for better education & training for engineer

Ideas

THE IMPACT OF GLOBALIZATION ON THE ENGINEERING EDUCATION AND ENGINEERING PRACTICE

Number 6
October 1999

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

COMMITTEE ON EDUCATION AND TRAINING

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IDEAS is a publication of the WFEO Committee on Education and Training, addressed to engineering educators, educational officers at Universities and leaders responsible for establishing educational policies for engineering in each country. The articles it contains reflect the concern of people and institutions linked to WFEO, to provide ideas and proposals with the object of improving formation of engineers.

EZ A KIADVÁNY AZ OKTATÁSI MINISZTÉRIUM, AZ OMFB ÉS A MTESZ TÁMOGATÁSÁVAL KÉSZÜLT.

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

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

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CONTENTS

GLOBALIZATION AND/OR NATIONAL INTERESTS

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

The reason, why we choose the title of this 6. Number of IDEAS was to share with our distinguished readers the thoughts of world-wide known excellent experts about the impact of globalization on the engineering education and engineering practice, which were widely discussed during the satellite conference (in Balatonfüred, Hungary, 22-26. June, 99.) of the World Science Conference (organized by the UNESCO with the contribution of the Hungarian Academy of Sciences, Ministry of Education, National Committee for Technological Development, Hungarian Academy of Engineering and also our Committee, Budapest, Hungary, 27. June – 2. July, 1999).

Prof. Jose Medem underlined in his lecture during the WSC the most important role of engineers in the interest of increasing the welfare of the societies. He strengthened the statement of our satellite conference, that the engineering profession represents an essential "bridge" between the science and society.

Prof. Miguel Angel Yadarola, Past President of our Committee wrote in his editorial of the 5. Number of IDEAS:

"The fundamental change in which we are already immerse is the supremacy of knowledge that means a new approach in the concentration of power of a nation. A power that does not lie exclusively in capital, in the production media or in the labour forces, but in the minds of engineers, workers, administrators and directors".

Following his uptodate order of ideas, the articles of this issue are grouped around three main topics:
– Global Perspectives
– Development in Teaching
– Regional and National Responses to Globalization

I do very much hope, that this volume will help for all of us to try to find the harmonization between our national and global interests.

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

Final report on the satellite conference of the World Science Conference

(Budapest, 26 June - 1 July 1999)

The Impact of Globalization on Engineering Education and Practice

(Balatonfüred, 22 June - 24 June 1999)

DESCRIPTION OF THE EVENT

More than 60 participants from more than 20 countries took part in the satellite conference. The central theme of the conference was globalization and its impact on engineering education and practice. There are many different aspects of globalization:

- the globalization of the world market and the world economy;
- the development of global communication systems;
- the globalization of international institutions, for example in the field of higher education, environmental protection, security policy, etc., and
- the globalization of political systems.

Engineers of the next century must respond to the consequences of the quick spread of globalization. More and more engineers will work across national boundaries, and therefore they must understand the cultures, traditions and languages of countries where they will work, or where their products will be utilised. These tasks set up new challenges and requirements the engineering education and for the engineering profession. Distinguished Hungarian and International experts active in the field of engineering education - including some from the developing countries who participated in this important international event, thanks to UNESCO support - debated the problems, arising from globalization. Included were the problems of mutual recognition of accreditation systems, the need to teach sustainable development in engineering education, the challenge of knowledge based societies and the permanent updating of engineering teachers. Also highlighted was the importance of quality control at engineering education institutions, given the wide differences between educational systems. In discussion many suggestions were made as to how the difficulties could be resolved. Remembering that globalization involves life long learning consideration was also given to the problems of continuous professional development of the graduate and of the continuing engineering education. The international conference was followed by the Annual Meeting of the Committee on Education and Training of the WFEO in the afternoon hours of 24 June; and by the joint meeting with the International Committee of Engineering Education of the UNESCO, in the forenoon of 25 June. A joint statement was sent to the WSC Secretariat in Budapest, emphasising that the engineering profession represents an essential "bridge" between the science and society.

Prof. János Ginsztler
Chairman of the Satellite Conference

International Recognition of Engineering Qualifications

Eur. Ing. Professor Jack Levy,
The City University, United Kingdom

SUMMARY: The writer was a UK representative in the original negotiations for the 'European Engineer' (EurIng) title, covering 27 countries, and also for the 'Washington Accord' on the mutual recognition of accreditation systems among a number of countries across the world. An account is given of the negotiating difficulties, due to the differences between educational systems, and how the difficulties were resolved. Based on these experiences, consideration is given to the possible types of agreement and to the problems of achieving global progress on the equivalency of engineering qualifications to the benefit of professional engineers and their employers. Some current initiatives on mutual recognition are briefly reviewed, involving countries not only in Europe but also in North America (NAFTA) and Asia (APEC).

KEYWORDS: Engineering Education — Accreditation Global

INTRODUCTION

Suppose all the delegates to this International Conference had the same academic and professional qualification, irrespective of the country in which they received their engineering education and training.

In that case, all of us would be able to practice in any of the countries on equal terms with those born in that country. Also, there would be much wider recognition among the general public of the meaning of our qualification. As it is, systems of engineering education and professional training are widely diverse. This results in a range of academic and professional titles which can cause confusion, not just among the general public but also globally among governments, employers and professional organisations.

Consequently, it is to the advantage of individual engineers and the profession as a whole that systems of mutual and international recognition of engineering qualifications should be developed and that common titles should be available for those engineers wishing to adopt them.

THE UNDERLYING EQUIVALENCE

The laws of physics, mechanics and good engineering practice are universal and no respecter of national boundaries. So, on the face of it, there is every reason to believe that engineers educated and trained to the appropriate standard in one country should be deemed competent to practice in other parts of the world.

THE VARIABLE BASIS OF QUALIFICATIONS

To be competent to practice it is generally acknowledged that a professional engineer must acquire :

a) An appropriate university level education, providing analytical and theoretical knowledge;
b) Training, which imparts skills in dealing with practical problems and people ;
c) Experience including some of a responsible nature.

While all these components of professionalism are needed, the way they are acquired varies, as does the point at which the national professional title is awarded. In particular, the length of the academic course may vary widely, from three years to five or more years. The differences may be illustrated by comparing three systems of engineering 'formation':

United Kingdom: A shorter university course of three years (now rising to four). This results in a university degree such as Master of Engineering (MEng). However, the professional title of Chartered Engineer (CEng) is only awarded after a further period of some four years supervised training and experience, plus an interview.

The USA: A four-year university course leading to a Bachelor degree. The Professional Engineer (PE) title is awarded by each State on success in two examinations, the first of which can be taken prior to graduation, while the second, requiring more training and experience, is taken two or three years after graduation.

Germany: A longer university course of five years or more, but which may incorporate elements of training and industrial experience. The university degree of, for example, Dipl. Ing., is regarded as the professional title and there are no further examinations.

These three examples, which do not exhaust the possibilities, demonstrate the inherent difficulties of equating systems at particular points in the 'formation' process.

There are also variations in methods of course validation and quality assurance. Some countries, such as the USA, have a well-established system of accreditation operated by ABET (the Accreditation Board for Engineering and Technology), which is in the control of the profession itself. A similar system is used in the UK, Australia and elsewhere. In other countries, the accreditation system is operated not by the profession but by the government. For example in the case of France the responsibility belongs to the Commission des Titres d'Ingenieur. Yet again, in some countries the responsibility for standards is left to the university itself, with no external checks.

POSSIBLE TYPES OF MUTUAL RECOGNITION AGREEMENT

With the variation of systems in mind, it seems that three main kinds of international agreements are possible.

a) Comprehensive agreement with transferable titles:

Engineers attaining the professional title in their own country could move to another participating country and use the professional title of the host country. No such examples are known, even between countries with almost identical systems. However, some bilateral agreements between the professional bodies of two countries do approximate to this comprehensive type of agreement. (In such cases, 'daily-chaining' is not allowed. That is, if A recognises B and B recognises C, it does not follow that A automatically recognises C).

b) Comprehensive agreement using a new common title:

A number of countries may agree that their formation systems, though different, produce comparable results, but custom and political barriers rule out the transfer of titles. In such cases a new title may be invented which can be used by all who meet the standard. The European Engineer (EurIng) falls into this category.

c) Agreement to recognise the academic component only:

This type of agreement falls short of full mutual recognition of the whole professional formation process. It means that an engineer, moving from one participating country to another, would have his or her university degree recognised as fulfilling the academic requirement of the host country. But the engineer would have to satisfy any further requirements regarding training, experience etc of the host country in order to qualify for the professional title. The 'Washington Accord' is the most notable example of such an agreement.

NEGOTIATIONS FOR THE EUROPEAN ENGINEER (EURING) TITLE

– Background:

The European Federation of National Engineering Associations FEANI (Federation Europeene d'Associations Nationales d'Ingenieurs) was established in 1951 and now has its headquarters in Brussels. Among its aims is securing the recognition of European engineering titles facilitating the freedom of engineers to move and practise within and outside Europe. FEANI now brings together engineering associations from 27 European countries as National Members. Each has a National Committee for FEANI with a Secretary-General.

– The EurIng System:

The difficulties of mutual recognition outlined above are partly political and partly technical. Politically, there is sometimes a reluctance to recognise engineers from other countries when work is short or when the level of salaries may be threatened by an influx of foreign talent.

Technically there are genuine concerns in some countries that the quality of education received by engineers in other countries may not equal their own standards. This concern expresses itself most openly in countries which have traditionally a longer degree course of four to six years compared with, say, the three years in the UK. But, as has already been noted, the UK professional institutions would claim that the training and experience element of the CEng qualification compensates adequately for the shorter academic course. Intensive negotiation to satisfy the various concerns and perceptions among the professional bodies represented in FEANI resulted in a formula for registration as a European Engineer (EurIng). Briefly, the standard is a total of seven years after secondary education, consisting of approved university education (minimum three years), training programme and relevant experience.

Registration gives one the right to be called European Engineer in the language of the National Member and to use the designatory letters EurIng, which is invariable in all the member countries, subject to national law. Persons registered as EurIng must abide by the FEANI code of professional conduct.

– Monitoring of the EurIng System:

Each of the FEANI National Committees has established a National Monitoring Committee (NMC) composed of representatives from engineering associations, industry and education. The NMC is responsible for checking the qualifications and experience of individual applicants. The basic philosophy is that different systems can co-exist, the focus being on attained competence. So, for EurIng applicants, in addition to checking academic qualifications, the NMC looks at appropriate engineering experience to complete the seven-year package.

The NMCs make recommendations on individual applications to the central European Monitoring Committee (EMC) whose task is to maintain a European-wide standard. It is also the responsibility of each NMC to keep the EMC well-informed on the structure of engineering education and the standard of the individual schools and/or courses in its own country. There are now some 24,000 EurIngs, though the rate of registration across Europe is far from uniform.

NEGOTIATIONS RESULTING IN THE 'WASHINGTON ACCORD'

Background:
Also in 1987, the present writer convened a meeting in London of representatives from countries which had a well-established degree course accreditation system operated by their professional bodies. In addition to the UK there were Australia, Canada, Ireland, New Zealand and the USA. The idea was to explore whether there could be mutual recognition of each other's accredited degrees. The London meeting was followed by one in Washington where the ideas were fleshed out – hence the 'Washington Accord' – and the agreement was finally signed concurrently with a WFEO meeting in Prague in 1989.

The Character of the Accord:
The Washington Accord falls into the category of international agreements mentioned above in *c)*. Any graduate successfully completing an accredited course in any of the participating countries would be deemed to have satisfied the educational standards in any of the others, but would still have to satisfy any additional requirements for full professional status. So, in the UK, for example, the training and experience provisions would need to be met and a professional review, with interview, taken. In the USA the second of the two examinations for the Professional Engineer (PE) title would have to be passed. The negotiations at international level represent only the surface of the effort. Each of the delegates has an internal national audience to convince. In the UK, the Engineering Council has to satisfy about 40 professional engineering institutions. ABET in the USA has to ensure that the 50 states of the USA would honour such an agreement as the Washington Accord, remembering that PE is awarded by each State. Similarly, in Canada there are 12 Provinces.

The Washington Accord is not intended to operate as a "closed shop". The door is open to any other nation to join, provided it can demonstrate that its course accreditation procedures are equivalent to those operated by the existing signatories to the Accord. In fact, two additional countries, South Africa and Hong Kong, have recently joined.

Monitoring of the Washington Accord:
The monitoring arrangement is to invite representatives from all the other participating countries to join in accreditation meetings and visits, in order to satisfy themselves of the continuing broad equivalence of graduate standards in each engineering discipline. A secretariat established in one of the countries (at present Australia) is responsible for making these arrangements, covering all the countries.

CURRENT DISCUSSIONS ON EXPANSION OF MUTUAL RECOGNITION

The EurIng title and the Washington Accord (WA) represent the present high point of international recognition agreements. One of their important side effects has been to instil confidence that such international agreements are actually workable. Consequently, a number of organisations have been looking at the possibilities of extending or emulating the two main agreements. These initiatives concern :

a) Agreements covering engineers in the technologist and technician categories;
b) Agreements similar to EurIng and WA in other parts of the world;
c) Extension of WA to cover entitlement to full professional recognition;
d) Wider accreditation possibilities.

A brief survey of these initiatives is given below, but it is fair to say that none has yet reached a stage where early agreement and implementation is to be expected.

Technologists and Technicians:
Many countries have grades of registered engineers in addition to the senior professional grade. They have titles such as Engineering Technologist, Associate Engineer or Incorporated Engineer.

A recent audit of the requirements and procedures across the WA countries, carried out by WATT, the Washington Accord working party on Technologists and Technicians, concluded that '... there appears to be a broad measure of commonality, which should give us confidence to recommend that extension of the Accord to cover Technologists. However, although similar processes for accreditation appear to be in place, it is not yet clear that programmes (courses) being accredited are at an equivalent level.' Within WATT, the discussions continue. As far as is known, only one agreement at Technologist level exists, and is bilateral between Ireland and the UK. Its provisions are similar to those of the Washington Accord.

As far as the European scene is concerned, two alternative routes for the mutual recognition of technologists and technicians are under consideration. There is an organisation, EurEta, which already registers Technologists on a pan-European basis, albeit in small numbers in only a few countries. The other approach is a proposal to provide a separate category for Technologists within the EurIng procedures. Only time will tell whether further negotiations will succeed in either of these approaches.

Draft Agreements in other parts of the world:
a) The Asia Pacific Economic Community (APEC) has produced a draft paper on the 'APEC Engineer' which bears similarity to the EurIng formula. The 1997 draft requires a candidate to have a recognised engineering degree, seven years' practical experience and two years in responsible charge of significant engineering work. The proposed monitoring arrangements are also similar to the EurIng provisions.
b) Discussions have taken place within the North American Free Trade Association (NAFTA) on the mutual recognition of qualifications.

Extension of the Washington Accord – the EMF:
The Washington Accord provides only for the mutual recognition of accredited degrees. In 1997, discussions began to extend this to full mutual professional recognition, under the acronym EMF – Engineers' Mobility Forum. The basis of proposed recognition is an accredited degree plus satisfaction of any additional requirements for the local professional title, plus X years of professional experience. Discussions are being conducted on the basis of X = 8 years and so introduces a new concept of the professional title of a host country (type *(a)* above) being readily open to those who have their own professional title plus more professional practice. Progress on the EMF is slow, because it is not yet clear how far the professional organisations in the participating countries will be prepared to waive their own requirements. The existing position is only that they will 'streamline' their procedures for such candidates.

Wider Accreditation Possibilities:
Representatives of a number of countries, including Mexico and Japan, have indicated an interest in joining the Washington Accord. To do so they will need to develop robust systems of engineering degree course accreditation and fulfil the standards set. It is likely that, over the next few years, the member countries of the WA will increase from the present eight to about a dozen.

In Europe there are a number of organisations active in engineering education who are interested in accreditation systems, with a view to possibly extending mutual recognition agreements. These organisations include:
– SEFI – the European Society for Engineering Education, which has 242

Higher Education Institutions among its membership. It aims to contribute to the development of engineering education and improve the position of engineering professionals;
- CESAER – Conference of European Schools for Advanced Engineering Launch – a consortium of approximately 45 leading research based universities across Europe;
- BEST – The Board of European Students in Technology;
- H3E – Higher Engineering Education for Europe, which is a European Economic Interest Grouping (EEIG) formed in 1996 by SEFI, CESAER and BEST. It is supported by a European Community SOCRATES grant.

Working Group 2 of H3E has established EWAEP, the "European Workshop on Accreditation of Engineering Programmes" which, in 1998, convened international meetings in Holland, UK and France. The present position is that EWAEP believes that the development of a single pan-European system of course accreditation is probably impractical. However, there is a need for 'networking' of Qualification/Accreditation bodies for exchange of information and views and the development of common practices. There is also a need for an agreed list of "qualification profiles" required of all professional engineers to become the basis of an agreed list of formal qualifications, facilitating mutual recognition.

THE EMPLOYER'S PERSPECTIVE

It is not unusual for employers of engineers to state that they are 'not interested in qualifications, only in what a person can do'. But of course a reputable qualification should indeed reflect what a person can do.

Such employers' statements may mask questions of salary and status, but to be fair we – and other professions – sometimes present employers with a multiplicity of qualifications which are difficult to assess and inter-relate. Any simplification by way of international agreements of equivalence and convergence of titles will benefit employers as well as the engineering profession. There are already some signs that employers welcome the EurIng qualification. For one thing, it will enable them to advertise for staff with a single qualification throughout Europe. At present, mention of any one of the national titles appears to exclude all those from other countries. In time it will be as natural for engineers to move from London to Madrid or from Paris to Rome as easily as they do from New York to Chicago. This new mobility will enhance individual prospects and promote engineering development across the whole of Europe. From a perspective outside Europe the EurIng title can represent a dramatic simplification of what is perceived. From the USA for example, Europe has a confusing array of national titles. The simplification represented by a single title must be to the advantage of individual European engineers and European industry generally.

If the profession shows itself to be united and dedicated to continuing improvement, employers' attitudes towards titles will gradually change. Nevertheless, it has always to be stressed that this will happen not because of the titles themselves but because of the underlying excellence of the education and training the titles represent.

Argentina

The Challenge of the Knowledge Society to the Permanent Updating of Engineering Teachers

Prof. Miguel Angel Yadarola
Consulting Professor – National University of Córdoba, Argentina
Plenary Professor – Belgrano University of Buenos Aires, Argentina
Past President, WFEO Committee on Education and Training

WHY WORRY

Why worry about the ways in which teachers and the rest of the educational staff of the Engineering Faculties, develop their knowledge, understanding, skills and techniques during the course of their careers?

The quality of the staff of the Institutions of Higher Education is, perhaps, the most critical factor for the improvement of the effectiveness of the services that these institutions must render to the public on the threshold of the Third Millenium.

Ambitious educational outcomes, as well as practical abilities and skills, capacity of responsible innovation and a humanistic and socio-economic vision of science, technology and environment are sought for those students of today that will soon become engineers working in a new and complex Knowledge Society. They will demand teachers familiarised with strategies for matching teaching and assessment methods, with learning goals, more concerned about the quality of education offered by an Institution than about their participation in research and frequent publications.

WFEO'S WORRY

The World Federation of Engineering Organisations, WFEO, through its Standing Committee on Education and Training has shown its committment with the development of human resources, well trained and motivated for teaching in Engineering Schools, summoning in September 1991 in Havanna, Cuba, its Second World Congress on the subject "Formation of Engineering Professors to face the challenges of the XXIst Century".

The Conclusions and Recommendations of the Second Congress *(1)* that are reproduced in the Appendix to this document have not lost current importance and should serve as a guide to promote actions aimed at strengthening the initial training of engineering professors and their continuing professional development (CPD) in the academic teaching profession.

THE MYTHS OF EDUCATIONAL EXCELLENCE

The last years of the 20th Century are witnesses of the great alterations in the behaviour of society at a world level, influenced by changes in politics and the economy brought about by globalization. This process is not just the result of the collapse of commercial frontiers, or of the growth of industrial production tied to patterns of quality to satisfy consumers, nor does it represent the trend to concentrate capitals to optimize results, thus increasing economic benefits.

Globalization is a consequence of science and technology efficiently administrated by engineering, whose undoubted protagonism in the creation of a cybernetic culture is throwing down intellectual frontiers to make possible access to knowledge and the creation of common bases, aimed at making the most of human and material resources; at reincorporating man as a person within the productive system offering him the prospect of a better life quality and fundamentally, to create the conditions for a better understanding between different cultures.

Many universities in developing countries, used to slow changes, have not yet assimilated the consequences of these transformations and this is particularly so in the case of Schools of Engineering because they are tied down to curricular designs and obsolete academic organizations built to satisfy rigid processes of teaching-learning.

The reality today is that the university faces the permanent challenge of not being displaced in its mission to search for new knowledge and new ways of transmitting it within a totally different communication environment and with very different technologies to those that characterize their present formation system. A key element in this are the engineering professors.

Maintaining a teaching staff of excellence, is not achieved only by exalting with priority the academic and professional capability of a professor, placing erroneously at the highest level of consideration their scientific formation, verified through master and doctor degrees, and research work, because they do not guarantee the necessary deep knowledge of the engineering method. Making a myth out of exclusive dedication in his job, to comply with which the professor must render a large part of his time to research in irrelevant or obsolete matters and to publications that only serve to enrichen his academic background. Many of these professors can demonstrate a deep specific knowledge in the area or subject in their charge, capability to transmit knowledge with conceptual celerity and skill in the use of new didactic resources. There are teachers that, showing these characteristics, may remain teaching engineering for life in a Universitym because the mechanisms for staff development in many countries are "being limited solely to the period spent achieving a doctorate outside their country, but they ignore all the later stages of CPD in teaching" *(2)*.

What this affirmation intends to discuss, is not only the didactic abilities and attitudes of engineering professors, but their competence to generate in students, from the very first years of their careers, professional skills that will develop the profile of the future engineer.

FAILURES IN THE FORMATION OF ENGINEERS

1. The erroneous construction of the curricular contents in some schools of Engineering, and particularly in many Developing Countries, is responsible for the formation of incomplete engineers. They have saturated the first years of their careers with a heap of abstract sciences that has retarded and sometimes inhibited, the growth of their professional personality, convincing them, that the scientific method is the basis of the creativity the future engineer must display, letting them find out only at the end of their studies, that the engineering method is the only course that will allow the birth and use of creativity and capability of innovation necessary for an engineer to make true, with originality, the project, the construction and operation of a work, a system, an industry or a component, giving the entire work an integrating and multidisciplinary vision.

2. Schools of Engineering fail to comply with their function of forming engineers when they leave in the hands of Doctors or Professors of Sciences, the development of programs of Mathematics and Physics: the Basic Sciences along with Chemistry and lately, Biology. They wrongly believe that without a previous strong scientific basis, it is not possible to learn engineering, when what is necessary, is to dose scientific knowledge and especially Mathematics, along the entire career (math, just in time).

Complementing this ambiguous concept Institutions fail when they do not consider or forget that Basic Sciences should be taught clearly oriented towards engineering, stimulating a professional attitude by means of laying out and solving problems and developing practical experiences. Therefore it is convenient to include in the teaching staff for Basic Sciences, *professional engineers, competent, capable and updated academically and pedagogically, to cooperate in the task.*

3. Schools of Engineering fail when they prepare their curricula oriented specifically towards a discipline, emphasizing specialization, teaching methods and technologies that for sure will be obsolete in a few years. Formation of engineers should be integral if we wish an engineer to continue to play a protagonic role in society, leading the rapid changes that will occur more and more rapidly.

We must emphasize then, the need to form generalized engineers, capable of understanding and interacting with different cultures, of mobilizing and conducting human resources and interdisciplinary groups, of expressing themselves fluidly in their own language and in another European language both in writing and orally and in public, trained to take decisions and take on responsibilities, to convincingly defend their ideas and proposals, to identify themselves with the policies, aims, objectives and ways of work in the structure of modern enterprises together with a capability of management. The development of these and other professional qualifications cannot be confined to certain curricular contents and isolated practices. They form part of the humanistic, social and political-economic formation of an engineer and should be developed within a concept of synthesis, as the students own construction, ellaborated on the basis of life *experiences that the professors should be able to motivate.*

Professors and the educational methodology that they use to transmit technical knowledge, integrated to a cultural basis, are key elements, not frequent in Engineering Schools. Nevertheless, it is possible to find many programmes with an adequate balance of subjects for humanistic and socio-economic formation, but most of this knowledge is taught in an isolated manner, split in subjects that the student undervalues because they do not show their intimate connection with engineering knowledge and with the ethical and economic impact that engineering works have on society and the environment.

A professor, each professor of engineering, should be a guide orienting the learning process aimed at the practice of all those attitudes that lead towards the formation of the professional personality of the future engineer. The idea is that *every professor should be a cultured person, an engineer with experience that has known how to capitalize experiences and is able to transmit them with an integral vision of culture, technology, science and the environment.* A man committed to the sustainable development of his country and the world.

THE PERFORMANCE OF ENGINEERING PROFESSORS

Quality in education becomes a reality when relative quantitative learning is achieved, the efficiency, efficacy and sufficiency of which can be measured by means of the professor's daily self control.

Creative learning is fundamental, especially in Engineering Schools, if it is the fruit of a construction performed by the student himself, incentivated and stimulated by the professor in his role of guide.

The verification the professor may carry out through evaluations, allows him to measure what the student has learnt, thus becoming a valuable feedback action of the teaching-learning process. Furthermore, making use of the modern concepts of psychopedagogy, *the professor may be learner and teacher at the same time,* as long as he is willing to analyse in the students the results of learning as a manner of judging himself, of knowing his own cognitive processes that allow him to reflect on his capabilities and limitations, in order to anticipate certain mental operations and plan intellectual actitivites in face of new experiences of learning (Metacognitive knowledge) *(3).*

"Questionnaires are the appropriate way to obtain feedback and allow both teachers and students to acquire better insights into the teaching/learning process. For example, they may need to be aware *(a)* of the difference between factual knowledge, skills, understanding, know-how and attitudes and values, *(b)* of how these kinds of learning can best be taught and *(c)* of students different preferred learning styles (such as "holist" versus "serialist" students; visualisers versus verbalisers versus doers, etc.). Even then, helpful feedback from questionnaires is only to be expected if the course aims have been clearly specified in terms not only of subject matter and level but also in terms of the above kinds of learning. *(4).*

It is a challenge and an opportunity for all our Schools of Engineering *to generate expertise and behaviours* as those described, in the work of the professors, as part of the development of a continuous process of improvement of quality and a real cultural transformation of the educational staff having in mind today's increasing number of people and organisations that are questioning the ways to evaluate the effectiveness of their performance. Institutions must resist the temptation to continue presenting as stereotypes, certain professors that are really learned in their subjects, undisputed authorities in knowledge, and some times respected by the international community, but incapable of really helping their students to learn. They still believe that teaching is transmitting knowledge, airing their wisdom, instead of worrying about *what the students may have learnt;* ignoring the danger of having passive students, fearful of making questions or giving opinions, and therefore non-critical and non-creative. Furthermore, the exclusive concentration of his classes on themes of the subject, inhibits many possibilities of transmitting engineering experiences.

THE ROADS TO ACADEMIC IMPROVEMENT

Educational systems have progressed as regards methodologies for curricular design and the evaluation of students, but has not evolved at the pace of other human activities in the processes of training and formation of professors, leaving in their hands the responsibility of acquiring knowledge of pedagogy and didactic resources that make interaction with students easier.

Formation, improvement and continuous development of the teaching staff of Schools of Engineering should be *stimulated and monitored permanently* by the Universities, with the support of the Government and Regional and International Institutions that promote progress in education and culture. It represents an essential *investment for the future* of not only the educational institutions but also of each country, given the evidence of the growing value of knowledge as a factor of development of the nations.

Each country, in cooperation with International Organizations must establish or strengthen "clear policies concerning higher education teachers, with provisions for updating and improving their *pedagogical skills,* with stimulus for constant innovation in curriculum, teaching and learning methods, and with an appropriate professional and financial status for excellence in teaching", in keeping with the provisions of the Recommendations concerning the Status of Higher Education Teaching Personnel approved by the General Conference of UNESCO in November 1997. *(5)*

With fast technological changes engineering professors will need to assume not only the commitment of keeping themselves periodically updated to progress in the field of their knowledge, but to be aware of the new technogical developments that will allow them to be prepared to change tasks and interests and achieve satisfaction in their work. *(6)*

THE CHALLENGE OF THE PERMANENT UPDATING OF ENGINEERING TEACHERS

In considering any strategy for the development of human resources, the Schools of Engineering must place in a relevant position the permanent updating of their teachers and also of all the rest of the staff; administrative and support personnel, well trained, working as partners of the professors they can play crucial roles in helping students to learn, creating an environment that favours learning.

The importance attached to the administrative and support personnel should not be a reason for the Institutions, many of which are organised regarding the person who teaches, to give way to a dangerous culture, centered on the person who administrates, on bureaucratic structures and management characteristics, intended to compare the Institution to a large industrial production enterprise. *(7)*

The establishment of strategies for the continuing development of all the staff in the Institution can help to clear up the way of misconceptions and distorsions and will mobilize all the human resources capacity of our Schools of Engineering to be fully and effectively utilised.

But strategies alone are not enough. It is necessary *to create* both in professors and in the administrative and support personnel, the awareness of the need for continuing development.

Organizing *Staff Development Units* (SDU) has demonstrated that often training courses for teachers are undersuscribed, due to a lack of institutional policies and personal motivations of the various participants. It is time to question why. What barriers obstruct the acceptance of the need of such training? Is it perhaps that the traditional culture of institutions is resistant to changes? Is it because of the shortage of financial resources? Could it be that the academic's prime loyalty to a discipline, has prevented the teacher from wanting to improve how to teach? *(2)* Should these courses be mandatory for those teachers that are willing to receive periodical confirmation of their academic post?

If the goal is to achieve a state of "systematic professionalism" for all the teaching staff, the key question becomes: Should the *financial burden* be supplied by the government, the institution or the individual?

At public supported universities, where quality of teaching is part of a national policy for the excellence of engineering education, the answer is obvious; but the increasing number of private institutions stimulates the search for other sources of funds or *ways to achieve effective staff development strategies. (2)*

SOME RECOMMENDED STRATEGIES

To the Schools of Engineering:

- To prepare a staff development plan that includes the managerial level and the administrative and support personnel, defining standards for each role, category or function.
- To link the institutional policies related to selection, promotion, confirmation and

award of tenure, to the achievement of staff development targets.
- To assure through the Dean or Head of the Institution, firm backing and support to staff development ensuring adequate funding.
- To establish a central Staff Development Unit entrusted to define staff development policies, provide a programme of courses and workshops and report to the Governing Body on overall performance.
- To seek, create and foster a culture of participation in staff development activities.
- To delegate responsibility for promoting staff development on the Heads of Departments allowing them to help members of their staff to show the best performance and effectiveness.
- To promote the development of staff performance indicators and professional standards to serve as a comparative basis for good practice.
- To involve trade union bodies to facilitate more staff development initiatives.
- To implement distance learning courses and activities for staff development.
- To determine what core competences are needed by a member of the teaching staff at its entry in the School of Engineering and during his career.

