. He was offered a guest lectureship at the Tongji University, Shanghai, in 1986, subsequently becoming a Honorary Professor. In 1991 he was appointed Professor at the University of Rostock in the areas of chemical technology. He is a full member WFEO-CET. 1998 he became a Honorary Member at the University of Rostock. Prof. Hopp has published extensively in journals on issues of chemical engineering. He is the author of five chemical engineering textbooks. He has received several prizes and decorations for contributions to co-operation between education and industry.

Abstract

A system is an unlimited and organized arrangement of elements of constructions and/or of functions. Thinking in systems means to think in connections and context and respectively in processes. Biological systems are open systems. They exchange permanently energy, matter and information with their environment.

Nano-science opens up the world of the invisible small sub-units. This world is more extensive and multifarious than the visible world. Nano-technology is the technical and biological use of material and energetic interactions between small ultimate particles on a molecular and atomic level.

Fertile farmland is a biological system consisting of three essential complex parts. The components are permanently influenced by climate and erosion. Water, farmland and solar energy are the conditions of regenerable biological systems. They are the basis for sufficient nourishment. Biological processes are reactions in nano-dimensions.

Nano-science is a part of fundamental science and engineering and should be in the university curriculum.

SYSTEMS

A system is an unlimited and organized arrangement of elements of constructions and/or of functions. They all depend on one another and they are connected by reciprocal actions. This system becomes dysfunctional or breaks down, if one of these elements veers out of order or indicates an irreparable and alien behaviour.

Elements of constructions and functions may be thoughts, terms, forces, particles of matter and substances respectively, cells etc.

The science of systems places the connections and not the isolated single-elements in the foreground. Thinking in systems means to think in connections and context and in processes respectively.

BIOLOGICAL SYSTEM

- Biological systems are *open systems*.
They permanently exchange energy, matter and information with their environment.
- Biological systems are also *regenerative systems*.
Their rhythms are the generation sequences of a total species and the biological system. In general rhythms are the measure of time of biological processes.
- Biological systems are also *innovative systems*. In biological terms there is no such thing as a quality value.
- *Innovative systems* include the potential for evolution, the hereditary ability of biological systems to adapt to changed living conditions and optimize the chances of survival.
- Biological systems are *symbiotic systems*.
- Biological systems are movement-systems.
Besides biological systems there are also *movement-systems*. Plants both grow and move vertically. Movement is not only a change of location, but also a change of quality, that means conversion.
- In a biological sense there are no malformations. Each species and partial systems are, in themselves equal in value.

The evolution potential of a biological system is inexhaustible, so that the fight against disease will never be completed.

– Nano-science

Nano-science is a very important fundamental science. Many properties of interaction between matter and energy in nature and technology may be explained only through their behaviour on a molecular and atomic level (fig. 2).

Nano-science opens up the world of the invisible small sub-units. This world is more extensive and multifarious than the visible world (fig. 3).

Nano-cosmos and astro-cosmos are states of matter over the total size of infinity (fig. 3). All states of matter are common to the reciprocal action with different forms of energies.

Nano-science is the science of matter and energy in the range of nano-dimensions (fig. 3 and fig. 6). The reciprocal actions of particles of matter change abruptly during the

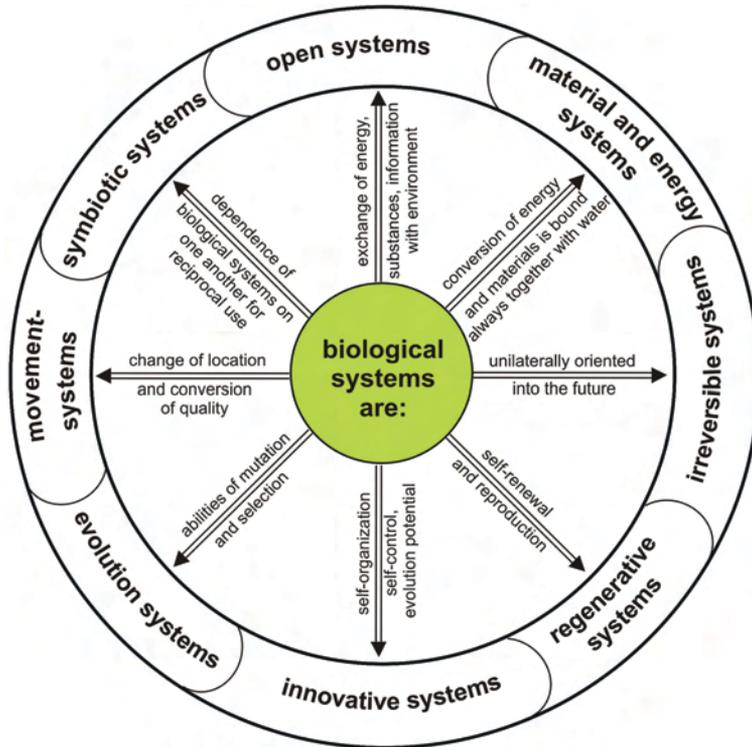


Fig. 1 Essentials of biological systems

transition from the range of macro-dimensions to nano-dimensions. These abrupt changes of the interactions between the particles are accompanied by a momentary change of their physical and chemical properties.

The particles of the macro- and nano-dimensions often exist side by side. Which properties of a particle system dominate depends on the distribution degree of the particle sizes.

Nano-technology is the technical and biological use of material and energetic interactions between small ultimate particles on a molecular and atomic level.

It investigates systems of nature and technique and it retraces their properties to the behaviour of constituent elements e.g. small ultimate particles, superficial structure, membranes, cells, energy quanta, etc.

The external circle mentions some well known companies, working successfully in nano-science fields.

On a molecular level, the limitations of classical science disappear. The different fields interact and complement one another. They “dissolve” into one another resulting in a new field with new properties.

Farmland as a biological nano-system (fig. 4)

Fertile farmland is a biological system consisting of three essential complex parts.

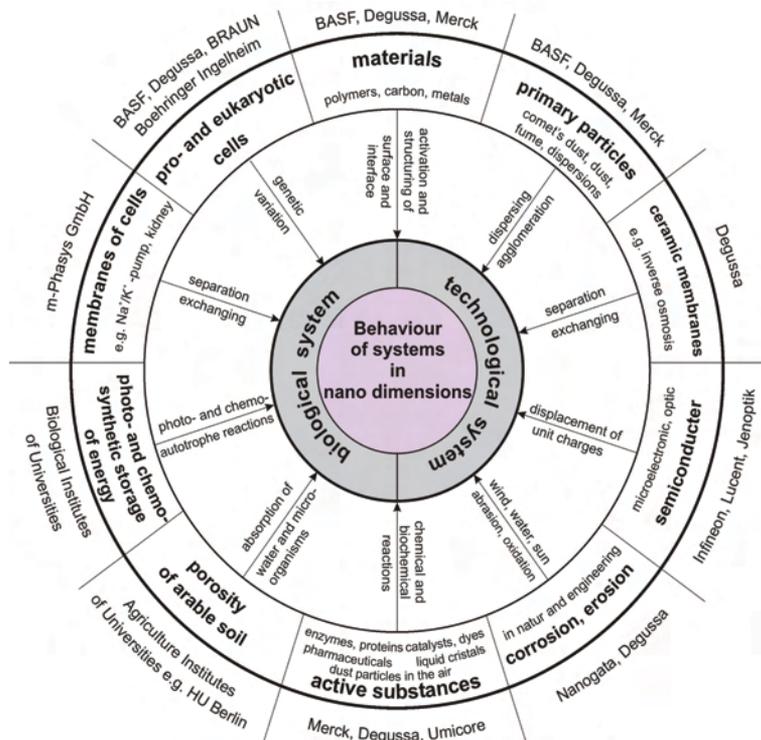


Fig. 2 Nano-science – an interdisciplinary fundamental science

These three parts are:

- the natural composition of earth with its special profiles,
- the water as groundwater, percolation water, capillary water and surface water,
- the humus layer with its micro organism systems, small earth creatures e.g. earth worms, insects, organic residual material and finally with its typical pore structure.

The components are permanently influenced by climate and erosion.

The size of topsoil particles measure between 20 μm and 200 μm (micrometer). The structures of pores are subdivided into fine, medium and coarse. Fine pores are less than 0,2 μm . Medium pores are between 0,2 μm and 50 μm , they are especially suitable for the increase of bacteria and the absorption of water. Coarse pores are greater than 50 μm . They are suitable for the growth of bacteria but not for the storage of water. Water storage and permeability of pores characterize the sponge effect of topsoil.