To the Governments and National funding agencies:

- To promote and support the creation and organisation of Staff Development Units in all the Schools of Engineering of the country.
- To foster the cooperation between Universities of the country and from abroad for the establishment or strengthening of an International Network of Unites for Staff Development.
- To encourage national associations of engineering educators able to sponsor programmes of staff development with the support of industries, services enterprises and the professors of the Schools.
- To back national organisations of engineering Deans/Vicechancelors/Rectors to support university units and act as a forum for the discussion of staff development policies and mechanisms of cooperation.
- To fund innovations in staff development.

To International Agencies:

- To support an International Staff Development Network.
- To run workshops for national policy makers in higher engineering education, encouraging institutional staff development.
- To support surveys of good practice and disseminate their results through networks.
- To promote joint projects between Staff Development Units.
- To help the staff in Developing Countries to maintain professional competence by funding participations in congresses, conferences and seminars.
- To fund a *UNESCO* chair in staff development for Schools of Engineering.
- To organise workshops on specialized topics, using international experts.

Undoubtedly, the task of preparing young engineers to live in the next millenium will demand that teachers broaden their professional role and responsbilities towards the institutions and the society. Let us *give teachers* adequate opportunities to render the best of their capacities by being lifelong learners through *professional development.*

Córdoba, June 1999.

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United States

Global Status of Engineering Education

OUTCOMES OF THE 1998 GLOBAL CONGRESS ON ENGINEERING EDUCATION AT CRACOW, POLAND

Prof. Russel C. Jones, Ph.D., P.E.
World Expertise LLC, Falls Church VA, USA

SUMMARY: The 1998 Global Congress on Engineering Education was organized around several major themes: effective teaching methods, curriculum design and evaluation, liberal education for engineers, use of new technologies in engineering education, current issues and trends in engineering education, international collaborations, education for sustainable development, exchange mechanisms in engineering education, academic/industry collaborations, international mobility, linkages between developed and developing countries, and management of academic and engineering institutions. This paper attempts to summarize the major themes and discussions at the Congress, as well as presenting recommendations from the assembled international group of engineering educators.

KEYWORDS: Engineering Education — Conference Outcomes — Curriculum — International Exchanges — New Teaching Technologies

INTRODUCTION

The Global Congress on Engineering Education, sponsored by the UNESCO International Centre for Engineering Education, was held from 6-11 September 1998 at Cracow, Poland. Some 140 papers from authors in 40 countries were presented, with lively discussion from the 150 Congress participants ensuing. A preprint volume published by the UNESCO International Centre for Engineering Education was distributed at the beginning of the Congress, and each paper was summarized by its author(s) to stimulate discussion, at breakout sessions during the Congress. On the final day of the Congress, plenary sessions involving all participants were conducted to allow general discussion of the conference topics, and to pull together a summary statement and recommendations. This paper attempts to capture the essence of those summary plenary sessions, and thus the essence of the Global Congress. In the judgement of the author, it provides a valuable snapshot of the status of engineering education in the World at this time.

GLOBAL CONGRESS DISCUSSIONS

Effective Teaching Methods – Several papers presented at the Global Congress stressed the need for ongoing innovation in teaching and learning methodologies in engineering education. It was noted in discussion that there needs to be variety and balance in teaching methods, and that technologies appropriate to the subject matter should be utilized. Laboratory development was stressed as a very important component of engineering education, and the integration of lectures with laboratory experiences and project work was identified as an ideal scenario.

From the observation of faculty members who use high technology instruction aids, it was noted that engineering students favor convenience (e.g. access to lectures on video, assignments on a Web site) higher than substance of content or quality of presentation. It was noted that many engineering faculty members still use yellow chalk on green boards, and that they needed to be motivated to move to more current presentation technologies.

Curriculum Design and Evaluation – Project centered learning was identified in several Congress papers as a highly effective way to develop problem solving and teamwork skills in engineering students. It was noted that engineering curricula should focus on developing these types of skills, recognizing that it is not possible to cram all the knowledge that a graduate will need over his or her career into four years of courses.

The preparation of engineers for international practice is a prime consideration in today's global environment. Increasingly, engineers will work across national boundaries.

Graduates must understand the cultures, traditions, and languages of countries where they will work, or where their designs or products will be utilized. It was also noted that engineering education in a given country or region must reflect and respond to local conditions.

The amount of practice orientation in the curriculum was explored by Congress participants, with wide differences of opinion on the desirable amount. It became clear that engineering programs in a particular country needed to provide graduates attuned to the current and future needs of their local economies, so that there would generally be significant differences in the amount of practice orientation that was deemed appropriate by the local faculty.

One basic set of skills that must be developed in engineering students is critical thinking and problem solving. These skills cannot be taught in any given course, but must be developed through a series of experiences throughout the undergraduate curriculum. The undergraduate curriculum must thus be coordinated between the faculty members involved, and cannot simply be a series of stand-alone courses.

Congress participants from developed countries noted a trend toward outcomes assessment as the preferred method for evaluating engineering programs, rather than the detailed technique specification of curriculum by accreditation or government bodies which has been more typical in the past. An outcomes assessment approach tends to more heavily involve industrial employers and technical societies in the evaluation process – seen as a healthy development by the Congress participants.

Liberal Education for Engineers – It was agreed that a liberal arts component for engineering students is appropriate and valuable, to broaden their horizons as they prepare for practice in today's complex world. One element in that liberal arts component that was seen as particularly valuable for engineering students – the history and heritage of technology.

Communication skills were also identified as a key outcome of engineering education desired by employers. Human interaction skills, key to teamwork and management of projects, were also seen as key outcomes desired from engineering education.

Use of New Technologies – Computer aided instruction is well established in many of the engineering schools represented at the Congress. Given the currently available technologies, simulation and virtual reality are particularly valuable tools for engineering education. It was noted, however, that there must be a balance between simulation and hands-on experience with real world elements. Engineering students should also be appropriately exposed to computer aided engineering, of the type that they will utilize when out in practice after graduation.

It was stressed in discussion, however, that computer learning should not attempt to replace valuable student interactions in the classroom – with faculty and with other students. Multiple pathways to learning are needed, and can complement one another in a flexible learning environment.

The Internet and the World Wide Web provide opportunities for engineering students to glean experiences from beyond their own campuses. Even on a given campus, Web pages provided by individual faculty members are useful in providing assignments, readings, etc.

Distance education is typical today for much continuing education for practicing engineers, and engineering students must be prepared to utilize it effectively. Thus some course components should be provided to engineering students via video or the Internet, so that they become comfortable with such delivery methods while still in a supportive campus environment.

Current Issues and Trends – In order to keep the motivation of students high during the early years of engineering education many schools are now moving engineering courses, such as introductory design exposure, into the first or second year of their programs. Design project laboratories in the Freshman year not only give engineering students a glimpse of what their upper division courses will involve, but also provide a rationale for the detailed study of mathematics and science that are typical in the lower division years.

Concluding that it is not possible to cram all the knowledge that an engineer will need throughout his or her career into a four year curriculum, engineering faculties are providing flexibility and diverse paths for individual students – while making sure that the fundamentals such as analytical problem solving , critical thinking and design methodology are included.

Recognizing that many of today's engineering students will choose to start their own businesses at some point in their careers, some engineering education programs are stimulating entreprenaurship and commercialism in the minds of their students – and providing course or project opportunities to learn basic business skills.

International Collaborations - Improvement of academic programs in engineering can often be effected by collaborations at the international level – particularly in developing countries. Both collaborations between developed and developing country engineering schools, and between engineering schools in similar developing countries, can be effective.

Collaboration across national border need not be limited to institutional and faculty exchanges, but can also be valuable at the student level. Electronic communications can currently readily facilitate interaction between students across international boundaries, for information exchange and joint project work.

Congress participants felt that a standard global curriculum for engineering education was neither desirable nor possible to effect. Among other things, the curricular approach used in a particular country needs to be tuned to local needs. It was suggested that curricular ideas and trends from various countries could be shared broadly throughout the international engineering education community via the World Wide Web.

Congress participants expressed the need for mutual recognition of engineering graduates across international borders, so that they can readily practice in the increasingly global technical marketplace. To achieve such recognition, development of some form of global accreditation, tied to engineering societies, may be appropriate. Any such international accreditation would have to be quite flexible in its criteria and their application, and likely should be based on outcomes assessment rather than quantitative specifications for the curricula.

Education for Sustainable Development Social Impacts of Engineering – Engineering educators and the programs they provide to their students must be geared to enhancing the environmental sensitivity of their students. Design methodologies incorporating the principles of sustainable development must be utilized throughout the education of engineers.

Standards for environmental protection, such as ISO 14000, should be highlighted during the formative period of engineers, so that their use becomes a natural part of the later practice of the engineer after graduation.

Engineering students must be taught to predict the societal impacts of their designs, and to modify those that would have undesirable impacts. It was recommended by the participants in the Congress that engineering students should have the experience of working with students from other disciplines – such as business, law, social science, architecture, etc. – on joint projects, in order to get a broader perspective of how their technology interacts with society.

Engineering schools must take the responsibility of preparing students for available and appropriate jobs and career paths, so that there will be an appropriate and rewarding role for them in society when they are ready to graduate and start on their careers.

Exchange Mechanisms in Education – While in the context of a major Global Congress on Engineering Education, participants in Cracow discussed the role of such conferences in promulgating good ideas for the enhancement of engineering education. One positive aspect of such face-to-face conferences is the making of personal connections, which allows follow-up interactions and perhaps long term relationships. It was observed, however, that such conferences are overly expensive for many engineering educators who would benefit from the type of presentations and discussions that occur – such as younger faculty members, and those from poorer countries.

It was suggested that future conferences on engineering education should have a large electronic component, allowing younger and less well off faculty members to benefit from presentations and discussions from close to their home bases. It was felt, however, that some core of participants should meet face-to-face to provide focus and interaction to such an electronic conference. It was also suggested that a series of smaller conferences – perhaps regional in scope – should be held to shape and provide input to each major international conference on engineering education.

The output publications of international engineering education are critical in providing information and stimulation to educators who cannot participate in person. The participants in this Congress recommended that the output from such conferences should be made available in both printed hard copy and via the World Wide Web. The latter should make the material available more broadly, and at more reasonable cost, to those in developing countries.

Academic/Industry Collaboration – Engineering schools must interact and collaborate with the industries they serve, for mutual benefit. Only through such interactions can the engineering education provided be assured to be relevant to the current market place. Students benefit greatly from practical experience gained during summer or co-op period jobs in industry – both in terms of making the remainder of their educational programs more meaningful, and in terms of gaining practical knowledge which will be valuable in full time employment after graduation. Engineering education faculty and administrators, and the programs that they offer, benefit greatly for guidance given by industry advisory groups. Industry also often provides direct support to engineering schools, through funded research projects, equipment grants, sabbatical opportunities for faculty, etc.

International Mobility – Engineering school graduates can benefit greatly from studying abroad for a portion of their educational programs. Formal exchange programs, such as the Tempus program in Europe, go far in preparing engineering students to eventually practice across international borders. Universities should prepare students for study abroad, and eventual practice internationally, by encouraging appropriate study of foreign languages and cultures – and by providing sufficient flexibility in the engineering curriculum to allow an academic term or more to be spent at a school in another country.

Ready international mobility of graduate engineers in practice is often a problem, particularly for those who offer their services directly to the public and thus typically require formal licensure in a jurisdiction in which they want to practice. Engineering educators must work with practitioners and licensing bodies to establish equivalency mechanisms for education, experience, and other licensing requirements.

Linkages Between Developing and Developed Countries – The UNECSO International Center for Engineering Education (UICEE), which organized this Global Congress, is one major effective mechanism for developing linkages between engineering education in developing and developed countries. Conferences, publications, short courses, Web based information, etc., provide linkages at UICEE and other such organizations.

Computer and communication based technologies are increasingly facilitating interchanges between engineering educators at the international level. Satellite delivered video courses, e-mail interchanges, Web based data bases, etc., have broken down previous feelings of isolation on the part of engineering educators in developing countries.

Management of Academic Institutions – Several papers at the Congress described effective practices for the management of engineering schools and the universities within which they exist. Quality control of educational programs, through such mechanisms as accreditation and the application of total quality management systems, was seen as a high priority. The effective management of workloads for faculty, and the appropriate allocation of funding and other resources, were seen as essential to smooth and effective operation of schools.

The problem of how to deal with aging, tenured faculty members was addressed in papers presented at the Congress. Early retirement incentives, retraining through continuing education, vitalization through research involvement, etc., are possible ways of addressing the problem.

Papers and discussion at the Congress also addressed the issue of how to best utilize feedback on the educational experience from students, graduates, and employers. Formal outcomes assessment methodologies can be one effective way to utilize such feedback for the continuous improvement of engineering education programs.

CONCLUSIONS AND RECOMMENDATIONS

Recommendations from the Congress included:

- A near future international conference on engineering education should contain a comprehensive coverage of the results of major educational programs currently revitalizing this field in several countries, such as the Coalitions Program of the National Science Foundation in the USA.

- Faculty in engineering schools need motivation and incentives to make greater utilization of new high technology teaching-learning methodologies.
- An international quality control system for engineering education is needed, perhaps based on the accreditation programs which utilize flexible criteria and outcomes assessment that are currently evolving in several countries.
- A continuing education system for faculty that can assist developing countries in keeping their engineering education programs current should be developed and updated regularly, perhaps by the UNESCO International Centre for Engineering Education. A near future Congress of the type held here in 1998 should be conducted electronically (satellite video, Internet discussion, etc) to allow broader involvement of engineering faculty participants, particularly younger faculty and those in developing countries. The year 2000 was suggested as a target date.

NOTE: For a more complete version of this paper, see Proceedings of the 2nd UICEE Annual Conference on Engineering Education, Edited by Zenon J. Pudlowski and Duyen Q. Nguyen, Auckland, New Zealand, 10-13 February, 1999, p 59-63.

Germany

Engineering Education for a Global Society

Dr. Kruno Hernaut
Siemens AG, Germany

SUMMARY: The globalization is the greatest challenge on the way in the next century. In order to remain successful, companies need highly qualified engineering graduates, who, in addition to excellent professional qualifications, are also familiar with other cultures. This preparation includes foreign languages competency and a knowledge of the culture of other countries. Engineers in a global society must be ready to live and work in another country, i.e. have personal mobility. The universities are faced with the growing need in promoting such students' abilities and to establish more compatibility and mutual recognition.

KEYWORDS: Engineering Education — Globalization — Global Society

INTRODUCTION

In recent decades and particularly in the last few years, mankind has made great progress in achieving worldwide cooperation in many areas of politics, economics, and culture. The greatest accomplishment of the closing 20th century will be to build a strong promising basis for establishing a global society in coming years.

Although this society has different roots, it will have common goals and be willing to share global resources and contribute to the well-being of all people. Creating this society is both an enormous challenge and an unprecedented opportunity for researchers, scientists and engineers to start working on solutions for the future. With this in mind, we must ask what academic engineering education can contribute, and how global research cooperation can be optimized to meet these objectives.

GLOBALIZATION: THE BIG CHALLENGE

The biggest challenge facing companies, the economy, and ultimately all of society, is globalization. For our company, it means securing our worldwide competitiveness in the global market.

Globalization – an open world market for capital, goods, services, and ideas – is reality today. And it is also reality in market segments, some countries haven't recognized as such, like the education market. We will be able to master the challenges of globalization only if we are prepared to question old structures, put the proven on the testing stand, and give new ideas a chance.

On the basis of our wide range of contacts with universities in different regions of the world, we can confirm that many of them have outstanding engineering programs. Yet these programs or products are all too often oriented exclusively to specific national requirements. Their products are hard to market in the international arena.

In the age of globalization, internationalized engineering education is coming to the fore. An open, global society needs an open and flowing exchange among regions. And industry increasingly needs employees with international orientation and stronger ties to diverse cultures. To meet these demands, students should have more opportunities to complete a phase of their studies abroad. This would give them valuable experience in other cultures during education.

The major requisites for developing a truly global society go beyond political actions, and include:

- eliminating barriers to promote the free exchange of goods, capital, services, ideas, and people;
- developing routes for both physical and virtual mobility;
- preparing and qualifying people to handle global challenges and use every new resource available.

These requirements have been met to a degree that makes global trade both possible and advantageous. The critical point has been passed; there is no turning back. The trends are clear. Yet success will ultimately depend on whether we can adequately prepare people for the challenges of globalization.

ENGINEERS IN A GLOBAL SOCIETY

World-wide, our company employs more than 400,000 people in all countries of the world. Today, less than the half of the workforce is located in Germany. This relation reflects the way our business is shifting. Roughly two third of 120 billion marks in sales is now generated abroad. And this trend will continue in the future, as our markets relentlessly globalize. At the same time, another significant change is occurring in our employee structure. In 1970, engineers and scientists made up about 10 percents of our German workforce. This number has now climbed to over 30 percent. World-wide, Siemens has around 120,000 engineers and scientists. Within the next few years, we project they will comprise about two third of our total workforce. In simple terms: every third Siemens employee will be an engineer or scientist with a university degree at Bachelor's, Master's or PhD level.

What challenges will engineers be facing in the future? And what will universities and engineering schools have to deal with in coming years?

In answering these questions, let me sketch my vision of the future. So, let me take you in my time-machine to a trip, say in the year 2005.

VISION 2005

A high level of engineering competence is crucially important in a global society. Yet competence has a new definition these days. While knowledge of facts stood in the foreground in the past, today's needs center on competence in methods and solutions. Facts are something you access in worldwide databases. Universities and engineering schools know this. And their programs reflect this. We can be assured that young engineering graduates are highly qualified, wherever they studied. Their qualification embraces a solid knowledge base, an appropriate skill base, a technology base, sound interdisciplinary competence, and personal skills.

Engineers and scientists see themselves as an integral part of a global society. At the same time, they are also totally embedded in their local environment. The slogan "think global, act local" is part of their philosophy of life. They have the will – and ability – to work across all political, cultural, and ethnic boundaries. They are aware of the cultural differences between different regions of the world. They are flexible and eager to learn. They master foreign languages. They adapt to their international partners and avoid misunderstandings that can arise due to cultural differences.

They have mastered the applications of state-of-the-art information and communication technologies. They are at home in worldwide data networks like the Internet and Intranets, and use them to reinforce their own skills at work. They communicate with their partners on all multimedia levels, and work efficiently in local and distributed teams. They practice real and virtual mobility on a global scale.

To sum up: they are thoroughly prepared for a globalized world, because their universities and engineering schools prepared them for this world.

Although universities and colleges remain anchored in their respective national educational systems, they take the challenges of globalization seriously. In fact, they are also being globalized.

Students are prepared to meet the challenges of a globalized world with internationally oriented studies. Basic courses are complemented by and enriched with interdisciplinary, cross-cultural contents. Curricula meet rigorous international standards. This ensures general compatibility for courses in different countries, and allows students to complete phases of their studies outside their own countries, with full recognition. Ever larger numbers of students are grabbing these opportunities to gain experience in foreign cultures before they graduate. They also learn foreign languages, make valuable worldwide contacts, experience real and virtual mobility, and work across cultures. They are far better prepared to work outside their home countries.

Universities and engineering schools have also discovered the global education market. They develop their products – that is, engineering curricula – and marketing strategies for the global education market. They work together in international education cooperations. They promote studies abroad on a broad basis, and prepare future engineers for a global society. National education systems are compatible with international standards. This compatibility is underscored by mutually acceptable mobility channels. Universities and engineering schools have taken a leading role in pushing towards a global society. They carefully watch over the quality of their offerings to make sure they remain competitive in an open, global market for students.

Many of these visions undoubtedly seem too good to be true from today's point of view. Others are already reality, or getting there, in many universities. Dream or reality, we are convinced that each of these visions can be realized. Why are we so confident about the future? Because we believe in the innovative strength of the universities and colleges. And we believe in the potential of the growing international educational market.

Our optimism is reinforced by examples of what has already been accomplished. The United States exports some 7.5 billion dollars in educational services and generates a 6.6 billion-dollar trade balance surplus. What better proof do we need that some nations are already well along the path toward a global educational market?

ENGINEERING EDUCATION FOR A GLOBAL SOCIETY

I'd like to give you a couple of ideas which have been developed recently in a Siemens international symposium on "Research and Engineering Education in a Global Society". Universities and colleges should immediately start working on urgently needed reforms of contents and structures. I see the following priorities:

1) Further development and modernization of existing engineering curricula:

- limit studies to the essentials;
- focus more strongly on teaching compe-

tency in methods and problem-solving;

- integrate interdisciplinary contents and promote key qualifications;
- promote internationalization by treating foreign topics, holding courses in foreign languages, or encouraging study time abroad.

2) Implementation of a worldwide compatibility in engineering studies:

- adapt studies to international standards. Here the Anglo-Saxon system has established a de-facto worldwide standard with its consecutive Bachelor's, Master's, and PhD degrees;
- define and introduce a core curriculum for engineering;
- win mutual recognition for studies done abroad. Here, universities and colleges should work across borders more effectively in order to learn from one another, to eliminate national prejudices, and to find mutual solutions.

3) Participation in the global educational market:

- introduce market-oriented administrative and organizational structures in the universities and colleges;
- treat students as customers who pay for their education and deserve commensurate services and product quality;
- offer products that are oriented to the international market and are in demand worldwide;
- build up global marketing strategies and structures to attract good students throughout the world.

4) In addition, the universities must demonstrate that their engineering programs enable graduates to develop their professional competence by in the following:

- An understanding of the engineering profession and an obligation to serve society, the profession and;
- A thorough knowledge of the principles of engineering, based on mathematics and a combination of scientific subjects appropriate to their discipline;
- A general knowledge of good engineering practice and the properties, behaviour, fabrication and use of materials, components and software;
- An ability to apply appropriate theoretical and practical methods to the analysis and solution of engineering problems;
- Knowledge of the use of existing and emerging technologies relevant to their field of specialisation;
- An ability in engineering economics, quality assurance, maintainability, and use of technical information and statistics;
- An ability to work with others on multidisciplinary projects;
- An ability to provide leadership embracing managerial, technical, financial, and human considerations;
- Communication skills and an obligation to maintain competence by continuous professional development (CPD);
- Knowledge of standards and regulations appropriate to their field of specialisation;
- An awareness of continuous technical change and the cultivation of an attitude to seek innovation and creativity within the engineering profession;
- Fluency in foreign Languages sufficient to facilitate communication when working abroad.

Another European Project defines the generic profile of engineers in the following way: An Excellent Engineer has/shows evidence of:

- Providing leadership and vision;
- Focus on business/clients;
- Focus on international opportunities;
- Focus on required roles/results;
- Commitment to ethical and social responsibilities;
- Team-working; multidisciplinary/cultural;
- Management of projects/events;
- Management/motivation of people;
- Management of knowledge/IT;
- Management of self/time;
- Communicating, verbal and written;
- Learning, developing and improving;
- Flexibility in adapting to change;
- Technical knowledge/expertise;

– Commercial/financial knowledge/expertise;
– Application of relevant knowledge/expertise;
– Systematic and logical approach.

CONCLUSION

In view of these recommendations the participants of the Siemens Symposium unanimously agreed to issue the following Declaration:

1) Competence: A global society and the profession requires engineers with different competencies. These engineers must be highly qualified whether research oriented or application oriented. This implies an understanding and appreciation of basic science, engineering, and different cultures including foreign languages. Engineers must also possess interpersonal skills such as communication and teamwork.

2) Global Mobility: Engineering education must recognize, promote, and reward the global mobility of students and professors in the spirit of mutual recognition of the various approaches to engineering education. This mobility includes courses, research, practical experiences, and degrees. The de facto international standard based on bachelor's, master's, and Ph.D. degrees appears to be a suitable model for engineering education in the global society.

3) Technological Literacy: Engineering must promote an understanding that technology is an integral part of society in order that young people, their teachers, and parents appreciate the fundamental role of engineering and technology in their everyday lives and work.

4) Quality Assurance: There is a need for quality assurance systems in education which are transparent and are based on mutual recognized minimum standards. These should be responsive to changing technology and world conditions.

5) Transnational Cooperation: Here is a need for global networks of universities cooperating at the professional level in order to integrate an understanding of other cultures and differing approaches to engineering education.

6) Global Marketing Strategies: Engineering education must introduce global marketing strategies and structures to attract students from other countries and cultures to participate in programs in initial and continuing engineering education. This may involve the delivery of education in foreign languages and may utilize modern technology such as quality assured distance learning.

The challenge for engineering education is to produce the changes required subject to the overall trends present in higher education. Some of these trends are pressure to reduce the costs of higher education, increased emphasis on accountability, pressure to demonstrate student achievement through various methods of assessment, increased pressure from university administrators and public officials to improve the quality of teaching, and pressure to reform science education.

The most of these objectives can only be achieved in a close cooperation between universities and industry. Cooperations between universities and Siemens have a long tradition. They have always been based on mutual interests and mutual benefits. Continuing this tradition we do hope that our ideas, how to prepare future Engineers for new challenges, will contribute to common efforts on

Germany

Life Sciences, Globalization and Engineering Education

Prof. Dr. Ing. Vollrath Hopp
University Rostock, Germany

WHAT DOES LIFE SCIENCES AND GLOBALIZATION MEAN?

Life sciences comprise an interdisciplinary science of nature, about nature, of mankind and its behavior, that means psychology and sociology. How mankind will behave in smaller and smaller living-spaces, is besides the basic needs of nutrition health and housing, the fourth problem we must solve in the near future facing *(Fig. 1)*.

In favoured areas of settlement population density is increasing all the time. Areas of the resources for raw-materials, energy and nutrition are not identical with the locations for production and housing.

Globalization means to construct a network of storage, production-, transportation- and communication systems so that we can exchange and use supplies of water, energy, raw-materials, products and information without disruption and according to need. But we also need supplies of capital. We should remember that money is, in principle, a means of comparing the value of products, and value is only a way of showing the usefulness of products.

Life sciences and globalization depend on one another and force us to adapt production methods to shortage of natural resources and the regeneration of the environment. Research aims should be newly defined. The ability to regenerate means more than environmental protection it means health in the widest sense. Nature may be changed, it is not static. But nature must be capable of being regenerated.

Innovation is not only the ability of a nation or its society to adapt to worldwide changes in nature, technology and the economy, but also the ability to influence the process of change. Population growth will give impetus to biotechnology, genetic engineering, environmental technology, nuclear energy etc. As a consequence of this development our chances of survival will be greater. These problems should be discussed openly and without ideological baggage or narrow-mindedness.

The creation of simple handicraft techniques should be an integral part of innovation in order that more people are enabled to participate in modern production processes.

Within the scope of globalization innovation in future must involve the setting up of new unsubsidised jobs. Innovation should not be restricted only to the fields of natural sciences, engineering sciences or of technologies.

Innovation potentials must be promoted and activated in the fields of economics, sociology and psycho-sociology.

Besides the requirements for sufficient nutrition and sustainable health it is necessary also to develop simple technologies and skills, which are cheap in production and which need no complicated maintenance. The new modern technology must be easy to use.

RESPONSIBILITIES OF THE INTERNATIONAL COMPANIES

It is a relatively simple matter for business to downsize and to cut tens of thousands of jobs in the pursuit of profitability, and for the state to be burdened with the consequent costs. However, to be able offer new job opportunities through innovative products, demands spirit, imagination and sense of responsibility.

The global spread of unemployment is the most fertile soil for revolutions, civil wars and wars. Politicians and top managers of international big companies should bear this in mind. Globalization also means the interdependence of the various financial markets all over the world.

That demands a high sense of responsibility on the part of the banks. They have to analyze the economies and not only look for quick profits.

The collapse of the financial markets in GUS (Russia) and in Asia were foreseen. The political background of the former USSR should teach us that the socialist systems could not operate with money. The governments of the following nations – e.g. Russia, Ukraine, Kasachstan and others – are still thinking in planned economic models. It will take one generation till they have understood and adopted a free market system.

One could foresee also the shadow of the disaster of the financial market in some Asian countries. This was only the greed for higher profit.

INTERNATIONAL ENGINEERING EDUCATION

The world's population is increasing both rapidly and continuously. According to the latest statistics, there are currently around 6 billion people on our planet. That compares with only 1.8 billion in 1930. This dramatic increase illustrates the rapid developments mankind is facing in terms of co-existence and meeting basic needs *(Fig. 2)*.

However, the negative consequences of industrial production methods must also be taken into consideration. The United Nations Conference on Environment and Development at Rio (UNCED) in 1992 and First Conference of the Parties (1st COP) to the Framework Convention on Climatic Change at Berlin in 1995, which was set up at the Earth Summit in Rio drew attention to this as did the World Congress on Population and Development in Cairo in 1994.

The tasks facing us can no longer be solved alone by a single nation or country. Nations must be able to communicate with one another. Professionals, including engineers, must work together and must be able to function as part of an international team. They must be able to speak the same language.

Engineering students must be prepared for and made sensitive to these demands during their university training. We need engineers who can think in terms of international, technical, social and financial relationships in addition to possessing expert knowledge. Apart from their native tongue, they must be proficient in at least two foreign languages (incl. English).

THE WORLD'S ENGINEERS SHOULD HAVE THE SAME LEVEL OF KNOWLEDGE BUT DIFFERENT SPECIALIZATIONS

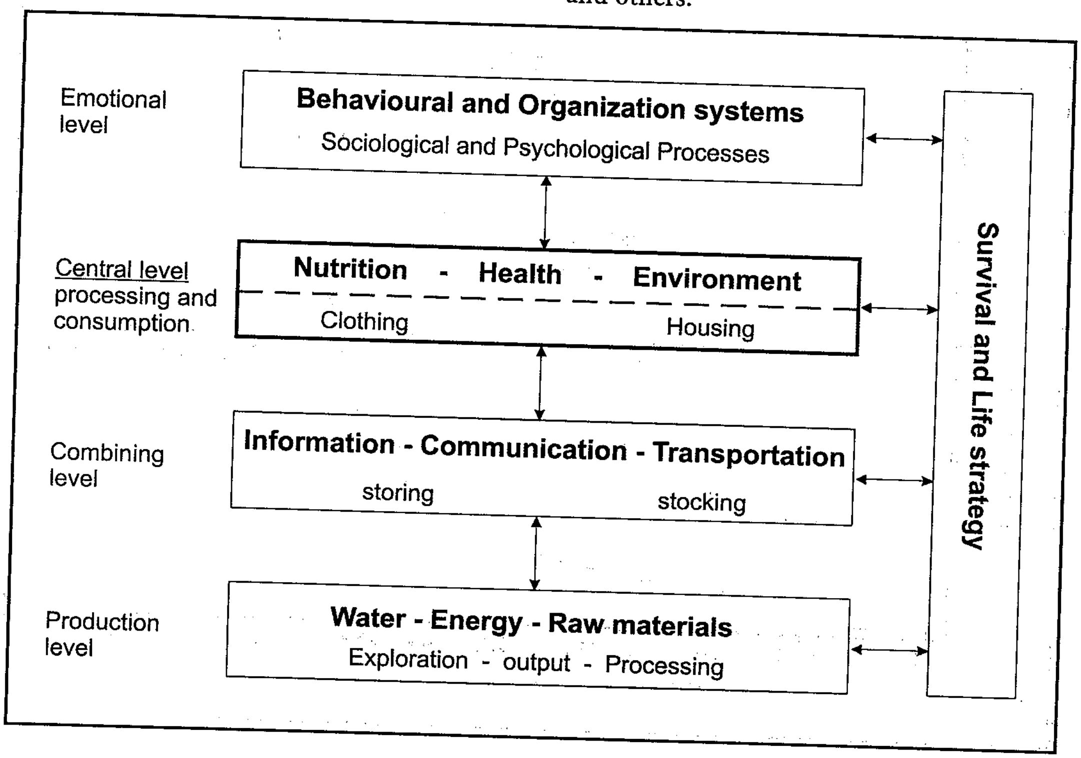
The spectrum of talents in the countries all over the world is wide and varied. The scientific and technical innovation potential lies in the diversity of the talents, behavior and characteristics of the people in the different countries. This will be the power in future, if the people don't forget to work.