Photosynthesis

Water (fig. 7), farmland and solar energy (fig. 6) are the conditions of regenerable biological systems. They are the basis for sufficient nourishment. Biological processes are reactions in *nano-dimensions*.

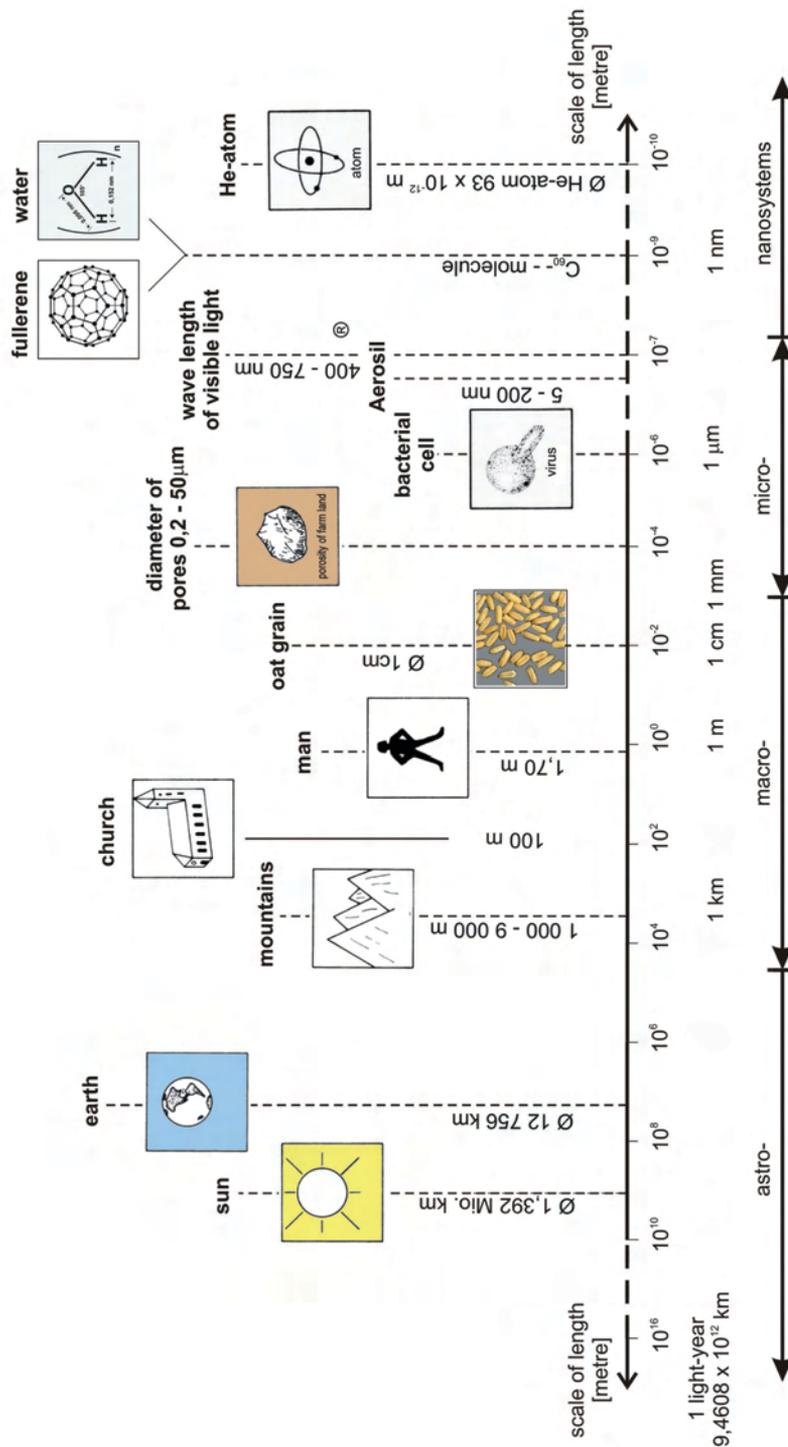


Fig. 3 dimensions of astro-, micro- and nano-systems

Doctors of medicine know, that micro-particles of special size from 1 micrometer to 10 micrometer adhere to the lung, if they are smaller than 1 μ m the lungs inhale and exhale them, they don't adhere.

Particles which are bigger than 10 μ m don't penetrate the lungs, they are filtered by superimposed protective systems. Tests are at present being carried out to determine if avians are transmitted by aerosols of corresponding size.

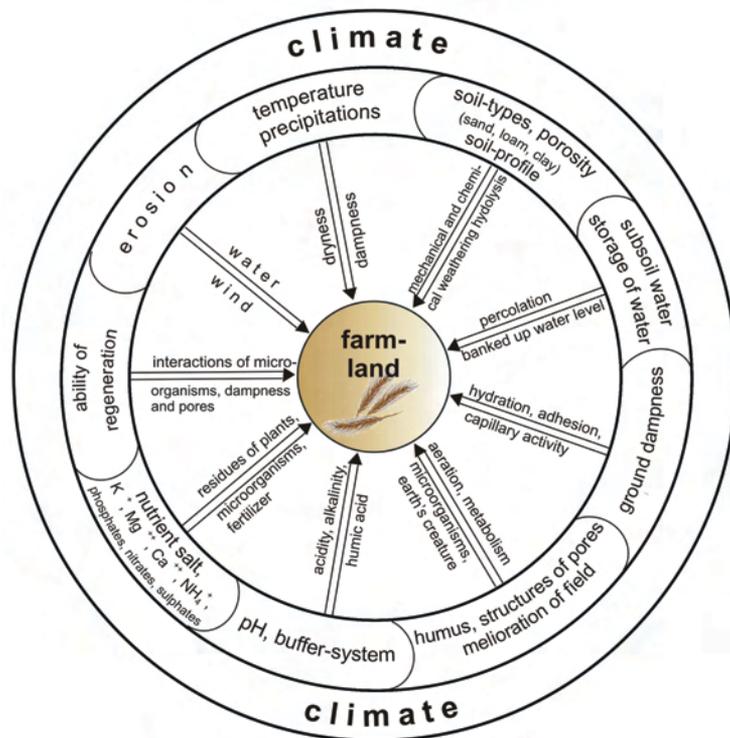


Fig. 4 Farmland as a biological nano-system in order to guarantee nutrition

Photosynthesis is the most important key reaction in the biological nano-system:

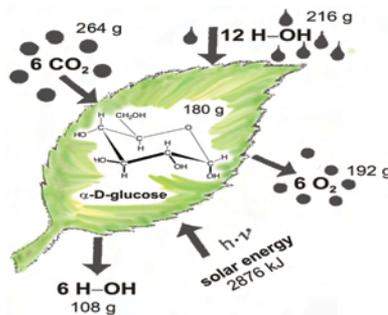


Fig. 5 Photosynthesis in a leaf as a membrane and bioreactor

A biological system contains the provision as well as disposal of matter and energy. They are jointly in flow equilibrium (steady rate). The excretion (waste) of one species is the food of another species.

Photosynthesis happens in the organelles of the plant leaves, that means in the chloroplasts. The chlorophyll, pigment of leaves, absorbs the sun's rays (solar energy). Photosynthesis is not only exclusive to the plant world, but also algae, lichen, plankton and numerous bacteria.