All nations have produced a lot of excellent and experienced engineers. The Italians are wellknown as excellent constructors and builders of roads, bridges, high-ways and so on. The French, Austrian and Egyptian engineers constructed the Suez-Canal (1859 - 1869) according to a concept of A. Negrellis. In the 18th and 19th century the Spanish, Portuguese and British were famous nations of maritime trade. Therefore they need excellent engineers for shipbuilding.

The French engineer Alexander Gustaf Eiffel (1832-1923) is wellknown worldwide. He built the Eiffel-Tower which bears witness to his knowledge of static. The efficiency of textile engineering in the beginning of industrialization in England, France and Germany must also be mentioned. Chinese engineers can look back on a long tradition of construction of the Great Wall, making rivers navigable and the industrialization in the last few decades. Indian engineers became famous for the construction of the Taj Mahal. The engineers of the United States are world wide well known for the construction of high-buildings, aeroplanes, computer-technology and so on.

If we describe the profiles of the engineering qualifications in the different countries of the world, then it is useful to describe the tasks and problems which they have to solve. The comparison of the training time, the curricula, the number of courses and disciplines do not give the realistic situation about the training-quality and the standard of a degree. The challenges, tasks and problems of the engineers in a country depend on the resources of raw materials, energy, climate and geological nature, geographical location, transport-infrastructure, materials and others.

Fig. 1. Concept for Applied Life Sciences

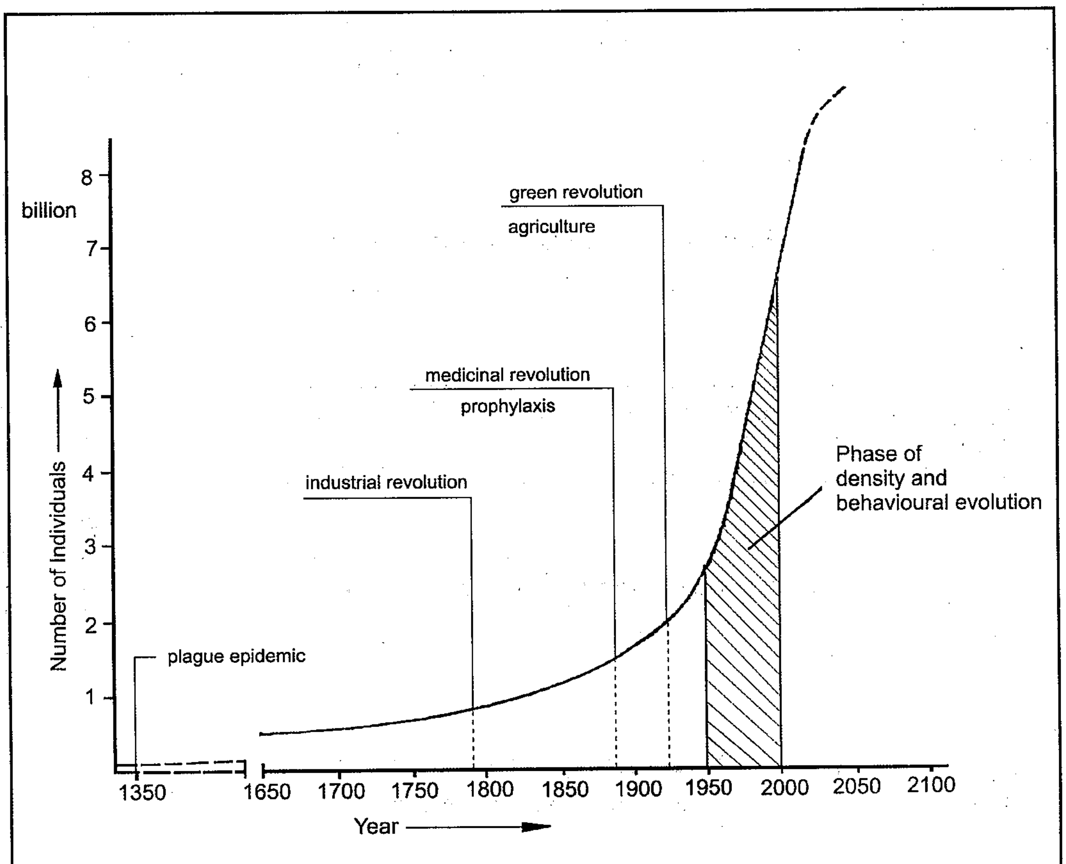


Engineers in mountainous regions require different knowledge and experience than engineers near the sea. In an area of earthquakes the houses must be built in an other manner than in a quiet area. But all the engineers who work in different specialized fields should have the same level of fundamental knowledge in engineering.

The Hungarians are very talented in the field of natural sciences namely mathematics, physics, chemistry, medicine etc. These comprise the basic knowledge of engineering science. As examples I would like to mention the architect Ernő Rubik and the statistician von Neumann. Both have expanded our basic knowledge of statistics. Ernő Rubik with his invention of the magic cube and von Neumann through the development of the play theory of Monte Carlo. Both theories are very important to the modern fundamentals of probabilities. Loránd Eötvös (1848-1919) was a well-known physicist. He developed circuit balances and demonstrated the identity of inertia and heavy mass. Albert von Szentgyörgyi (1893-1986) was a famous medical doctor and chemist. He discovered and isolated ascorbic acid (vitamin C) in paprika. He explained the mechanism of biological oxidation.

The reputation of an engineer depends on his efficiency and experience during his occupation and not on his examination results. If we compare the training qualification, then we must analyze the curricula, the teaching-contents of the disciplines, the didactic methods, the professors and so on,

Fig. 2. Growth curve of the population of the earth



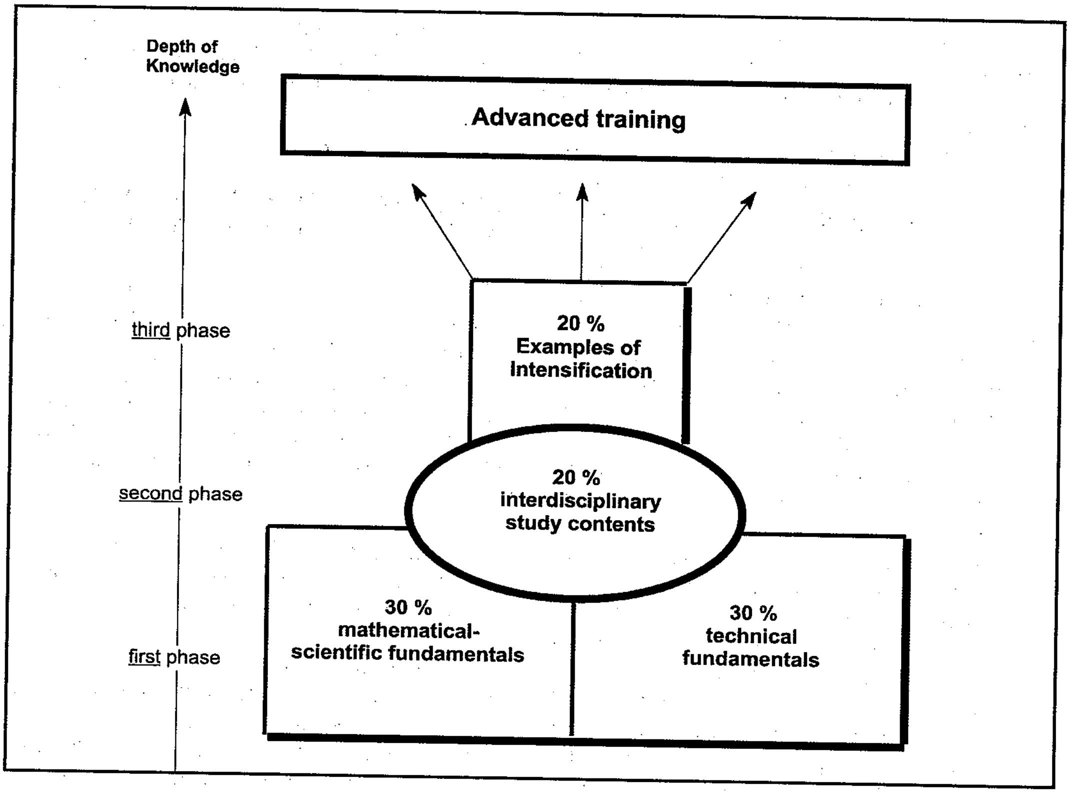


Fig. 3. Education concept for engineers

that's very complex. In training we are not dealing with machines. Training is an individual, continuous long-term process that never ends.

THE ORGANIZATION OF ENGINEERING STUDIES INTO THREE PHASES *(Fig. 3)*

A modern course of study in engineering that will fulfill all future requirements within the international countries could feasibly be organized into three phases.

- The first phase would consist of "general-studies" dealing with the basics of engineering and the natural sciences and including a foreign language. After one year, a written or oral examination must be taken in every subject.

  General studies in engineering and the natural sciences include the basics of mathematics, informatics, geometry, physics, chemistry, biology, technical drawing and an introduction to the engineering disciplines which the student has decided to pursue, e.g. mechanical engineering, electrical engineering, construction, metallurgy, etc.

  In this connection, the basic knowledge requirement in the biosciences is an important novelty. The biosciences are concerned to make future engineers sensitive to the laws of biological processes, selective optimization and evolutionary mechanisms and to show the relationships, similarities as well as the differences to technical processes.

  General studies for degrees in engineering and the natural sciences should take up to 20 to 25 percent of the normal course duration.
- The second phase of engineering course work is then devoted to the subject-specific material. Since the basics of engineering and the natural sciences have already been

mastered, phase two leaves enough time for the in-depth study of engineering. Yet the contextual components of this phase should always emphasize the fundamentals.

- In the third phase of this course of study, which only makes up 15 to 20 percent of the total, the student is to be given in-depth exposure to special fields, depending on his/her own interests. The dissertation is to be written during this phase. This gives the student the opportunity to demonstrate his/her own performance and thinking ability. The qualification of good young engineers can be seen in their mastery of the fundamentals of engineering science and technology. It also exists in the ability to apply these basics to different problems in special fields. Specialized knowledge is however best obtained at the workplace and not during university training. This knowledge is gained from topical subjects and its focal points often change rapidly. It is frequently short-lived.

In this context, the need to overhaul university curricula is applicable. This overhaul means doing without special fields while retaining the classical foundations of a field of speciality.

It is apparent that students conscientiously learn a great deal during their university education yet lack experience in problem-solving.

PROPOSAL FOR FOUNDATION OF AN INTERNATIONAL UNIVERSITY

An international technical university should be set up. This university will be unencumbered by national traditions and can focus on the requirements of the global village of the future. The international Engineering Association (WFEO) should create a program to set up a new technical university.

The future is now. However, our education systems have not yet adapted to contemporary needs and developments.

This international university must develop suitable curricula. Financing could come from the World Bank until this university develop their own infrastructure and dynamics. The money invested would be sustainable development in the best sense.

India

Impact of Globalization on Products and Manufacturing Education and Practice

Prof. M P Chowdiah
President The Institution of Engineers, Calcutta, India

SUMMARY: The Impact of Globalization on Products and Manufacturing Education and Practice in the present liberalized economy of the world has resulted in an integration of product, quality assurance, design, equivalent stages of manufacturing education and practice and policy of product design.
The paper attempts to analyze the different elements involved in product design and manufacture for globalization. The concept, strategy and policy for the impact of globalization are also discussed in this paper.

KEYWORDS: Globalization — Education — Agile Manufacturing — Product Quality — Assurance — Design & Manufacturing

INTRODUCTION

In the globalization of economy lifting trade barriers, converting local trade into global market, blending of engineering and technical knowledge with information at the global level have all contributed to the zenith of quality assurance in all the manufacturing activities, such that the product is reliable and suitable in all types of working conditions, remain durable with long period of service utilizing least power and cost. This requires sound knowledge of product design acquired by engineers with the desired education and practice at all levels of manufacturing system, which leads to globalization in the liberalized economy.

MANUFACTURING TECHNOLOGY AND ENGINEERING

Technology and Engineering:

Technology and engineering as applied science encompasses several divisions, such as: Agricultural Engineering, Architectural Engineering, Aerospace Engineering, etc. that contribute to manufacturing directly or indirectly.

The impact of globalization on manufacturing leads to global competitiveness which in turn leads to Cost Effective Quality Customized Products globally and thus to Agile Manufacturing.

IMPACT OF GLOBALIZATION ON PRODUCT DESIGN

The globalization impact on product design is an integration of product design policy with equivalent stages of manufacturing, education and practice for customized product with quality assurance. The Product Quality Assurance Design demands the quality at all stages of material selection, the selected design, established processes and fabrication, assembly, testing, packing and finally marketing as well as to execute the standard product design in which the workforce must be injected with quality education based on source of control such as Admission, Criteria, Curriculum Design, Programme Selection and Implementation, Evaluation and Employability, etc. In view of economic reforms based on policy of globalization which affects the industrial and economic scene by increasing competition in quality and practice of the products and services, they must prove to be of highest quality and yet competitive. It is therefore necessary to have desired policy of Research, Development and Technology Transfer, and of policy for product design for globalization as the Post Manufacturing Education and Practice for globalization.

IMPACT OF GLOBALIZATION ON MANUFACTURING AND PRACTICE

Before the discussion of the changes in manufacturing for globalization it is necessary to discuss the global development of manufacturing from 1942-2000. Further the sequential scenario of manufacturing in the world presents the history of manufacturing from the past to the present status. The Impact of Globalization on Manufacturing has led to Agile Manufacturing, which may be defined as follows:

Agile Manufacturing:

Agile manufacturing is the science of a business system, that integrates management, technology and workforce, making the system flexible enough for a manufacturer to switch over from one component that is being produced to another component that is desired to be produced in a cost-effective manner, in a short-time, within the frame work of the system.

Agile Manufacturing Approach:

The goal of Agile Manufacturing Approach *(AMA)* is to discover and codify guiding principles for the manufacturing, educate future leaders for manufacturing workplace and otherwise infuse important principles and technologies into manufacturing practice. The manufacturing has to be viewed as broad-based activity ranging from product design through production, product use, maintenance etc. But the AMA recognizes as an interdisciplinary activity that requires the seamless integration of Technology.

Management, Information System, Workforce, etc. It approaches holistically, rather than taking rifle-shorts at individual issues, to achieve quick fixes by bridging the Traditional Technology, Management, Workforce, etc, with a broad understanding of manufacturing that integrates key functions and disciplines involved in creating, designing, making, selling/servicing products, etc. It encompasses not only the critical operations like technology, product process engineering, administration and marketing/sales/services within a corporation but also vendors/suppliers, customers, community and government.

Meeting Globalization Impact:

In order to meet globalization impact, the following factors need to be considered:
- Supply of customer oriented products.
- Challenges posed by Multi-national Companies, which are already practising the concept of Agile Manufacturing
- Need to produce components of International Standards, in terms of quality and cost.
- Healthy environment and enhancement of skill for the workforce.
- Energy conservation, Environment friendly products.
- Implementation of Green Engineering.

CONCLUSION

The impact of globalization on products and manufacturing education and practice has led to an educational structure like a pyramid. It can be seen that with an effective leadership, with integration, internship, operations management, product-/process design, manufacturing, TQM, plant visits, etc, it is possible to lay strong foundation for a sustained growth and stability at all levels.

Hungary

Innovation on the Engineering Industry

Dr. Ödön Hajtó, civil engineer
President, Hungarian Chamber of Engineers

SUMMARY: The innovation is continuously present in the engineering work. Every project is a little bit better than the preceding one. The industrial parks, innovation centers, icubator houses of the consulting engineering industry are the engineering organizations, but the engineering offices do not have to move to one place geographically as well, one building or one park in order to promote the development of the engineering sector.

KEYWORDS: Consulting Engineering Industry — Routinish Innovation — Radical Innovation — Engineering Organizations

All the engineering intellectual services are to be included in the engineering category indicated in the title, namely:
- planning
- expertising
- consulting
- project control
- developing.

The implementation process of innovation related to product manufacturing is presented by *Chart 1*. First of all, an idea is needed which applies either to quite a new product or suggests another one of better quality, more durable and cheaper instead of the existing product. In the second step the idea has to be developed until it can be decided if it is marketable or not? In the third step prototypes have to be made, the buyers have to be made to get familiarized with the product in order to obtain feedback on its acceptance. Up to this point the innovation requires significant investments for which it is not always easy to find the risk capital partner. In the fourth step, at last we step onto the market, then the fifth step is also very important in order that the new product could be kept on the market as long as possible.

The innovation is present in the engineering intellectual service providing sector in an other way than in the industry. In the architecture, in the structural and civil engineering works, in the electrical and mechanical engineering works there are no series products. Every project is different and different and as regards the standard of the engineering service, it is improving from project to project. Every plan is a little bit better than the preceding one. The experience of the previous project and the information acquired in the meantime are already present as innovations in a routinish way in the next plan. *(Chart 2)*

The innovation level of the engineering offices performing consulting engineering service providing activity is measured not by the number of publications and refer-

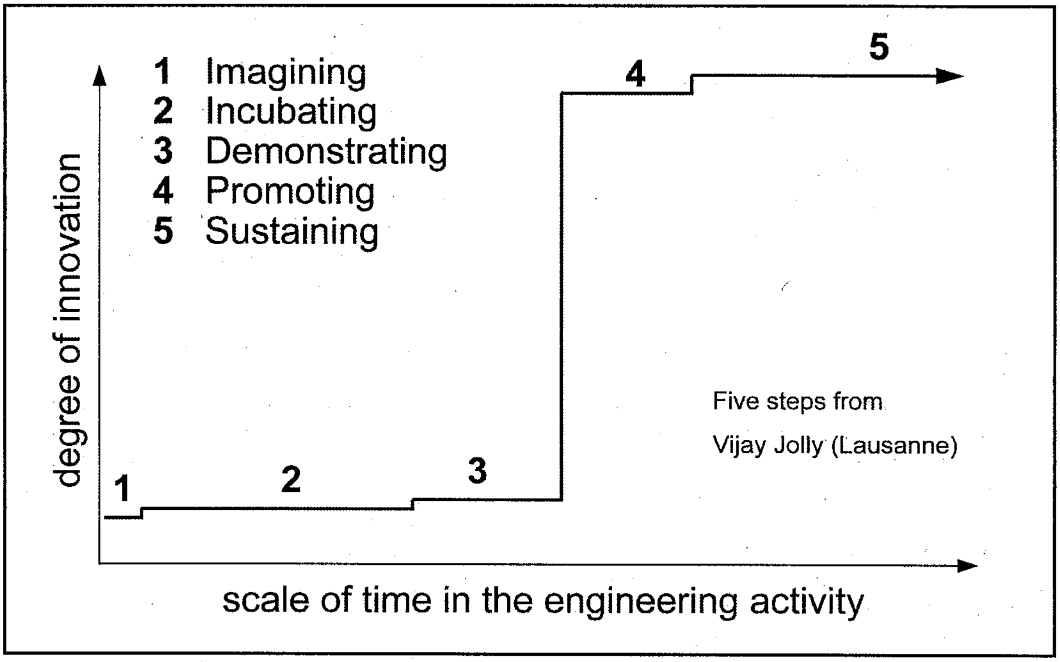


Chart 1. Innovation in Industry

ences, not by the number of patents, not by the proportion of the participation of engineers possessing PhD degree, but by the number and quality of the facilities implemented.

Not all the engineering activities are equally innovative. There are special fields with lower innovation content such as e.g. civil engineering and special fields with high innovation content such as e.g. telecommunication and biotechnology.

In the process of the engineering work the innovation steps can be higher and lower as shown by *Chart 2.* The height of "stepping-up", the steepness of the innovation process are influenced by the following factors:

1. Is there a demand and, if yes, of what size for innovation on the part of the society, economy and the politics?
2. Do the technical and scientific base research develop?
3. What is the quality of the technical higher education like?
4. Is there any material support for the innovation of the engineering services?
5. Is the engineer informed? Does he/she trains himself/herself further? Does he/she apply the aids of the up-to-date computer science?
6. On what level does he/she manage his/her activity? Does the engineer work with suitable partners? Do they hold consultation (brain-storming) on the solution?
7. Does the engineer find a partner in his/her client for jointly bearing the risk of a higher scale innovation?

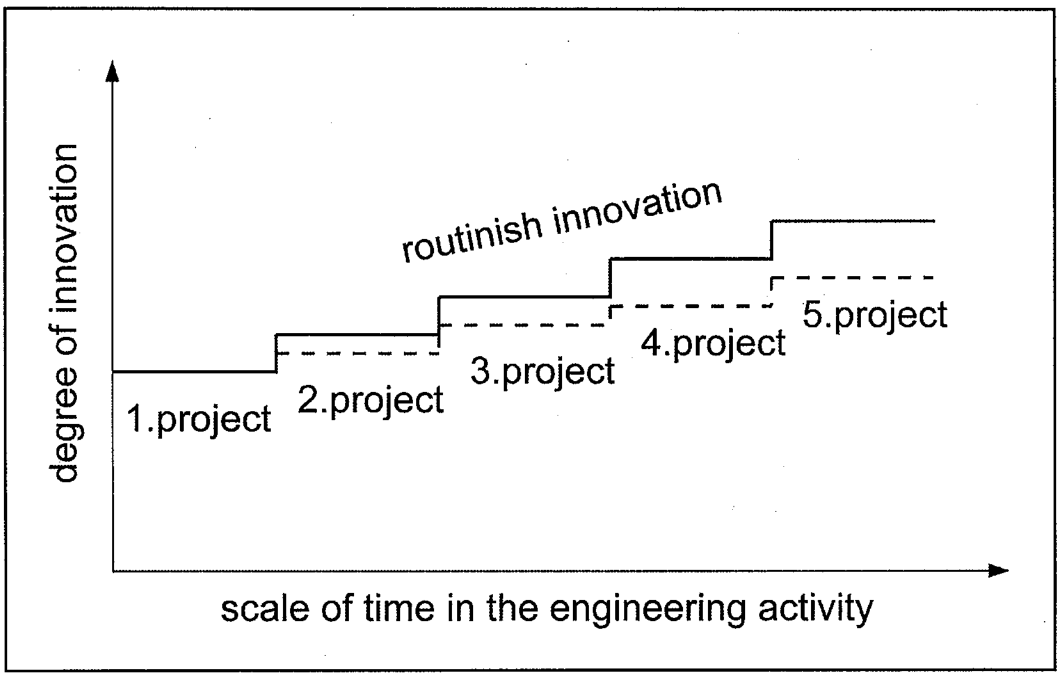
In the course of the engineering activity there occur, though rarely, but do occur radical innovation changes as well, by the use of some newer material, technology, invention or a bold idea. These solutions generally entail a risk higher than usual, therefore they can come about only with the joint consent of the engineer and his/her client. *(Chart 3)*

The industrial parks, innovation centers, incubator houses of the "consulting engineering industry" are the engineering organizations. The persons, offices, micro-, small- and medium-sized enterprises performing innovative engineering activities do not have to move to one place geographically as well, one building, one park in order that the development of the engineering sector could be promoted to a greater extent.

The demands and tasks generated by the globalization are clear for the engineering organizations:

- the standards, rules, decrees, regulations have to be rendered accessible to those performing engineering activity by the informatical tools of today, on CD and internet;
- aids have to be prepared continuously for the way of use of the new standards, rules, decrees, with a lot of numerical examples in order to facilitate their introduction and application;
- "master schools" have to be operated where the elder, more experienced colleagues hand over their experience to the younger career-starters;
- the most recent and most successful technical books have to be translated to several languages. Due to the small number of circulation copies, this is not possible on a business basis in the case of countries of small number of inhabitants like Hungary;
- the "engineering" micro and small enterprises have to be prepared and certified at a reasonable price for the quality assurance system of ISO 9000;
- the chairmen of the European engineering chambers will meet in Budapest in the year 2000 already for the second time where the harmonization and mutual recognition of the engineering licenses will be addressed;
- The engineering design and consulting enterprises have to be assisted in purchasing at a cheaper price the softwares deemed to be the best by the way that the engineering organizations can procure them in bigger lots, at more favourable price;
- innovation design competitions have to be arranged for the search of new technical solutions;

Chart 2. Innovation in Consulting Engineering Services



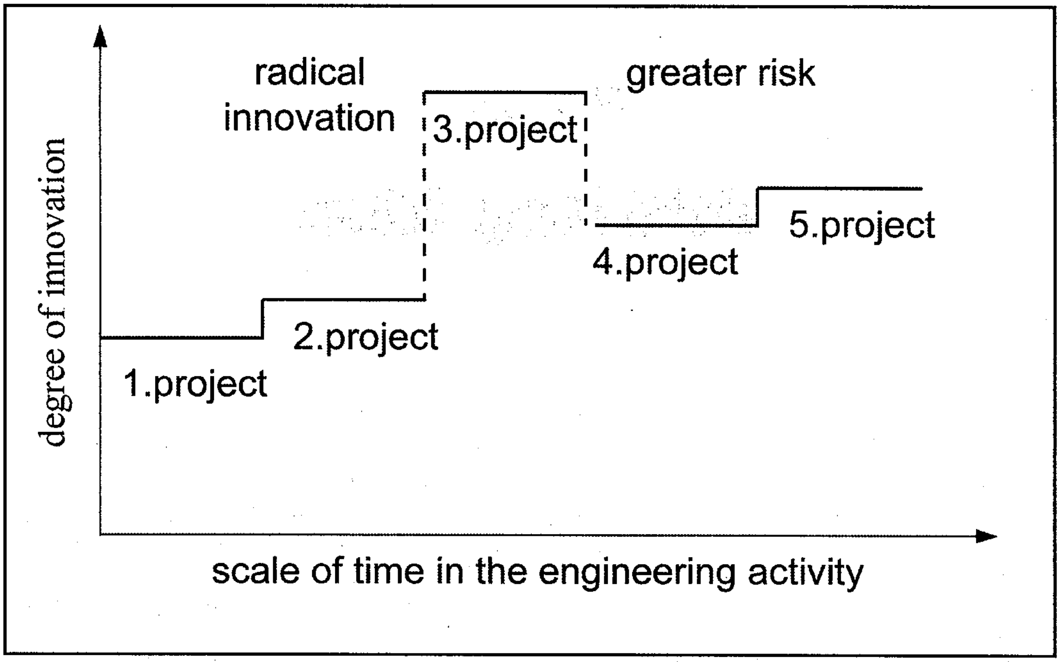


Chart 3. Innovation in Consulting Engineering Services

- the participation of engineers at conferences has to be supported;
- the innovation situation of the "engineering" micro-, small- and medium-sized enterprises has to be surveyed and analyzed from time to time.

The engineering organizations, the engineering chambers, however, cannot raise the financial coverage of the innovation support of the engineering activity only from the membership fees, its is necessary that the governments should support it during their innovation development program.

Hungary

Global Energy Outlook

Prof. Tamás Jászay
Technical University of Budapest, Department for Energy

History of the now bygoing century has showed more explicitly than any epoch in the past that energy is a global issue. Economic and social structures of our time are leaning and depending on energy services to such an extent that even short and local interruption of energy supply cause quite uncomfortable and dangerous situations going often with heavy economic losses. The consequence of a full and long lasting energy supply interruption hitting continent wide regions would become a catastrophe, causing more loss of life than the worst wars of human history. The more we are developed technically and economically the more is our civilisation sensitive to stable availability of energy.

Globalization of world economy is not just a slogan, it is a real process going on and accelerating. Parallel to that energy has also got its global dimension in the strictest physical sense too. While energy set free by man in chemical and nuclear reactions is negligible compared to the energies moving in the thermal (heat) radiation exchange processes between Sun, Planet-Earth and the Universe, the by-products of combustion and other technical economic activities interfere in this radiation exchange and, doing so, may modify the average atmospheric temperature of the "middle station": our Globe, the Earth. This possible phenomenon is nowadays mentioned repeatedly as "Green House Effect" "Global Warming" or in a more balanced formulation: "Climate Change". The scientific community of the whole world works hard on understanding of the extremely complex global climate system and on predicting and evaluating the possible consequences of increasing concentration of Green House Gases (GHG) in the Earth's atmosphere.

The problem outlined here brings the energy business of human civilisation onto the global stage in its physical and political sense alike.

To be more specific: energy arriving to the Earth by the incident solar radiation is *126000 TW*. Practically the whole amount of this energy is passed on from the Earth to the space of the universe, again by thermal radiation. Antropogen energy release coming from combustion, nuclear reactions and other technologies is nowadays a mere *9 billion tons of oil equivalent per year* (9 Gtoe/y). Expressing this in usual performance units the result is *12 TW*. Comparison of the two numbers tells convincingly that antropogen energy release is a negligible item in the energy balance of the Globe. Climate change could never come from antropogen energy release. It might (if might!) come just from GHG interference in the big radiative exchange mentioned above.

Coming to the "outlook" theme of this paper let us consider first the energy demand forecast. Based on predictions on population growth, GDP/capita growth, declining energy intensity (toe/GDP), improved technologies in energy conversion and in energy final use alike, to meet a realistically expected demand, *total primary energy supply (TPES) has to grow to about 13 Gtoe by the year 2020.*

As to the composition of this supply: Oil remains the dominant energy carrier of the market. Natural gas consumption grows and takes the equal share as coal has now in the market. Nuclear power stabilises in absolute terms. Hydro power and renewables increase steadily but still remain at low levels.

OIL DEMAND AND RESERVES

Year	1995	2010	2020
Gtoe/y	3,3	4,3	5,1
Mbbl/day	70,1	90,6	106,5

To give some orientation concerning the reserves that are available to cover this demand let us mention that in the 1985 to 95 period *proved oil reserves were around 1100 - 1200 Gbbl* while the yearly production was running at about 20 Gbbl/year. This means that exploration goes at a pace to keep proven reserves on a comfortable level over the yearly production. Reserves are, of course, not infinite. The category *"ultimate reserve" of conventional oil* is estimated to be *2300 Gbbl,* meaning that already in 2020 some "unconventional oil" has to be taken into production to keep the reserves/production ratio on an acceptable level. Unconventional oil is in form of oil sands, oil shale and/or oil in water depths more than 1000 m. Reserves of *unconventional oil* are estimated to *2000 Gbbl.*

GAS DEMAND AND RESERVES

Gas demand will increase in the 1995 - 2020 period in an average annual rate of 2,6%. Natural gas increases its share in the world energy balance because, among fossile fuels, it has the most favorable H/C ratio, meaning that to produce a given heating value natural gas produces the lowest CO_2 emission. Natural gas can be converted in other forms of energy in relatively cheap equipments with high efficiency. Gas demand predictions are the following:

Year	1995	2010	2020
Gtoe/y	1,8	2,7	3,5

Ultimate conventional gas reserves are estimated at *267 Gtoe,* meaning that reserve/production ratio is quite promising for a while. Concerning unconventional gas reserves estimates are an order of magnitude higher. It is worth to mention that transportation of natural gas on sea is solved by LNG (liquified natural gas) tankers.