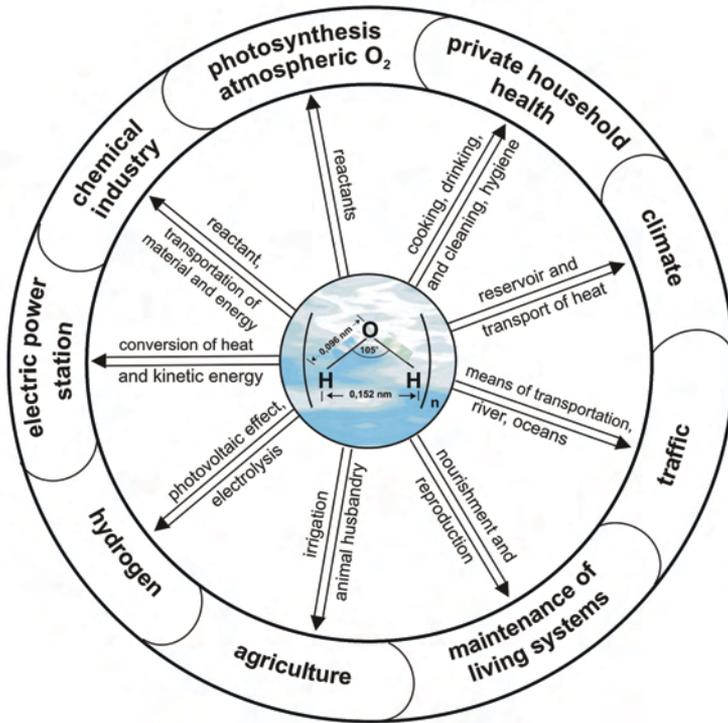


Fig. 7 Water, a system of linking molecules and key-product in nature and technology

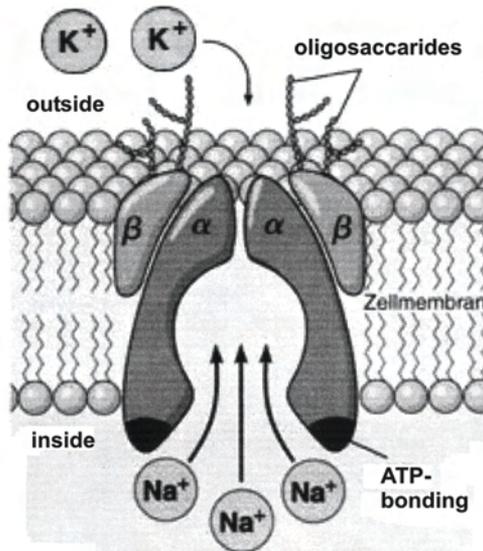


Fig. 8 Gap-junction, e.g. Na⁺/K⁺-pump

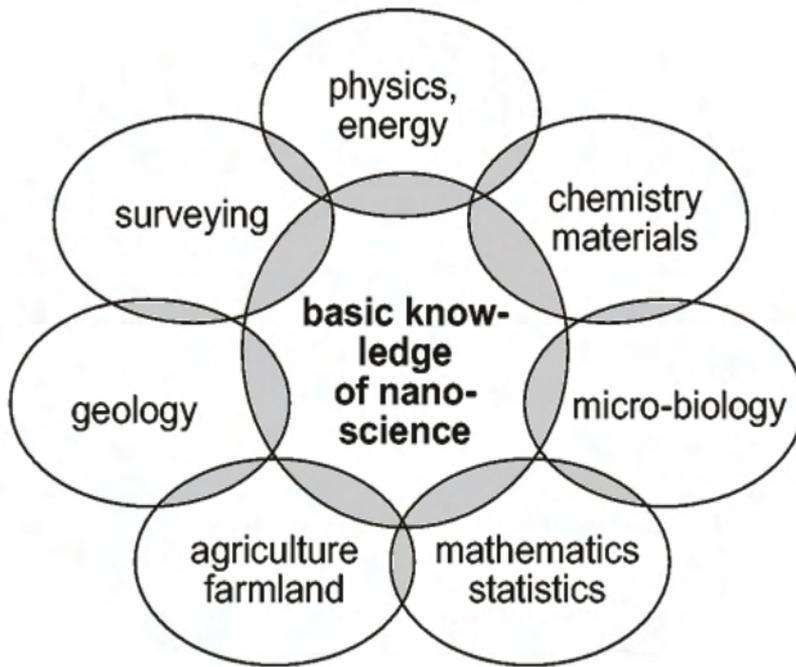


Fig. 9 Interdisciplinary basic knowledge of nano-science

- chemistry, elementary particles, atoms, molecules, kinetics, states of equilibrium.
 - microbiology, cells (animal and vegetable matter), cell membranes, viruses, protozoa, bacteria, fungi.
 - thinking in micro- and nano-dimensions and abstract models.
2. System types
 - closed and open systems, demarcations of systems, barriers of systems (permeable, semi-permeable, non-permeable) e.g. Na^+/K^+ -pumps in a human body (fig. 8).
 - The biological system (fig. 1); Water, a system of linking molecules and a key-product in nature and technology (fig. 7).
 3. Matter
 - biological and non-biological matter. Classification of compositions, forms, structures, functions, surface constitutions and interfacial activity (hydrophobic, hydrophilic, non-polar groups, with different adsorptive capacities) e.g. lotus-effect.
 - materials, active substances, fillers, solids, hollow particles e.g. nanotubes, plane materials e.g. foils and membranes, carbon nanotubes, classification of matter in macro-, micro- and nano-dimensions (fig. 3).
 4. Energy
 - classification of energy types; sources, transmission, transformation, energy storages, the radiation energy spectrum in nanodimensions (fig. 6).