COAL DEMAND AND RESERVES

Coal is used mainly in power generation, in industry and in the residential sector. The consumption's center of gravity is moving towards the biger consumers, as coal use on small scale is less comfortable than the use of oil, gas or electricity.

Market position of coal is weakened also by environmental considerations. Namely the heating value of coal comes mainly from Carbon atoms which burn to CO_2. So when delivering a given heating value coal emits more CO_2 than other fuels having higher Hydrogen-to-Carbon ratio. To burn coal with good efficiency one needs more expensive equipment. That means that specific investment costs of coal burning units are higher. All this drawbacks may be offset by the lower price of coal pro unit of energy and its much more stable price.

Coal reserves (world total 1032 Gtoe) are distributed on the Globe much more evenly than the other energy carriers. The main coal producing countries have the following shares in reserves: FSU 23.4%, USA 23.3%, China 11.1% Australia 8.8%, India 6.8%, Germany 6.5%, South Africa 5.4%, Poland 4.1%, Indonesia 3.1%, Canada 0.8%, rest of the world 7.5%. This distribution makes coal markets practically independent of political stresses and contributes to long term price stability.

Finally coal is the fuel with the most plentiful reserves. The global ratio of coal reserves to production was 224 years in 1996. This means that mining coal at the 1996 rate the now known proven reserves would last to the year 2220.

Summing up: coal can not be discarded because of its relative discomforts. Technology to handle the difficulties is already available. Coal was and remains an important energy source.

Total primary coal demand in coming decades:

Year	1995	2010	2020
Gtoe/y	**2,2**	**3,1**	**3,8**

ELECTRIC POWER AND GENERATING CAPACITY DEMAND

Electricity is the most comfortable form of energy. Its source can be any kind of primary energy and, with the sole exception of aviation, it can be used to cover any kind of energy demand. The share of primary energy used to generate electricity is growing continuously and passed the 40% share recently.

The energy and generating capacity demand for the 1995 - 2020 period is listed in the following table showing the change of primary sources as well:

Year	1995	2010	2020
Total electricity generation in TWh	**13204**	**20852**	**27326**
Solid fuels	5077	7960	10490
Oil	1315	1663	1941
Gas	1932	5063	8243
Nuclear	2332	2568	2317
Hydro	2498	3445	4096
Other renewables	49	154	239

Year	1995	2010	2020
Energy inputs in Mtoe	**3091**	**4470**	**5482**
Solid fuels	1362	2023	2521
Oil	308	367	418
Gas	565	1034	1477
Nuclear	608	670	604
Hydro	215	296	352
Other renewables	34	80	110
Capacity in GW	**3079**	**4556**	**5915**
Solid fuels	1032	1362	1760
Oil	404	527	604
Gas	571	1309	2035
Nuclear	347	375	334
Hydro	713	940	1109
Other renewables	13	43	73

Stagnation of nuclear and strong increase of gas based electricity generation features the development. To explain the favourite position of natural gas we can mention the low carbon content of methane (low CO_2 emission), the low investment cost and high efficiency of gas-steam combined cycles, which run on natural gas.

BIOMASS

Biomass is, as a matter of fact, a prehistoric fuel, but a new item in "end of 20th century" energy balances. Biomass energy currently represents 14% of world final energy consumption. In developing countries where 3/4 of the world's population live, biomass energy (firewood, charcoal, crop residues and animal waste) accounts, on average, for 1/3 of total final energy consumption and for nearly 3/4 of energy used in households. OECD-/IEA uses the term biomass to designate the aggregate combustible renewables and waste.

In connection with GHG emission biomass can be considered as a CO_2 free fuel. Namely carbon content of the biomass fuel comes from photosynthesis in previous years. As long as the use of biomass fuels does not mean deforestation (use is in equilibrium with natural production of the vegetation) it is a very welcome fuel helping to reduce CO_2 emission. Out of this reason energy plantations (biomass production for explicit energy carrier production) may, and will, play an important role in stabilising CO_2 emission and preventing climate change by that. At the same time, reduction of very high biomass shares in energy use of developing countries is also desirable. Namely most of the household energy use takes place in extremely low efficiency stoves etc. Substitution of biomass in low efficiency stoves with commercial fuels (e.g. LPG) used in high efficiency appliances may reduce the energy consumption of DC households to 1/3 of the original value.

A counter current development can (and should!) happen in this field. In developing countries reduction of biomass share in the energy mix and in industrialised countries an increasing share of biomass in the energy balances. A special application of biomass based liquid fuels is the use of methyl and/or ethylalcohol as motor fuel.

ENERGY EFFICIENCY

Energy efficiency, in other words producing the same quantity and quality of products and services with using less energy becomes more and more accepted as the "sixth energy source". According to well based analysis, just by using the best *available* technology everywhere and in all applications, the world energy demand could be reduced by 30%. This means that new energy demands, originating from increased standard of living in developing countries, could be covered by energy saved in existing production processes without the use of new primary energy sources. Importance of this branch of energy technology can not be over estimated. Due attention has to be paid to it.

CO_2 DISPOSAL

Stabilisation of GHG emission, as aimed at in the Kyoto Protocol of the UNFCCC, can hardly be achieved when energy demand increases as we have seen in the tables above. Justification of demand for increased energy supply in developing countries is not questionable if we consider their very low energy per capita consumption. Increased use of fossil fuels seems to be unavoidable. To stabilise or reduce CO_2 emission separation and disposal of CO_2 has to be considered. As in ocean sediments are huge amounts of Carbon compounds the ocean seems to be an unlimited capacity sink of CO_2. Research at MIT shows that this direction of solution choices is promising.

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Monaco – Hungary

How to Avoid Global Warming by use of Complete Combustion Reactor with flue-gas condenser for clean CO_2 for industrial recycling

Dr. Allan Inovius
RCWO, Reactor Combustion World Organization S. A.

Carlo P. A. Inovius
CCB Kft., Complete Combustion Bureau Kft. of Hungary

SUMMARY: This lecture shows another technology for a complete combustion of gasformed, liquid and solid fuels and wastes. The Patent of the method is based in Hungary for EPC in 100 countries. Capacity: 16kW-44MW/unit heat production/TEP. Advantages of an always complete combustion to extremely low oxygen content with flue-gas condenser, saving energy costs to a better environmental protection. The main opportunity with an always clean flue-gas is the key function to collect CO_2 as a valuable raw material to be bubbled up in a lake or other growing system to produce rice, algae or biomasses – not destroying the ozone layer. See *http://www.rcwo.com*

KEYWORDS: Complete Combustion Reactor — Flue-Gas Condensing — Flue-Gas Acid to Gypsum — Recycling of Clean CO_2 — Nitrified SiC, SiSiC Ceramic

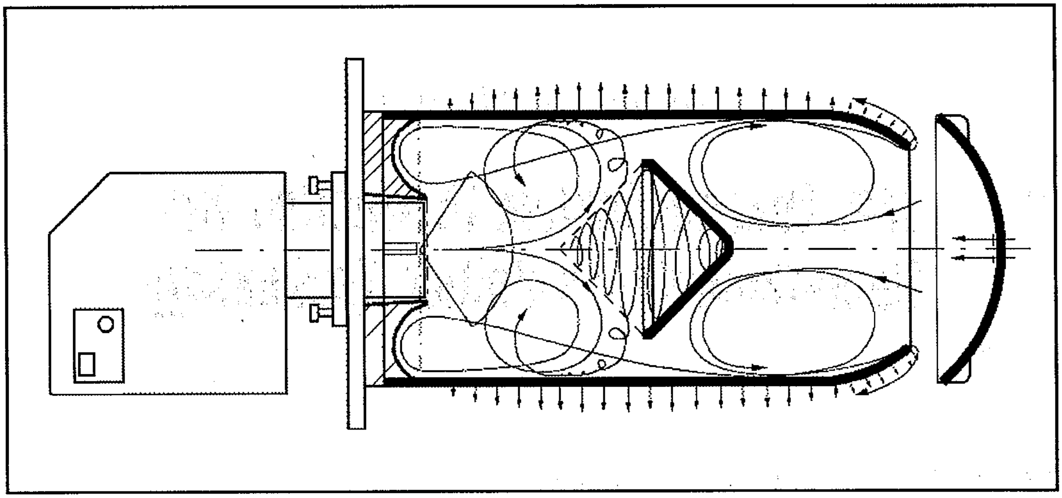
CCR – THE COMPLETE COMBUSTION REACTOR

The Patent for the complete combustion reactor, with an always clean burnt flue gas, is based in Hungary with EPC for 100 countries.

Smoke and smell of all kind of unburnt hydrocarbons from gaseous, liquid and solid fuels and wastes are lost energy, increasing the air and water pollution. It results in high costs and lost money.

A boiler/incinerator, equipped with the CCR, produces hot water/steam or hot air for heating premises, running power plants and dryers. CCR units are in Nitrified SiC or SiSiC ceramic available in a diameter range from Ø165mm to Ø950mm in various length according to the needed capacity from 16 kW to 44MW/unit.

The big hot surfaces of the glowing CCR, Complete Combustion Reactor, bring 80% of all produced heat value directly by radial



Turbulences in the CCR, Complete Combustion Reactor; 80% infra-red radial radiation of the produced heat value

infrared radiation to always clean surfaces of the burning chamber. The resting 20% energy is absorbed in the boiler giving after this very special combustion process an always clean burnt and dryer flue-gas to a temperature as low as around 120°C.

Without a Complete Combustion Reactor, the CO_2 in the flue gas is a barrier preventing the radiation from the core of the burner flame to reach the walls of the burning chamber.

The sparks from the flame pattern over win after few minutes the CO_2 barrier around the flame and reach some of the millions of facets on the CCR's SiC ceramic inner walls, starting a ping-pong effect like a laser principle with the continuously accelerating sparks from the flame pattern. At only 1,000°C the process reaches a frequency able to crack the moisture of the overheated water steam in the burning process to hydrogen energy H_2 and oxygen O_2 which in the process goes to ozone O_3.

$$O_2+O_2+O_2 <=> O_3+O_3$$

$$2C+O_3 <=> CO + CO_2$$

$$SO_2+CO+H_2O <=> H_2S+CO_2+O+O$$

$$SO_2+H_2S <=> S+S+H_2O+O <=> \ldots$$

$$\ldots S_2+H_2O+O$$

In the process produced required ozone guaranties a safe end-combustion of the VOC (Volatile Organic Carbons) such as Benzopyren, Formaldehydes, CO etc. to a very low oxygen rate in the flue gas.

This process is of importance by use of low-grade fuels, heavy fuel and other fuels or wastes rich in not oxidated sulfuric or other acid contents – partly separated to the ashes in a dry form easy to collect from an always soot free boiler.

This opens, through condensation, the way to collect suphur/acids, and micro particles passing a dry bed of lime stone (calcium) of the flue gas into gypsum. The cleaned water from the flue gas condensing is treated as rainwater.

An always cleaned flue gas containing mainly CO_2 at a temperature after the condenser of 20-30°C gives the opportunity to bubble in industrial recycled CO_2 to a lake or other growing system to produce rice, algae, biomasses.

THE RECYCLING OF CO_2 IS THE ONLY WAY TO AVOID GLOBAL WARMING.

Monaco – Ukraina

TEP, Thermoelectric Production with Semi-Conductors-Peltier Technology

Dr. A. Inovius
RCWO, Reactor Combustion World Organization S. A.

S. Dubovskoy
Institute of Engineering Thermophysics, Ukrainian Academy of Science

ABSTRACT: The preliminary estimation of the possibilities and of the main characteristics of electricity production by Thermoelectric Power Generator (TPG), based on the CCR, Complete Combustion Reactor, with heat capacity 16 kW - 44 MW, is done. Different cases of using TPG with CCR are examined. It's shown, that efficiency of TPG, based on available low - & middle - temperature semiconductor materials can be as high as 7-14% . The practical application of high temperature materials which could help to obtain an efficiency of about 20% needs more detailed scientific study.

KEYWORDS: Boiler — Waste Fuels — Electricity — Cogeneration — Thermoelectricity — Semiconductor Materials

CCR is a well-known combustion device, which has more then 150 different practical applications. Special property of CCR is it ability to burn gaseous, liquid or solid fuel and waste, such as rubber tires, waste oil and others without any visible injurious pollution. All combustion by the CCR technology has to be done in following stages. The First stage is to use good common technology for Boiler, Stoves and Incinerators completed with. Stage two - the missing link between the burner and the boiler. Here is the key function for an always complete burned combustion gas without PAH polyaromatic hydrocarbons and VOC light gasformed carcinogen/cancer causing hydrocarbons as CO, formaldehydes, benzpyrenes and dioxines.

First now the process is entering stage Tree to condense the always cleanburned flue- gas to remove the acids from sulphur, chlorine, etcetera and to separate all microparticles down into the calcium filter-cake neutralizing sulphur into gypsum. At *stage Four*, for complete recycling of the total combustion process the clean flue-gas with its CO_2 leads into a lake/water system bubbling up CO_2 as a fertilizer able to grow rice and algae to give good protein.

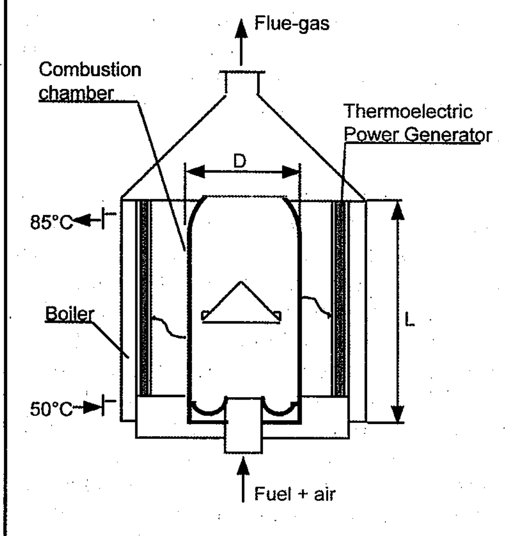
The level of burning temperature in CCR is quite high and the temperature of its ceramic shell reaches 1000-1100 °C. Thus, CCR is a good emitter of intensive infrared radiation (IR). The radiation heat flow rate is close to 80% of the total heat production of combustion chamber and only 20% goes out with flue-gases.

The density of IR results to the small dimensions of apparatus, assembled with CCR. But being absorbed on the wall of boiler, the high temperature IR becomes heat upon quite low temperature. According to the point of view of the Second Law of Thermodynamics Analyses the temperature drop between the boiler and the reactor must be regarded as a loss of the temperature potential. This loss can be reduced by transformation of the heat into another kind of energy, in particular, into electricity. It is rather desirable from the practical point of view.

When a boiler with CCR is powered with a device for electricity production it becomes a power plant for combined production of heat and power. In this case, the efficiency of heat's transformation into electricity determines only the value of the electricity part of total energy output, but doesn't influence the value of specific fuel expenditure for getting electricity. It gives the possibility to get relatively cheap electricity even with a rather low efficiency of heat's conversion into power, especially when CCR burns waste fuel.

The direct conversion of heat by means of thermoelectricity phenomena is not the only and the most effective way to do it. But this technology seems to be the simplest and the most suitable for CCR among all the available ones.

The advantages of the thermoelectric transformers, such as absence of any mechanical motion, noise and high-pressure equipment, high reliability, absence of service, seem to be a good addition to the advantages of CCR technology, which does not break it's ecological cleanliness and simplicity. The inclusion of TPG into CCR boiler for domestic water heating with total heat capacity of about 2 MW is schematically shown at the *Fig.1.* There are also presented the major parameters of the boiler. They should be taken into account when TPG is calculated.



CCR equipped with TPG; Overhead 2

Diameter of reactor, m:	0.9
Length of reactor, m:	3.5
Temperature of the reactor shell, °C:	1100
Total heat capacity, MW:	2.0
Heat capacity of boiler, MW:	1.6

Fig. 1.

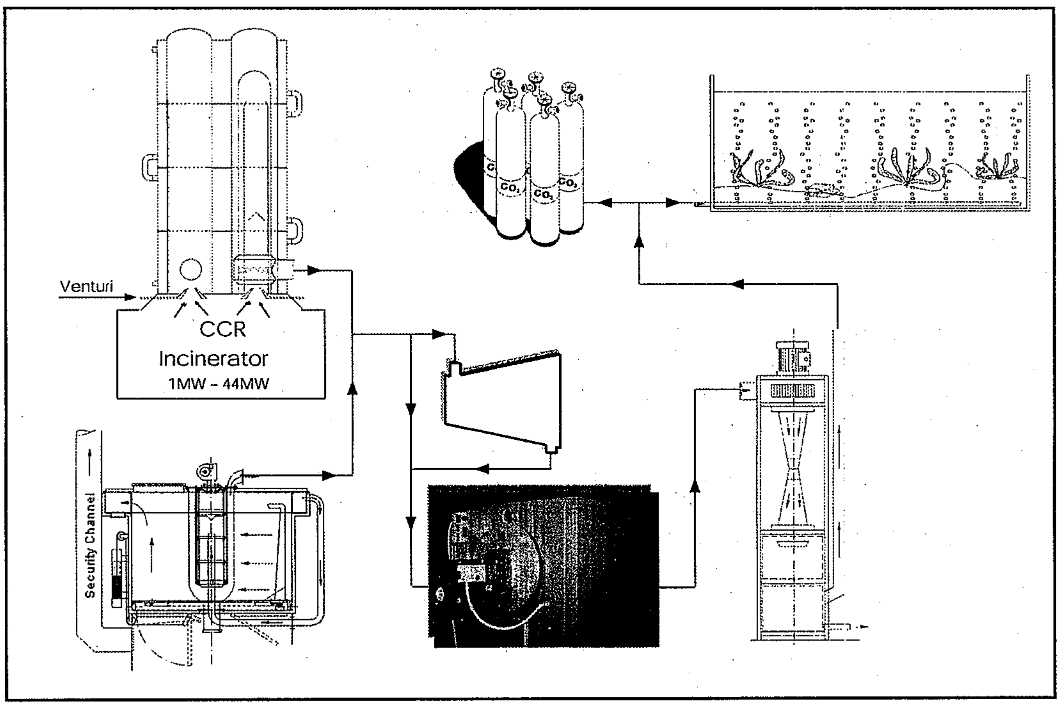
In the calculations, TPG is supposed to consist of one or two different cascades, each of which being formed by a number of semiconductor thermopiles that are joined together electrically. Connection is determined by electrical parameters of useful needed load. On its hot junction, each thermopile of the first (upper) cascade has a receiver plate which absorbs the IR of the CCR. Cold thermojunctions of thermopiles in the second (lower) cascade are assembled on the inner wall of the boiler. Efficiency of TPG is firstly determined by the properties of thermoelectrical materials that are used. At the same time, the right choice of the materials depends on thermal regime of working of the cascades. It is determined by conditions of optimal accordance of TPG with IR emitter.

In the case of CCRs, these materials are found by taking into consideration the thermal interaction between the reactor and the receiver plates of thermopiles. The higher the receiver plate's temperature, the bigger the electrical output of TPG, but so is its thermal resistance. Therefore, if the temperature of the CCR is constant, its heat power falls as the electrical output of TPG increases. This is the reason why there is an optimal temperature of thermopile receivers at which the electrical output of TPG reaches its maximum value. According to our calculation, the optimal temperature of the receiver is around 800 K to 900 K. This region assumes the optimal application of middle- and low - temperature materials in one or two cascades.

...How to Avoid Global Warming by use of Complete Combustion Reactor with flue-gas condenser for clean CO_2 for industrial recycling

PARAMETERS	SINGLE CASCADE LOW-TEMPERATURE TPG	DOUBLE CASCADE MIDDLE TEMPERATURE TPG
Hot junction temperature, °C	270	550
Cold junction temperature, °C	68	68
IR capacity of the reactor, MW	1,57	1,40
Relative IR capacity, %	98	87,5
Electrical output, kW	115	196
Efficiency, %	7,3	14,0

The results of more detailed calculations of TPG, which were held for CCR with the heat capacity of 2 MW (the IR capacity - 1.6 MW) in accordance with the traditional method of "average properties" [1], are presented in the table above. The calculations were held by taking into account the properties of easy available materials, such as low temperature



triple alloys of Bi, Sb and Te, and middle temperature alloys of Pb and Te. The thermal leakage and contact electrical losses of TPG were determined as shown in [2,3]. According to the presented results, and using the single cascade low temperature, TPG (in 2 MW boiler) permits to obtain 115 kW of electricity production and does not visibly influence the CCR's work. The use of the double cascade increases the electrical output up to 196 kW, but makes the heat capacity of the reactor fall down to 12.5%. Therefore, any increase of working temperature to get more electricity must be accompanied by special measures directed to the intensification of heat transfer between the reactor and the TPG. If the measures are successful, the efficiency of the TPG will go up to 20 %.

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New Zealand

Teaching Sustainable Development

Prof. David Thom,
President of Committe on Engineering and Environment, WFEO, New Zealand

SUMMARY: The evident importance of the contribution of technology to sustainable development increases. Sustainable development is fundamentally different from traditional development. Teaching SD requires changes of attitude. Integrated teaching requires faculty literacy in SD. Since there is much learning material available, this can be achieved. Policy for the development of faculty capacity has been proposed, as well as guidelines for new curricula. There is now much experience with adaptive, and new curricula development, and specifications, as well as much innovation. The importance of university engineering research into the engineering application of sustainable development is fundamental.

KEYWORDS: Sustainable Development — Attitudes — Integrated Teaching — Faculty Literacy — Research

INTRODUCTION

In spite of global progress with the transition to Sustainable Development (SD) since the UNCED of 1992, the reviews in 1997 confirmed that the concept was not well understood or applied, and that the global environment is still deteriorating (1). It becomes clearer, with time, that the difference between forecasts of hope and gloom, lies in what technology can do to bridge the gap between a declining resource base and escalating demand. Time scale is a critical problem. Society now expects engineers to take account of social, economic, ethical, and non-technical issues in their work. Employers give preference to environmentally literate applicants over those who are not (2). To make a difference, the re-orientation of technology identified by the 1987 Report of the World Commission on Environment and Development must be implemented in the short time of perhaps 20 years. This is a huge challenge for educators. Many have tried to respond by introducing or adding new subjects into established curricula, and there is now a wide spread of these "adaptive" courses. A few bold front runners have introduced a totally new approach, but some courses have not changed at all.

The time scale indicates that it is necessary to radically increase rate of change. How is this to be done when many teachers feel uncomfortable with the concept of sustainable development, and even more uncomfortable with the concept of integrated teaching, as recommended by the Paris Conference on "Engineering Education and Training for Sustainable Development" of September 1997 (3).

Some faculties have responded by introducing guest lecturers with a reputation in the teaching of SD, a fundamental divergence from the concept of integrated teaching. If students thus meet the concept for the first time, having heard nothing about it in other parts of their programme, such lectures read as "add-ons". Since SD in its fundamental meaning represents a different development philosophy from the traditional, this approach can create confusion of objectives, particularly if teachers of the balance of the course project traditional development philosophy. Integrated teaching requires faculty wide SD literacy.

Since the application of sustainability requires changes of attitude, its teaching must be based in different attitudes. Attitudes are acquired from the teaching environment rather than taught. The only response that can project new attitudes, integrate teaching, meet demand, and provide the research component essential for progress and for teaching, is for whole faculties that are SD literate. Since there is a great deal of material about the concept and teaching of SD now available, there is little doubt that a faculty with the will to do so, could create new capacity and programmes within a two year period. It is the objective of this paper, by reference to new initiatives, to highlight possible steps in the building of capacity for faculties and individual teachers to deliver integrated teaching.

FACULTIES

Faculties can still be divided on, or dismissive of, the recent changes in the societal expectations of engineering. But the evidence is now compelling, whether in the form of UN resolutions, or of "state of the world" reports, or policy statements by major engineering bodies (for example, the US Engineering Deans Institute is currently working on an SD policy for the consideration of the American Society of Engineering Educators), or statements from major business, or the plethora of conferences, or the large number of "catch-up" adaptions to engineering courses. To become convinced, it is necessary to study the evidence, and the initiatives being taken within engineering teaching around the world. Reference material is widely available, in reports, policy statements, and on web sites. Gunn has described a faculty re-orientation strategy that was put before the faculty of the engineering school of the University of Auckland. This had eight elements:

1. All staff commit to a declaration of principles.
2. An environmental and sustainability audit for all existing and proposed courses.
3. A programme of workshops to support staff.
4. A year 1 course in environmental principles to complement engineering principles.
5. Incorporation of environment and SD in design teaching in all disciplines.
6. Promotion and encouragement of research activity.
7. An award to encourage innovation in teaching and research.
8. Annual reviews of the plan to ensure focus on SD is maintained.

The principles to which staff would commit were as follows:

1. Recognition of the ecological foundations for technology and economy.
2. Ensuring that professional engineering is taught and researched within a framework of SD. (This is integrated teaching).
3. Incorporate cleaner production, waste minimisation, pollution prevention, energy efficiency, resource recovery and conservation, risk reduction and environmental protection into all relevant teaching and research programmes.
4. Interact with related academic disciplines and university environmental initiatives.
5. Assist business, commerce, industry, government and the profession.
6. Develop communications skills.
7. Ensure that social, cultural, stewardship and ethical values are incorporated within programmes.

CURRICULA

The desirable elements of SD curricula, if the adaptive courses, the new "green fields" initiatives, the international workshops, and the innovations that have developed from these are used as a guide are:

- Attitude to, and understanding of, sustainable development.
- The skills that foster application of engineering principles in a SD context.
- Emphasis on systems.
- Experience in working with non-engineering disciplines.
- SD research and student (and teacher) case learning in working on SD projects.
- Teaching within the SD framework (Integrated teaching).

A working party of the 1997 Paris Conference produced a sample "old/ new" comparative curricula:

OLD	NEW
Physical Sciences	**Modelling**
– mathematics	– analytical
– physics	– computational
– mechanics	– conceptual
– chemistry	– systems
– logic	
Natural Sciences	**Natural systems**
– biology	– biological cycles and systems
– geology	– geophysical cycles and systems
Engineering materials	**Eng. materials**
– introduction to properties, use and production	– introduction to properties, use and production
Communication	**Communication**
– written and oral presentations	– negotiation graphics
	Strategic solutions (introduction)
	cleaner production and life cycle management
	environment management systems and tools
	resource efficiency
	environmental design

The Georgia Institute of Technology (USA) in 1993 launched an Institute wide project to develop a new curriculum in sustainable development and technology. This has emerged as a three-course sequence: Introduction to Sustainable Development; Case Studies in Sustainable Development, and Designing Sustainable Engineering Systems. Students gain a broad overview of the concept of sustainability, and the case study and design courses encourage the use of decision-making skills in applying the concepts and principles. Key subject areas that are taught across the curriculum include ethics and humanity, and thermodynamics and complexity.

In 1993, this was a bold step towards a new approach which has the essentials of integrated teaching; grounding in basic concept and principles, and student experience in their design application, supported by case studies and research. The approach has thoroughness and integrity. By comparison, the fundamental weaknesses in "add-ons" and adaptive courses are thrown into relief, as also is the need for faculty commitment.

However, as Royal Academy of Engineering in the UK has shown, there is more than one way of approaching the teaching of design for sustainability. The RAE's "Visiting Professors" scheme brings in senior engineers from industry to work with undergraduate students in design classes. One objective is to develop teaching materials based on real case studies which will show how engineering principles can be applied to design products and systems that meet the need of a sustainable way of life.

Another important development in the UK is a specification for the core learning agenda for sustainable development published as a Government Sustainable Development Education Panel position paper. This specification is based on a government and engineering institution supported questionnaire to engineering faculties on current sustainable development engineering education practice.

Among other important curricula initiatives is Monash University's (Melbourne, Australia) "Context of Engineering", a new subject in a new degree which will be common across four campuses. First year students often lack understanding of what engineers actually do, and the environment in which they work and interact in the community. The subject attempts to show the breadth and multi-disciplinary nature of engineering, information access and retrieval, communications (written, oral and visual) economics, quantity estimating, sustainable development and ecology, life cycle assessment, quality control and safety, and ethics. With introductory lectures, most of the learning occurs through tutorials and a group project which runs through the whole semester. Students, in groups, develop a project brief outlining the important issues to be dealt with, invitation to tender, two alternative conceptual designs, a preferred solution based on sustainability, life cycle, economic, quality and safety issues, and a final report.

THE INDIVIDUAL TEACHER

Among its recommendations for business, academic institutions, and the engineering profession, the Report of the Paris Conference addressed several recommendations to the individual teacher to do with raising both personal and faculty capacity.

- Disseminating information to colleagues, and organising fora.
  Creating dialogue as a means of promoting changes of attitude.
- Getting sustainable development onto the routine agenda for meetings/reviews.
- Raising SD issues with funding agencies, professional institutions and accreditation bodies.
- Initiate or participate in university "greening" projects.
- Develop teaching materials and courses that include SD.
- Plan a university project integrating preventive environmental strategies in technical courses.
- Incorporate environmental concerns into criteria for engineering awards.

These practical proposals will all help to develop grasp of concept and fluency in the integration into teaching. And for the individual wishing to develop personal SD literacy, there is now a very large amount of material available. A few selected examples:

Concept and philosophy: UN Documents, Agenda 21, the Conventions, UN Newsletters and web sites (e.g. The Commission for Sustainable Development), engineering society policy statements, codes of ethics that now require engineering involvement in SD etc.

Web sites and data bases: e.g.: The World Business Council test of Env. Literacy:
http://wbcsd.ch/foundation.
Sustainability generally. The international Institute for Sustainable Development:
http://iisd.ca.
Cleaner Production. UNEP Industry and Environment. Industrial pollution prevention, environmental technology assessment, energy efficiency, ozone action. Over 400 referred case studies on the ICPIC database:
http://www.unepie.org
Internet course on sustainable development:
http://www.sustainability.com/orcad/sdeng

Unless the one of the primary goals of teaching is inculcation of attitudes, as well as communication of new information, new curricula will not attain potential effectiveness.

CONCLUSIONS

As integrated teaching of sustainable development is the teaching of a new engineering philosophy of development, including communication of attitudes, and new curricula development, sustainability literacy of whole faculties is required. The shortness of the time scale for evolutionary change means that new tools and principles have to be developed "as we go". Since such change bears on both the professional and the general futures of the students, there is an argument for co-operative student/teacher endeavour in some aspects of new curricula development.

There is now a great deal of material available on the engineering philosophy of sustainable development, and on appropriate teaching and practice in books, papers, and web sites. The Paris conference established a network providing for periodic updates from which progress, ideas, and initiatives can be disseminated. Faculty literacy is an attainable goal.

The importance of university engineering research into the application of engineering to sustainable development cannot be underestimated. "It is no longer admissible to train engineers who ignore the societal consequences of the exercise of their engineering skills" – Fritz Balkau, Principal Officer, UNEP Industry and Environment Office, Paris.

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France

New Global Information Technologies (NGIT) and their Impact on Engineering Education

Prof. Jean Michel,
Ecole Nationale des Ponts et Chaussees – ENPC, France

The information revolution is one of the most important factor of change for higher education and for engineering education. How to rethink higher engineering education in the context of post-industrial societies influenced by of a world-wide globalization of their economy, by also an incontestable elevation of the knowledge and competency levels and by a more and more intricate situation of productive forces, thanks to the huge development of the electronic networks? Can we invent and establish new ways of education and training that can better take into account the generalized access to specialized information and knowledge and the world-wide networking? The virtual university is becoming the key concept to be taken into account now for the future of higher engineering education.

THE EMERGENCE OF THE INFORMATION TECHNOLOGY AND SOCIETY

The present situation can be characterized by the emergence of information and communication in all fields of individual and professional life. The specialized information systems, tools and networks become more and more important and powerful. Internet is the most obvious phenomenon of such a revolution. Governments, companies, local authorities, universities, etc. are now strongly discussing the need of new information infrastructures, putting milliards of dollars or EURO in the construction of information superhighways. They also put emphasis on the need to develop the "content industry". Data bases, data banks, experts systems, CAE, CAM, CIM, EDI, CD-ROM, CD-I, Internet, Groupware, Websites, Intranet, etc.: engineers, entreprises, educators are really facing a new situation in which information resources (whatever the way of accessing them) are becoming key resources for the development of industry, education and society activities.

One can assert today that virtual universities (and the use of NGIT in education) are not just a fashion. One can observes a true explosion of experiments or realizations. For instance, if one tries to retrieve information on the Web, requesting Alta Vista to find pages related to "Virtual University", one will find more than hundred thousands of references. More than 20 international electronic mailing lists are entirely devoted to debates on distance education. More than 30 international conferences were dedicated to NGIT in higher education during the year 1998. Such an explosion of realizations does not mean that traditional universities will no more be useful and that only virtual universities will survive in the future. Nevertheless one cannot ignore that trend and one has to better understand what is behind it.

SOME KEYWORDS LINKED TO NGIT AND TO VIRTUAL UNIVERSITIES

The use of NGIT in education is not really new. During the last 20 years, many specialists, many educators, tried to find solutions to a not very well defined problem (what to do with computers and information technologies in education?). At the same time, new concepts of education appeared or, more precisely, were successfully developed and used as for instance it was the case with distance education, or also with open learning. If one tries to clarify such concepts, one can notice the following items:

- computer aided learning, which can also be linked with computer aided teaching, computer aided education (CAL, CAT, CAE), ...; that concept is often the keyword for the development and the use of simulation tools in engineering education
- coursewares (didacticiels in French): many professors in technical universities are fascinated by the development of such coursewares, easily available through Internet but generally ignore the economic dimension of the problem;
- self learning (autoformation in French) which focuses on the free move of the learners in their learning processes, according to their learning profiles or styles;
- distance learning and distance education which are well represented by the positive experience of the Open University in UK;
- open and flexible learning (or education) which puts emphasis of the diversity of the learning routes (at an individual or at a more collective level);
- mediated education (use of NGIT and multimedia);
- asynchronous learning: the new "time" dimension of education; - interactive learning that leads to collecfive learning processes;
- cooperative learning (education) which is based on interaction between different groups of people, thanks to NGIT (groupware, intranet, electronic forums, ...);
- educational platforms which are the most advanced tools for the dissemination of information and knowledge for educational purposes at a local or at a worldwide level;
- knowledge pools (such as for instance ARIADNE in Europe);
- distributed learning environments, integrating different tools (platforms, knowledge pools, forums, etc.);
- and finally virtual universities which are of different types, according to their origin or to their development.

THE REASONS OF A REVOLUTION: THE NEW FEATURES BEHIND NGIT

When talking of NGIT, one has generally in mind "computers" and "telecommunications" which are only tools and are not so much different (functionally speaking) from what are the blackboard or the classroom. If one wants to better understand the present revolution behind the use of NGIT in education, one must take into account some important features that characterize the information technologies today. Thus, one can mention:

- the generalized use of the PC, the personal computer, which is very close to the person, an intelligent pen, a personal virtual memory and the key tool for the access to information and knowledge;
- the digitization of texts, images and sounds; any kind of document whatever its original format or appearance can be simplified in a given set of digits, 0 and/or 1, exploited, transfered, reused, etc, at a very low cost thanks to the digitization;
- the development of huge storage capacities: all my personal work during my ten last years can be saved on a cheaper and cheaper hard disk (6 Go) of my PC;
- in parallel, the development of width-band communication channels which allows access facilities at a very high speed to datas at a worldwide level or allows the transfer of huge amounts of datas;
- the client-server architecture of the computers that has an impact on the distribution and the sharing of resources;
- the impressive development of electronic

networks, with the fabulous Internet protocol Tcp/Ip that facilitates the decentralized and universal access to datas or files, whatever their format;

- the interesting and succesful development of hypertext that establishes links between different documents; hypertext facilitates navigation, surfing and a new concept of discovering the global knowledge world;
- intelligent agents for retrieving datas, searching pertinent information, translating texts, push technologies, etc., a lot of new tools that help the people when confronted to the enormous, multilingual world wide web;
- Internet, intranet, extranet, groupware, also considered as tools that link people together and facilitate the electronic communication (electronic forums and chats, ...).

IMPACT ON PEOPLE AND ON EDUCATIONAL PROCESSES

It is obvious to say now that NGIT are changing the way of communicating, thinking, working,... being,... and also learning. Considering more precisely education, what are the consequences or the impact of the use of NGIT ? Some are very interesting and explain certainly why govermnents, but also educators, are pushing in that direction:

- delocalisation and decentralization, access to decentralized information and knowledge : from the traditional "one to many" way of disseminating knowledge, one now moves towards a much more systemic, complex, distributed learning environment;
- teleworking, telelearning, etc.: it is no more pertinent to build huge buildings and campuses for providing courses to hundreds or thousands of students; learning and working at home (or in any choosen place), having access to decentralized resources, seems to be an unavoidable trend;
- a new time management: one can choose when one wants to learn something, when one wants to communicate with other people; one can adapt education (teachning, learning activities) to personal learning styles or profiles, quicker and/or slower;
- indivual and collective implications: the individuals can develop their own (independent) learning approaches (selflearning) but one can also explore new ways of cooperative learning playing on interactions between people;
- groupware and collective tools such as Intranet sites, platforms, etc. are very useful for sharing rare (and less rare) resources;
- new roles facing the use of information: people can be at the same time user and producer (produser) ; one learns also when one produces his or her own information and knowledge and disseminates it to colleagues; - active implication, interactivity;
- globalization, internationalization: this is an interesting dimension one has to mention; one opens a window on the world and one can learn from a more diversified and multicultural environment (learning from the world, from a web withoutfrontiers);
- a new citizenship in the information & knowledge society; one cannot use this new information environment and learning facilities without developing new attitudes and ethical values.

DIFFERENT LEVELS OF IMPLICATION OF UNIVERSITIES

Facing the important development of NGIT, universities tried and try to find appropriate solutions for integrating these new tools in their strategy and in their day to day activities. It is possible to differentiate different approaches. Thus, Marcel Goldschmid (Epfl Lausanne) considers four types of universities:

- "traditional" universities in which individual independent initiatives constitute the unique strategy, a traditional teaching approach with new electronic textbooks;
- "exploring" universities in which individual initiatives are combined with institutional experiences at a given university level, with more structured projects (often

with external financial support for these projects);
- "innovative" universities which believe firmly in NGIT and promote innovative usages of these technologies, with more systematic approaches and with the development of educational plates-forms;
- true "virtual" universities, developing global projects, created as new institutions for which the extensive use of NGIT constitute managerial and strategical issues (this is for instance the case of the new West Governors University in the USA).

One can also ranked the present experiences on a scale with four levels of development:

- *level 0:* NGIT are used as pure audiovisual tools; one delivers traditional courses through the use of Internet tools (html textbooks, images for film in education, etc.);
- *level 1:* towards a global educational scenario: electronic texts, interactivity, assessment procedures, etc., a new interactive encyclopedia, open on the world, created and developed by disciplinary teams in given domains (an example can be founded at ENPC, with the courses on urban hydraulics);
- *level 2:* development of innovative approaches based on integrated contributions (different specialists working on a global project): content, information technologies, pedagogy, communication and management; one moves towards new concepts (educational platforms, knowledge pools, ...);
- *level 3:* towards true virtual universities with the creation of new consortia, decentralized units, cooperative work, resources centres: a new vision on education management for the future.

NGIT USED FOR WHAT OR ON WHICH COMPONENT?

If one examines more in detail the various present experiences in higher education, one can say that NGIT can be used in four different domains or areas or for four different purposes (independantly considered or combined):

- application to knowledge, content or subject development: hypertext, courseware, electronic textbook; the knowledge content is redesigned (thanks to NGIT) but it can also be unchanged;
- using NGIT for stimulating people relations or interactions: electronic tutoring, learning communities, global interactive learning strategies; the principle and system of interactions between people is redesigned (through the use of NGIT) but can also be unchanged;
- the institutional component as such, with creation of new institutions, partnership, integration of various resources, development of integrated platforms and knowledge pools, development of networks, consortia ; one can consider situations with no subtantial changes in that domain or, on a contrary, with totally redesigned structures (for a more systematic use of NGIT in higher education);
- strategical and managerial issues, global projects for new open flexible learning environments with the possibility to enter new educational markets (life long learning, worldwide knowledge industry,...).

These four domains or areas can also be viewed or analyzed as:

- editorial issues: editing and publishing new course material for instance;
- educational issues with emphasis on new learning methods and on pedagogy related to the use of NGIT;
- communication issues with the development of learning communities and of interactive learning processes;
- entrepreneurial issues: new educational projects such as platforms, a vision of new educational markets.

VIRTUAL YES, BUT WHAT CAN BE "VIRTUALIZED"?

When using NGIT in higher education, when talking of virtual universities, one cannot avoid to debate the "what" can be virtualized. Thus, one can consider the different items, which can be independantly or integratively virtualized:

a) PEOPLE:
- the individual learner (being not necessary present on the traditional campus)
- different groups, subgroups or metagroups of learners, with the possibility to set-up temporary virtual groups, closed or open groups , mixed groups, etc.
- the individual teacher (provider of educational resources) – different groups of teachers and new virtual teams
- tutors and other contributing people (from industry, from other countries,...)

b) CONTENT:
- the disciplinary subjects (at different levels of analysis: elementary lecture, module, full course,...)
- the curriculum itself (flexible or not)
- the peripheric content (other knowledge inputs from outside,...)

c) EVALUATION PROCEDURES:
- formative evaluation (virtual tests at a distance,...) – summative evaluation (virtual exams,...)
- assesment of courses

d) LOGISTIC:
- softwares, computing resources
- coursewares
- electronic libraries

e) ADMINISTRATION:
- selection and enrollment of students - registration
- fees management

f) THE GLOBAL ENVIRONMENT:
- virtual campus
- facilities (transport, accomodation, financing,..).

WHO IS CONCERNED BY THE DEVELOPMENT OF VIRTUAL UNIVERSITIES?

It is interesting to notice that the use of NGIT in higher education leads to new perspectives in the management of universities and in the cooperation between different groups of people. Thus, when moving towards virtual universities, one has to consider the specific input of the following partners:

- the computing centre and its specialists
- the librarians, the information management experts - teachers, professors, as content experts
- educational specialists (pedagogy, use of NGIT in education,...)
- communication professionals - editors, publishers, press specialists - motivated innovators, whatever their domain of innovation
- project managers or leaders - people from outside the University (tutors from industry, ...)
- the learners themselves.

It seems important to say here that most authors and experts consider important to set up ad-hoc multidisciplinary teams for the efficient development of virtual universities.

THE OBSTACLES, THE DIFFICULTIES, THE PROBLEMS TO SOLVE

In many recent international conferences debating the question of virtual universities and the use of NGIT in higher (engineering) education, people point out some serious problems which need efforts to be solved.
Thus:

- the lack of appropriate equipment : this is true, but not a serious reason for deciding not to do anything ; however the problem appears when one moves from slight experiments (a simple electronic textbook) to much more advanced projects (creation of global learning environments);
- another problem related to equipment is what is called now the "logistic" crisis (how to maintain correctly the functioning of all the electronic environment?);
- the lack of "mediacy" (especially for professors of a certain age or generation) ; this is a true and serious reason ; one has to set-up policies which can help people in that domain (sensibilization, formation, etc.);

- the lack of vision and strategy of the top level management, the managerial misunderstanding of what is happening now and of the new worldwide educational market;
- the economical problem: one needs fresh money for investing in appropriate resources centres, for paying creators who do not teach but are entering this new educational market, money also for maintaining and developing tools and contents;
- the intellectual property problem for individuals who want to create new coursewares but will have few returns on investment, problems also for educational communities who will be obliged to pay so much for accessing some licensed resources (risk of monopoly);
- the difficulty to cooperate at national and international levels, especially if one needs to establish efficient consortia (are traditional professors able to cooperate on such new projects?);
- some existing rules (as for instance accreditation procedures in engineering education in some countries) which are not compatible with the new openess and flexibility offered by NGIT.

NGIT AND VIRTUAL UNIVERSITIES: SOME CONCRETE PROPOSALS

To help educators and universities to enter the new information society, one can suggest some very simple proposals:

- to multiply and to support conferences, seminars, and workshops devoted to that issue helping people to better understand what is happening now; this is important for convincing top-level managers of universities to define appropriate strategies;
- to promote interesting experiences through traditional channels as well as through Internet; one needs to better know what are the most interesting tendencies, the successful projects;
- to assess advanced succesful realizations through traditional procedures as well as through new approaches of evaluation and assesment;
- to involve industry in educational projects, with the purpose to find money for a long term succesful development of NGIT in higher education; industry can be interested by projects dedicated to life long learning;
- to sensibilize, educate and train teachers, professors, for a better use of NGIT and for the creation of electronic resources (coursewares, electronic content to be put on platforms or in knowledge pools,...);
- to develop incitement procedures within universities for stimulating the creation of new educational projects based on the use of NGIT;
- to implicate students and young people in the development of new projects: the "web generation" is strongly pushing.

Who would have thought, in 1747, when one founded the Ecole Royale des Ponts et Chaussees in Paris, with the purpose to educate and train the French civil engineers, that two and a half centuries latter, people would communicate through satellites or optical fibers, would fly over oceans and continents, would cross the Channel using their own car or a fast train (TGV)? Would Diderot, the editor of the French Encyclopedia, have imagined just before the French Revolution that the numerous volumes of his work would be contained on a small CD-ROM and have become a testimony of the information revolution?

Hungary

The Knowledge Engineer

Miklós Havass,
Számalk Systemhouse Co., Hungary

SUMMARY: The globalization process leads to the birth of the information society. According to the author a layer of persons engaged in the management of information, so-called "knowledge engineers" will develop in the information society. This layer will also include the engineers of the present day and its importance will be upgraded substantially. The training of engineers will undergo fundamental changes as a result of the above-mentioned process and information infrastructure making its way into the system of tools of education. It is necessary to anticipate future changes in developing the engineer training institutions of the present.

KEYWORDS: Engineer — Globalization — Information Society — Knowledge Engineeer — University

1. The main topic of the conference: the impact of globalization on the engineering education and practice. However, we will start the analysis one layer "higher" by inspecting how the role of engineers will change in the information society. This is necessary, because globalization is only the first strong sign of the society of the future: the information society. Globalization is rooted in the potential for fast processing of large volumes of financial, business and cultural data, transfer of the same via telecommunications - in other words worldwide communication - as well as the fast and relatively inexpensive movement of persons and goods. Thus, it is purposeful to expand the topic of the survey, if we are truly interested in near-future impacts, and try to find the joint impacts of this widened domain. The question is what impact will the information society have on engineers?

2. In order to have a look at the most general change of the existence of engineers let's define the meaning of the word engineer. The word comes from the Old-French engine originating from the Latin word ingenium having the meaning of "natural ability, skill, talent". The engineer is the person having knowledge about nature as well as skills for successfully maneuvering and managing himself and the "world-segment" under his influence.

The Hungarian language offers further details on activities of the engineer. The Hungarian word engineer *(mérnök)* also expresses that the engineer is a person measuring, that is quantifying phenomena, forming models of the existing world with the help of such quantified information, make projections and influence the progress of the world by employing the tools at his disposal. (It has to be mentioned that in Hungary - from a historical point of view - the word engineer developed by reference to the work of the "land surveyor" engineer.) The special branches of engineering were created depending on which "part" of the world was measured, modeled or quantified by the engineer: chemical-, civil-, hydraulic-, marine-, mechanical-, statical engineer.

In respect of the "scope of knowledge" represented engineers differ from one another, but their methods, way of thinking and modeling abilities are similar in spite of that engineers acquire their knowledge at different faculties in today's modern universities.

3. The information society - based on digitalization, in other words "reception", processing and transferring the world's measurable quantities in an identical manner - will be the society of knowledge relying on measurable information, where the inter-connection and sub- or super-ordination of persons, social strata and countries will be determined by their relation with information. Information about the world (theoretically all information), as well as the vast majority of (algorithmic) processes making possible their arrangement and "compilation" will be (theoretically) available for anyone on the "information web". The question is how to find the necessary information and methods for their processing, and - this being the real issue of excellence - how will we able to link those in a new and unusual manner.

In this respect each member of industrial, business, legal and scientific societies, as well as providers of servicer will become "engineers", what is more "knowledge engineers", whose work will consist in large part from organizing, processing, complementing, and transferring such information. Thus, the engineer of the present day operating in various fields will become somewhat like a universal "knowledge engineer" but the most outstanding players will show increasing differentiation, because they will require the ability to find much more diverse special "knowledge".

In this sense the broad notion of "knowledge engineer" will come into existence to become a layer of key importance, because:

- this layer will know the most about nature, and have the ability to handle global environmental problems,
- the world surrounding us can be viewed ever increasingly as an "artificial world" created by the work of this layer,
- the extensive and complex models of this layer will lead to finding a solution for many problems in the society, health care, etc.

It has to be recognized that the "knowledge engineer" of the future is not simply the child of today's engineer and IT specialist. Many economists, medics, service providers and producers will also be part of the process. Even the vast majority of artists. In other words everyone engaged in intellectual activities, that is working with "knowledge".

4. A whole range of issues are raised by the (higher) education of new engineer types. It will surely require long discussions and a long period of time to think these over, and to deduct and adapt consequences of the same in the training of engineers. The notions have not yet been formulated, the information society is under development and the conservative attitude of higher education also doesn't facilitate the process. At the same time we should not forget that globalization coincides with the increasing mobility of students and teachers (we will refer to this hereunder). This also means that parts of the world, where concrete experiments are started sooner and in a more dynamic form have a better chance for educating the "global elite" or having global competence centers established.

In the presentation I would like to list some key points of expected changes and consequences of the same.

First of all the education of "knowledge engineers" will be mass education. Countless persons standing on the continuous spectrum of knowledge and skills will want to use it, because the available knowledge will lead directly to their happiness and work opportunities. At the university they will have to deal with the joint but altering speed and depth training of high numbers of youth at different levels of progress. This will require new type of teachers, teaching tools, and curricula. Tele-learning methods - based on individual learning - are also expected to spread.

Higher education is the ticket to a job the relation of teacher-student (the word-by-word translation of the latter Hungarian word would be "listener" that is the one who listens and accepts knowledge passively) transforms into supplier-client relation. The student intends to buy competitive knowledge (wherever that can be found at the highest quality for the most favorable price).

The hallmark of knowledge will be its usefulness, thus learning can be viewed as an investment one has to pay for and will pay for. (This issue will become a question of calculation.) Social-level learning will not be financeable without the above-mentioned social contribution. At the same time it will be the role of the state to ensure financial constructions (loans, scholarships, social funding, aimed support) which can make education available for wide strata of society (the poor, future workers of low-paid jobs, etc.) and which can facilitate the generation of sizable funds for excellence-training.

The vast majority of jobs - even if created under a national framework and becoming work performed at home by making use of the opportunities of teleworking - will be connected to transnational companies. This means that the University should provide preparation for international cooperation in a world where the majority of products and services are assembled in team work from ready-made knowledge, component, and procedure "capsules". It is thus necessary to know the customs of team work, cooperation, use of standards, and quality guaranteed in itself not to mention international communication and efficiency being present everywhere in activities.

One has to prepare for Humboldt's closed science theory to dissolve. Social magnitude scientific and technological research - supported with IT tools - produce results on the large-scale as well as creating new and even newer areas of science. For this reason - and because the lexical knowledge achieved will be accessible on the information network - it will be necessary to develop the ability of higher education that makes man capable of understanding the "whole" and accepting continuous change.

The relation of higher education - and work - is becoming closer with the tools of information technology. Their use requires not only technical skills, but a new way of thinking and new planning techniques. Acquisition of the "new literacy" will be a basic requirement at the new university.

In addition to the above there will be changes that are administered in the structure of the university because information technology elbow out and replace a whole line of earlier techniques and methods.

In the next point we will take a look at some of these expectable changes.

5. First of all the role of the university as a library containing up-to-date knowledge will undergo a change. Rapidly changing dynamic knowledge will not be locked away in paper-based libraries or at a central place (this is quite rare), but it will be accessible from the network available everywhere. It will not be necessary to visit the university physically to access such knowledge.

The task of the teacher will become highly polarized: the two main poles will be the producer of study materials and the facilitator making possible studying in person. Of course it need not to be mentioned that these (especially the former one) do not require meeting the student at any concrete geographical location. Similarly to how present-day film stars and media starts are becoming increasingly independent from the film company and TV station the "teacher star" of the future (excellent lecturers) will become independent from university or country and become a commodity of high quality, who appear at times here and at times there in person at conferences (having high attendance) or digital media forms.

The technology of virtual reality, as a highly effective modeling tool will take over the role of workshop. The exhausting creation of an experimental environment and the tiresome work of making a freehand drawing can be replaced by diverse parameter experiments made with highly effective models and enable better "reception" of overall processes.

The allocation of the same planning - production - distribution process on the network will result the establishment of international research collectives without requiring a single physical location. In such a sense socialization, the field of "joint" work will also become virtual. Of course filling this complex framework with content (and filling it over and over again) and its organization requires much care. This role will be played by the university - being a totally new institute in outward appearance, role and functions.

Communication on information networks decreases the importance of time and space but people will continue to reside at geographical locations (possibly in nation-state or other social organization). Thus, it is expected that the hierarchy of university will be created. There will be some educating the leading global intelligentsia. There will be ones managing regions, and there will be many training average "knowledge engineers". The positioning and hierarchy of the universities not yet existing will also be significantly dependent on when each country and university will recognize the start and direction of changes, and how they will adapt to those.

6. Finally, let me present to you possibly the most important thought of the study. The engineers of the present day makes preparations under the framework of nation-states also acquiring knowledge on how they can become a useful citizen of their nation - loyal to the values of the same. In a global world, the world of huge transnational companies and financial institutions over-bridging countries, in the world of global mobility universities must create a new ethos and generate a new sense of responsibility, which points beyond nation-states.

The fate of the entire planet will be in the hands of the new knowledge engineers. However, universal limits and behavior standard are not (yet) available. It still depends on them how we handle atomic or nuclear energy, how we "consume" our environment, whether or not we leave the majority of the planet's population in poverty, and how we manipulate our human existence (genetic surgery, digital media.) In order for the global world to take its role as step in the direction of progress in human history the "knowledge engineer" of the new age must learn global responsibility and values, and the methods for acquiring the same.

Czech Republic

IMPORTANCE OF THE DEVELOPMENT OF THE ENGINEERING EDUCATION FOR QUALITY IN GLOBAL ECONOMY

Dr. Růžena Petříková,
VŠB – Technical University of Ostrava, Czech Republic

SUMMARY: So called quality management is an integral part of all useful management systems aimed to the high customers and stakeholder's satisfaction. There is no doubt that modern universities need also modern management system, including quality management. An international standards ISO 9000 family can serve as basic approach for quality management systems building within industrial sphere. But these standards don't seem to be suitable starting point for creation of quality management at universities. This type of educational institutions asks for special model of quality management system.

KEYWORDS: Quality Management — Engineering Education — European Quality Charter — European Model TQM

To achieve total involvement in the field of the quality which is the condition for further progress and competition, European public authorities (EU, EOQ, EFQM...) signed the *European Quality Charter* in Paris in October 1998. *Quality: An advantage for Europe in international competition.*

THE REASONS

In a global economy, competition is all around us. To win, European products and services have to be the best – the best if our Continent is to have a chance on the international market. Quality has become the key to competitiveness.

1. Today it is quality that will attract businesses. Quality is an organisational excellence objective. Quality is also a methodology and a way of promoting people's active participation based on the involvement and responsibility of each individual. Quality is:

- an objective because, to be competitive, organisations must respond precisely to the needs and expectations of customers and users.
- a methodology that promotes participation because one cannot ask total commitment from people without, at the same time, developing the appropriate working environment. Quality also implies motivation and responsibility, and thus an organisation, its behaviour and methodologies must be based on initiative and concern for the customer.

2. Quality is a priority. Quality is an indisputable measure of efficiency (non-quality results in a waste of resources estimated at hundreds of billions of Euros per year). By reducing costs, engaging people's imagination, promoting innovation, renewing the organisation and encouraging initiative, quality becomes the driving force for competitiveness and thus of employment. But economic competition always demands that organisations do more and better. Quality must be a priority for everyone for all time.

3. No quality without solidarity: complete involvement. In our complex organisations, quality is inseparable from solidarity. Quality concerns all the functions of, and every individual in the organisation. It concerns all sectors (industrial, commercial, craft, or service) of all sizes. It also concerns public services such as the civil service. There can be no quality without an environment of quality. The "chain-of-quality" unites and links all the economic and social players. Quality is thus the concern of everyone and demands that everyone has to be involved.

COMMITMENT OF THE EUROPEAN PLAYERS

To achieve this total involvement, which is the condition for further progress, public authorities, professional and consulting organisations have decided to sign a European Quality Charter that commits them to act.

THE SIGNATORIES UNDERTAKE TO:

- Promote a general quality approach in businesses and the public sector.
- Develop the teaching of quality at all levels of education, from elementary to higher education.
- Develop current thinking on quality methods and tools and make it more accessible to everyone.
- Actively participate in the dissemination of quality experiences.
- Promote the quality image of Europe abroad.
- Endeavour throughout the year to achieve new quality progress.
- Be involved in the European Quality Week (in November each year), in order to report on the activities held, current initiatives and future projects.

One of the most important undertakes of this Charter is: *To develop the teaching of quality at all levels of education, from elementary to higher education.*

The Department of Quality Management TU Ostrava in the Czech Republic is partly engaged in solving this activity. Let me present one of the results that our team has obtained while working on this special project aimed at the feasibility study concerning quality assurance at universities.

A present trend in educational organisations aims at to quality management system implementation similarly as in industrial sphere before. This type of educational institution, however, asks for a special model of quality management system. We are sure that Czech universities are in a bad need of such kind of management model too. Therefore, our team has tried to solve this problem. To build this model we were inspired by a well-known Total Quality Management philosophy and principles especially by the so called The European Model for TQM worked out by the European Foundation for Quality Management (EFQM) at the beginning of the 1999s.

This EFQM Model is determined namely to the industrial sphere and it was necessary to transform it into the model suitable for education. *(Fig. 1.)*

This proposed basic model of quality management at universities has the following key modules:

M1 – University leadership
M2 – People management
M3 – Data management
M4 – Process management
M5 – Student's satisfaction
M6 – Stakeholder's satisfaction
M7 – University results

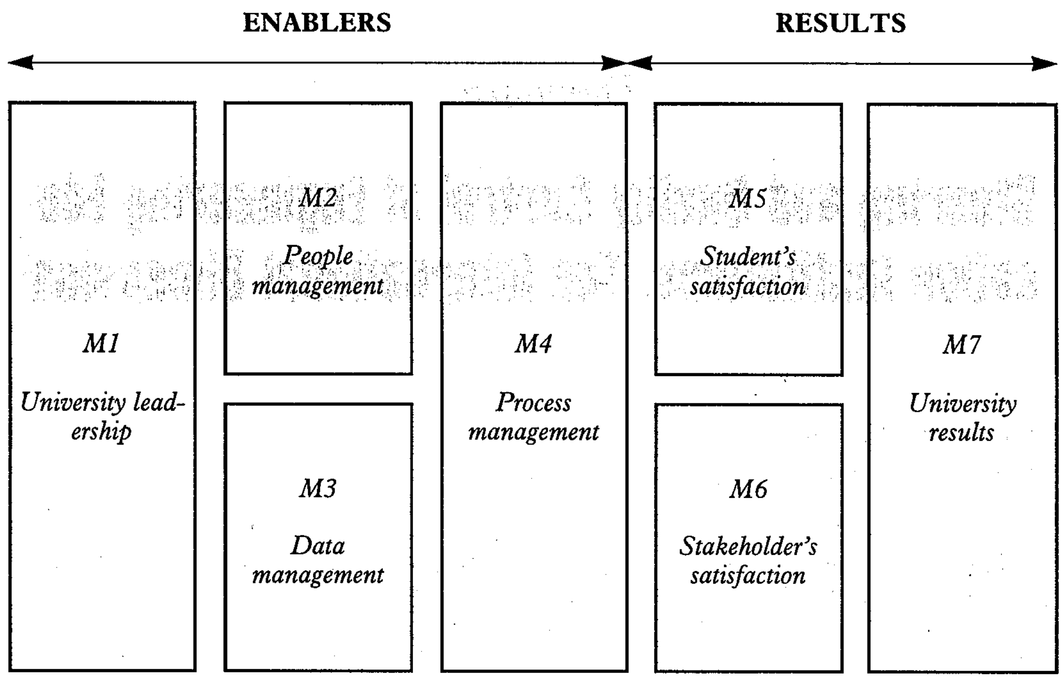


Fig. 1. The basic model of university quality management approach

We see the modules from *M1* to *M4* as enablers, the modules from *M5* to *M7* are results similarly as in TQM Model.

M1 – aimes at university top administrators' leadership and involvement in creating and sustaining a student focus, clear targets, expectations and a management style that promotes performance excellence.

M2 – People management category aims at the university staff development, the building and maintaining climate conductive to performance excellence, etc. This factor is, in my opinion, one of the most important items in QS building.

M3 – Module 3 asks for the management and efficiency of use data and information to support overall university performance including education.

M4 – The area of process management at universities cover educational and business activities, for example learning-focused education and courses, school services, business operations, etc.

M5 – This module is focused on student's satisfaction because they are the most important customers.

M6 – University must co-operate and communicate with all relevant stakeholders (companies, state and regional authorities, parents, etc.). The level of stakeholder's satisfaction shall be monitored of course.

M7 – Module 7 covers student's performance and improvement, performance of university business processes and benchmarking with other school (including abroad).

We suppose that this model described above could be a powerful tool for all university administrators. I hope that you will agree with me that these people must be, first of all, very good managers.

Denmark

Steering and Quality Control at Engineering Education Institutions. The International Dimension[1]

Prof. Hans Peter Jensen,
Rector of the Technical University of Denmark (DTU)

SUMMARY: The Paper addresses the question of International Quality Control in Relation to Engineering Education. The paper suggests that in times of Globalization of Education and Increased Mobility of the Graduates institutions must be prepared to participate in International Evaluations of their Educational Programmes. The author suggests that institutions on a voluntary basis participate in evaluations in the form of Benchmarking which can be an answer to the demands of comparability of engineering institutions.

INTERNATIONAL PROSPECTS

It is part of a natural progression for the institutions in Denmark offering engineering degree programmes to increase their collaboration with universities and engineering colleges' abroad in the future. Although the national evaluation systems are greatly beneficial, an assessment of the educational value of these degree programmes may be problematic due to the small number of institutions. Until recently, only two Danish universities (Aalborg University and the Technical University of Denmark) offered a master's degree programme in engineering. Although the evaluation system is interdepartmental and includes both engineering programmes (undergraduate and master's), I remain convinced that there is a need for collaboration across national borders.