- interaction of energies and matter e.g. photosynthesis, erosion, corrosion, catalytic and enzymatic processes (fig. 5).

In finishing I would like to quote Dr. Alfred Oberholz, a member of the board of the well-known chemical company Degussa AG and responsible for research and development: “Science is giving mankind opportunities for progress and advancement. Opportunities always come with risks. The question is, do we look at the risks first and never come to develop them”.

Let me give you an example. Going back to the time when men learned to use fire. Fire gave him a lot of advantages, among others that he could cook his meal, that he could heat his place of living. Fire also gave him risks, because he would surely burn his fingers. So from today’s view, exaggerated regulation might have limited the temperature of fire to 36 degrees and thus would have killed all innovation and man would still be a hunter and gatherer, eating his food uncooked.”

WFEO-CET CHRONICLE OF EVENTS

CHRONICLE OF EVENTS (OCTOBER 2005 – MARCH 2006)

The WFEO Committee on Education and Training has existed since 1970. At the 2nd General Assembly of WFEO held in October 1969 at the UNESCO Headquarters in Paris, it was decided that a new Standing Committee on Education and Training would be created. Its first meeting took place in December 1970 in Monte Carlo and was sponsored by UNESCO. Dr. J.M. Ham (Canada) was elected President of CET and Eng. L.M. Nadeau became its Secretary. The Committee Secretariat was located in Ottawa in the Headquarters of the Canadian Council of Professional Engineers. So, this year, the WFEO-CET will have celebrate its 36th birthday.

The magnificent history of WFEO-CET covering the period of 27 years (1970–1997) was written by Prof. Miguel Angel Yadarola (Argentina), the Committee President in years 1989–1997. The said history was published in IDEAS twice – in No.10 and No.12. Prof. Yadarola has agreed to continue the CET history. Therefore, in order to facilitate recording of the Committee activities and important events in its life, the present editor of the journal has decided to publish the chronicle in every issue of IDEAS which embraces a yearly period of the Committee activities.

20 October, 2005

General Assembly of WFEO at its meeting in San Juan Puerto Rico accepted the proposal from the Polish Federation of Engineering Associations to take over the Committee on Education (CET).

2 November, 2005

The Polish Federation of Engineering Associations takes over the WFEO Committee on Education and Training (CET) and its Secretariat.

Secretariat of WFEO-CET has been located in the Warsaw House of Engineers – headquarters of the Polish Federation (in Czackiego Str.3/5), at the Office of its Executive Board, at the Department for International Affairs and Professional Development. Mrs. Teresa Domańska, Manager of the Dept. has been nominated CET Secretary. Though formally Secretariat started on November 2, 2005 (November 1 is a holiday in Poland), preparatory works had been initiated

some months earlier (already in May 2005 – a delegation composed, among others, of the then President-Elect Prof. Włodzimierz Miszański and Secretary-Elect of CET Mrs. Teresa Domańska visited the CET Secretariat in Budapest in order to get acquainted with its work and documentation and financial details concerning the Committee and its Secretariat. The delegation was headed by Mr. Kazimierz Wawrzyniak, Secretary General of the Polish Federation. Since the end of October 2005 (i.e. just after Puerto Rico GA meeting) the new CET President and CET Secretary have intensively worked on securing appropriate conditions of the Secretariat's functioning. And due to their activity the new Secretariat has started its proper and smooth operation.

23 November, 2005

Official overtaking of the Committee and its Secretariat from Hungarian Colleagues took place in Warsaw at the official celebrations of the 170 Anniversary of the Association Movement of Engineers in Poland, 100 Anniversary of the Warsaw House of Engineers and 60 Anniversary of the Polish Federation of Engineering Associations.