However, the number of institutions should not be the most important reason for setting up an international evaluation system. In the light of the increased mobility of highly educated workers on a global level, educational institutions in most parts of the world will have to prepare for a future in which they will to an increasing degree be compared not to their own country's institutions, but to institutions in other nations.

At the same time, we are experiencing a rising demand from students and the business community that degree programmes be internationalised; students also want a system where they can transfer academic credit for courses they have taken abroad back to their "home" institution. At a time when a number of Western European countries especially are experiencing a decline in student applications for admission to educational programmes in the natural sciences and technology, internationalisation is also one way the door can be opened to students from

1 *The paper is partly a rewrite of the concluding remarks in an article submitted to the International Journal of Engineering Education*

abroad. However, this is possible only if the quality of the engineering education provided to international students can be ensured.

In order to tackle these challenges, universities and other institutions of higher learning will have to work towards methods of evaluating educational programmes across national borders so that they can continue to improve the quality of the engineering degree programmes they offer.

In addition to the quality management aspect, international evaluation will also present an opportunity for co-operation in other areas of engineering education. The resulting familiarity with the curricula and studies structure of institutions in other countries will make it easy to approve student wishes to receive academic credit for study abroad, and it will certainly promote mobility among students. Universities will be able to provide better guidance to students wishing to study abroad so that what students end up choosing also fulfils their expectations. Students can then also expect to complete their studies without unfortunate delays due to non-transferability of academic credit from universities abroad.

An increased mobility of master's-programme students will presumably also have an effect on the mobility of doctoral students. Doctoral students will have formed research and social networks with their fellow students and researchers at the university where they earned their master's degree, and will thus have a better chance of success during their stay at a university in another country.

Such efforts will be a natural extension of the international collaborations traditional in research and development in the engineering sciences. As the fields of engineering research become more complex, we have seen a development towards an increasingly international orientation in research collaborations. This trend should also be reflected in the educational collaboration among universities. This does not mean that universities or engineering colleges should be identical or offer the same educational programmes, nor should universities offer the same selection of fields of study. Universities must endeavour to work together, each within its areas of specialisation, towards a goal of providing the highest level of education – also internationally – for engineering students, whatever their field of study.

As regards international co-operation, it is not realistic to expect that all institutions offering engineering education within a specific field should be evaluated together. One realistic solution is for universities, through recognised international collaborative organisations, to establish general guidelines for how a university can voluntarily implement benchmarking in collaboration with selected comparable sister institutions abroad.

BENCHMARKING

The nature of universities as educational institutions makes it necessary for such comparison to be more than a simple copy of the quantitative methods of measurement used in benchmarking in the business world. When a university performs poorly, the consequences are not necessarily that it is outcompeted or forced to move the production to another country - contrary to what can happen with private-sector companies, for which benchmarking was originally designed. Bad performance means first and foremost that the university produces low-quality engineers and inferior scientific research. As a result, the main focus in benchmarking at universities must be on development and improvement. Benchmarking is a specific challenge for universities for the following reasons:

- Their core services (research and education) produce unique results with a very long delivery time.
- Many universities may have almost a national monopoly on the education they provide, and they educate primarily for their "domestic market". This means that they cannot use measurements of customer

satisfaction, salaries earned by graduates, unemployment, etc. for purposes of comparison.

- Competition does exist on the research side, but possible central measuring criteria may to a certain extent lie outside the control of a university. DTU's ability to recruit researchers, for example, depends very much on Danish tax policy and how attractive Copenhagen is as a place to live: neither of these things presumably say very much about DTU as an educational institution.
- Universities are driven by supply. They supply the services for which they receive money or from which they can earn money by supplying. When DTU spends a certain amount of money on education, it is primarily as a result of the state funding that follows each student admitted.

It must be emphasised that universities should not implement benchmarking within the borders of a single country. Firstly, universities in smaller countries often have close to a monopoly in one or more field and thus a unique obligation: this makes it difficult to compare the institutions on a national level only. Secondly, benchmarking implies comparing oneself with one's best competitors, and a university should never be satisfied simply to be the best in the country.

For universities, three types of benchmarking seem at first glance to be the most relevant, either separately or in combination with one or more of the others:

1. Key figures. Figures and other quantitative indicators of central importance can be carefully selected and an attempt is made to compare them.

Advantages: This lives up to the widespread perception that comparing something statistical automatically gives it some kind of objectivity. However, it would be relatively interesting to compare a number of statistics: faculty/staff and staff/student ratios, number of square metres per student or staff member, non-governmental research funding, publications and others.

Disadvantages: Relevant statistics are difficult to find: the important things simply cannot be measured. Differences in starting points, etc. would make comparison very difficult, and it would be possible to come up with an explanation for any result obtained. The numbers would put the focus on less important factors.

2. Peer reviews. A peer review system could be used. Let researchers and professors from recognised universities evaluate the quality, content and organisation of, for example, research groups or educational programmes.

Advantages: If good evaluators are selected, universities will benefit from relevant contributions to their improvement and, not least, inspiration to do things better (which is certainly the main idea behind benchmarking). The technical approach – experts looking through the lens of their area of expertise – will give their results a great deal of credibility. Evaluations will generally be constructive.

Disadvantages: This method is costly and slow. The technical approach requires a relatively precise and detailed look at individual subject areas or educational programmes, which means that it would hardly be possible to evaluate an entire university at once. Results are difficult to evaluate and compare with others.

3. Quality and management systems. Evaluation focuses on ensuring quality and management. In other words, for example, quality and management systems are described and compared, but the primary focus is not on the results of this process. The idea is thus to ensure that teaching is evaluated and to look at how it is done, but not to consider the results produced by the evaluation process.

Advantages: The focus on management and quality is oriented towards change and more than simply a description of the status quo. These areas can presumably better be compared and evaluated than the purely technical side. The focus is on the process and directly on changes and quality improvement.

Disadvantages: Perhaps this does not quite live up to the expectations of the world outside, which expects an explanation of how well universities perform these tasks. The danger may lie in a tendency for this focus to move away from the research groups and thus perhaps also away from the core services of universities.

International evaluation under such a framework might promote the collaboration already existing between many universities without strangling it in a formal structure. This would help promote internationalisation in our particular area of education, which is necessary if engineering education is to continue to produce graduates with both technical and human qualifications corresponding to the needs of society and technological advancement.

CONCLUSION

Seen from my point of view, there is no doubt that an evaluation of education and educational programmes performed in a methodical and politically sensible manner can help contribute to an improvement of the quality of engineering education.

From an international point of view, there is no doubt that there should be international co-operation in the field of quality management of engineering education; not only in countries with a small number of educational institutions, but for engineering education in general all over the world. We should not attempt to construct a single, huge and complex system for inter-institutional evaluation and comparison for the purpose of accrediting educational programmes across national borders. Such a system would not only be extremely costly – a factor which is prohibitive in itself – but it would also build up so much inertia that instead of promoting change and improvement, it would bring progress to a halt.

Quality management on an international level should be based on goal-oriented and voluntary collaboration between institutions working together to shed light on development activities and teaching standards. This kind of collaboration should be promoted with a view to the opportunities for development and the exchange of ideas and competencies and in order to help students prepare for the challenge of rising competition for jobs, whether they wish to work at educational institutions as researchers and teachers or in the corporate sector as practising engineers.

The most important point in connection with the evaluation and quality management of engineering education is that their chief purpose must never be lost from view: development in the direction of better and modern educational programmes which ensure that educational institutions can continue to recruit students and provide them with a high standard of engineering education.

If educational institutions and authorities simply use evaluation as a guideline for the allocation of resources or rights, the result may be that these institutions begin planning on the basis of what is more profitable in the short term rather than on the basis of what is best for the engineering profession from a professional standards and educational point of view.

Hungary

Materials Science Education Network: a Tool for Promoting Mobility of Students in Europe

Dr. Pál Tardy,
Vice President, MTESZ, Hungary

SUMMARY: Using Phare grant a database containing description and parameters of European universities educating materials science has been built up. The objective of the database was to provide information on education and research programmes of universities throughout Europe and so to promote the mobility of students and young scientists. The database contains information on curricula, available degrees, infrastructure, staff, laboratories, admission requirements, etc. of about 400 educational institutions. The database was made by 5 scientific societies from Western and Central Europe.

KEYWORDS: Materials Sience — Universities — Study Programmes — PhD Programmes — Education Network — Mobility of Students

INTRODUCTION

Materials science is a truly interdisciplinary subject, incorporating and interacting with most engineering and science disciplines. Traditionally, education in materials science has therefore been organised within the frame of the classical engineering and science disciplines. However, over the past 20 years, independent materials science departments have gradually grown in the universities of most European countries, inducing a variety of different characteristic national "features" in both education and research. Today, as a result, there is a broad spectrum of subjects offered by universities and institutions.

This wide choice of opportunities is very often confusing for students and young researchers. On European scale, they find an even greater variety of disciplines, curricula, degrees, etc. The way in which young researchers perceive personal involvement in any international cooperation depends on information formed at an early stage of their educational development. Therefore "mobility" should be encouraged before graduation. The first prerequisite for mobility is information on possibilities. Information on relevant opportunities must then include details of curricula and on their compatibility with the student's personal professional development and financial considerations.

To solve these problems five members of the Federation of European Materials Societies (FEMS) formed a Working Group and exploiting the possibility provided by an EU grant in the Human Capital and Mobility Program have built up a database, called *Eu-*

ropean Materials Science Education Network (MatNet). The Network is available on Internet since 1997 and - as it will be demonstrated - is widely used by students and young researchers since then.

GENERAL DESCRIPTION OF THE NETWORK

In the EU project for building up MatNet the following materials-related societies were involved:

The Deutsche Gesellschaft für Materialkunde (DGM) as coordinator, the Institute of Materials (IOM), the Société Francaise de Métallurgie et de Matériaux (SF2M), the Országos Magyar Bányászati és Kohászati Egyesület (OMBKE) and the Czech Society for New Materials and Technology (CSNMT). Each society was responsible for collecting data from several countries in each of which a National Representative was appointed. The overall aim of the project was to provide information that promotes mobility i.e. the exchange of people and information between academic centres. This has been done by:

- Creating this database of detailed information about Materials Science education across Europe.
- Presenting a so-called "Communication Board" MatNet contains a further mean of building up Europe-wide contacts. The Board is for current news, discussion of materials related issues, and for contact and exchange views, addresses and to collect further information.

The data for the database were collected by questionnaires sent to relevant university faculties, institutes and departments in 25 countries, to about 650 academic units altogether out of which over 400 units responded. The database gives details about:

- Curricula
- Examinations and degrees
- Admission requirements
- Statistical information
- Structure of the organization
- Research projects
- Cultural aspects and costs
- Contact addresses

Putting the database on Internet provides academic staff with the possibility of continuous modification of data which means that the latest information is always available.

PERFORMANCE OF MATNET

Performance of MatNet is demonstrated by the information available on MatNet on the *Technical University Kosice* (Slovakia). All education institutions (universities, colleges) were required to submit information as demonstrated below.

– *Name of the institution:*
Technical University Kosice,
Letna 9, 042 00 Kosice, Slovakia

Number of faculties: 7
Number of students: 7029
...of which foreigners: 86

– *Materials Science related units: 3*

a) Dep. Metallurgy and Engineering Technology:
Staff: 26 teachers, 2 researchers, 8 technicians, 4 administrative
No. of students involved: 580 (52 graduating, 5 PhD)

b) Dep. Materials Science
Staff: 22 teachers, 3 researchers, 12 technicians, 3 administrative
No. of students involved: 920 (58 graduating, 6 PhD)

c) Dep. Metal Forming
Staff: 7 teachers, 3 technicians, 1 administrative
No. of students involved: 38 (10 graduating, 1 PhD)

– *Organisation of study programmes:*
Study program is not subdivided in the first three years. After the third year a state examination is required and then students can specialise in nine different fields.

– *Graduation assessment:*
30 credits per each semester

– *Documents necessary to start study:*
- valid secondary school final examination
- filled in application form
- health certificate

– *Fee for foreign students:*
- bachelor and master studies: 5000 US $ per year
- living costs: 400 US $/month, including food and student hostel

– *Postgraduate courses:*
available for nationals and foreigners

– *Expected length of postgraduate study (PhD):* 4 years

– *Postgraduate final examination:*
State examination and public discussion of the thesis

– *Prerequisite for foreigners:*
university diploma (MSc)

– *Research projects (Dep. Metal Forming):*
- Mathematical description of structural development and properties of materials in forming processes 4 researchers, 3 others
- The formability of isotropic electrotechnical sheets 3 researchers, 1 PhD, 2 others

– *Equipment at Metal Forming Department:*
Workshop, laboratory scale equipment for rolling, forging, drawing, pressing and heat treatment.

– *Important features of the town and the University:*
TU Kosice was established in 1952. The Faculty of Metallurgy, also established in 1952 is continuing the tradition of the Mining Academy Banska Stavnica (then Selmecbanya), founded in 1752. Kosice, with its more than 250.000 inhabitants is the historical, political, industrial and cultural centre of the Eastern part of Slovakia. Kosice is an ancient university town. The first university was established here in 1657. Today there are four universities in the town. Students of the universities are accommodated in several student's hostels.

– *Special information*
Ratios of Material Science, Engineering and Natural Sciences in the study programmes can be also collected. Using these information the fields covered by individual countries or by regions can be demonstrated.

PRACTICAL EXPERIENCES WITH MATNET

According to the statistics the number of contacts since October 1997 was more than 70 thousand. The monthly distribution of contacts is in accordance with the schedule of the school-years: the highest number of contacts were made in February, March, September and October. In July and August the use of MatNet was lowest.

Regarding the practical use of MatNet one must admit that only part of its potentials is exploited today. The main problem is that the system does not permit to perform certain direct searches (like identifying universities in Europe with given research programmes of equipment, etc.). In our opinion, with relatively low costs MatNet could be improved and developed to the level meeting the standards of today's interactive information systems. A real up-to-date MatNet system might be a very effective tool in establishing a "single market" in materials sciences' education .

To get more information please contact:
http://www.matnet.mcs.de

Austria

European Engineering Educator – an International Standard for the Training of Those Who Educate Engineers

Univ.-Prof Dipl.-Ing.DDr. A. Melezinek,
University of Klagenfizrt, Austria

SUMMARY: The paper deals with the problem of "educational quality"; describing the qualifications profile European Engineering Educator – Europäischer Ingenieurpädagoge INGPAED IGIP" in the process. The necessary qualifications for inclusion in the regarding professional register are on the one hand a high technical competence in accordance with FEANI's "EUR-ING" and, on the other hand, a high engineering educational (ingenieur-padagogical) competence. This paper will briefly define the scientific background as well as the basic model for the above mentioned qualification profile and requirements for inclusion on the register.

QUALITY IN ENGINEERING EDUCATION

Over the last few years a series of norms has been developed which a quality control must fulfil. The international ISO-9000 series being particularly well known. Recognised in some 60 countries, it stands for quality control standards in business and defines a yardstick for quality control.

More and more companies require an ISO Certificate from their suppliers as proof of their quality and as a prerequisite for possibly being awarded a contract or taking part in public projects and calls for tenders. Not only manufactures are effected but an increasing number of services as well. Even training programmes can be awarded quality certificates. UNISYS Customer Training, for example has compiled with ISO-9001 for almost five years now. The world-famous company MICROSOFT proposes three levels of certified professionals, including the "Microsoft Certified Trainer". This proof of competence is intended for instructors at Authorized Technical Education Centers and Authorized Training Centers.

This article should not analyse the complex problems of quality in education. Instead I will concentrate on what I believe is *the most important factor* belonging to this problem - on *the teachers,* and particularly on *technology teachers.* The quality of teaching depends greatly on the qualifications of technology teachers. *Qualifications systems and certificates* for technology teachers vary quite considerably and *transparency* is not one of their strong points. Scientifically sound criteria on a solid theoretical and practical basis which could provide a guarantee of quality are often non existent.

THE PROFESSIONAL REGISTER "EUROPEAN ENGINEERING EDUCATOR"

The International Society for Engineering Education - IGIP - was founded in 1972 in Klagenfurt/Austria. Since then this society has developed into an important and well-known international association. Today IGIP has members in 72 countries and is recognized as a consultative body by UNESCO and UNIDO.

One of the most urgent problems which IGIP faces in its work is the issue of technical teacher training. In this light, delegates at IGIP's 1988 international symposium in Basel/Switzerland formulated a recommendation with the following preamble:

Nobel prizes and research results create the prestige of educational institutions of technology. The quality of the education, however, is determined by the teacher's daily instruction. This statement is still true. IGIP therefore set up the register "European Engineering Educator Europäischer Ingenieurpadagoge - ING-PAED IGIP". This register is based on a minimum qualification profile for teachers and trainers in engineering education.

The Purpose of the Register:
In times of increasing European integration, it is more useful and necessary than ever before to formulate a common minimum standard or well-balanced competence profile for technical teachers.

The International Society for Engineering Education's register "Europäischer Ingenieurpadagoge - European Engineering Educator ING-PAED IGIP" meets these requirements:

- The register guarantees that competence profiles will be defined, monitored and reviewed, thus encouraging a solid theoretical and practical basis for qualifications within an international framework.
- Furthermore, it guarantees a high level of competence for engineering educators and should also facilitate working abroad.
- The register provides detailed information on the education, training and professional experience of those listed for the benefit of potential employers.
- Both the register and the title "ING-PAED IGIP" will generally improve the position, role and responsibility of engineering educators in society.

The Qualifications Profile for the Register:
The qualifications profile is based on three fundamental premises:

- A solid foundation in engineering disciplines is an essential requirement. It follows that inclusion on the register calls for engineering qualifications and professional experience at an advanced level.
- A good knowledge of the pedagogy of engineering education is just as important and an appropriate training course should be equivalent to one semester at university (a minimum of 200 hours). In terms of content, it should be based on the "ingenieurpadagogical" model and curriculum and can only be taken at institutions approved by IGIP.
- A further requirement for inclusion on the register is a minimum of one year practical work in the field of engineering education (e.g. technology lecturer, in-service trainer etc.).

Thus, the formula for the title "ING-PAED IGIP" reads:

Engineering qualification + Engineering pedagogical training + Practical work in engineering education

The Engineering Qualification:
The technical qualifications required for inclusion on the register should preferably comply with the requirements laid down by FEANI, the Federation Europeenne d'Associations Nationales d'Ingenieurs, for their "Europa Ingenieur - EUR-1NG" title. More

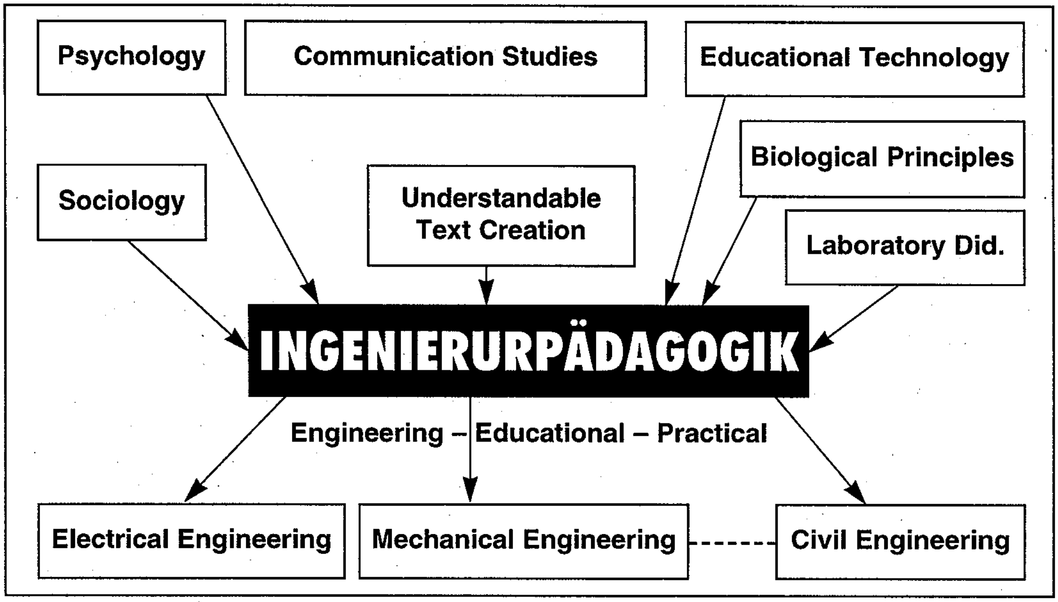


Fig.1

information on this qualifications profile can be found in [1], for example.

The actual engineering pedagogical qualification:

The model in *Fig. 1* depicts university-level training for teachers of theoretical technical subjects and lies at the heart of the "ING-PAED IGIP" curriculum [6, 7, 8, 10]. The principles of "Ingenieurpadagogik" and "Engineering Education Practicals" form the integrative core of the model and draw together the threads of the other subjects on the timetable. The *Table 1* summarizes the ingenieurpädagogical curriculum.

Practical work in engineering education:

One of the requirements for inclusion on the register is a minimum of one year practical work in the field of engineering education. Recognized activities include teaching at almost all kinds of technical education institutions, such as technical schools and colleges, technical universities, inservice teach-

Table 1

Ingenieurpädagogik	(min. 36 sessions)
Engineering Education Practical	(min. 36 sessions)
Educational Technology	(min. 12 sessions)
Laboratory Didactics	(min. 12 sessions)
Understandable Text Creation	(min. 16 sessions)
Rhetoric	(min. 12 sessions)
Communication and Discussion Training	(min. 32 sessions)
Selected Principles of Psychology	(min. 16 sessions)
Selected Principles of Sociology	(min. 8 sessions)
Principles of Biological Development	(min. 8 sessions)
Other Subjects (e.g. school law, school management...)	(min. 16 sessions)
TOTAL	min. 204 sessions

ing for initial and further training in companies, etc.

Organizational structure of the ING-PAED IGIP Register:

To carry out the tasks associated with the register, IGIP's executive committee set up an international committee of experts - the European Monitoring Committee EMC - as well as groups of experts on a national basis - National Monitoring Committees NMCs. This structure is illustrated in *Fig. 2.*

IG1P's EMC consists of leading experts working in specialist technical educational systems from regions and countries all over Europe. Both EMC members and its chairperson are nominated by IGIP's executive committee.

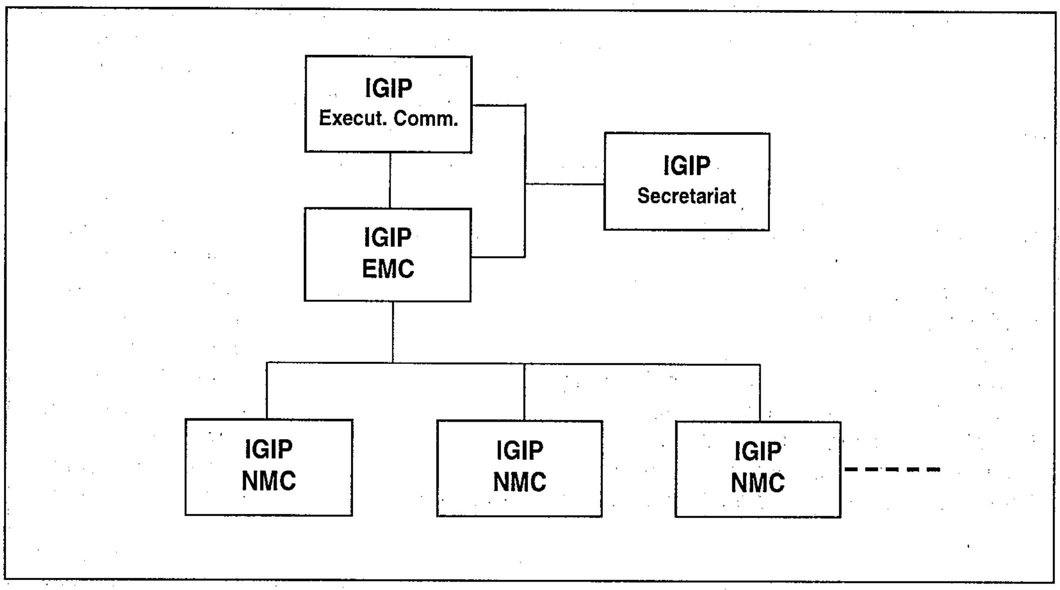
IGIP's NMCs, on the other hand, are national groupings, made up of leading representatives from the educational system in their own particular countries. The NMC chairperson and national contact points are proposed by IGIP's executive committee after consultation with the EMC. The members of NMCs are proposed by the chairperson of an NMC, endorsed by the EMC and confirmed by IGIP's executive committee. At present, there are active NMCs in seventeen countries.

CONCLUSION

The quality of teaching crucially depends on the quality of technical teachers. IGIP's "Europäischer Ingenieurpadagoge - European Engineering Educator ING-PAED IGIP" qualifications profile fulfils the requirements for a common minimum standard which the IRDAC (Industrial Research and Development Advisory Committee of the Commission of the European Communities) has defined as a pan-European challenge.

IGIP's "Europäischer Ingenieurpadagoge - European Engineering Educator ING-PAED IGIP" register has been received with great interest. At the major "Second European Conference on the Assessment and Accreditation of Engineering Training and Qualifications" in December 1994 in Paris, the register was basicially recognized as a basic qualifications profile for lecturers in technical subjects. On the suggestion of UNESCO Paris, the register was presented at the "6th World Conference of Continuing Engineering Education" in May 1995 in Sao Paulo and Rio

Fig. 2



de Janeiro and met with an enthusiastic response. Suitably qualified applicants are being continuously added to the register in Europe.

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France

Structural Reforms in French Engineering Education to Foster Internationalization

Dr. Claude Maury,
CEFI, France

SUMMARY: The French engineering educational system is organized according to specific rules, which do not make easy the enrolment of foreign students, especially if they come from outside Europe. Numerous initiatives have however been taken in the last years to foster the international dimension of French Grandes Ecoles, but a majority is aimed at French students'mobility. A national debate has been opened recently to modify the higher studies scheme, with the introduction of undergraduate and postgraduate studies. The hope is to reach a harmonization in Europe and to encourage overseas students to choose France for further studies. Nothing concrete has been decided up to now, and the final result still remains rather uncertain.

THE FRENCH ENGINEERING EDUCATION SYSTEM FACING INTERNATIONALIZATION

Although the French system of engineering is organized as in most European countries to grant a full title of engineer, a more in-depth analysis reveals specific features and rules, which are on one hand the source of its flavour and prestige (a French engineering degree guarantees a good career and a high social status), but on another hand restraint its internationalization, making the integration of foreign students quite uneasy:

a) Engineering education is mainly organized in Grandes Ecoles, and is not compatible with the University studies (although bridges exist)
b) French students must pass through strict selection procedures (intensive preparatory classes, competitive examinations) where maths are the core subject.
d) Each student has to strictly respect a five-year scheme to get his degree (without flexibility given by credits, poor possibilities to repeat a year or to study part time)
e) Educational standards are under a formal control of a national habilitation body: the CTI

Basically, the French system of engineering education is very demanding and consequently lacks flexibility, which is essential for international exchanges. However, there has been a strong movement for the last 10-15 years towards internationalization in French engineering schools, based on initiative taken by directors, who benefit of an actual freedom, probably more than their European counterparts.

A STRONG IMPULSE GIVEN BY EUROPEAN EXCHANGE PROGRAMMES

1. A stream of innovation in French engineering programmes

European programmes like ERASMUS and COMETT have played a very important role in the internationalization process of many engineering schools. They have provoked a wide range of reflections, discussions and initiatives to adjust engineering programs, in order to promote international exchanges and mobility. These initiatives have been taken at the level of the engineering schools or of groups of schools; the changes or adjustments which were introduced were controlled and regulated by them, in order to preserve the consistency of their educational aims and the quality of the engineering degree. The CTI also enacted guidelines and rules to orient the internationalization of engineering programmes according to quality criteria.

Series of concrete changes and innovations may be given :

a) The recognition of study periods abroad (3 months to one year, sometimes longer) validated in the curriculum to obtain the French engineering degree; these study periods have to be spent inside a circle of foreign institutions with which there is a partnership agreement.

b) The creation of double engineering degree programmes.

These double degree schemes, enabling French and foreign students to get two engineering degrees (French + foreign engineering institution), have become very popular in French engineering schools. It is a privileged way to internationalize a curriculum, by mixing it with the course of a foreign institution. There are different double degree schemes, some of them require an additional time of study (6 months to 1 year), and some others are built as fully integrated curricula (e.g. EPF with FH Munich, ENSAM with TU Karlsruhe). According to the CTI rule, a minimum of 18-month study has to be spent in the French school to get the French engineering degree. In the last years, the number of double degree agreements has considerably increased. CEFI surveys show that between 1995 and 1997 their number has nearly tripled (see *Table 1*).

Since 1997 new agreements of this type have been concluded, not only with European institutions, but also with some North-American institutions

c) Implementation of the ECTS system

The ECTS system was not easy to implement in French engineering schools, because their study programmes were not organized in credits (except in the Universities of Technology like Compiegne). However, an important effort was made in many schools to adapt their study programmes to this system, and the number of engineering institutions adhering to ECTS has been regularly increasing (from 22 to 65 between 1995 and 1997, about 50% of the schools by today).

Table 1

	CEFI survey 1995	CEFI survey 1997
Number of French engineering schools offering a double degree programme to French and foreign students	**25**	**48**
Number of double degree agreements set between French and foreign institutions	**90**	**230**
Number of French engineering schools participating to the ECTS system	**22**	**65**

d) Compulsory industrial periods abroad

One of the main features of French engineering education is the connection of engineering studies to industrial experience. Engineering curricula include around 7 month's internship in industry. For the last years, the trend is to give students the opportunity to carry out these internships abroad. In many schools growing flows of students are encouraged to take this opportunity (50% and more do so in some schools), because it is considered as a very good preparation to work later in an international environment. In some schools, it has been decided to make these industrial periods abroad compulsory: about 30 schools are in this case

e) European programmes and Schools

There are a few initiatives of this sort: one may quote:

- The INSA First European Cycle called *EURINSA,* welcomes yearly about 100 students from 30 European countries. It is a very special programme, adapted to students whose secondary studies preparation differs from the French one; the programme is European-oriented with the teaching of 3 European languages as well as courses on European economy and culture. It leads to the INSA de Lyon engineering degree.
- The *EEIGM* in Nancy (European Engineering School in Material Engineering): the engineering programme is organized in partnership with Saarbrücken University in Germany, Universidad Politecnica de Barcelona in Spain and Lulea University in Sweden.

f) More flexibility in the CTI rules

For the last years, the CTI has also adapted some of its rules to favour international exchanges and the integration of foreign students. A minimum of 2 years of studies in the engineering school was usually required to obtain the French engineering degree; now the duration has been reduced to 18 months (this step is particularly important for the implementation of double degree programmes).

2. The results

The before mentioned initiatives and the adaptation efforts of French engineering schools have produced positive results in the field of internationalization, but there are still weaknesses in the system.

a) Striking positive results for French students:

- A lot of work has been done to have a more flexible and open system; through the impulse of European programmes, French engineering institutions are now better prepared to the challenges of internationalization
- The mobility of French engineering students has increased: in the Erasmus programme, French engineering and technology students are the third group of mobile students, after management and language studies
- Some European experiences have been extended to other parts of the world: on the same lines as EURINSA, INSA de Lyon has created ASINSA to welcome students from Asia.

b) A clear unbalance

- There is still a clear unbalance between the flows of French students going abroad and the flows of foreign students studying in French engineering institutions; an average of 15% of French engineering students follow a part of their studies abroad, whereas only around 6% of foreign students are integrated in French initial engineering education (the proportion is much higher in postgraduate studies, around 30 % foreign students in specialized and doctoral programmes).
- Very few engineering courses in English are proposed to foreign students even at the postgraduate level.

THE NEW CHALLENGE: TO INTEGRATE A GREATER NUMBER OF STUDENTS FROM ALL OVER THE WORLD

1. Distribution of foreign students in French engineering institutions

The results of a survey made by CEFI in 1998 for the Ministry of foreign affairs show the following distribution of foreign students in French engineering schools. The survey is based on the answers of 90 engineering schools in which 2900 foreign students were registered (see *Table 2*). The table shows clearly that about 3/4 of foreign students come from the European Union and Africa. The very low proportion of students coming from Asia or North America brings to light the difficulty of the French system of engineering education to integrate students coming from the anglo-saxon system of education, because of the differences in the structure and the profile of studies.

2. Special tailored programmes to integrate students from the anglo-saxon education system

Different schools and groups of schools have tried to build special programmes to be able to integrate overseas students.

a) ASINSA first cycle:
We already mentioned this programme created by INSA de Lyon, which follows the pattern of EURINSA

b) N+1 programme for British and Irish students at the Bachelor level

This programme has been created by the CDEFI (group of engineering schools depending on the Ministry of National Education). It is a one year tailor made programme for students at the Bachelor level including an industrial period. It may lead under certain conditions to further studies in the French institution to obtain the French engineering degree.

c) INP (Institut National Polytechnique) preparatory cycle for Asian students in the framework of the France-Asie Campus project.

In the framework of the France-Asie Campus project which aims at welcoming 5000 Asian students in France, the three National Polytechnic Institutes (Grenoble, Nancy, Toulouse) have proposed a tailor-made preparatory cycle, lasting 2,5 years instead of 2 years. This preparation period should enable the students to integrate an INP engineering school without going through the competitive examinations, and obtain the engineering degree.

THE INTRODUCTION OF A NEW STUDIES SCHEME

1. The proposal of an official commission

An official report on the French higher education, written by a commission chaired by Jacques Attali (May 1998), has, among

Table 2

Geographical Area	Distribution of foreign students in French engineering schools in initial education, %
European Union	50.4
Eastern and Central Europe	8.7
USA	2.7
Canada	2.1
South America	4.2
Africa	2.6
Near and Middle-East	2.2
Australia	0.1

other points, stressed the importance to make the French education system consistent with its international environment.

The basic postulate of the Attali report is that France should adapt the so-called international scheme, based on a three-level degree framework:

- A first degree granted after 3 years of higher education (undergraduate education)
- An advance second degree granted two years later
- The doctorate three years later

A big congress was organized at la Sorbonne in 1998 to gather the formal agreement of three other European countries (UK, Germany, Italy) on the following principles

- No changes in existing degrees
- Insertion of new titles - or landmarks - to facilitate the comprehension of foreign students

2. The questions raised by the perspective of the reform

Although the proposal may appear appealing at the first sight, it raises several questions, with unclear answers.

– Is there an international standard? The answer is not clear, if one thinks for example of the UK, where 4-year Meng curricula have been recently introduced as first degrees. The main difference appears indeed not to be in terms of duration of studies.

In many European countries there are two types of engineering studies

- Short (3 or 4 year) studies with a specific title
- Long (4 to 5 years) studies

– Is it possible to introduce new levels of studies into the French system without a deep perturbation? This is not a minor issue, with following hypothesis:

- One more year for our two-year programmes (IUT)
- One more year for our 4 year programmes (IUP)
- Shift of the DEA[1] towards doctoral studies, with unclear consequences

Next steps:

The official decision should be announced soon, to create a new "grade", called "Mastaire", which could be used as an added label to all 5-year degrees.

Engineering schools should be allowed to create new programmes opened to Bsc students, which could be called Master (making it possible to get the grade of Mastaire).

3. What conclusion?

Although the aim to harmonize European degrees appears as a motivating goal, the way to reach that objective could be much longer as thought. One important point in the actual debate is that the problem should be set less in terms of duration, than in terms of serial or parallel schemes.

One may understand the motivation to switch to the so-called US system, but the matter is cultural and the tempo is quite slow. European are surely quite attached to the formal title of engineer, and are not ready to translate it into a simple engineering degree. In the short term a good compromise could be - at least for engineering studies - to agree on a form of advanced studies, with a possible reduction of the first studies to 4 years.

Such a reform should be first accepted at the bottom, and only in a second step covered by a decision at the top.

1 DEA: Diplome d'Etudes Approfondies: first preparatory year for the doctorate.

Italy

The Italian Experience of the Industrial District: a Unique Way to Tackle Global Market Challenge

Dr. Gianfranco Cicognani,
Executive Secretariat of the Central European Initiative (CEI), Italy

SUMMARY: The Italian experience of the so-called "Industrial District" is presented with the help of a few relevant examples. The main requirements to be met aiming to reproduce this model in different industrial environments are discussed with a specific reference to the Countries of Central and Eastern Europe. Technological transfer\adaptation to the SMEs and the related professional education programs are indicated as two key points for a proper implementation of this organisative model.

1. The small and medium sized enterprises (SMEs) play a primary role in the European industrial system - specifically within the Italian one – in creating both wealth and employment. It is enough to say that more than 2\3 of the total employed manpower in the European Union can be referred to the SMEs, to fully understand their importance in most of the sectors producing goods and services.

In my presentation I refer to the SMEs dealing with the so-called "traditional sectors" (such as textile, ceramics and tiles, shoes, furniture and wood machinery, leather, agricultural machines, etc.), where the role of new technologies focused to improve processes and products appears increasingly more important. This not only because of the huge economical impact of those sectors, but also considering the unique performances obtained by the Italian SMEs facing the challenge of the national and international market with exceptional results. A full understanding of the reasons of this performance appears to be important for two reasons: on one hand, for promoting future activities along the most favourable path, and on the other, for giving an answer to the following question: how far could this model be exported outside the country thus offering a similar economical potential to other economical environments?

2. In order to properly describe the reference frame, we can start with considering one typical characteristic of the Italian frame. The SMEs committed to the different productive sectors show a clear concentration at the territory level. The expression "Industrial Districts" represents well this model of development which takes full advantage of the specific industrial culture and tradition recognised on the local basis, and then step by step developed and implemented through a typical bottom-up process counting on a very specific work organisation focused on both co-operation and competition.

Generally speaking, the SMEs count on a number of basic advantages in comparison with larger industrial structures, such as high flexibility of the production cycle, capability of meeting the demand request in a short time, on-real time decision making approach, readiness in considering modernisation processes, strong attention to the more suitable associative forms. On the other hand, the SMEs could face major difficulties along a few development lines which for sure will present an increasing importance in the coming years. This mainly refers to:

- The capability to reach an acceptable level in the international environment which represents the key point for successful competition in a global and dynamic market, where the interdependencies related to the productive processes are more and more significant. In a few words, a continuous and well stabilised presence in the international markets represents a real necessity, not always properly fulfilled at the SME level.
- The extensive use of the new technologies helping to achieve both better processes and products. In most cases an SME itself cannot play a relevant role in the production innovation and it could face many difficulties even in trying to adapt the new technologies to its own necessities.

On those points a strong improvement can be offered by a more comprehensive and well focused organisation, which is the one responding to the necessity of an Industrial District in particular. We shall come back to those aspects.

3. All that being said, let us examine the conditions allowing the creation and growth of the Industrial Districts in Italy.

There are more than 200 Industrial Districts at present in the country. Immediately it appears evident that their distribution on the national territory is far from being uniform. A high density is visible in the North of the country, more in the North East than in the North West, where the big industries are prevalent. In Central Italy their presence refers mainly to Marche and Toscana, while a strong reduction is evident in South Italy . On our major islands (Sicily and Sardinia) no significant presence of Industrial District is shown.

Two first lessons can be drawn immediately from this evidence: a) this association form can be proposed and properly implemented where an industrial environment is already well settled, also because it can count on an efficient network of services and infrastructures; b) the presence of the big industries does not help the establishment of the Industrial Districts.

A deeper socio-economic analysis is however necessary, should the real situation require a better understanding. Let me shortly tackle this relevant aspect with the help of a practical example.

The reconstruction of the Italian economy, fully destroyed after the 2nd World War, started practically at the beginning of the 1950's to be completed in the next 20-25 years. At that time in the large agricultural areas of the Po Valley a fast decrease of the employed farmers occurred. The factors that caused it were the following: the first of them was a sharp increase in the number of agricultural machines determined by the implementation of the so-called "Piano Verde" (Green Plan) launched by the Government, for increasing the food-feed production. In the same period many big factories were closed in the region, because of their obsolete performances. Among them was "Officine Caproni", well known world-wide before the war because of its capability in construction of airplanes. As a result a huge amount of skilled people were kicked out of their jobs, thus increasing the offer of qualified manpower, especially in the mechanical field. This way proper conditions were created for starting an aggregation process of small entrepreneurs ready to take full advantage from the availability of qualified manpower, as well as from the benefits offered by the governmental and local institutions in terms of reduced taxes, low rate financing and finalised grants. A big help was also given by the "co-operative culture", traditionally developed in the region, which made easier the establishment of complementary agreements among the different SMEs, based on the law but also on a kind of a mutual trust. Step by step the Industrial Districts of Machines for Agriculture became more and more important: today they count about 600 Enterprises and they represent one of the most interesting industrial realities within the Emilia Romagna Region.

Through a similar process, a number of Industrial Districts was created in a few years. On the world market their label became a message of the Italian way of producing high-quality, certified products: textile in Prato, Carpi and Biella; silk based products in Como; ceramics (tiles in particular) in Sassuolo; wood machinery in Rimini and Pesaro; furniture in Udine, Pordenone and Pesaro; gold and jewellery in Vicenza; leather and shoes in Venezia, Macerata and Puglia Region; typical food products in Parma (Parmigiano cheese and ham), etc.

Everywhere the mechanism was the same: a "bottom-up" driven force; a great attention to the real opportunities; a network of inter-company relationships aiming at optimisation of the production cycles (with a specific care towards the "on-real time" interaction between producers and sub-producers); a special care towards the logistic and quality related aspects; the approach to the market based on the demand forecast rather than coping with the actual demand requirements; a continuous effort in the field of technological innovation.

4. It is important to underline how the Industrial Districts operate for achieving those results with the highest efficiency possible. A number of strictly finalised structures have been created for that. Let us examine two of them, namely the *Service Centres* and the *Technological Observers.*

The *Service Centres* aim to increase the SMEs competitiveness in terms of marketing, quality assurance and control, information exchange, professional education, technological development, exhibitions\simposia organisation, identification of the organisative models which better respond to specific needs, and technical assistance. Just to make an example within the already mentioned Industrial Districts of the Agricultural Machines, the CESMA Service Centre was created in Reggio Emilia, covering most of the above mentioned items.

Many other examples of Service Centers can be recalled here, such as CITER (Carpi) for the textile District and CATAS (Udine) for the wood furniture District.

The *Technological Observers* duty mainly refers to the promotional side: monitoring of the internal and international market, partners research, investment evaluation opportunities and risk factors analysis, etc.

The outcome has never represented a sort of limitation for the SMEs of the District, each of them being absolutely free to follow its policy. However, in most cases, those indications are strictly respected, being well evident that they were elaborated with the aim of achieving the best solution allowed by the general frame.

Again, just an example: the Technological Observer of Pesaro-Urbino, related to the wood machinery and furniture (mainly kitchen) Districts. This structure covers the need of some 500 firms and of about 700 connected handcraft units.

5. Within the Industrial District organisation many activities are performed with the aim of helping the proper development of the associated SMEs. One of them deserves to be underlined here because of its growing importance in a short-medium term perspective: the effort on the line of innovation and technological transfer, that represents a widely recognised tool of major importance to keep high the competitiveness level demanded by the global market challenge.

This is a very difficult task, to be tackled through a strict interaction between the research producers and the SMEs themselves, in the first line those organised in the Districts.

In this case the co-operation between the National Research Centres and the Service Centres may represent a shortcut in achieving the expected result, which is to meet the SMEs' request with the transfer and the adaptation of proper technology.

There is no use to go into details on this matter. Simply let me recall two points:

- the importance of the demonstrative projects, as a tool to convince the SMEs that their problems can be solved by a proper use of a new technology;
- the role of specific technological transfer Programs promoted by public and private Research Centres with the financial help provided by both national and international Institutions and the European Union itself.

On the second point we can recall here the European Network of the Innovation Relay Centres, aiming to improve the competitiveness of the European SMEs.

The network counts about 50 Relay Centres established on a regional basis. In Italy the IRENE Relay Centre covers the North Eastern Region of the country and it also represents an important structure, open to a strict co-operation with the PECO countries and with Hungary in particular.

6. In conclusion of this presentation, let us try to answer the question about the possibility of transferring the Italian model of Industrial Districts to other countries, more specifically to those of Central and Eastern Europe. Under a very general approach it must be recognised that this kind of industrial organisation was developed under very specific conditions which cannot be reproduced easily in other environments. Should it be the case, it is clear that the response cannot simply be a generic "yes". But on the other hand, also a generic "no" does not appear fully appropriate; it could be considered a kind of a "shortcut", surely neglecting a number of opportunities deserving a deeper analysis.

In summary, it is not possible to draw a general conclusion of this matter, being wiser to follow a kind of a "step by step" approach taking into a due account both opportunities and boundary conditions, for sure different case by case.

A few general trends, however, can be recalled here as a kind of necessity independently from the different conditions. Among them:

- the support of the political Institutions, more at regional/local level than at the national one. The aggregation process of the SMEs will be strongly helped by the assistance of the Administration structures, promoting the private firms along a selected number of priority lines.

This does not mean going back towards a development strategy decided by centralised political decision makers; on the contrary, to properly address the private SMEs - also through the financial and institutional support - along promising opportunities suggested by either the market or the national priorities.

- the importance of promoting as far as possible the professional education at different levels, thus assuring the productive sectors on the availability of a well qualified manpower.
- last but non least, to enhance the policy of the technology transfer to the SMEs, having well in mind the necessity to follow a demand-based mechanism. Offering a new technology to an SME generally does not help, unless that technology is not fully adapted to the real need of the final user.

On that line the "demonstration" of the proper use of the technology could be a useful, if not necessary step.

It goes without saying that the international co-operation can help the improvement of many industrial systems in Central and Eastern Europe. Among the others, the model of the Industrial Districts, developed so well in Italy, must be considered. Italy is ready to co-operate on that line, using all the possibilities offered by the different agreements established on bilateral, multilateral and regional basis, including the Programmes promoted by the EU.

We are fully convinced that the SMEs network will be a key factor in the economic development of the region and that its role will become more and more important in the near future. We are ready to share our experience on a real partnership basis, being fully convinced that this shall be of benefit to all the committed partners.

Hungary

Where should the New Silicon Valleys of Eastern Europe Emerge? National Innovation Regimes and Centres of Excellence on the Semiperiphery

Dr. Pál Tamás,
Institute of Sociology, Hungarian Academy of Sciences, Budapest, Hungary

EXTENDED ABSTRACT

1. Countries embarking on industrialization drives shared two assumptions: that a. protection was required, b. international trade would provide no support for the drive [WATERBURY, 1999, 331]. It would be tedious to review all the reputable economists who shared this view [Prebisch, Hirschman, Lewis, Amartya Sen, Gunnar Myrdal]. The notion that there is a fundamental contradiction between capitalist development in the centre and industrialisation and development in the periphery was first expounded by the "dependency theory" of the late 60s. According to that approach the capitalist development in the periphery is impossible, the incorporation of those territories into the world system set in motion a metropolis-satellite power structure, that permits the former to develop by expropriating economic surplus from the latter ["development of underdevelopment" in the periphery][AYRES-CLARK, 1988, 89]. From a different perspective -but also on the side of a general social critics- Bill WARREN [1973] presents evidence that between the 1950s and 1970s the growth of manufacturing was faster in the Third World that in the First World, and at the same time the share of manufacturing, in terms of GDP and employment increased in many developing countries and highly diversified consumer durable markets continuing to expand into the lower income groups. In fact the experience of the last 30 years indicates great diversity in the periphery and implies that from one side WARREN overstated the case, but from the other side the Dependency Theory's validation is also limited. It is necessary to go beyond the notion of external domination. National autonomy and external dependency not only [or nor proper at all] categories for the interpration of development or underdevelopment. We need to study the specific social fabric- the balance of power, the conflicts between the main players and the rate of accumulation - in concrete situations. Only integrating internal and external structures and mechanisms we shall to understand "the particular" form of development.

2. This set of questions concerns the pattern of international mobility in the modern world [JANOS, 1997, 134]. By this is meant a rate of growth that puts one society ahead of others [in that way the latecomer should find itself in the company of the better placed nations of the "core"]. Surveying economic history texts it seems to us, that mobility from the poor to the middling and from there to the rich has been relatively limited. In Angus Maddison's sample of 56 countries, 9 of the 12 richest in 1820 were still part of the 12 in 1992. Bairoch's sample of 24 European countries shows that 8 from the top 10 in 1830 were the same in 1913 and 1950, though with a turnover of 4 countries between 1950-1975. [cited by JANOS, 1997, 135]. Some new industrialising countries are naturally moving upward, but as of 1995, they had no entered the 25 of the top.

3. The rigidities of developmental resources in the context of globalization makes problemetization of the state and effective state sovereignty rather complicated and from our perspective the state theory in question must be able to handle the dynamic elements of the state action. We use parameters which JESSOP [1990, 345] identifies as six dimensions of the state. The first 3 are formal institutional dimensions which correspond to the "organizational form" of the state [a. forms of political representation, b.the distribution of powers within the state system, c. tools and means of intervention in civil society and the economy]. The focus of our presentation is around the strategic industrialization and therefore is on the 3 "behavioural or strategic" dimensions. These are the aspects most important for the discussion of effective souvereignty [d. the character of the historic power bloc and the social forces which support it, e. the way in which the state apparatus is defined and unified into a coherent frame and f. the manufacture of ideology- the discourse]. The approach demonstated here generates those fundamental dimension of the state which should be the basis of understanding of the globalization-national technology policy interplay:

a) the nature of the hegemonic bloc and its ability to articulate a hegemonic project,

b) the character of accumulation and the state's ability to offer a compromise between market playing and decommodification,

c) community discourse which contributes to configuration of rule-making authorities and identity-building [HASLAM, 1999, 49]. The last point couldn't be ignored as the "diffusion of authority" away from the national governments towards supranational and local authorities has been one of the fundamental changes in the international political economy [STRANGE, 1996, 72].

4. Due to rapid international diffusion of technologies, countries are becoming more similar in terms of availability of infrastructure, marketing frames and distribution networks. Some new firms in the newly industrialising economies emerge as full-fledged international competitors and the intensity of competition has also risen, setting higher standards for success [PORTER, 1986, 3]. Since the mid-80s, globalization of R+D concluded to programs including access to R+D personnel as well as exploit the cost differentials [PRASADA REDDY, 1997, 1821]. The NIEs becoming important targets of this new localisation policies.

TNCs, -expecting to derive competitive advantage from their distinctive domestic environment- historically, tended to confine R+D to their home countries. At the time, when the necessity arose TNCs performed some types of R+D abroad -developing new products for the local markets drawing on local technology, to provide local technical services or to develop products and processes for the regional markets, as well. In this period some regional clusters are also emerging. In the 80s the nature of demand and increasing science base of new technologies are leading to homogenization of major international markets [at the same time generating greater variety and fragmentation in other markets]. The result of this restructuring is transformation of the traditional headquarters-subsidiary relationship into a global intraorganizational network-based management structure.

The key driving force for globalization of R+D in the 1990s has been the increasing demand for skilled scienctists. The existence of international markets for research and education investments is leading the firms to direct their investments to those geographical areas which can best meet their research and manpower needs. In the first wawe of that locational competition TNCs recognize the talent available in such countries as Israel, India and Brazil, and later -after 1989-91- in Russia, Poland, Ukraine and Hungary as well.

Different generations of internalization are emerging [reformulating PRASADA REDDY, 1997, 1824-25]:

a) beginning of the internationalization [up to the 1960s],

b) growth of international corporate R+D [the 1970s],

c) trajectories from internationalization to globalization of R+D [the 1980s],

d) evolving patterns of globalization [in the 1990s].

Table 1 Foreign R+D locations and expansion strategies

	Driving forces	Type of R+D	Forms of R+D	Facilitating factors
a) Up to 1960s	Local markets abroad	Adaptation	Own R+D with manufacturing	Large markets, proximity to production facilities
b) 1970s	Market shares in local markets, governmantal policies	Product development for local markets	Acquisition in own R+D and production units	Protected major markets, proximity to customers and production facilities
c) 1980s	Worldwide learning + new technology inputs	Product + process development for global markets + basic research	Own R+D units, sponsor university research, subcontracting R+D	Information technologies, flexibility to delink R+D
d) 1990s	Access to scare R+D personnel and the cost problem	Basic research and complex development for global markets	Joint ventures, subcontracting own R+D affiliates	Dicisibility of R+D into core and non core functions

Source: modified after Reddy, 1997, 1826

5. Utilizing the PEREZ-SOETE [1988] concept on "life cycles of technology systems" and the PRASADA REDDY [1997] generations [in his formulation "vawes" the next frames of interpretations emerge:

R+D in the new technologies is divisible into subactivities, which can later be integrated to result in final innovation. This new moment is what enables joint R+D projects and technology alliances. This also means that R+D in new technologies can be divided into "core" and "non-core" activities. Multinational companies can save on costs by locating some of the non-core activities in low-cost countries and release the resources in home countries for concentration in core activities. In contrast to earlier attention paid to the firm size for R+D, critical mass can be conceived in our days in terms of the size of the "system", needed to acquire the knowledge, rather than the size of the firm itself [MYTELKA, 1993, 703]. Using the classical RONSTADT -type classification [1977] of

ALL PRODUCTS, %

	DE	Austria	Italy	NL	DK	France	EU15
Poland	21.1	1.0	4.1	22.2	33.2	5.9	18.8
Czech	15.2	5.9	3.8	4.6	1.1	3.0	10.2
Slovak.	10.4	7.5	13.5	22.1	2.4	2.9	3.3
Hung.	13.6	15.5	16.7	16.9	7.8	8.3	11.1
CEC4	29.6	3.2	2.9	2.8	1.9	1.1	43.4

ELECTRICAL MACHINERY, %

	DE	Austria	Italy	NL	DK	France	EU15
Poland	18.8			6.5			1.0
Czech	26.9	23.4		29.2			2.4
Slovak.	11.8	21.6					0.3
Hung.	14.4	21.0		25.8			2.2
CEC4	4.2	1.0		0.2		0.2	5.9

Table 2 Proportions of OPT re-imports after processing in total EU imports from the CEE4 [%], and absolute levels [ECU 100 million]. 1996

R+D activities carried out abroad [Technology Transfer Units, Indigenous Technology Units {products for local markets}, Global Technology Units {products and processes for global markets} and Corporate Technology Units {generate basic technology}] it's easy to differentiate the effects on the host countries. The ties are limited in the case of "simple" technology transfer [it involves only adaptation of the parent's technology to the local conditions]. The product development of the foreign firms may have stronger ties with the local R+D system [even they basically re-do the designs supplied by the parent]. The GTU and CTU type of activities and organisations have stronger ties both to the local innovation system and the global R+D networks. The less complex foreign research units mainly utilize the knowledge already available within the local innovation system. But this doesn't mean that their impact is hierarchical [that if they are more complex, their impact is automatically stronger]. The simpler cases are also important, if the conversion of reseach results into products occur at the same place, in the local technological environment. And if the more complex organisations are delinked from the operations of production and diffusion, their innovations are less likely to lead to production related benefits in the host country.

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Brazil

Consequences of Globalization on Engineering Education in Developing Countries

Prof. Leizer Lerner,
Brazilian Federation of Engineers Associations, Febrae, Brazil

SUMMARY: Considerations about actual trends into Globalization and Regionalization of nations and the main fields of its influence – economy and finances, education, culture, science and technology, communications . The creative Engineer as agent of nation's transformation. Science & Tecnology – a powerful tool. The tendencies to graduate creative or operational Engineers. Official and private organizations of Engineering Education. International mobility of Engineers and the necessity of evaluation and accreditation of courses and/or institutions of Engineering Education, and of professional habilitation.

KEYWORDS: Globalization — Regionalization — Developing Countries — Creative Engineering — Operational Engineering — Science&Technology — Work Market — Evaluation and Accreditation — Professional Habilitation

GENERAL CONSIDERATIONS

We live at the end of the second millenium – an era that indicates a strong tendency towards nations Globalization and Regionalization. This evident tendency to Globalization comprehends the removal of borders and barriers of all order in our planet. Globalization is preceded by a preliminary Regionalization. Regionalization is nowadays a reality in several parts of our Globe.

From the confrontation post-2nd World War (1939-1945) between the two big blocks of nations, leaded by the USA and the URSS, called the "cold war", most recent events in this last ten years marked the end of the 20th century we are living in: the sudden fall of Berlin's wall; the last soviet policies of "glasnost" and "perestroika"; the astonishing demolition of this regime and fragmentation of the immense territory coordinated by the Varsow Pact; the economic liberalization of continental China; the political and economical reunification of the two Germanies. These are some of the dramatic signs of the era we are living in and that haven't been already entirely absorbed and understood.

Between the reasons of the fall of these barriers it is certainly the fantastic improvement of communications, announced three decades ago by Mc Luhan. It is becoming every time more difficult to maintain men apart from each other, not to know the realities of other men, their dreams, successes and frustrations.

Slowly, the global village vision of Galbraith is becoming materialized. A progressive and apparently inexorable Regionalization – initially, by forming blocks of military nature, as the NATO - North Atlantic Organization Treaty and the Warsaw Treaty, and afterwards passing by the recent changes in the world's political panorama - is concentrating its effects in the economic and financial fields, with evident consequences on Education and Culture; Science and Technology; Ecology; Work; Demography; Nutrition; Sanitation and Health; Housing; Urbanization; Social Assistance; Security; etc.

This tendency to Regionalization is already present for some decades in Europe. As Benelux, this tendency has covered Belgium, The Netherlands and Luxembourg; later on, as European Common Market, has enlarged its frontiers and continue to flourish through the most part of Europe.

Nowadays, the economic and financial hegemony of north-Americans and Canadians, and their crescent influence in fields of the science and technology, culture, politics, military – is a very sharp reality. In opposition to this hegemony we can only observe other two important blocks, the European Common Market and Japan with its Asiatic mates. In this context and from a long time ago it exists always a Third World, with countries decided to maintain their individualized nationality. Some of these countries, called Developing Countries – in opposition to a less euphemistic denomination as Underdeveloped Countries – have geopolitical characteristics which allowed them to feed the pretension of preserve their national skills and resist against the unrestricted and disfiguring overflow of Globalization . We could list some of this kind of countries: China, India, and Brazil, for instance. These countries, each one for itself with geopolitical remarkable characteristics, can count with eventual alliances with regional neighborhoods or with mates of complementary resources; in this case we could mention Australia, South Africa, Pakistan, Mexico, Argentina.

Countries with a lower geopolitical expression, but always with strong and deep national traces have to seek alliances, usually in the same region, to become feasible in this new and challenger Globalized World.

ENGINEER AS AGENT OF TRANSFORMATION

Production factors are, as in the classical theory:
– natural resources
– capital or financial means
– man or agent of transformation

Actually, a fourth and powerful factor was added:
– science and technology

Globalization acts over all these factors, and our attention in this paper shall be conducted over the two last factors:
– Man - the agent of transformation
– Science and Technology - the powerful tool for transformation

Transformation agent for excellence, the Engineer of Developing Countries suffers the specific deficiencies of Education in that kind of country in which the absence of means results in low comparative levels (relatively with the more Developed Countries) as in the quantity as in the quality of graduates.

Some Developing Countries concentrate in a few Universities, mostly officials, and their main resources in Engineers formation of higher level. In these Universities, and they are usually in a very small number, Engineering Education is doing in the total amplitude of:
– graduation courses;
– technological applied research (sometimes also basic research); and

- extension activities in a complete range of courses and other activities for under-graduate, graduate and post-graduate participants.

However, most part of Engineering Education institutions are limited to graduation courses and activities of actualization or training, being quite unusual some research activity. General deficiency on the quantity of graduates in Engineering becomes already worse in Developing Countries because of the low percentage of better-qualified graduation courses.

In Brazil, Engineering graduation follows two main tendencies, as well we have also observed in some other Developing Countries. A small quantity of better-prepared professionals is coming mainly from official Universities, which promote creative capability of its graduates. The biggest part of graduates has a limited capacity to create or adapt new technologies to which they have not been prepared; their capability is mostly to operate, repair and maintain machines or engineering systems.

THE DEVELOPING COUNTRIES' CREATIVE ENGINEERS FOR A GLOBALIZED WORLD

Some principles can be placed concerning the formation and acting of creative Engineers, considering them as essential agents of the production of goods and services and for the development of every nation.

The first step should be the establishment of a common sense about the profile to fulfill when we graduate an Engineer, especially if we are thinking in a creative Engineer and, more than that, if we intend to prepare a professional to act in an international level. This is for itself a complex work, already more difficult at the moment we pass from the national boundaries to the large horizon of the entire world. Anyway, some indications we can afford to mention, as the convenience of reinforcing in such a case of graduation, the basic subjects as Mathematics, Physics, Chemistry, Drawing, as well as the modern instruments of Informatics.

A kind of international education means also the enlargement of the cultural horizons of Engineering students, with more learning of Social Sciences, Economics, Sociology, Legislation, Professional Ethics, Management, Ecology and Sustainable Development, Languages, History and Geography, etc.

The general perspective of this kind of Education is to reach a broader international and regional knowledge, always preserving and respecting local and national cultures and traditions.

SCIENCE & TECHNOLOGY AND THE WORK MARKET IN DEVELOPING COUNTRIES

Globalization presents some perverse results to Developing Countries that must be foreseen and controlled.

Globalization claims for new levels of competitiveness and efficiency that pushed some Developed Countries to privatize large sectors of activity, which were before linked to the governmental structure. Several States have diminished strongly their participation on sectors of production and of services, concentrating their action in sectors considered essentials to the national sovereignty and security, restricting itself to the normalization and control of other activities of collective interest.

In the domain of Engineering Education, exists a large discussion about the State participation in that activity – if the official action should be limited to normalize and control private institutions, even eventually to preview some financial aid, or if, apart of this action, should the State maintain some high level educational institutions directly linked to the official structure – practicing graduation Education simultaneously with research and activities of extension in its very large spectrum (as before mentioned).

The target of this second policy should be to guarantee the formation of Engineers capable to follow science evolution and the advances of the most recent technologies all over the world, even if the most part of the national professionals are limited to the operation, maintenance and repair of productive systems or services. The existence in Developing Countries of Centers of Excellence in Engineering Education is relevant. The reduced capacity to invest in Science & Technology in these countries should not obstruct them the possibility to count with certain number, even reduced, of educational Centers of Excellence to prepare their leadership in Engineering. A certain number of creative Engineers is always necessary to follow the world evolution of advanced technologies, adapt it to the better national conveniences, even to create new technologies to allow every country advance in the general development ranking .

Mobility of creative Engineers is very important. When creative Developing Country's Engineers stay in advanced scientific and technologic centers of the world's most developed countries, they acquire precious knowledge and take back home this assessment.