On invitation of the Authorities of the Polish Federation of Engineering Associations, Mr. János Ginzstler – Past President of WFEO-CET, Mrs. Zsuzsanna Sárkozi-Zagoni – Past Secretary of WFEO-CET, Mrs. Tahani Lefebure – Executive Director of WFEO and Mr. Hisham Shihaby – Vice-President of WFEO and Vice-President of WFEO-CET paid a visit to Warsaw due to the overtaking by the Polish Federation of Engineering Associations (PFEA) of WFEO Committee on Education and Training (WFEO-CET) and its Secretariat. On 23 November, in the morning, Mr. János Ginzstler, Past President of WFEO-CET and Mrs. Zsuzsanna Sárkozi-Zagoni, Past Secretary of WFEO-CET have officially transferred the tasks of leadership and management of the said Committee and its Secretariat/Bureau to Mr. Włodzimierz Miszański, new President of WFEO-CET, Chairman of Committee on Professional Development of PFEA and Mrs Teresa Domańska, new Secretary of WFEO-CET, Manager of the Department for International Cooperation and Professional Development of PFEA, Head of Secretariat of the Polish National Committee for FEANI. The said ceremony took place in the presence of Mr. Kazimierz Wawrzyniak, Secretary General of PFEA, Mrs. Tahani Lefebure, Executive Director of WFEO and Mr. Hisham Shihaby, Vice-President of WFEO,

Vice-President of WFEO-CET. Pro Memoria from the said meetings was signed on Nov. 23. On the same day, in late afternoon hours Mr. Hisham Shihaby and Mrs. Tahani Lefebure participated at the official celebrations of the 170 Anniversary of the Association Movement of Engineers in Poland, 100 Anniversary of the Warsaw House of Engineers and 60 Anniversary of the Polish Federation of Engineering Associations. Mr. Hisham Shihaby, Vice-President of WFEO informed the Executive Board of the Federation about official acceptance by WFEO General Assembly of taking over WFEO Committee on E and T by the Polish National Member, i.e. the Polish Federation of Engineering Associations, at its meeting in Puerto Rico on October 20, 2005 and congratulated Polish engineers on occasion of the anniversaries.



Photo 1. Official Overtaking of CET and its Secretariat – Talks and Pro-Memoria Signing (23 November, 2005, Warsaw).

From the left: H. Shihaby, T. Lefebure, T. Domańska, J. Ginsztler, Zs. Särkozi-Zagoni, Interpreter, K. Wawrzyniak, W. Miszalski



Photo 2. Official Overtaking of CET and its Secretariat Talks and Pro-Memoria Signing (23 November 2005, Warsaw). From the left: H. Shihaby, T. Lefebure, T. Domańska, J. Ginsztler, Zs. Sárkozi-Zagoni, Interpreter, K. Wawrzyniak, W. Miszalski



Photo 3. H. Shihaby' Speech at the Official Celebrations of the 170 Anniversary of the Association Movement of Engineers in Poland, 100 Anniversary of the Warsaw House of Engineers and 60 Anniversary of the Polish Federation of Engineering Associations (23 November, 2005, in Warsaw).

H. Shihaby, Vice-President of WFEO and Vice President of WFEO-CET, Speaking in Warsaw House of Engineers during the Anniversary Celebrations.

4–7 March, 2006

WFEO-CET Members actively participated at the 7th WFEO World Congress on Engineering Education devoted to “Mobility of Engineers”. At the Congress participated 9 Committee Members with 8 papers.

8 March, 2006

The 35 WFEO-CET Meeting (i.e. the first Committee meeting under the Polish presidency) was organised by its new President and Secretary on in Budapest after the 7th WFEO World Congress on Engineering Education devoted to Mobility of Engineers (March 4–7, 2006).



Photo 4. 35 WFEO-CET Meeting on 8 March, 2006 in Budapest.

From the left: W. Butcher, G. Johnson, B. Gear, S. Ioakimidis, M. Al-Hajeri, T. Domańska, W. Miszalski, H. Shihaby



Photo 5. 35 WFEO-CET Meeting on 8 March, 2006 in Budapest. From the left: M.A. Yadarola, Z. Gaal, Zs. Sárközi-Zagoni, A. M. Alameddine, V. Hopp, R. Petřikova, L. Lerner



Photo 6. 35 WFEO-CET Meeting on 8 March, 2006 in Budapest. From the left: W. Miszalski, H. Shihaby, A. Hay, C. Smith, J. Al-Dabbek, E. Peeters, D. Danyluk, T. Siller, P. Molnar

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