In the other hand, when foreign Engineers come to work in a Developing Country bringing more advanced knowledge and technolgy, if there is a real transfer to the local Engineers, enterprises and centers of Education and research, this presence is also positive for his host. Exchange should be encouraged and directed to creative Engineers. Some control may be necessary over the mobility, which could affect the very sensitive internal technological work market in Developing Countries .

EVALUATION AND ACCREDITATION & PROFESSIONAL HABILITATION

It is to remark the importance of build in every Developing Country a structure of Evaluation and Accreditation of its courses and/or institutions of Engineering Education and of the habilitation of Engineers to practice the profession.

Some national systems of evaluation and accreditation may serve as model to be adapted to the specific characteristics of other nations, as it is the case of the oldest and experienced organization in this field, ABET. Some countries work towards the creation of their own system of evaluation and accreditation, and we can mention, between Developing Countries, Mexico – which system is based in the American ABET system with some improvements – and Brazil.

An important result of Globalization is the necessity of more rigorous habilitation of professionals to attend the crescent work market exigencies . International accreditation and professional qualification and habilitation are so related with the internal systems of evaluation and accreditation of courses and/or institutions of Engineering Education of each country and its equivalency and accreditation at international level, as well the professional habilitation criteria of every country.

An evaluation and accreditation international system could be intended through agreements between nations and/or important groups of Engineering Education institutions, under the umbrella of a well known and prestigious entity (as UNESCO , WFEO) as a way and first step to attain an international professional qualification and habilitation.

Denmark

Research and Higher Education in Science and Engineering: How Can They Support Economic Development in Low Income Countries?

Prof. Erik W. Thulstrup,
Department of Life Sciences and Chemistry, Roskilde University, Roskilde, Denmark

SUMMARY: Low income countries are increasingly aware of the power of modern, research based technology, but its successful use is limited by a shortage of research trained manpower. Therefore, higher education and research in natural science and engineering must be strengthened in developing countries. Unfortunately, when such capacity building has been attempted, it has often failed to support "real life" applications. Therefore a new capacity building strategy is proposed which, right from the beginning, emphasizes cooperation between higher education and industry. This way, university researchers will learn applied aspects of their science and industries may learn to appreciate the efficiency of research based methods. The involvement of students through project learning is crucial and will, in addition, facilitate badly needed reforms of educational strategies.

KEYWORDS: Low Income Countries — Developing Countries — Higher Education — Research Based Technology — University-Industry Cooperation — Capacity Building — Higher Education Reform — Project Learning

RESEARCH AND HIGHER EDUCATION CAPACITY BUILDING IN DEVELOPING COUNTRIES

Partly as a result of the recent "globalization" most developing countries have felt an increasing need for access to modern, research based technologies. Although such technologies are often for sale at affordable prices, their successful purchase and use is dependent on the availability of research trained manpower, which is able to select, adapt, and further develop the technologies for local use (Thulstrup, 1994). In many countries the capacity within key science and engineering fields is insufficient to support research-based training of the needed manpower. Such countries are forced either to rely on foreign, research trained experts or to send their own staff for research training in other countries. Import of research trained manpower tends to be very expensive, in many cases much more expensive than similar services in industrialized countries. Training of young researchers from developing countries has often been successful, but it is also expensive and not without risks, especially in the form of brain drain (Thulstrup, 1996).

Therefore, it is not surprising that both developing countries and many donors, international organizations, and development banks give high priority to capacity building within university education and research, with the purpose of facilitating domestic, research based training. For years, the subjects favored have been health and agriculture; today an understanding of the importance of science and engineering fields that support industrial development is slowly emerging - clearly economic development in developing countries can no longer be based on agriculture alone. Typical components in higher education and research capacity building projects include: Training of university staff, construction of buildings for educational activities, research, libraries, and administration, laboratories, educational and research equipment, computers, and service facilities for such equipment, funds for operation and maintenance, textbooks, research journals, and access to data bases and other communication channels (Thulstrup, 1996).

Unfortunately, some highly efficient, additional components are often not included the projects, for example individual incentive systems for university staff (especially fair promotion rules and salaries, which make full time work efforts possible). When in place, such incentive systems may help ensure that facilities and working time are used in the most productive fashion possible. Also the provision of monitoring and evaluation systems is essential, not only for the build-up phase, but more importantly for the productive situation that is supposed follow after the initial investments (Thulstrup, 1998a).

Among the components frequently missing are also renewal of educational strategies and support for cooperation between universities and users of knowledge (industry). In such projects the interdependence of research and education is often overlooked and the creation and the use of higher education and research capacity are viewed as two completely separate activities. In most cases this is an inefficient strategy. Industry in developing countries has generally a very limited experience in the use of knowledge services and may not be ready to use a newly created research capacity. In order to promote economic development university research capacity building projects may have to develop a wider clientele for research based services in the process, see for example Soewandhi (1996). Outside clients may also make it possible to sustain research and higher education capacity at an acceptable level during periods of limited government and donor support. Many examples exist of donor supported research capacity that has failed to enter the productive phase outside education after an otherwise successful capacity building period. In the following we shall see how university-industry cooperation may help sustain university research activities, contribute to national economic development, and, at the same time, renew higher education in developing countries.

THE NEED FOR RENEWAL IN HIGHER EDUCATION: PROJECT BASED LEARNING

Higher education today takes place in many different forms. Traditionally, the two major activities are:

- Teaching (done by the teacher)
- Learning (done by the students, but often by the teacher, too)

Clearly, the main purpose of education is learning and not teaching. Teaching, however, is often considered a main remedy for learning, although considerable evidence indicate that very active teaching may reduce both the time and the student attention available for the more important learning processes. The risk is greatest when the teacher is placed in the center of the educational activities and directs these with little insight in and regard for the learning processes among individual students (Thulstrup, 1998). There is today a widespread agreement that major educational reforms are needed in many countries and universities (World Bank, 1994).

In order to place the teacher in a more constructive role as "facilitator" for learning by individual students, one may let the educational activities to depend on other factors, for example an open-ended laboratory experiment or the progress within independent student work. An important example of the latter type of educational activity is project-based learning, in which students – often in small groups – work on the solution of a specific problem. Although project learning is not new at universities - it is traditionally used in connection with thesis research projects during the final year of degree programs – a wider use seems to offer highly relevant opportunities. At some universities project learning has to a large extent replaced traditional lectures and "cook-book" laboratory experiments and is by many considered one of the most promising renewals of learning strategies today (Legge, 1997; Thulstrup, 1998b).

A key quality associated with project learning is that it provides the students with a high degree of responsibility for their own learning; the feeling of personal responsibility is one of the strongest motivational forces available in the workplace. A comparable feeling of responsibility can hardly be developed through traditional teacher centered education (based on, for example, "chalk and talk", memorization, and rote learning). The direct, personal responsibility for outcomes of project activities results in high levels of student motivation and efficient learning (Thulstrup, 1998b). However, educational environments tend to be surprisingly conservative and renewal in educational strategies is often difficult to accomplish (Goodwin, Miller, and Cheetham, 1991).

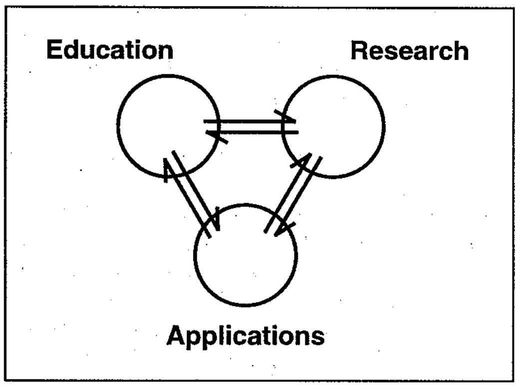
Among the learning outcomes, that may result from project work, are (Thulstrup, 1998b): An ability to think independently and to accept personal responsibility, flexibility that makes it possible to adjust to and work effectively under new conditions, experience in the analysis and solution of specific problems within a given time-frame, inquiry skills and attitudes, experience in dissemination, interdisciplinary knowledge, insight and interest in applied aspects of academic knowledge and in how industry functions in real life. Project learning has an added advantage in that the work form approaches conditions which students will experience after graduation. Project work may often benefit in several ways from covering themes of direct industrial or societal interest; this way it may even be possible to replace costly, traditional university laboratory activities with work in industrial workplaces.

INVOLVEMENT OF STUDENTS IN UNIVERSITY-INDUSTRY COOPERATION

In the 1970s university teachers (more so in science, less in engineering) preferred to look at education, research, and science applications as three fairly separate activities, as shown in *Figure 1.*

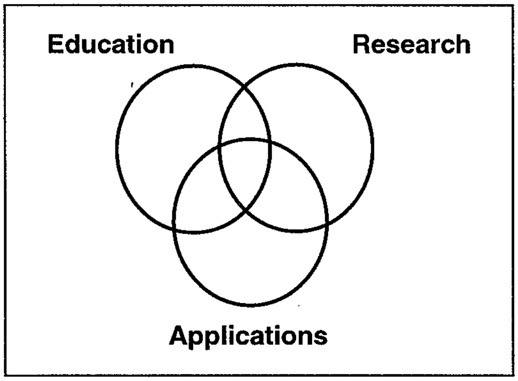
Today most university teachers, even in the basic sciences, have realized both that education and research are strongly interdependent and that they overlap strongly with science applications, as shown in Figure 2. At the same time industry has become increasingly interested in academic research and higher education.

Fig. 1. The Relation Between Education, Research and Applications in the 1970s (Thulstrup, 1999)



There are several reasons for the increased interest within industry, especially the fast development toward more directly research based technologies increasing the need for in-service training of industrial staff as well as for research and development projects. The changed attitudes within Academia may have more complex causes, including the realization that financing of higher education in many countries may benefit from the introduction of paying customers in addition to the state and young students (although the state is likely to remain a key sponsor in any country). Universities with up-to-date research activities in science and engineering are able to produce a whole string of offers relevant for industry as well as for the public sector, including course activities, research and development services, and technology evaluation (Kornhauser, 1992). In addition, the interest among academics for industrial cooperation has been strengthened by the obvious need to renew higher education and by a better understanding of the strong interaction between education and research (*Figure 2*), especially that one of the main outcomes of research, even in industry, is learning.

Fig. 2. The Relation Between Education, Research and Applications in the 1990s (Thulstrup, 1999)



An important condition for successful university-industry cooperation is the observation that bright and well-trained students represent a considerable, high quality work force, one of the most valuable assets universities have to offer industry. Although students may learn effectively "by doing", this should not lead to exploitation. It is important that universities, when they become "entrepreneurial" (Clark, 1998), preserve solid academic quality standards, also in their industrial cooperation. Universities should not become regular businesses (Thulstrup, 1999), student learning must remain the key goal, and, for example, excessive amounts of routine work by students should never be accepted.

CONCLUSION

Research capacity building projects in developing country universities often fail to directly promote economic development, and the capacity created is often difficult to sustain in the absence of "outside" clients. At the same time, university education is frequently inefficient, and is constrained by insufficient resources. It is therefore proposed that research and higher education capacity building projects within engineering and science are carried out in cooperation with users of the relevant knowledge, especially industry. This should be done in such a way that the ability of the users to benefit from research based knowledge is developed together with the strengthening of educational strategies and research capacities at universities. Students must be involved in the industrial cooperation, if possible from year 1, for example by replacing a considerable part of the traditional course work with student group projects carried out in cooperation with industry and other potential customers for research based services. Once the capacity to benefit from knowledge services has been created in industry, it will be expected to pay for these.

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Mexico

Steps to Improve Engineering Courses in Mexico

Prof. Fernando Ocampo-Canabal

At the last years, the evaluation and accreditation processes in Latin American countries, have been object like a goal to increase the quality level of higher education; but certainly, these processes respond to the demand to have a professional more competitives; also, because the professions play a vital leadership role in society, specially the engineers:

"As a dreamers, builders and creators, engineers contribute to economic advancement, wealth generation and improvement in the human condition trough the creative application of science and technology in a local, national and global context "[1]

However, an important think related to this citation, is coherence betwen the professional activities and the educational programs. But, what happened in higher education in México?

The government scheme followed in our country to certify the quality of educational programs was suitable for the conditions under which it was stablished, over time the expansion of the educational system and its growing complexity, have created the necessity of establish accreditation systems that efficiently respond to real educational requirements, and, of course, of a different type then those employed by the government today.

1 *Consensually Validated Elements of a Vision for the Engineerig Profession-CCPE*

In this way, the more important actions was taken by the Ministery of Education and presidents of Higher Education Institutions; together took a resolution in the middles of seventies established an organism to help institutions to develop plans: National Coordination for Planning Higher Education (Coordinación Nacional para la Planeación de la Educación Superior - CONPES); after, at the end of the eighties it was in advance in the necessities of evaluation and accreditation processes like a mechanism to increase the quality in higher education: National Commision for Evaluation of Higher Education (Comisión Nacional para la Evaluación de la Educación Superior - CONAEVA), and as a consequence was created the National System of Evaluation of Higher Education (Sistema Nacional de Evaluación de la Educación Superior) with three different functions:

- Institutional Self-Evaluation
- Evaluation of the Educational System
- Interinstitutional Evaluation

Initially the accreditation was responsability of the " Interinstitutional Committees for the Evaluation of Higher Education (Comit,s Interinstitucionales para la Evaluación de la Educación Superior - CIEES), program founded in 1991. But, other countries experiences (ABET, CEAB) indicate the importance of the participation of different sectors related to the professional of enginneers (professional associations), also the government and representative sector from industry . This, constitute a reason to put into operation a civil association whose main objective is the accreditation. This civil associatiation, called the "Engineering Education Accreditation Board" (Consejo de Acreditación de la Enseñanza de la Ingeniería - CACEI), was legalized on the fifth of July in 1994, and consequently as a legal organization.

1994 TO PRESENT – ACTIVITIES OF CACEI

Before CACEI was established, some activities related to the purpose of its creation was developed: a declaration from National Association of Schools of Enginneering (Asociacion Nacional de Facultades y Escuelas de Ingeniería - ANFEI) related to the importance and necessity to establish a Mexican System for accreditation in enginnering , workshops sponsored by ABET to promote the accreditation and experiences of interinstitutional evaluation.

There are several important aspects, at the same time interesting, wich should be mentioned regarding CACEI:

- The way in which it is incorporated, as it's members are representatives of the different sectors related to the formation and professional practice of engineers.
- The participation of ANFEI and the engineers guilds through the associations of professionals from different specialities.
- The Association objectives:
  - To contribute to knowledge and improvement of the quality of teaching of engineering in the public and private educational institutions in the country, following a model that responds to the needs of Mexico and to the engineering practice conditions in the nation.
  - To contribute to the establishment of paradigms and engineering teaching models according to scientific advances and the resources of professional practice, derived both from the needs of the society and those of future professionals.
  - To contribute to improvement of the quality of professional engineering practice.
  - To inform educational institutions, students, parents, employers and those interested public and private bodies, about quality of engineering teaching conditions in the different schools of engineering in the country.

The first step, after the legal requirements to establish the Association, was developing a methodology. In this aspect, the previous experiences in other contries, support from ABET and its interest in developing accreditation outside of United States, was very important element to have a succesfull goal.

CACEI published a Manual in 1996; this contents almost total aspects in accreditation processes. At the same time was necessary promote the "Accreditation Culture". ANFEI and CACEI took an initiative: accreditation workshops; together realized in each region of country, seven of them. Also CACEI offered workshops to training evaluators; at this moment seventh have been realized.

The CACEI's purposes, objectives, policies, method of evaluation, criteria and procedures, are similar to ABET.

By example, we can take the IVC.3.1. from ABET General Criteria:

"one year of an appropiate combination of mathematics and basic sciencies"

CACEI requirements, 4.10 (curriculum):

"...subjects must be covered in a minimum of theoretical and laboratory teaching class hours, according to the following chart:

Basic sciencies and mathematics - 800 hours"

Another important aspects from CACEI , is the participation in NAFTA negotiations. The Mutual Recognition of Registered Licensed Engineers by Jurisdictions of Canada, the United States of America and the United Mexican States Document. Signed at Washington, D.C. the 5th of July, 1995 recognise CACEI as an official body for accreditation in Mexico; also indicate:

"Substantially Equivalent Engineering Program" means a non accredited program which has been recognized by the CEAB of CCPE, of ABET or CACEI.

In other way, CACEI participate in the creation of an accreditation framework of engineering programs and the development of an accreditation system in Latin American countries.

The specific benefits will result from the accreditation system in the Latin American countries can be summarized as follows:

- Support the changes demanded by engineering practice, nationally and internationally
- Involving by engineers from industry, academia in the processes:
- Identification of engineering programs which currently meet good quality education standards.
- Provision of international recognition of engineering education credentials thereby improving the international mobility of engineers.
- Increase the collaboration amongst engineering organizations throughout the Americas.

Finally, as already mentioned, the action of establishing an accreditation system for engineering education, has a direct effect on the quality of the programs and consequently on their professional performance.

In the case of enginnering, better program quality will result in direct benefits for the manufacturing and service sectors, given that professional engineers graduated from accredited programs will generally perform more efficiently than those who graduate from non-accredited programs, This also contributes to an improvement of the manufacturing systems, by increasing the efficiency of the operating systems of bussinesses, and in general by increasing the quality of a group of elements that form part of goods and service producing companie's activities, making them more competitive with better financial and operating conditions, as well as providing greater benefits to society.

Hungary

Specialised Engineering Education and Globalization at the Faculty of Agricultural Engineering at Gödöllő University

Dr. János Beke and Dr. Attila Vas,
Gödöllő University, Hungary

SUMMARY: In agrarian mechanical engineering education the influences of globalization, the social-economical changes and the institutional traditions have to be taken into consideration at the same time. In reply to the effects of globalization a modular credit type education system was developed including a standardised core curriculum. Negative impacts of the social-economical changes which took place in Hungary were compensated for by introducing a new admission and preparatory procedure and also, a manifold professional education system. According to the institutional traditions serving the technical development of the countryside and educating the provincial intelligentsia are sustainable activities of the faculty.

KEYWORDS: Standardised Core Curriculum — Manifold Professional Education — Admission and Preparatory System — Credit Type Education — Engineering Education

PRELIMINARIES

The history of the Faculty of Agricultural Engineering can be divided into two main periods. In the first period only agricultural mechanical engineers were instructed. The main task was to establish and manage the so called agricultural machine centres. These depots concentrated the limited agricultural machines and instruments available and guaranteed the technical infrastructure for the socialist co-operatives. These co-operatives acquired their own machines at the beginning of the sixties and the mechanical engineers who graduated from our faculty provided the technical management. The faculty became the dominant institute of the agro-mechanical profession, furthermore its education and research activity had a high international reputation. Specialists graduated from the faculty played leading roles in the mechanisation of agriculture and in regional development. The reason for this significant development was that, in spite of the strongly centralised education policy, a continuous curriculum development took place. In this way it was able to avoid the usual difficulties of short-sighted educational policy and it was able to predict the likely direction of development.

THE CHALLENGES

The most significant reappraisal resulted from the social and political changes in 1990, marked the second major period for our faculty. The impacts which directly influenced higher education at this time came partly from international globalization, and partly from the Hungarian social-economical changes. It must be stressed that the agro-mechanical engineering education was the most radically affected by the general international tendencies and by the special Hungarian circumstances.

The international effects:

The international effects can be divided into three groups:

- Information shock: The information revolution modified our whole life. Learning and working could hardly be separated, the characteristic difference between teacher and student partly disappeared.
- Globalization shock: In Hungary a multinational economical sphere has been established. In the higher education, corresponding to the international trends, demands of international equivalency of degrees and standardisation of curricula have arisen. At the same time the government gradually cut the educational budget, which led to a risk of reducing the education standard and its infrastructural facilities, and increased the undesirable brain drain phenomena and reduced the available choice of lecturers.
- Civilisation shock: The accelerating obsolescence of knowledge caused feelings of uncertainty, while the qualification and creativity have increased in importance.

National effects:

Special national effects can be evaluated on one hand as natural consequences of the social changes, on the other hand as impacts of official political decisions. These effects can be divided into at least four groups:

- Change of paradigm in economics and politics: The paternalistic attitude, which was customary over fourty years, lost its validity at a stroke. Higher education was abandoned, because the government was exhausted from its political skirmishing and from starting the privatisation process and from this point of view, higher education as a long-term investment was not considered. Although management in the institutes of higher learning were fully aware of the international challenges, they could only partly respond to them, because of lack of finances. Consequently contraselection and brain drain began.
- The land as a political consideration: The land – and with it the whole of agriculture – has emerged as one of the most important political issues. The first aim of the political regime which came to power demolished the large-scale socialist co-operatives as the typical symbol of the former communist authority. These measures might have been justified in political terms, but they caused immense damage in economics and in agricultural higher education. The conditions for efficient agricultural production were removed and agricultural higher education became apparently redundant. It is true that family farms with only a few hectares do not require qualified mechanical engineers of the classical type.
- Non-homogeneous economical development: Under the conditions of a non-controllable and territorially uneven economical transformation the most important task for people was to acquire property. This kind of activity needed first of all legal, financial and economical knowledge but it led to a devaluation of engineering. While it is important traditional agrarian mechanical engineering education is based in the countryside, the disadvantageous influences of the social changes, such as the uncertainty of basic income and an unstimulating environment in the countryside, significantly hindered our education activity.
- Non-uniform system of secondary education: The formal uniform system of secondary schools fell apart. The number of secondary schools doubled and their teach-

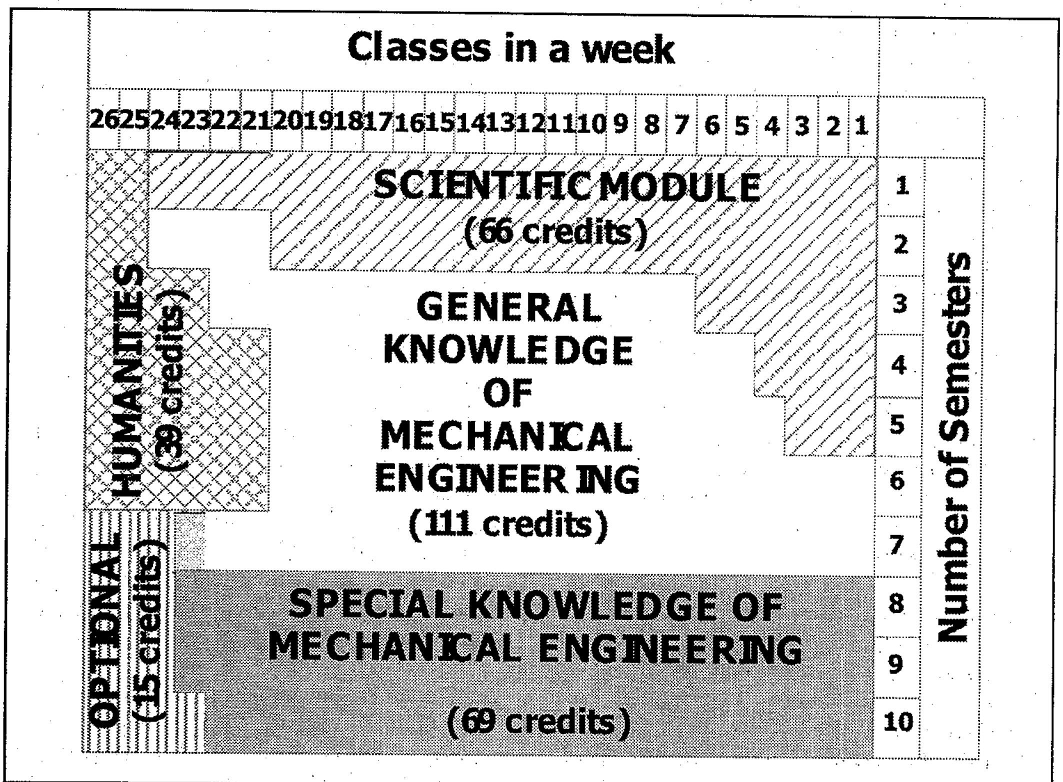
ing standard became extremely heterogeneous. The level of education definitely dropped, particularly in the provincial schools. Preliminary training of many candidates was so low that it made it impossible for them to take on the essential knowledge of engineering.

THE SOLUTIONS

It is unquestionable that the agriculture and the rural engineering need mechanical engineers with biological and economic knowledge for now and for the future, but approximately half of the agro-mechanical engineers who graduated before 1990 found their careers outside classical agricultural production and this proportion has grown to about 90% in the nineties. At the same time agricultural production as well as the manufacturing of agricultural products, food industry, materials handling and packing, logistics, production-type services, rural engineering, maintenance and development of infrastructure, technical requirements of administration, reconstruction of industry, development of information technology, or trade of production implements have brought about new challenges and new opportunities for employment.

The main challenge is to give a high-level basic education which makes students capable of obtaining special knowledge prerequired by the current economic conditions. The first task of establishing a curriculum which meet the above expectations is degree equivalency, which means double task. On the one hand the experience of international higher education should be taken into consideration, and should also meet the expectations of some international consortia e.g. ECTS (European Community Course Credit Transfer System); on the other hand, reasonable discussion should be undertaken between the Hungarian

Fig. 1. Curriculum structure in the branch of agrarian mechanical engineering



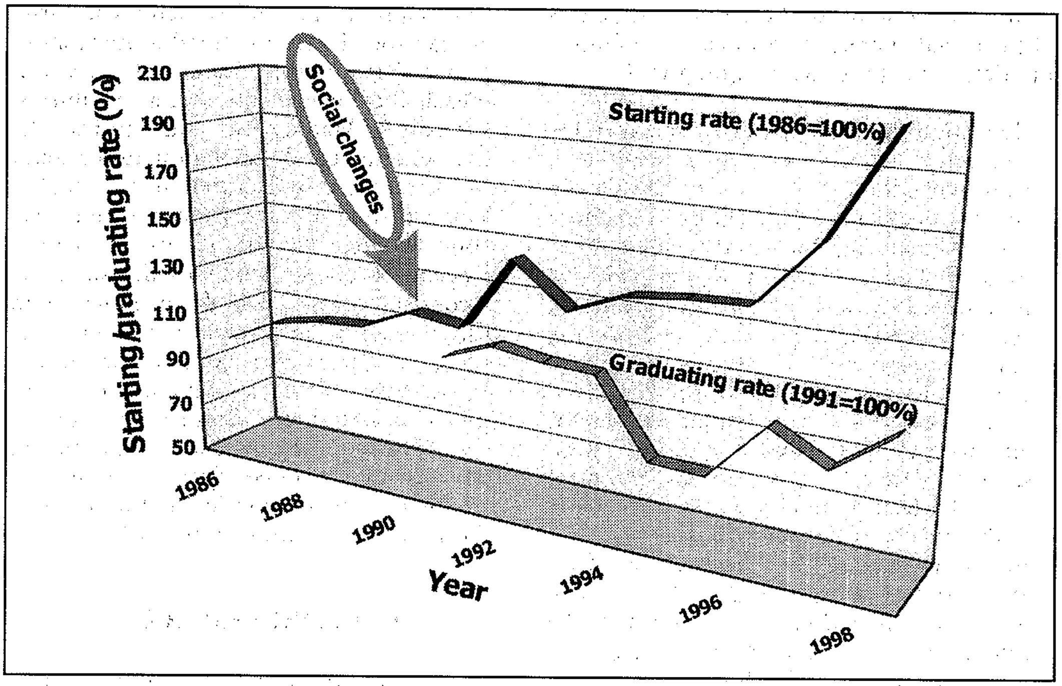


Fig. 2. Dropout situation at the branch of agro-mechanical engineering

universities. Additionally these factors need to be implemented in keeping with national and institutional traditions.

All of these require improving pure and applied scientific education and also economic and management knowledge, and additionally the human disciplines, enhancing the sense of intellectual vocation. The time which is used with more or less restriction by students according to their professional interests, is a significant part of the total course duration (different skill studies, seminars, language courses, etc.). The pure and applied scientific disciplines became of increasing importance together with economic knowledge (Figure 1). As a result of improving the scientific education also, specialised teaching belongs to the engineering technologies to promote the convertibility of knowledge and opportunities for employment (see *Fig. 1*).

Teaching of the core curriculum takes place in the first seven semesters, this is followed by the professional education period which is at least three additional semesters. The courses which are relevant to the diploma project are taken in close co-operation with a department. The Special Knowledge of Mechanical Engineering consists of the following specialisations:

- Agricultural Production Technology and Maintenance
- Production and Product Design
- Food Processing Technology
- Technical Economy and Management
- Rural Engineering
- Service Engineering
- Environment Protection Engineering
- Human Settlement Engineering
- Automotive Technology
- Logistics
- Engineering Mathematics

Students must study prescribed curriculum concerning the selected specialisation, and work in a scientific research/development laboratory of the University or at another institution under the supervision of the department and must develop their diploma projects using this experience.

In order to address the special influences of the social changes in Hungary the following fields of activity were highlighted:

- Education should meeting the social and economical expectations: As a result of a continuos development today the course content of the branch of agrarian mechanical engineering has transformed completely. The solving of theoretical and practical technical problems concerning regional development, rural engineering and environmental protection now have more and more importance, including environment, service and human settlement engineering. Nowadays, it is the technology-development engineers who graduate from the faculty and who create the basis of the provincial intelligentsia.
- Increasing the openness of education: After 1990, first of all as a result of the official policy in connection with agriculture, the interest in agrarian mechanical engineering education severely diminished. In order to compensate for this disadvantageous trend and to improve the openness of the education the admission's system followed by the faculty was modified. The traditional entrance examination was dropped and candidates were ranked on the basis of their secondary school results. In practice the admissions procedure was extended over the first semester, because the newly enrolled students got a whole semester instead of an entrance examination of 20-30 minutes to prove their ability in fulfilling the education requirements. This is the positive side of this method. To be honest this procedure makes the first semester overcrowded, furthermore the acceptable number of students is limited by the capacity of the institute and by the prescriptions of Ministry of Education. Besides, instead of input-control now output-control had to be introduced. This means more candidates were allowed to enroll, but the education requirements were maintained at the original level. Consequently, the dropout rate of students increased dramatically (see *Fig. 2*).
- Promoting remedial and preliminary training: Candidates not fulfilling the admission requirements and students who drop out get the chance to attend a preparatory course. Within this framework they can breach their gap in the entrance subjects, specially in Mathematics and Physics. The course content and the examination criteria are determined by lecturers of the faculty. The course results are taken into consideration during the admissions procedure. Depending on the student's decision, the secondary school results in Maths and Physics can be substituted with course results, or the closing examination of the preparatory course may function as an entrance examination. Besides the subject Communication Knowledge taught during the preparatory course gives the possibility for some career orientation and to improve the students' communicative skills.

CLOSING REMARKS

In order to achieve the results of information technology the general professional literacy was increased, especially in computer sciences, in linguistic education and in creativity.

To meet the needs of globalization a flexible modular curriculum was developed. The core curriculum was standardized and in order to make the acquired knowledge transferable a credit system type curriculum was developed. By introducing standardized modules of subjects the obtained knowledge can be credited which makes possible student mobility between universities of a similar profile. In response to special circumstances in Hungary a new admission and preparatory system was introduced, taking the territorially uneven economical development of the country into consideration. Manifold professional education was built on to core curricula so that the thorough grounding of graduate agrarian mechanical engineers fully meet the economical and social expectations. Unfortunately Hungarian higher education is under-financed even when compared to the national GDP, and due to this pressure it is not easy to realize the curricula development described above.

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